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Türkiye, Bulgaria and Romania

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CONTENTS

1. INTRODUCTION.....	10
2. CURRENT STATUS OF BIODIVERSITY	14
2.1. TÜRKİYE	14
2.1.1. <i>Species Diversity in the Black Sea of Türkiye</i>	14
2.1.2. <i>Key Ecosystems and Habitats</i>	30
2.1.3. <i>National Inventories and Monitoring</i>	34
2.2. BULGARIA.....	36
2.2.1. <i>Species Diversity in the Black Sea of Bulgaria:</i>	36
2.2.2. <i>Key Ecosystems and Habitats</i>	90
2.2.3. <i>National Inventories and Monitoring</i>	93
2.3. ROMANIA.....	97
2.3.1. <i>Species diversity and their role in the food web</i>	97
2.3.2. <i>Key Ecosystems and Habitats</i>	116
2.3.3. <i>National Inventories and Monitoring</i>	124
THREATS TO BIODIVERSITY.....	130
3.1. TÜRKİYE	130
3.1.1. <i>Overfishing and IUU Fishing</i>	130
3.1.2. <i>Pollution and Eutrophication</i>	140
3.1.3. <i>Habitat Loss and Degredation</i>	140
3.1.4. <i>Invasive Alien Species</i>	143
3.1.5. <i>Abandoned, Lost or Discarded Fishing Gear (ALDFG)</i>	144
3.1.6. <i>Climate Change</i>	147
3.2. BULGARIA.....	151
3.2.1. <i>Overfishing and Illegal Fishing</i>	151
3.2.2. <i>Pollution and Eutrophication</i>	153
3.2.3. <i>Habitat Loss and Degradation</i>	155
3.2.4. <i>Invasive Alien Species:</i>	156
3.2.5. <i>Climate Change and Ocean Acidification</i>	158
3.3. ROMANIA.....	159
3.3.1. <i>Overfishing and Illegal, Unreported, and Unregulated (IUU) Fishing</i>	160
3.3.2. <i>Pollution and Eutrophication</i>	160
3.3.3. <i>Habitat Loss and Degradation</i>	161
3.3.4. <i>Invasive Alien Species (IAS)</i>	161
3.3.5. <i>Climate change and ocean acidification</i>	161
4. BLACK SEA FOOD PYRAMID	162
4.1. TÜRKİYE	162
4.1.1. <i>Primary Producers (Phytoplankton and Seagrass)</i>	162
4.1.2. <i>Primary Consumers (Zooplankton)</i>	170
4.1.3. <i>Secondary Consumers (Small Pelagic Fish)</i>	172
4.1.4. <i>Tertiary Consumers (Medium-Sized Pelagic and Benthic Fish)</i>	172
4.1.5. <i>Apex Predators</i>	173
4.2. BULGARIA.....	176
4.2.1. <i>Primary Pproducers: Phytoplankton and Seagrass:</i>	176
4.2.2. <i>Primary Consumers: Zooplankton and Benthic Invertebrates:</i>	177
4.2.3. <i>Secondary Consumers: Small Pelagic Fish: (anchovy, sprat, mullet species)</i>	177
4.2.4. <i>Higher Predators: Medium-Sized Pelagic and Benthic Fish: (bonito, mackerel, zander, etc.)</i>	178
4.2.5. <i>Apex Predators: Dolphins (Sharks were more common in the past):</i>	179
4.3. ROMANIA.....	181

NEXT Black Sea Basin

4.3.1. Primary Producers: Phytoplankton and Macrophytes.....	181
4.3.2. Primary Consumers: Zooplankton and Benthic Invertebrates.....	181
4.3.3. Secondary Consumers: Small Pelagic Fish.....	181
4.3.4. Higher Predators: Medium-sized Pelagic and Benthic Fish.....	182
4.3.5. Apex Predators: Cetaceans and Elasmobranchs.....	182
5. MARINE PROTECTED AREAS (MPAS)	184
5.1. TÜRKİYE.....	184
5.2. BULGARIA.....	187
5.2.1. Monitoring Methods within MPAs	188
5.2.2. Governance Structures, Monitoring, and Enforcement Mechanisms.....	188
5.2.3. Contribution to Biodiversity and Ecosystem Services	188
5.3. ROMANIA.....	188
5.3.1. Vama Veche – 2 Mai Marine Reserve (ROSCI0273 / ROSPA0076)	189
5.3.2. Danube Delta Marine Zone (ROSCI0066 / ROSPA0031)	189
5.3.3. Cape Tuzla (Capul Tuzla - ROSCI0094 / ROSPA0041).....	190
5.3.4. Submerged Beach of Eforie (Plaja Submersă Eforie Nord – Eforie Sud - ROSCI0197).....	190
5.3.5. Mangalia Submarine Sulfurous Springs (Izvoarele sulfuroase submarine de la Mangalia - ROSCI0095).....	190
5.3.6. Razim-Sinoe Marine Transition Zone (ROSCI0065 / ROSPA0027)	190
5.3.7. The "Black Sea" Offshore Area (Marea Neagră - ROSPA0076).....	191
6. LEGAL AND INSTITUTIONAL FRAMEWORK.....	192
6.1. TÜRKİYE.....	192
6.1.1. International and Regional Agreements	192
6.1.2. National Regulations.....	195
6.1.3. Other Key Legal Frameworks Supporting Biodiversity Protection	197
6.2. BULGARIA.....	200
6.2.1 International and Regional Agreements	200
6.2.2. National Regulation.....	204
6.3. ROMANIA.....	206
6.3.1. International and Regional Agreements	206
6.3.2. European Union Integration	209
6.3.3. National Legislation.....	211
7. ANALYSIS AND GAPS.....	214
7.1. TÜRKİYE.....	214
7.1.1. Biodiversity Implementation	214
7.1.2. Biosafety Governance.....	214
7.1.3. Black Sea Marine Protected Areas (MPAs).....	215
7.1.4. Fisheries Management	215
7.1.5. Main Impacts of Regulations.....	215
7.1.6. Recent Developments.....	215
7.1.7. Good Practices and Transferable Models	216
7.1.8. Main Regulatory and Implementation Gaps	220
7.2. BULGARIA.....	221
7.2.1. Lessons Learned.....	221
7.2.2. Good Practices and Transferable Models	221
7.2.3. Methodological Gaps	222
7.3. ROMANIA.....	222
7.3.1. Progress and Implementation Barriers.....	222
7.3.2. Good practices and transferable models.....	223
7.3.3. Integrated Marine Spatial Planning (MSP).....	223

NEXT Black Sea Basin

7.3.4. <i>Sophisticated Biotic Metrics</i>	223
7.3.5. <i>Methodological and information gaps</i>	223
7.3.6. <i>Strategic Path Forward</i>	224
8. CONCLUSION	225
8.1. TÜRKİYE	225
8.2. BULGARIA	225
8.3. ROMANIA	226
REFERENCES	228

FIGURES

FIGURE 1: THE BLACK SEA BASIN	13
FIGURE 2: THE MOST COMMON MICROZOOPLANKTON SPECIES FOUND IN THE BLACK SEA. A) <i>TINTINOPSIS CAMPANULA</i> , B) <i>LEEGAARDIELLA OVALIS</i> , C) <i>CODENELLOPSIS SP.</i> , D) <i>EUTINTINUS SP.</i> RESPECTIVELY (PHOTO: A.M. FEYZIOGLU)	19
FIGURE 3: A) <i>ACARTIA CLAUSI</i> AND B) <i>CALANUS EUXINUS</i> ((PHOTO: İLKNUR YILDIZ)	19
FIGURE 4: THE MOST COMMON CTENOPHORA SPECIES FOUND IN THE BLACK SEA. A) <i>MNEMIOPSIS LEIDYI</i> , B) <i>BEROE OVATA</i> , C) <i>PLEUROBRACHIA PILEUS</i> , D) <i>MNEMIOPSIS LEIDYI</i> BLOOM RESPECTIVELY (PHOTOS: A.M. FEYZIOĞLU).....	20
FIGURE 5: THE MOST COMMONLY OBSERVED SCYPHOZOA SPECIES IN THE BLACK SEA A- <i>AURELIA AURITA</i> MOONFISH, B- <i>RHIZOSTOMA PULMO</i> BARREL JELLY, C- <i>AURELIA AURITA</i> BLOOM, D- <i>RHIZOSTOMA PULMO</i> BLOOM RESPECTIVELY (PHOTO: A.M. FEYZIOGLU)	21
FIGURE 6. <i>HUSO HUSO</i>	103
FIGURE 7. <i>ACIPENSER GUELLENSTAEDTI</i>	103
FIGURE 8. <i>BELONE BELONE</i>	104
FIGURE 9. <i>SPRATTUS SPRATTUS</i>	104
FIGURE 10. <i>ALOSA MAEOTICA</i>	105
FIGURE 11. <i>ENGRALIUS ENCRASICOLUS</i>	105
FIGURE 12. <i>NEOGOBIOUS MELANOSTOMUS</i>	106
FIGURE 13. <i>SCOMBER SCOMBRUS</i>	106
FIGURE 14. <i>SQUALUS ACANTHIAS</i>	107
FIGURE 15. <i>SYNGNATHUS TYPHLE</i>	107
FIGURE 16. <i>CHELIDONICHTHYS LUCERNA</i>	108
FIGURE 17. <i>SCOPHTHALMUS MAEOTICUS</i>	108
FIGURE 18. <i>MUGIL CEPHALUS</i>	109
FIGURE 19. <i>RAJA CLAVATA</i>	110
FIGURE 20. <i>DASYATIS PASTINACA</i>	110
FIGURE 21. <i>MULLUS BARBATUS</i>	111
FIGURE 22. <i>MYTILUS GALLOPROVINCIALIS</i>	112
FIGURE 23. <i>PHOCOENA PHOCOENA RELICTA</i>	113
FIGURE 24. <i>DELPHINUS DELPHIS PONTICUS</i>	114
FIGURE 25. <i>TURSIOPS TRUNCATUS PONTICUS</i>	114
FIGURE 26. <i>MNEMIOPSIS LEIDYI</i>	115
FIGURE 27. <i>RAPANA VENOSA</i>	116
FIGURE 28. <i>COSGINODISCUS</i>	118
FIGURE 29. <i>CHAETOCEROS</i>	119
FIGURE 30. <i>CERATIUM</i>	120
FIGURE 31. <i>ACARTIA CLAUSI</i>	121
FIGURE 32. <i>CALANUS EUXINUS</i>	122
FIGURE 33. BLUEFISH (<i>POMATOMUS SALTATRIX</i>)	122
FIGURE 34. <i>ZOSTERA MARINA</i>	123
FIGURE 35. CHANGES IN THE NUMBER OF FISHING VESSELS AND MARINE CAPTURE PRODUCTION IN TÜRKİYE (2000–2025).	133
FIGURE 36. ANNUAL CATCHES OF MAJOR COMMERCIAL FISH SPECIES IN THE BLACK SEA.	135
FIGURE 37. LONG-TERM TRENDS OF COMMERCIALY IMPORTANT FISH SPECIES (2000–2025).	136
FIGURE 38. TRENDS IN TURKISH FISHERIES PRODUCTION BY PRODUCTION SECTOR (2000–2025).....	137
FIGURE 39 A DOLPHIN ENTANGLED WITH ALDFG ON THE COAST OF SÜRMENE TRABZON TÜRKİYE (CAPTURED DURING BLACKNETS PROJECT).....	147
FIGURE 40. SPATIAL MAP OF THE BLACK SEA SST UNCERTAINTY FROM 1982 TO 2020 (MOHAMED ET AL, 2022) .	148
FIGURE 41. <i>SYNECHOCOCCUS SPP.</i> OBSERVED IN THE BLACK SEA. (PHOTO: A.M. FEYZIOGLU)	163
FIGURE 42. <i>PYRAMIMONAS ORIENTALIS</i> (HTTPS://WWW.CCAP.AC.UK/CATALOGUE/)	164

NEXT Black Sea Basin

FIGURE 43. SOME SILICOFAGELLATES OBSERVED IN THE BLACK SEA. (A) <i>DICTYocha SPECULUM</i> , (B) <i>OCTACTIS OCTONARIA</i> (PHOTO: A.M. FEYZIOGLU)	165
FIGURE 44. <i>EMILIANA HUXLEYI</i> (PHOTO: A.M. FEYZIOGLU) AND <i>E. HUXLEYI</i> BLOOM ALONG THE BLACK SEA COAST NASA (HTTPS://WORLDVIEW.EARTHDATA.NASA.GOV)	166
FIGURE 45. SOME DIATOM SPECIES OBSERVED IN THE BLACK SEA A) <i>PROBOSCIA ALATA</i> , B) <i>THALLASIONEMA NITZSHIODES</i> , C) <i>RHIZOSOLENIA CALCAR-AVIS</i> D) <i>CHAETOCEROS DIDYMUS</i> , E) <i>CHAETOCERUS CURVISETUS</i> , F) <i>DITYLUM BRIGHTWELLI</i> , G) <i>CHAETOCEROS COMPRESSUS</i> , H) <i>DACTYLIOSOLEN FRAGILISSIMUS</i> , I) <i>COSGINODISCUS RADIATUS</i> , J) <i>RHIZOSOLENIA HEBETATA</i> , K) <i>SKELETONEMA COCTATUM</i> RESPECTIVELY (PHOTO: A.M. FEYZIOGLU)	167
FIGURE 46. SOME DINOFLAGELLATA SPECIES OBSERVED IN THE BLACK SEA: A) <i>DINOPHYSIS CAUDATA</i> , B) <i>PROROCENTRUM MICANS</i> C) <i>SCRIPSIELLA TROCHOIDEA</i> , D) <i>PROTOPERIDINIUM PALLIDUM</i> E) <i>P. COMPRESSUM</i> F) <i>TRIPOS FUSUS</i> VE <i>TRIPOS FURCA</i> , G) <i>POTOPERIDINIUM CONICUM</i> , H) <i>PROTOPERIDINIUM DEPRESSUM</i> , I) <i>KATODINIUM GLAUCUM</i> , J) <i>DISSODINIUM PSEUDOLUNEATA</i> RESPECTIVELY (PHOTO: A.M. FEYZIOGLU).....	169
FIGURE 47. A) <i>NOCTILUCA SCINTILLANS</i> AND B-C) THE RED-TIDE EVENT CAUSED BY <i>NOCTILUCA SCINTILLANS</i> . (PHOTO: A.M. FEYZIOGLU)	169
FIGURE 48. THE MOST COMMON EUGLENA SPECIES <i>EUTREPTIA LANOWII</i> (PHOTO: A.M. FEYZIOGLU)	170
FIGURE 49. RATIO OF MAIN PHYTOPLANKTON CLASS LIVING IN BLACK SEA ANATOLIAN COAST	174
FIGURE 50. THE CHANGING BLACK SEA ECOSYSTEM (SOURCE: HTTP://BLACKSEA-EDUCATION.RU/).....	176
FIGURE 51. COASTAL HABITATS 2 MAI – VAMA VECHE	189

TABLES

TABLE 1: THE MOST COMMONLY OBSERVED PHYTOPLANKTON SPECIES IN THE BLACK SEA ECOSYSTEM.	14
TABLE 2: VARIOUS SIZE CATEGORY OF PLANKTON (SHUTHER AND RISSIK, 2009)	16
TABLE 3: THE MOST COMMON OBSERVED ZOOPLANKTON SPECIES IN THE BLACK SEA ECOSYSTEM.	17
TABLE 4: THE FISH SPECIES IN BLACK SEA OF TÜRKİYE	21
TABLE 5: THE THREATENED FISH SPECIES IN THE IUCN RED LIST IN BLACK SEA OF TÜRKİYE	29
TABLE 6: ENDEMIC FISH SPECIES IN THE BLACK SEA OF TÜRKİYE	29
TABLE 7: INVASIVE AND ALIEN SPECIES IN THE BLACK SEA OF TÜRKİYE.....	29
TABLE 8. SPECIES COMPOSITION, ORIGIN, HABITAT, FISHERIES, ECOLOGICAL, AND CONSERVATION STATUS OF THE BULGARIAN BLACK SEA ICHTHYOFAUNA.	37
TABLE 9. FREQUENCY OF OCCURRENCE OF PHYTOPLANKTON SPECIES DEVELOPING IN BULGARIAN MARINE WATERS, 2008–2010 (GERDZHIKOV, 2014)	45
TABLE 10. MICROPHOTOGRAPHS OF FREQUENTLY OCCURRING PHYTOPLANKTON SPECIES OFF THE BULGARIAN COAST (IMAGES-KLISAROVA&GERDZHIKOV) (FROM SOURCE:HTTPS://PHYTOPLANKTONBLACKSEA.COM/EN/).	54
TABLE 11. MAIN ZOOPLANKTON GROUPS, STUDIED IN THE BULGARIAN BLACK SEA SECTOR.....	59
TABLE 12. LIST OF MAIN GROUPS ZOOBENTHIC SPECIES STUDIED ALONG THE BULGARIAN BLACK SEA COAST.....	64
TABLE 13. GROUP OF SPECIES AND LIVING HABITATS	97
TABLE 14. PRESENTS A COMPREHENSIVE LIST OF BLACK SEA SPECIES ENCOUNTERED OVER THE LAST 10 YEARS AT THE ROMANIAN SEASHORE.....	99
TABLE 15. CLIMATE CHANGE EFFECTS ON BLACK SEA WATER MASSES AND ECOSYSTEM.....	150
TABLE 16. NUMBER OF SPECIES BELONGING TO PHYTOPLANKTON GROUPS IDENTIFIED IN THE BLACK SEA.	163
TABLE 17. PROTECTED AREAS WITHIN THE NATURA 2000 NETWORK CONTAINING MARINE WATERS (THE INDICATED AREAS ARE APPROXIMATE AND INCLUDE COASTAL TERRITORIES).	187
TABLE 18. INTERNATIONAL ORGANIZATIONS AND CONVENTIONS ON BIODIVERSITY TO WHICH TÜRKİYE IS MEMBER.....	194
TABLE 19. SUMMARY TABLE FOR MAJOR REGULATIONS, OBJECTIVES AND COMPETENT INSTITUTIONS	197
TABLE 20. INTERNATIONAL ORGANIZATIONS AND CONVENTIONS ON BIODIVERSITY TO WHICH BULGARIA IS MEMBER.....	202
TABLE 21. SUMMARY OF CRITICAL NEEDS FOR THE MAJOR GAPS	220

1. INTRODUCTION

Marine ecosystems are the largest and most critical reservoirs of global biodiversity, encompassing a vast range of habitats from sun-drenched coral reefs to the crushing depths of the abyssal plains. Marine ecosystems are essentially the lifeblood of our planet, covering more than 70% of Earth's surface and containing about 97% of its water. Because of their sheer scale and variety, they are divided into several distinct zones. Estuaries and Salt Marshes: These are "nurseries" where freshwater from rivers meets the salty sea. They are incredibly productive areas that filter pollutants and provide a safe haven for juvenile fish to grow. The Pelagic Zone (Open Ocean): This is the vast, blue "highway" of the sea. It is home to migratory species like whales, tuna, and sharks. At the surface, microscopic phytoplankton serve as the foundation of the global food web, producing half of the oxygen we breathe through photosynthesis. Coral Reefs: Often called the "rainforests of the sea," these occupy less than 1% of the ocean floor but support over 25% of all marine species. They provide essential coastal protection and are hotspots for biodiversity. The Deep Sea (Benthic and Abyssal Zones): In these lightless depths, creatures have evolved extraordinary adaptations, such as bioluminescence. Around hydrothermal vents, life thrives without sunlight, relying instead on chemicals from the Earth's crust—a process known as chemosynthesis.

These ecosystems serve as living areas for all types of organisms which is call biodiversity. Biodiversity is the extraordinary variety of all life on Earth and the complex interactions between them. It is not just a tally of plants and animals; it is a sophisticated "life-support system" that has evolved over billions of years. Biodiversity is the variety of life on Earth, including the differences within species, between species, and among ecosystems. It is not limited to the number of species in an area but also involves genetic variation, ecological relationships, and the dynamic processes that keep natural systems functioning. Biodiversity reflects the complexity and interdependence of all living organisms that together form the foundation of life on our planet. This biodiversity is not merely a collection of species but a complex, functional network where every organism plays a role in maintaining the planet's life-support systems. The high level of biological variety in aquatic environment provides ecological resilience, allowing the ocean to absorb carbon dioxide and buffer the effects of climate change. When marine biodiversity flourishes, it ensures the stability of global food webs and the continued provision of resources.

The importance of biodiversity lies in its essential role in maintaining the balance and stability of ecosystems. Each organism – from plants and microorganisms to herbivores and predators – has a specific role in the flow of energy and nutrients within food webs. These connections ensure that ecosystems can produce food, recycle nutrients, and support life at every level. When biodiversity declines, food webs weaken, reducing the productivity and resilience of ecosystems. The biodiversity may categorized into three sublevels;

NEXT Black Sea Basin

Genetic Diversity: The variation of genes within a species, which allows populations to adapt to changing environments, resist diseases, and evolve.

Species Diversity: The variety of different species (plants, animals, fungi, and microorganisms) within a habitat or across the planet.

Ecosystem Diversity: The variety of habitats, such as rainforests, wetlands, and coral reefs, and the complex interactions between the living communities and their non-living environment.

Biodiversity also strengthens the ability of ecosystems to recover from disturbances such as climate change, pollution, or species loss. High biological diversity means that if one species disappears, others can perform similar functions, helping maintain ecosystem balance. Therefore, protecting biodiversity is vital not only for the survival of wildlife but also for human well-being, since healthy ecosystems provide us with food, clean water, and a stable climate.

Marine and coastal ecosystems provide vital services that sustain human life and economic stability. They are major sources of food through fisheries and aquaculture, offering livelihoods to millions of people worldwide. These ecosystems also supply materials used in medicine, industry, and biotechnology, contributing to both local and global economies. Marine and coastal areas also hold strong cultural and recreational value. Tourism, fishing, and seaside recreation generate income and promote well-being. When these environments are degraded by pollution or overexploitation, humanity loses not only natural resources but also protection and cultural heritage. Therefore, conserving marine ecosystems is crucial for both environmental health and human prosperity.

Beyond resource provision, coastal habitats such as mangroves, coral reefs, and wetlands regulate natural processes. They protect shorelines from erosion and storms, purify water, and absorb large amounts of carbon, helping to mitigate climate change. Healthy marine ecosystems maintain balance within food webs and support biodiversity essential for ecosystem resilience.

The Black Sea: The Black Sea lies between 40°55'N and 46°32'N latitude and 27°27'E and 41°42'E longitude, situated in an east-west depression between two alpine fold belts: the Pontic Mountains to the south and the Caucasus Mountains to the northeast. The northwestern coast, with the exception of Crimea, is relatively low-lying. Recognised as the world's largest semi-enclosed marginal sea, the Black Sea's physical and chemical structure is primarily governed by its hydrological balance (Caspers, 1957; Sorokin, 1983). The continental shelf is widest in the northwest, whereas much of the remaining basin is unexpectedly deep for a marginal sea. The Bosphorus Strait, ranging from 0.76 to 3.60 km in width and less than 93 m in depth, serves as the only natural connection between the Black Sea and the Mediterranean. The sill depths are approximately 32-34 m at the southern end and 60 m at the northern end (Gunnerson and Ozturgut, 1974; Latif et al., 1991). This narrow passage allows the inflow of saline water into the basin while exporting fresher surface waters. Deep-water salinity reaches $S = 22.33$, while surface salinity remains lower ($S \approx 18.0-18.5$ in the central basin) due to

NEXT Black Sea Basin

substantial freshwater inputs from major European rivers such as the Danube, Dniester, Dnieper, Don and Kuban.

The Black Sea is globally recognised as the largest internal water body and the largest meromictic basin on Earth. The most distinctive feature shaping the oceanographic structure of the Black Sea ecosystem is its two-layer vertical stratification, which results from the interaction between freshwater inflow from major rivers and saline Mediterranean waters entering through the Turkish Straits System. This unique hydrographic structure, together with the anoxic conditions prevailing in deep waters, makes the Black Sea exceptionally vulnerable to external disturbances (Zaitsev, 1992). The permanent density barrier restricts vertical water mixing, causing waters below approximately 150-200 m to become completely devoid of oxygen while accumulating high concentrations of toxic hydrogen sulfide (H_2S). Consequently, biological life is confined to only the upper 10-15% of the total water column (Zaitsev, 1992).

Evaporation exceeds precipitation, and the net surface outflow is nearly twice the volume of the deep inflow through the Bosphorus. Currents in both directions are intense. Vertical stratification leads to striking chemical and ecological contrasts. The surface layer (0-50 m) is well oxygenated, supporting marine life. The deep layer (100-2000 m) is entirely anoxic, enriched in hydrogen sulphide, and biologically uninhabitable except for microorganisms. At the suboxic boundary zone (50-100 m), concentrations of both oxygen and hydrogen sulphide are extremely low and exhibit little vertical or horizontal variation (Murray et al., 1989; Codispoti et al., 1991).

The Black Sea, during the last Ice Age, approximately 10,000 years ago, alternated between a dry seabed, a freshwater lake, and ultimately a marine basin. The sea is bordered by Ukraine, Russia, Georgia, Türkiye, Romania, and Bulgaria. Although often described as an inland sea, some sources classify it as a bordering Mediterranean Sea of the Atlantic Ocean, despite being thousands of kilometres away. The Black Sea's water budget reflects a delicate equilibrium. It receives about 350 km³ of river discharge and 230 km³ of precipitation annually, while evaporation removes approximately 354 km³ (Figure-1). This hydrological balance maintains its stratified structure, in contrast to the shallower Marmara Sea, where freshwater and saline interactions differ. Temperature and nutrient dynamics also vary significantly between layers: the surface zone sustains productive ecosystems, while the vast deep waters remain biologically dead, devoid of higher life forms. Only oxygen-rich shallow waters support fish and other marine species, whereas the deep anoxic regions are inhabited solely by microbial communities (BSC, 2025).

NEXT Black Sea Basin



Figure 1: The Black Sea basin

The Black Sea ecosystem is both unique and fragile. While its oxygenated surface waters support rich biodiversity and important fisheries, they are under growing pressure from pollution, overfishing, invasive species, and climate change. Sustainable management, regional cooperation, and stronger conservation measures are essential to protect this remarkable ecosystem and ensure its long-term resilience. Historically, this narrow but highly productive surface layer supported substantial primary production and exceptionally rich fish stocks. The pressure of the Black Sea environment might be grouped like that:

Pollution and Eutrophication: Nutrient-rich runoff from agriculture and untreated wastewater from urban and industrial sources cause eutrophication, leading to harmful algal blooms and oxygen depletion in coastal waters. Accumulation of heavy metals, plastics, and chemical pollutants threatens marine species and food safety.

Overfishing: Excessive fishing pressure has severely reduced stocks of key species, disrupting the ecological balance. Illegal, unreported, and unregulated (IUU) fishing further intensifies the decline of fish populations.

Invasive Alien Species (IAS): Species such as the comb jelly (*Mnemiopsis leidyi*) have drastically altered the ecosystem by consuming plankton and competing with native fish larvae, leading to fishery collapses in the 1980s. Continued introduction of non-native species via ballast water and shipping routes remains a critical challenge.

Climate change: Raising sea temperatures affect plankton dynamics and fish distribution. Sea level rise threatens coastal wetlands and deltas. Increased frequency of extreme weather events impacts nutrient input, erosion, and sediment dynamics.

NEXT Black Sea Basin

Hydrological Vulnerability: The Black Sea relies on a delicate balance between riverine freshwater input, evaporation, and limited exchange with the Mediterranean through the Bosphorus Strait. Any disruption in this balance (e.g., from damming or climate-driven river discharge changes) can destabilize its stratification and ecosystem health.

2. CURRENT STATUS OF BIODIVERSITY

The current species diversity in the Turkish Black Sea region consists of 401 phytoplankton, 98 zooplankton, 419 invertebrates (such as crabs, shrimp, mussels, snails, polychaetes, and echinoderms), 156 fish, and 3 marine mammal species.

2.1. Türkiye

2.1.1. Species Diversity in the Black Sea of Türkiye

2.1.1.1. Planktonic Species Diversity in the Black Sea Coast of Türkiye

The term plankton is defined by various researchers as communities of organisms suspended in water that are immobile or move only to a limited extent, but can passively move with water currents (Strickland, 1960). Basically, planktonic organisms are grouped under two main categories: zooplankton and phytoplankton. Planktonic animals that feed during the Halozoic are classified as zooplankton, while autotrophic planktonic plants that contain chlorophyll and are therefore capable of photosynthesis are called phytoplankton (Davis, 1955). In addition, planktonic organisms are classified according to their size as picoplankton (<2 µm), nanoplankton (2-20 µm), microplankton (20-200 µm), mesoplankton (200-2000 µm), and macroplankton (>2000 µm) (Valiela, 1995).

Phytoplankton Groups

Diatoms (class: Bacillariophyceae), dinoflagellates (class: Dinophyceae), green algae (class: Chlorophyceae), silicoflagellates (class: Chrysophyceae), euglenoid flagellates (class: Euglenophyceae), and coccolithophores (Prymnesiophyceae) are the most important phytoplanktonic groups in the seas. Table-1 present the most frequently observed phytoplankton species within the Turkish waters of the Black Sea.

Table 1: The most commonly observed phytoplankton species in the Black Sea ecosystem.

	GROUPS	SPECIES	NO	GROUPS	SPECIES
1	DIATOM	<i>Ceratoneis arcus</i>	36	DINOFLEGGELATA	<i>Dinophysis fortii</i>
2		<i>Chaetoceros compressus</i>	37		<i>Dinophysis hastata</i>
3		<i>Chaetoceros curvisetus</i>	38		<i>Dinophysis rotundata</i>
4		<i>Chaetoceros decipiens</i>	39		<i>Diplopsalis sp.</i>
5		<i>Chaetoceros diadema</i>	40		<i>Dissodinium pseudolunula</i>
6		<i>Chaetoceros didymus</i>	41		<i>Gonyaulax spinifera</i>
7		<i>Chaetoceros simplex</i>	42		<i>Gymnodinium sp</i>
8		<i>Chaetoceros socialis</i>	43		<i>Gyrodinium sp.</i>

NEXT Black Sea Basin

9		<i>Coscinodiscus radiatus</i>	44		<i>Gyrodinium Spirale</i>
10		<i>Ditylum brightwellii</i>	45		<i>Heterocapsa triquetra</i>
11		<i>Gomphonema sp.</i>	46		<i>Katodinium glaucum</i>
12		<i>Leptocylindrus danicus</i>	47		<i>Katodinium sp</i>
13		<i>Licmophora sp.</i>	48		<i>Noctiluca scintillans</i>
14		<i>Navicula sp.</i>	49		<i>Pronoctiluca sp.</i>
15		<i>Nitzschia closterium</i>	50		<i>Prorocentrum compressum</i>
16		<i>Nitzschia longissima</i>	51		<i>Prorocentrum micans</i>
17		<i>Pleurosigma sp.</i>	52		<i>Protoceratium reticulatum</i>
18		<i>Proboscia alata</i>	53		<i>Protopteridinium bipes</i>
19		<i>Proboscia indica</i>	54		<i>Protopteridinium crassipes</i>
20		<i>Pseudo-nitzschia pungens</i>	55		<i>Protopteridinium claudicans</i>
21		<i>Rhizosolenia calcar-avis</i>	56		<i>Protopteridinium conicum</i>
22		<i>Rhizosolenia delicatula</i>	57		<i>Protopteridinium curtipes</i>
23		<i>Skeletonema costatum</i>	58		<i>Protopteridinium depressum</i>
24		<i>Striatella unipunctata</i>	59		<i>Protopteridinium divergens</i>
25		<i>Thalassionema nitzschioides</i>	60		<i>Protopteridinium granii</i>
26		<i>Thalassiosira sp.</i>	61		<i>Protopteridinium oblongum</i>
27	SILICOFLEGELLATA	<i>Dictyoca speculum</i>	62		<i>Protopteridinium ovatum</i>
28		<i>Octactis octonaria</i>	63		<i>Protopteridinium pallidum</i>
29		<i>Achradina pulchra</i>	64		<i>Protopteridinium pellucidum</i>
30		<i>Ceratium furca</i>	65		<i>Protopteridinium pyriforme</i>
31		<i>Ceratium fusus</i>	66		<i>Protopteridinium steinii</i>
32		<i>Ceratium tripos</i>	67		<i>Protopteridinium subinerme</i>
33		<i>Dinophysis acuminata</i>	68		<i>Pyrophacus sp</i>
34		<i>Dinophysis acuta</i>	69		<i>Scrippsiella trochoidea</i>
35		<i>Dinophysis caudata</i>			

Marine organisms adapted to three fundamental modes of life in order to survive in aquatic environments have: **planktonic, nektonic, and benthic**.

Plankton comprises all organisms that drift within the water column. Although many planktonic organisms possess locomotory organelles, their ability to move is extremely limited and

NEXT Black Sea Basin

insufficient to overcome water currents. Their movement is primarily restricted to the vertical direction; therefore, their distribution and position in the marine environment are largely determined by water currents. Planktonic organisms are divided into 7 categories according to their size groups (Table-2).

Table 2: Various size category of Plankton (Shuther and Rissik, 2009)

Size class	Size Dimension
Ultraplankton	0.02-0.2 μm
Pico-plankton	0.2 μm - 2 μm
Nanoplankton	2 μm -20 μm
Mikroplankton	20 μm - 0.2 mm
Mezoplankton	0.2 mm -20 mm
Makroplankton	2 cm -20 cm
Megaplankton	20 cm <

Photosynthetic, chlorophyll-containing autotrophic planktonic organisms are referred to as **phytoplankton** (Davis, 1955). Phytoplankton are microscopic, primarily unicellular or colonial plant-like organisms that inhabit the sunlit surface waters of aquatic ecosystems such as oceans, seas, and lakes. As the primary producers of aquatic ecosystems, they convert inorganic carbon into organic matter through photosynthesis and form the foundation of the marine food web. In terms of size classification, **phytoplanktonic organisms** generally range from the **ultraplankton** to the **mesoplankton** size classes.

The morphology of phytoplanktonic algae is highly diverse. These organisms may occur as single cells or colonies and exhibit a wide variety of forms, including filamentous, ribbon-like, and other morphologically distinct structures. The main characteristics of phytoplankton are summarized below:

- **Base of the food web:** Phytoplankton constitute the primary producers at the base of aquatic food webs. They serve as the principal food source for a wide range of organisms, from zooplankton to large marine mammals such as whales.
- **Photosynthetic capability:** Owing to the presence of chlorophyll pigments, phytoplankton convert sunlight, water, and carbon dioxide into organic matter through photosynthesis. Consequently, they inhabit the euphotic zone, where sufficient sunlight penetrates the water column.
- **Oxygen production:** Phytoplankton are responsible for producing approximately **50-70% of the Earth's atmospheric oxygen**. By assimilating carbon dioxide and releasing oxygen through photosynthesis, they play a vital role in regulating the global carbon cycle and maintaining climate balance.

Zooplanktonic Groups:

The most common zooplankton groups in marine environments are copepods, often dominating both marine and freshwater environments. Other highly abundant groups include cladocerans, rotifers, gelatinous zooplankton (jellyfish), and various meroplankton (larval stages of

NEXT Black Sea Basin

invertebrates living in benthic and pelagic zone). Table-3 present the most frequently observed zooplankton species within the Turkish waters of the Black Sea.

Table 3: The most common observed zooplankton species in the Black Sea ecosystem.

NO	GROUPS	SPECIES	NO	GROUP	SPECIES
1	PROTOZOA-CILLIATES	<i>Amphorellopsis acuta</i>	26		<i>Oithona davisae</i> Ferrari F.D. & Orsi, 1984
2		<i>Codonellopsis sp.</i>	27		<i>Calanipeda aquaedulcis</i> Krichagin, 1873
3		<i>Askenasia sp.</i>	28		<i>Pontella mediterranea</i> Claus, 1863
4		<i>Eutintinnus medius</i>	29		<i>Anomalocera patersonii</i>
5		<i>Favella ehrenbergi</i>	30	APPENDICULARIA	<i>Oikopleura (Vexillaria) dioica</i> Fol, 1872
6		<i>Favella sp</i>	31	BIVALVIA	<i>Bivalvia</i> Linnaeus, 1758
7		<i>Halteria sp.</i>	32	BRANCHIOPODA	<i>Evadne spinifera</i> P.E.Müller, 1867
8		<i>Laboe strobila</i>	33		<i>Penilia avirostris</i> Dana, 1849
9		<i>Lohmaniella oviformis</i>	34		<i>Pseudevadne tergestina</i> Claus, 1877
10		<i>Lohmaniella sp</i>	35		<i>Pleopis polyphemoides</i> Leuckart, 1859
11		<i>Salpingella sp</i>	36	GASTROPODA	Gastropod Larvae
12		<i>Strombidium delicatissimum</i> cf.	37	CIRRIPEDIA	Balanus sp Larvae
13		<i>Strombidium sp.</i>	38	SAGITTOIDEA	<i>Parasagitta setosa</i> J. Müller, 1847
14		<i>Strobilidium spiralis</i>	39	MALACOSTRACA	Decapoda Larvae
15		<i>Strombidium wulfii</i>	40		Isopoda Larvae
16		<i>Tiarina fusus</i>	41	POLYCHAETA	Polychaeta Larvae
17		<i>Tintinopsis sp</i>	42	PHORONIDA	Phoronida Hatschek, 1888
18	PROTOZOA-MASTIGOPHORA	<i>Noctiluca scintillans</i> Macartney Kofoid & Swezy, 1921	43	BRYOZOA	Bryozoa
19	METAZOA- COPEPODA	<i>Acartia (Acartiura) clausi</i> Giesbrecht, 1889	44	CTENOPHORA	<i>Beroe ovata</i> Bruguière, 1789
20		<i>Acartia (Acanthacartia) tonsa</i> Dana, 1849	45		<i>Pleurobrachia pileus</i> O. F. Müller, 1776

NEXT Black Sea Basin

21		<i>Calanus euxinus</i> Hulsemann, 1991	46		<i>Mnemiopsis leidyi</i> A. Agassiz, 1865
22		<i>Pseudocalanus elongatus</i> Boeck, 1865	47		<i>Bolinopsis vitrea</i> L. Agassiz, 1860
23		<i>Paracalanus parvus</i> Claus, 1863	48	SCYPHOZOA	<i>Aurelia aurita</i> Linnaeus, 1758
24		<i>Centropages ponticus</i> Karavaev, 1895	49		<i>Rhizostoma pulmo</i> Macri, 1778
25		<i>Oithona similis</i> Claus, 1866			

Planktonic animals that obtain their nutrition through holozoic feeding are classified as **zooplankton**. So, **zooplankton** is the term used to describe heterotrophic planktonic organisms (animal plankton). Zooplanktonic organisms generally range from microplankton to the megaplankton size classes.

Organisms that spend their entire life cycle in the plankton are referred to as **holoplankton**. Copepods and krill are typical examples of holoplanktonic organisms. In contrast, organisms that spend only part of their life cycle as plankton are known as **meroplankton**. The larvae of many fish and benthic organisms are planktonic during their early developmental stages and are therefore classified as meroplankton. Planktonic organisms constitute the largest proportion of the Earth's biomass.

Microzooplankton consists of unicellular zooplankton, generally up to **200 µm** in size, that feed primarily on pico- and nanoplankton. This group includes species belonging to the phylum **Protozoa**, particularly the subphyla **Ciliophora** and **Mastigophora**. Among these groups, members of the class **Ciliata** are the most common representatives of the microzooplankton community.

Microzooplankton are an essential component of the **microbial loop**, particularly in oligotrophic waters and the offshore regions of the Black Sea. They play a crucial role in transferring biomass from pico- and nanoplankton to higher trophic levels, thereby contributing significantly to the aquatic food web. The most common microzooplankton species reported from the Black Sea include *Tintinnopsis campanula*, *Leegaardiella ovalis*, *Codonellopsis* spp., and *Eutintinnus* spp. (Figure-2).

NEXT Black Sea Basin

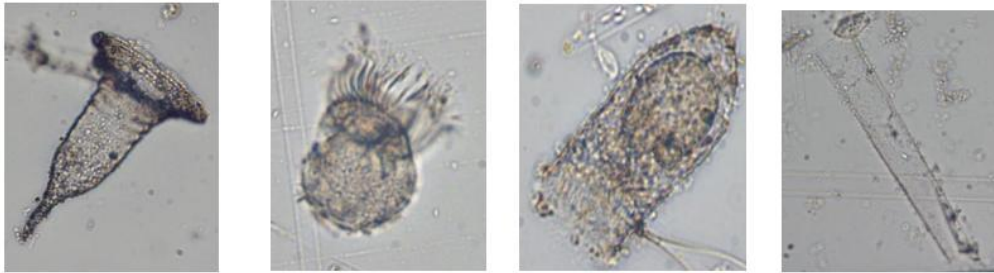


Figure 2: The most common microzooplankton species found in the Black Sea. a) *Tintinopsis campanula*, b) *Leegaardiella ovalis*, c) *Codenellopsis* sp., d) *Eutintinus* sp. respectively (Photo: A.M. Feyzioğlu)

The principal members of the **mesozooplankton** community are *Calanus euxinus* and *Acartia clausi* (Figure-3). These species play a pivotal role in the trophic dynamics of the Black Sea by exhibiting both **herbivorous** and **carnivorous** feeding habits. As herbivores, they graze on nanoeukaryotes, diatoms, and dinoflagellates, whereas as carnivores, they prey primarily on ciliates. Through this omnivorous feeding strategy, they contribute significantly to the transfer of energy and matter through the Black Sea food web.

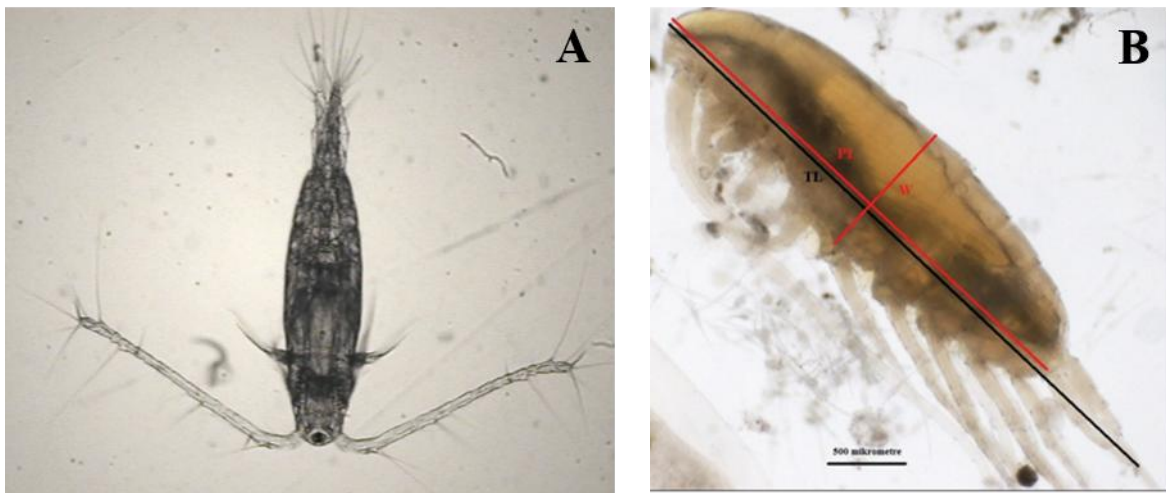


Figure 3: a) *Acartia clausi* and b) *Calanus euxinus* ((Photo: İlknur Yıldız)

Copepod species constitute an important food source for commercially valuable fish, particularly anchovy (*Engraulis encrasicolus*), during the winter months. Until the 1970s, the Black Sea ecosystem was primarily regulated through **bottom-up control**, whereby ecosystem dynamics were largely governed by the availability and productivity of lower trophic levels, particularly plankton. Over the past three decades, however, changes in fish stocks together with the increasing grazing pressure exerted by *Mnemiopsis leidyi* and *Pleurobrachia* spp. on plankton communities have shifted the ecosystem toward **top-down control**, in which higher trophic levels play a dominant role in regulating ecosystem structure and functioning (Oğuz and Gilbert, 2007).

NEXT Black Sea Basin

The **macrozooplankton** and **megazooplankton** communities are primarily represented by members of the phyla **Ctenophora** and **Scyphozoa**. The phylum **Ctenophora** is a relatively small taxonomic group comprising approximately 90 exclusively marine species. Most ctenophores are pelagic and constitute an important component of the zooplankton community, particularly in coastal ecosystems. Most ctenophores are globular in shape and typically range from 1 to 7 cm in length. They are commonly known as comb jellies, with some species also referred to as sea gooseberries or sea walnuts. However, some species possess a flattened, ribbon-like body form and may reach lengths of up to 1 m. Ctenophores exhibit a wide variety of larval forms and possess remarkable regenerative capabilities, with even half or a quarter of an individual being capable of regenerating into a complete organism.

The most common ctenophore species recorded in the Black Sea are *Mnemiopsis leidyi*, *Pleurobrachia pileus*, and *Beroe ovata* (Figure-4). The introduction of *Mnemiopsis leidyi* into the Black Sea during the 1980s placed the ecosystem under severe ecological stress (Zaitsev and Aleksandrov, 1997; Caddy and Griffiths, 1990). The rapid population increase of *M. leidyi* was accompanied by a dramatic decline in mesozooplankton abundance (Vinogradov et al., 1989). In addition, intensive predation by *M. leidyi* on the eggs and larvae of zooplanktivorous small pelagic fish contributed significantly to the depletion of fish stocks in the Black Sea (Özdemir et al., 2004).



Figure 4: The most common Ctenophora species found in the Black Sea. a) *Mnemiopsis leidyi*, b) *Beroe ovata*, c) *Pleurobrachia pileus*, d) *Mnemiopsis leidyi* bloom respectively (Photos: A.M. Feyzioğlu)

The class Scyphozoa, which includes the true jellyfish, represents the largest class within the phylum Cnidaria. This group comprises more than 200 planktonic species. The medusa stage is the most common life form; however, many species also possess a sessile polyp stage during their life cycle. Medusae are solitary organisms and do not form colonies. Compared with many other planktonic organisms, they are relatively strong swimmers and are capable of active movement through the water column. The most common scyphozoan species observed in the Black Sea are *Aurelia aurita* and *Rhizostoma pulmo* (Figure-5).

NEXT Black Sea Basin

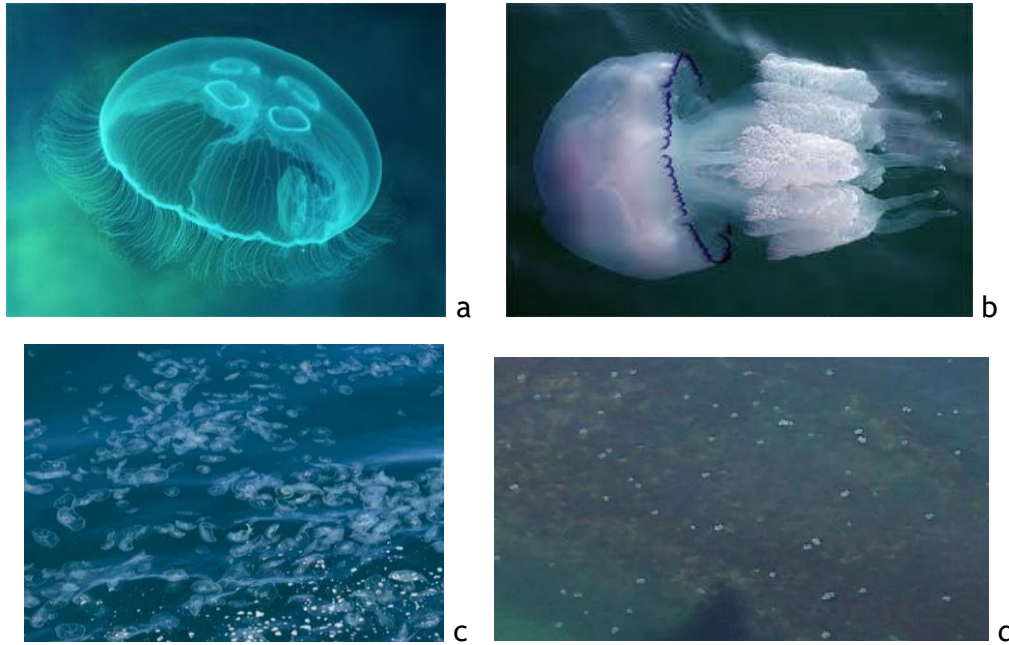


Figure 5: The most commonly observed Scyphozoa species in the Black Sea a-*Aurelia aurita* moonfish, b-*Rhizostoma pulmo* barrel jelly, c-*Aurelia aurita* bloom, d-*Rhizostoma pulmo* bloom respectively (Photo: A.M. Feyzioğlu)

2.1.1.2. Fish Species Diversity in the Black Sea of Türkiye

According to the literature review, a total of 156 fish species belonging to 49 families have been recorded in the Turkish Black Sea. The most species-rich family is Gobiidae with 26 species, followed by Sparidae (14), Blenniidae (10), Syngnathidae (9), Clupeidae (8), Labridae (8), and Acipenseridae (7). In addition, 2 shark and 2 ray species have been reported from the Black Sea (Aydın and Sözer, 2016; Aydın and Karadurmuş, 2023; Keskin, 2010). The fish species in the Black Sea of Türkiye are presented in Table-4.

Table 4: The fish species in Black Sea of Türkiye

Order	Family	Latin name	Common name	Turkish name
Acanthuriformes	Chaetodontidae	Heniochus acuminatus (Linnaeus, 1758)	Pennant coralfish	Bayrak mercan balığı
Acipenseriformes	Acipenseridae	Acipenser gueldenstaedtii Brandt & Ratzeberg, 1833	Russian sturgeon	Rus mersini/Karaca
Acipenseriformes	Acipenseridae	Acipenser nudipectus Lovetsky, 1828	Spiny sturgeon	Şip balığı
Acipenseriformes	Acipenseridae	Acipenser persicus Borodin, 1897	Persian sturgeon	Iran mersin balığı
Acipenseriformes	Acipenseridae	Acipenser ruthenus Linnaeus, 1758	Sterlet sturgeon	Çuka balığı

NEXT Black Sea Basin

Acipenseriformes	Acipenseridae	Acipenser stellatus Pallas, 1771	Starry sturgeon	Sivruška
Acipenseriformes	Acipenseridae	Acipenser sturio Linnaeus, 1758	Sturgeon	Kolan balığı
Acipenseriformes	Acipenseridae	Huso huso (Linnaeus, 1758)	Beluga	Mersin morinası
Anguilliformes	Anguillidae	Anguilla anguilla (Linnaeus, 1758)	European eel	Avrupa yılan balığı
Anguilliformes	Congridae	Conger conger (Linnaeus, 1758)*	European conger	Mıgır
Atheriniformes	Atherinidae	Atherina hepsetus Linnaeus, 1758	Mediterranean sand smelt	Gümüş balığı
Atheriniformes	Atherinidae	Atherina pontica (Eichwald, 1831)	Big-scale sand smelt	Küçük gümüş balığı
Beloniformes	Belonidae	Belone belone (Günther, 1866)	Garfish	Zargana
Blenniiformes	Tripterygiidae	Tripterygion tripteronotum (Risso, 1810)	Red-black triplefin	Karabaş balığı
Blenniiformes	Blenniidae	Aidablennius sphynx (Valenciennes, 1836)	Sphinx blenny	Sfenks balığı
Blenniiformes	Blenniidae	Blennius ocellaris Linnaeus, 1758	Butterfly blenny	Kelebek balığı
Blenniiformes	Blenniidae	Coryphoblennius galerita (Linnaeus, 1758)	Montagu's blenny	Tepeli horozbina
Blenniiformes	Blenniidae	Lipophrys adriaticus (Steindachner & Kolombatovic, 1883)*	Adriatic blenny	Adriyatik horozbina
Blenniiformes	Blenniidae	Parablennius sanguinolentus (Pallas, 1814)	Rusty blenny	Paslı horozbina
Blenniiformes	Blenniidae	Parablennius tentacularis (Brunnich, 1768)	Tentacled blenny	Kahküllü horozbina
Blenniiformes	Blenniidae	Parablennius zvonimiri (Kolombatovic, 1892)	Red blenny	Kızıl horozbina
Blenniiformes	Blenniidae	Parablennius gattorugine (Linnaeus, 1758)	Tompot blenny	Bantlı horozbina
Blenniiformes	Blenniidae	Parablennius incognitus (Bath, 1968)	Pygmy blenny	Horozbina
Blenniiformes	Blenniidae	Salaria pavo (Risso, 1810)	Peacock blenny	Tavuskuşu balığı
Callionymiformes	Callionymidae	Callionymus fasciatus, Valenciennes, 1837	Banded dragonet	Üzgün balığı
Callionymiformes	Callionymidae	Callionymus lyra Linnaeus, 1758	Common dragonet	Üzgün balığı
Callionymiformes	Callionymidae	Callionymus pusillus Delaroche, 1809	Sailfin dragonet	Üzgün balığı

NEXT Black Sea Basin

Carangaria/misc	Sphyraenidae	Sphyraena pinguis Günther, 1874	Red barracuda	Küt burunlu Iskarmoz
Carangaria/misc	Sphyraenidae	Sphyraena sphyraena (Linnaeus, 1758)	European barracuda	Iskarmoz
Carangiformes	Xiphiidae	Xiphias gladius Linnaeus, 1758	Swordfish	Kılıç Balığı
Carangiformes	Carangidae	Lichia amia (Linnaeus, 1758)	Leerfish	Akya
Carangiformes	Carangidae	Trachurus mediterraneus (Steindachner, 1868)	Mediterranean horse mackerel	Sarıkuyruk istavrit
Carangiformes	Carangidae	Trachurus trachurus (Linnaeus, 1758)	Atlantic horse mackerel	Karagöz istavrit
Carcharhiniformes	Sphyrnidae	Sphyrna zygaena (Linnaeus, 1758)	Smooth Hammerhead	Çekiç Balığı
Carcharhiniformes	Scyliorhinidae	Scyliorhinus canicula (Linnaeus, 1758)	Small-spotted catshark	Küçük Lekeli Kedi Balığı
Clupeiformes	Engraulidae	Engraulis encrasicolus (Linnaeus, 1758)	Anchovy	Hamsi
Clupeiformes	Clupeidae	Alosa caspia (Eichwald, 1838)	Caspian shad	Tirsi
Clupeiformes	Clupeidae	Alosa fallax (Lacepede, 1803)	Twaite shad	Tirsi
Clupeiformes	Clupeidae	Alosa immaculata Bennett, 1835	Pontic shad	Tirsi
Clupeiformes	Clupeidae	Alosa maeotica (Grimm, 1901)	Black sea shad	Tirsi
Clupeiformes	Clupeidae	Clupeonella cultriventris (Nordmann, 1840)	Black and Caspian Sea sprat	Pontik çaçası
Clupeiformes	Clupeidae	Sardina pilchardus (Walbaum, 1792)	European pilchard	Avrupa sardalyası
Clupeiformes	Clupeidae	Sardinella aurita Valenciennes, 1847	Round sardinella	Büyük sardalya
Clupeiformes	Clupeidae	Sprattus sprattus (Linnaeus, 1758)	European sprat	Avrupa çaçası
Perciformes	Labridae	Coris julis (Linnaeus, 1758)	Mediterranean rainbow wrasse	Akdeniz gökkuşağı balığı
Perciformes	Labridae	Ctenolabrus rupestris (Linnaeus, 1758)	Goldsinny-wrasse	Çırçır/Ot balığı
Perciformes	Moronidae	Dicentrarchus labrax (Linnaeus, 1758)	European seabass	Bayağı Levrek
Perciformes	Labridae	Labrus viridis Linnaeus, 1758	Green wrasse	Yeşil Lapina
Perciformes	Sciaenidae	Sciaena umbra Linnaeus, 1758	Brown meagre	Eşkina (Kaya Levreği)
Perciformes	Sparidae	Spicara maena (Linnaeus, 1758)	Blotched picarel	İzmarit

NEXT Black Sea Basin

Perciformes	Sparidae	Spicara smaris (Linnaeus, 1758)	Picarel	İzmarit
Perciformes	Labridae	Symphodus cinereus (Bonnaterre, 1788)	Grey wrasse	Çırçır balığı
Perciformes	Labridae	Symphodus bailloni (Valenciennes, 1839)	Baillon's wrasse	
Perciformes	Labridae	Symphodus ocellatus Forsskål, 1775	Ocellated wrasse	Benekli Çırçır
Perciformes	Labridae	Symphodus roissali (Risso, 1810)	Five-spotted wrasse	Beş Benekli Çırçır
Perciformes	Labridae	Symphodus tinca (Linnaeus, 1758)	East Atlantic peacock wrasse	Lekeli çırçır balığı/Lapina
Perciformes	Sciaenidae	Umbrina cirrosa (Linnaeus, 1758)	Shi drum	Kötek (Minakop)
Perciformes	Sparidae	Boops boops (Linnaeus, 1758)	Bogue	Kupes
Perciformes	Sparidae	Dentex dentex (Linnaeus, 1758)	Common dentex	Sinarit
Perciformes	Sparidae	Diplodus annularis (Linnaeus, 1758)	Annular seabream	İsparoz
Perciformes	Sparidae	Diplodus puntazzo (Cetti, 1777)	Sharpsnout seabream	Sivriburun Karagöz
Perciformes	Sparidae	Diplodus sargus (Linnaeus, 1758)	White seabream	Sargoz
Perciformes	Sparidae	Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)	Common two-banded	Karagöz
Perciformes	Sparidae	Lithognathus mormyrus (Linnaeus, 1758)	Striped seabream	Mırmır
Perciformes	Sparidae	Oblada melanura (Linnaeus, 1758)	Saddled seabream	Melanur
Perciformes	Sparidae	Pagellus erythrinus (Linnaeus, 1758)	Common pandora	Mercan balığı
Perciformes	Sparidae	Sarpa salpa (Linnaeus, 1758)	Salema	Sarpa
Perciformes	Sparidae	Sparus aurata Linnaeus, 1758	Gilthead seabream	Çipura
Perciformes	Sparidae	Spondylusoma cantharus (Linnaeus, 1758)	Black seabream	Sargoz Karagöz
Gadiformes	Phycidae	Gaidropsarus mediterraneus (Linnaeus, 1758)	Shore rockling	Gelincik Balığı
Gadiformes	Gadidae	Merlangius merlangus euxinus (Nordman, 1840)	Whiting	Mezgit
Gobiesociformes	Gobiesocidae	Lepadogaster candollei Risso, 1810	Connemarra clingfish	Ördek /Lapa balığı

NEXT Black Sea Basin

Gobiiformes	Gobiidae	<i>Aphia minuta</i> (Risso, 1810)	Transparent Goby	Şeffaf Kaya Balığı
Gobiiformes	Gobiidae	<i>Babka gymnotrachelus</i> (Kessler, 1857)	Racer Goby	Çıplakense Kaya Balığı
Gobiiformes	Gobiidae	<i>Benthophiloides braueri</i> Beling & Iljin, 1927	Danube goby	Küçük dere kayası
Gobiiformes	Gobiidae	<i>Chromogobius quadrivittatus</i> (Steindachner, 1863)	Chestnut goby	Dört bantlı kaya balığı
Gobiiformes	Gobiidae	<i>Gobius bucchichi</i> Steindachner, 1870	Bucchich's goby	Anemon kaya balığı
Gobiiformes	Gobiidae	<i>Gobius cobitis</i> Pallas, 1811	Giant goby	Kurbağa kaya balığı
Gobiiformes	Gobiidae	<i>Gobius cruentatus</i> Gmelin, 1789	Red-mouthed goby	Kırmızı ağızlı kaya balığı
Gobiiformes	Gobiidae	<i>Gobius niger</i> Linnaeus, 1758	Black goby	Kömürcü kayası
Gobiiformes	Gobiidae	<i>Gobius ophioccephalus</i> Pallas, 1814	Grass Goby	Saz Kayası
Gobiiformes	Gobiidae	<i>Gobius paganellus</i> Linnaeus, 1758	Rock Goby	Kurbağa Kayası
Gobiiformes	Gobiidae	<i>Gobius xanthocephalus</i> Heymer & Zander, 1992	Yellow-headed goby	Sarbaş kaya balığı
Gobiiformes	Gobiidae	<i>Knipowitschia caucasica</i> (Berg, 1916)	Caucasian dwarf goby	Kafkas cüce gobisi
Gobiiformes	Gobiidae	<i>Knipowitschia longicauda</i> (Kessler, 1817)	Longtail dwarf Goby	Uzun Kuyruk Kaya Balığı
Gobiiformes	Gobiidae	<i>Mesogobius batrachocephalus</i> (Pallas, 1814)	Knout goby	Kurbağabaş kaya balığı
Gobiiformes	Gobiidae	<i>Neogobius fluviatilis</i> (Pallas, 1814)	Monkey Goby	Kum kayası
Gobiiformes	Gobiidae	<i>Neogobius melanostomus</i> Pallas, 1814	Round goby	Kum kaya balığı
Gobiiformes	Gobiidae	<i>Pomatoschistus bathi</i> Miller, 1982	Bath's goby	Küçük Kaya balığı
Gobiiformes	Gobiidae	<i>Pomatoschistus microps</i> (Kroyer, 1838)	Common Goby	Küçük Kaya balığı
Gobiiformes	Gobiidae	<i>Pomatoschistus minutus</i> (Pallas, 1770)	Sand Goby	Küçük Kum Kayası
Gobiiformes	Gobiidae	<i>Ponticola kessleri</i> (Günther, 1861)	Bighead Goby	Kaya balığı
Gobiiformes	Gobiidae	<i>Ponticola eurycephalus</i> (Kessler, 1874)	Mushroom goby	
Gobiiformes	Gobiidae	<i>Ponticola platyrostris</i> (Pallas, 1814)	Flat-snout Goby	Yassıburun Kaya Balığı

NEXT Black Sea Basin

Gobiiformes	Gobiidae	Ponticola ratan (Nordmann, 1840)	Ratan Goby	Taş kayası
Gobiiformes	Gobiidae	Ponticola syrman (Nordmann, 1840)	Syrman Goby	Sırmalı Kaya Balığı
Gobiiformes	Gobiidae	Proterorhinus marmoratus (Pallas, 1811)	Tube-nosed goby	Tüp burunlu kaya balığı
Gobiiformes	Gobiidae	Zebrus zebrus (Risso, 1827)	Zebra Goby	Çizgili Kaya Balığı
Gobiiformes	Gobiidae	Gobius ophiocephalus Pallas, 1814	Grass Goby	Sazlık Kaya balığı
Lamniformes	Alopiidae	Alopias vulpinus (Bonnaterre, 1788)	Thresher Shark	Sapan balığı
Lophiiformes	Lophiidae	Lophius budegassa Spinola, 1807*	Black-bellied anglerfish	Küçük Fener Balığı
Lophiiformes	Lophiidae	Lophius piscatorius Linnaeus, 1758	Angler	Fener Balığı
Mugiliformes	Mugilidae	Chelon labrosus (Risso, 1827)	Thicklip grey mullet	Kalın Dudaklı Kefal
Mugiliformes	Mugilidae	Chelon auratus (Risso, 1810)	Golden grey mullet	Altınbaş Kefal
Mugiliformes	Mugilidae	Planiliza haematocheilus (Temminch & Schlegel, 1845)	So-iuy mullet	Rus Kefali
Mugiliformes	Mugilidae	Chelon ramada (Risso, 1827)	Thinlip mullet	İnce Dudaklı Kefal
Mugiliformes	Mugilidae	Chelon saliens (Risso, 1810)	Leaping mullet	Sıçrayan Kefal
Mugiliformes	Mugilidae	Mugil cephalus Linnaeus, 1758	Flathead mullet	Has Kefal
Mulliformes	Mullidae	Mullus barbatus (Linnaeus, 1758)	Red mullet	Barbunya
Mulliformes	Mullidae	Mullus surmuletus Linnaeus, 1758	Striped red mullet	Tekir
Myliobatiformes	Dasyatidae	Dasyatis pastinaca (Linnaeus, 1758)*	Common stingray	İğneli vatoz
Myliobatiformes	Gymnuridae	Gymnura altavela (Linnaeus, 1758)*	Spiny butterfly ray	Kelebek vatoz
Ophidiiformes	Ophidiidae	Ophidion rochei Müller, 1845	Roche's Snake Blenny	Kayış Balığı
Ovalentaria/misc	Pomacentridae	Chromis chromis (Linnaeus, 1758)	Damselfish	Papaz Balığı
Perciformes	Triglidae	Chelidonichthys lucerna (Linnaeus, 1758)	Tub gurnard	Kırlangıç Balığı
Perciformes	Scorpaenidae	Scorpaena porcus Linnaeus, 1758	Black scorpionfish	İskorpit
Perciformes	Serranidae	Serranus cabrilla (Linnaeus, 1758)	Comber	Hani Balığı

NEXT Black Sea Basin

Perciformes	Serranidae	Serranus scribe (Linnaeus, 1758)	Painted comber	Yazılı Hani
Perciformes	Trachinidae	Trachinus draco Linnaeus, 1758	Greater weever	Trakonya
Perciformes	Uranoscopidae	Uranoscopus scaber Linnaeus, 1758	Stargazer	Kurbağa Balığı
Perciformes	Ammodytidae	Gymnammodytes cicerelus (Rafinesque, 1810)	Mediterranean sand eel	Kum yılan balığı
Pleuronectiformes	Bothidae	Arnoglossus kessleri Schmidt, 1915	Scaldback	Dil balığı
Pleuronectiformes	Bothidae	Arnoglossus laterna (Walbaum, 1792)	Scaldfish	Dil balığı
Pleuronectiformes	Bothidae	Arnoglossus thori Kyle, 1913	Thor's scaldfish	İnce pisi balığı
Pleuronectiformes	Soleidae	Buglossidium luteum (Risso, 1810)	Solenette	Küçük Dil Balığı
Pleuronectiformes	Soleidae	Microchirus variegatus (Donovan, 1808)	Thickback sole	Lekeli Dil Balığı
Pleuronectiformes	Soleidae	Pegusa nasuta (Pallas, 1814)	Blackhand sole	Dil Balığı
Pleuronectiformes	Pleuronectidae	Platichthys flesus (Linnaeus, 1758)	Flounder	Dere Pisi
Pleuronectiformes	Scophthalmidae	Scophthalmus maximus (Linnaeus, 1758)	Turbot	Karadeniz Kalkanı
Pleuronectiformes	Scophthalmidae	Scophthalmus rhombus (Linnaeus, 1758)	Brill	Çivisiz Kalkan
Pleuronectiformes	Soleidae	Pegusa lascaris Risso, 1810	Sand Sole	Kum Dil Balığı
Pleuronectiformes	Soleidae	Solea solea (Linnaeus, 1758) = Solea vulgaris	Common sole	Dil Balığı
Rajiformes	Rajidae	Raja clavata Linnaeus, 1758	Thornback ray	Dikenli Vatoz
Salmoniformes	Salmonidae	Salmo labrax Pallas, 1814	Black Sea salmon	Karadeniz Alabalığı
Scombriformes	Trichiuridae	Lepidopus caudatus (Euphasen, 1788)	Silver scabbardfish	Palaska Balığı
Scombriformes	Scombridae	Auxis rochei (Risso, 1810)*	Bullet tuna	Tombik Balığı (Gobene)
Scombriformes	Scombridae	Euthynnus alletteratus (Rafinesque-Schmaltz, 1810)*	Little tunny	Yazılı Orkinos
Scombriformes	Pomatomidae	Pomatomus saltatrix (Linnaeus, 1766)	Bluefish	Lüfer
Scombriformes	Scombridae	Sarda sarda (Bloch, 1793)	Atlantic bonito	Palamut
Scombriformes	Scombridae	Scomber colias Gmelin, 1789	Atlantic chub mackerel	Kolyoz

NEXT Black Sea Basin

Scombriformes	Scombridae	Scomber scombrus Linnaeus, 1758	Atlantic mackerel	Uskumru
Scombriformes	Scombridae	Thunnus thynnus (Linnaeus, 1758)	Atlantic bluefin tuna	Mavi Yüzgeçli Orkinos
Squaliformes	Squalidae	Squalus acanthias Linnaeus, 1758	Piked dogfish	Mahmuzlu Camgöz
Squaliformes	Squalidae	Squalus blainvillei (Risso, 1827)	Longnose spurdog	Camgöz
Squatiniiformes	Squatinae	Squatina squatina (Linnaeus, 1758)*	Angelshark	Melek Köpek Balığı
Syngnathiformes	Syngnathidae	Hippocampus guttulatus Cuvier, 1829	Long-snout seahorse	Uzun Burunlu DenizAtı
Syngnathiformes	Syngnathidae	Hippocampus hippocampus (Linnaeus, 1758)	Short-snout seahorse	Kısa Burunlu Denizatı
Syngnathiformes	Syngnathidae	Nerophis ophidion (Linnaeus, 1758)	Straight-nose pipefish	Deniz İğnesi
Syngnathiformes	Syngnathidae	Syngnathus abaster Risso, 1827	Blackstripe pipefish	Küçük Deniz İğnesi
Syngnathiformes	Syngnathidae	Syngnathus acus Linnaeus, 1758*	Greater pipefish	Büyük Deniz İğnesi
Syngnathiformes	Syngnathidae	Syngnathus schmidtii Popov, 1927	Schmidt's pipefish	Karadeniz Deniz İğnesi
Syngnathiformes	Syngnathidae	Syngnathus tenuirostris Rathke, 1837	Narrow-snouted pipefish	İnce Burunlu Deniz İğnesi
Syngnathiformes	Syngnathidae	Syngnathus typhle Linnaeus, 1758	Broad-snouted pipefish	Geniş Burunlu Deniz İğnesi
Syngnathiformes	Syngnathidae	Syngnathus variegatus Pallas, 1814	Thickly snouted pipefish	Benekli Deniz İğnesi
Tetraodontiformes	Balistidae	Balistes capriscus (Gmelin, 1789)	Grey triggerfish	Çütre balığı
Zeiformes	Zeidae	Zeus faber Linnaeus, 1758	John dory	Dülger Balığı

Table 5 shows the IUCN Red List conservation status (CR, EN, VU, NT) of fish species in the Turkish Black Sea. Critically Endangered (CR) species are mainly sturgeons and the European eel, with severe declines. The Endangered category includes a few species such as butterfly ray (*Gymnura altavela*) and Schmidt's pipefish or Black Sea pelagic pipefish (*Syngnathus schmidtii*). In the Turkish Black Sea, 10 fish species are classified as Vulnerable (VU), 8 as Critically Endangered (CR), 2 as Endangered (EN), and 6 as Near Threatened (NT). Overall, migratory and large predatory species in the Turkish Black Sea are under higher threat due to overfishing, habitat degradation, pollution, and disrupted river connectivity (Başçınar and Sağlam, 2009).

NEXT Black Sea Basin

Table 5: The threatened fish species in the IUCN Red List in Black Sea of Türkiye

CR	EN	VU	NT
<i>Huso gueldenstaedtii</i>	<i>Gymnura altavela</i>	<i>Trachurus trachurus</i>	<i>Dicentrarchus labrax</i>
<i>Huso nudiventris</i>	<i>Syngnathus schmidtii</i>	<i>Sphyrna zygaena</i>	<i>Sciaena umbra</i>
<i>Huso persicus</i>		<i>Labrus viridis</i>	<i>Proterorhinus marmoratus</i>
<i>Huso ruthenus</i>		<i>Umbrina cirrosa</i>	<i>Chelon labrosus</i>
<i>Huso stellatus</i>		<i>Dentex dentex</i>	<i>Chelon auratus</i>
<i>Huso huso</i>		<i>Alopias vulpinus</i>	<i>Raja clavata</i>
<i>Acipenser sturio</i>		<i>Dasyatis pastinaca</i>	
<i>Anguilla anguilla</i>		<i>Pomatomus saltatrix</i>	
		<i>Squalus acanthias</i>	
		<i>Balistes capriscus</i>	

Table-6 present **six endemic fish species** from the Turkish Black Sea, along with their families and common names. This limited number highlights the region's unique but relatively low endemic fish diversity and its conservation importance.

Table 6: Endemic fish species in the Black Sea of Türkiye

Family	Species	Common name
Syngnathidae	<i>Syngnathus schmidtii</i>	Narrow-snouted pipefish
Tripterygiidae	<i>Tripterygion tripteronotum</i>	Red-black triplefin
Salmonidae	<i>Salmo labrax</i>	Black Sea salmon
Gobiidae	<i>Ponticola platyrostris</i>	Flat-snout Goby
Gobiidae	<i>Knipowitschia caucasica</i>	Caucasian dwarf goby
Gobiidae	<i>Ponticola platyrostris</i>	Flatsnout goby
Bothidae	<i>Arnoglossus kessleri</i>	Scaldback (Dil balığı)

Table 7 lists 23 non-native and invasive species found in the Turkish Black Sea, covering fish and other marine groups such as crustaceans, mollusks, and gelatinous organisms. Several species, including *Rapana venosa*, *Mnemiopsis leidyi*, and *Callinectes sapidus*, are well-established invaders that have significantly altered food webs and ecosystem structure. These species were introduced mainly via shipping activities and ballast water, and they can impact native biodiversity through competition, predation, and habitat modification.

Table 7: Invasive and alien species in the Black Sea of Türkiye

No	Family	Species	Common name	Turkish name
1	Chaetodontidae	<i>Heniochus acuminatus</i>	Mediterranean sand smelt	Küçük gümüş balığı
2	Blenniidae	<i>Parablennius incognitus</i>	Pygmy blenny	Horozbina
3	Lophiidae	<i>Lophius budegassa</i>	Black-bellied anglerfish	Küçük Fener Balığı
4	Lophiidae	<i>Lophius piscatorius</i>	Angler	Fener Balığı
5	Pomacentridae	<i>Chromis chromis</i>	Damselfish	Papaz balığı
6	Zeidae	<i>Zeus faber</i>	John dory	Dülger balığı

NEXT Black Sea Basin

7	Sparidae	<i>Pagellus erythrinus</i>	Common pandora	Kırma mercan
8	Tetraodontidae	<i>Lagocephalus spadiceus</i>	Half smooth golden pufferfish	Balon balığı
9	Lophiidae	<i>Lophius budegassa</i>	Blackbellied angler	Fener balığı
10	Sebastidae	<i>Sebastes schlegelii</i>	Korean rockfish	Pasifik iskorbiti
11	Mugilidae	<i>Planiliza haematocheilus</i>	Mugil soiuy	Rus kefali
12		<i>Parablennius incognitus</i>		
13	Pomacentridae	<i>Chromis chromis</i>	Damselfish	Papaz balığı
14	Sparidae	<i>Lithognathus mormyrus</i>	Sand steenbras	Mırmır
15	Gobiidae	<i>Gobius cruentatus</i>	Red-mouthed goby	Kırmızı ağızlı kaya balığı
16	Muricidae	<i>Rapana venosa</i>	Rapa whelk	Deniz salyangozu
17	Penaeidae	<i>Penaeus kerathurus</i>	Caramote prawn	Çil karides
18	Bolinopsidae	<i>Mnemiopsis leidyi</i>	Sea walnut	Taraklı medüz
19	Beroidea	<i>Beroe ovata</i>	Comb jelly	Taraklı deniz anası
20	Ostreidae	<i>Crassostrea gigas</i>	Pacific oyster	Pasifik istiridyesi
21	Arcidae	<i>Anadara kagoshimensis</i>	Ark clam	Ak midye
22	Portunidae	<i>Callinectes sapidus</i>	Blue crab	Mavi yengeç
23	Balanidae	<i>Balanus improvisus</i>	Acorn barnacle	Balanus

2.1.1.3. Marine Mammals Species Diversity in the Black Sea of Türkiye

The marine mammal species diversity in the Turkish Black Sea is represented by only three cetacean species: the harbour porpoise (*Phocoena phocoena*), the **short-beaked common dolphin** (*Delphinus delphis*), and the common bottlenose dolphin (*Tursiops truncatus*).

According to recent literature, the total dolphin population in the Black Sea is estimated to be around 250,000 individuals. Specific field studies conducted between 2019 and 2020 along the Sinop Peninsula—specifically between Gerze and Ayancık—identified approximately 1,000 harbour porpoises, 300 common dolphins, and 200 bottlenose dolphins. Despite these numbers, these species face significant threats, with the majority of mortalities occurring due to accidental entanglement in fishing nets.

2.1.2. Key Ecosystems and Habitats

The Black Sea is one of the most unique and complex marine environments in the world. Its status as a semi-enclosed basin with a permanent vertical stratification (layering) creates distinct ecosystems that are not found in most other seas (EEA, 2022). The key ecosystems of the Black Sea can be categorized based on their depth, salinity, and oxygen availability:

2.1.2.1. The Epipelagic (Oxic) Ecosystem

This is the "life-giving" layer, extending from the surface down to approximately 150-200 m. It is the only part of the open sea where oxygen is present.

NEXT Black Sea Basin

- **Characteristics:** High primary productivity driven by phytoplankton (diatoms and coccolithophores).
- **Key Species:** Small pelagic fish like **anchovy** (*Engraulis encrasicolus*) and **sprat**, which form the base of the food web for apex predators like **dolphins**.
- **Role:** This layer facilitates the entire commercial fishing industry and acts as the primary site for carbon dioxide absorption.

2.1.2.2. Benthic (Seabed) Habitats of the Shelf

The continental shelf, particularly in the North-Western part and along the Turkish coast, hosts the highest biodiversity.

- **Seagrass Meadows (*Zostera*):** Located in shallow, sandy areas. They act as "blue carbon" sinks and nursery grounds for many fish species.
- **Macroalgal Forests (*Cystoseira*):** These brown algae form complex "forests" on rocky substrates, providing shelter for diverse invertebrate communities.
- **Mussel and Oyster Beds:** Natural bio-filters that help maintain water clarity. The "*Modiolus phaseolus*" (bean mussel) beds are characteristic of the deeper shelf.

2.1.2.3. Estuarine and Deltaic Ecosystems

The Black Sea receives massive freshwater input from major rivers like the **Danube, Dnieper, and Dniester, Kızılırmak, Yeşilırmak, Çoruh....**

- **Characteristics:** These are brackish-water zones where freshwater and saltwater mix.
- **Significance:** They are hotspots for Ponto-Caspian relics (species that survived from the ancient Paratethys Sea). The Danube Delta is a UNESCO World Heritage site and a critical habitat for sturgeon species. Kızılırmak Deltaic area is a Ramsar Site.

2.2.4. The Deep Anoxic and Monimolimnion Ecosystem

Below the 200m mark, the Black Sea is devoid of oxygen and saturated with **hydrogen sulfide (H₂S)**. This area accounts for nearly **87% of the sea's total volume**.

- **Lifeforms:** No fish or plants can survive here. Instead, it is dominated by extremophile bacteria and archaea that utilize methane and sulfur for energy.
- **Geological Value:** Because there is no oxygen to aid decomposition, ancient shipwrecks and organic matter are perfectly preserved for thousands of years in this "underwater museum."

NEXT Black Sea Basin

We use habitats to understand biodiversity

Marine habitats are as unique and varied as terrestrial ones. We use factors like depth, exposure and sediment types to classify habitats.



WE HAVE

100's

of types of marine habitats
in our coastal waters.

Number
of habitats



Biodiversity

Biodiversity increases with
the number of habitat types.

The Black Sea provide a range of habitats, including coastal marshes, rocky coastlines, sandy and muddy bottoms, and submerged plant regions which provide essential feeding, breeding, and nursery grounds for native and migratory species from neighbor seas.

Coastal habitats extend to the margins of the continental shelves, occupying about 7 percent of the ocean surface area. Marine coastal ecosystems include many very different types of marine habitats, each with their own characteristics and species composition. They are characterized by high levels of biodiversity and productivity. (https://en.wikipedia.org/wiki/Marine_coastal_ecosystem). For example, estuaries are areas where freshwater rivers meet the saltwater of the ocean, creating an environment that is home to a wide variety of species, including fish, shellfish, and birds. Salt marshes are coastal wetlands which thrive on low-energy shorelines in temperate and high-latitude areas, populated with salt-tolerant plants such as cordgrass and marsh elder that provide important nursery areas for many species of fish and shellfish. Mangrove forests survive in the intertidal zones of tropical or subtropical coasts, populated by salt-tolerant trees that protect habitat for many marine species, including crabs, shrimp, and fish.

Seagrass meadows can be adjacent to coral reefs. These meadows are underwater grasslands populated by marine flowering plants that provide nursery habitats and food sources for many fish species, crabs and sea turtles, as well as dugongs. In slightly deeper waters are kelp forests, underwater ecosystems found in cold, nutrient-rich waters, primarily in temperate regions.

Directly and indirectly, marine coastal ecosystems provide vast arrays of ecosystem services for humans, such as cycling nutrients and elements, and purifying water by filtering pollutants. They sequester carbon as a cushion against climate change. They protect coasts by reducing

NEXT Black Sea Basin

the impacts of storms, reducing coastal erosion and moderating extreme events. They provide essential nurseries and fishing grounds for commercial fisheries. They provide recreational services and support tourism. These ecosystems are vulnerable to various anthropogenic and natural disturbances, such as pollution, overfishing, and coastal development, which have significant impacts on their ecological functioning and the services they provide. Climate change is impacting coastal ecosystems with sea level rises, ocean acidification, and increased storm frequency and intensity. When marine coastal ecosystems are damaged or destroyed, there can be serious consequences for the marine species that depend on them, as well as for the overall health of the ocean ecosystem. Some conservation efforts are underway to protect and restore marine coastal ecosystems, such as establishing marine protected areas and developing sustainable fishing practices.

Coastal habitats extend to the margins of the continental shelves, occupying about 7 percent by area of the Earth's oceans. These coastal seas are highly productive systems, providing an array of ecosystem services to humankind, such as processing of nutrient effluents from land and climate regulation. However, coastal ecosystems are threatened by human-induced pressures such as climate change and eutrophication. Recent studies have shown that over half of the world's population lives within 200km or so of a coastline, making these areas particularly susceptible to compounding pressures from climate change, lack of resources, and socioeconomic changes, illustrating that the future of coastal human-natural systems are now caught in a 'perfect storm'

In 2015, the United Nations established 17 Sustainable Development Goals with the aim of achieving certain targets by 2030. Their mission statement for their 14th goal, *Life below water*, is to "conserve and sustainably use the oceans, seas and marine resources for sustainable development". The United Nations has also declared 2021-2030 the UN Decade on Ecosystem Restoration, but restoration of coastal ecosystems is not receiving appropriate attention.

The full title of Target 14.2 is: "By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans". This target has one indicator: Indicator 14.2.1 is "Number of countries using ecosystem-based approaches to managing marine areas". This indicator aims at protecting and managing sustainably the marine and coastal ecosystems to avoid adverse impacts. An exclusive economic zone (EEZ) is a sea zone prescribed by the 1982 United Nations Convention on the Law of the Sea over which a sovereign state has special rights regarding the exploration and use of marine resources, including energy production from water and wind. Target 14.5: "Conserve coastal and marine areas". By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information. The indicator for this target is 14.5.1: "coverage of protected areas in relation to marine areas". The term "Marine Protected Areas" includes marine reserves, fully protected marine areas, no-take zones, marine sanctuaries, ocean sanctuaries, marine parks, locally managed marine areas and others. Each area has a specific level of protection and a specific allowed range of activities.

NEXT Black Sea Basin

The landmark global agreement to protect biodiversity in the high oceans entered into force on Saturday, January 17, 2026, providing countries with a legally binding framework to combat threats such as overfishing and achieve the goal of protecting 30% of the oceans by 2030. The agreement, named Biodiversity Beyond National Jurisdiction (BBNJ), was concluded in March 2023 after 15 years of negotiations and will enable the creation of a global network of “marine protected areas” in vast ocean ecosystems in international waters. Türkiye has ratified the Global Ocean Treaty for the Protection of Oceans. However, due to various types of pollution, habitats losses, overfishing, non-indigenous species, and climate change, many species are threatened or endangered. Başusta et al. (2024) reported that 63 marine species were threatened and legally protected in Turkish waters. The main conservation actions are illustrated by the establishment of marine protected areas, which aims at preserving the diversity and habitats alike in the Turkish waters for sensitive and endangered species (Güçlüsoy 2016).

Türkiye has no clear definition for the terminology of “Marine Protected Area” in the national legislation. Marine protected areas (MPAs) in Türkiye have been designated as Natural Protected Areas, Special Environmental Protection Areas, National Parks, Nature Parks, Nature Conservation Areas and Ramsar Areas. Assigning IUCN protected areas categories to Türkiye’s MPAs is currently an ongoing endeavour.

Natural populations of turbot are under significant anthropogenic pressure, including habitat loss, overfishing, and pollution, and their status in the Black Sea is currently assessed as “Vulnerable” (VU) and “Near Threatened” (NT) according to the IUCN Red List criteria.

Black Sea’s coastal and marine habitats, their ecological classification, biodiversity, and the significant anthropogenic threats they face. It integrates findings from recent academic research, international projects such as Environmental Monitoring in the Black Sea (EMBLAS, 2021), and European environmental frameworks like EUNIS (

In the Sinop coastal zone, Sentinel-2 imagery and machine learning identify three primary habitats: seagrass meadows (~10%), which act as essential ecosystem engineers for carbon sequestration and biodiversity; macroalgae (~21%), which dominate rocky substrates and drive primary production; and other substrates (~68.5%), consisting of non-vegetated sandy, rocky, or deep-water areas. These coastal habitats are vital for maintaining regional biodiversity but remain highly vulnerable to climate change and human-induced pressures (Kavak et al., 2025).

2.1.3. National Inventories and Monitoring

Türkiye has some monitoring and inventory programme to understand and prevent national resources. Here some regulations and programmes are;

a) National Inventories:

- **Regulation on the Prevention, Management and Control of the Introduction and Spread of Invasive Alien Species (2026):** The Regulation on the Prevention,

NEXT Black Sea Basin

Management and Control of the Introduction and Spread of Invasive Alien Species is Türkiye's first comprehensive national legal framework addressing invasive alien species (IAS). The Regulation establishes provisions for the prevention, early detection, monitoring, rapid response, control and management of IAS. It also provides the legal basis for risk assessment, early warning systems, the establishment of a national inventory, and inter-institutional coordination. Furthermore, the Regulation establishes the National Invasive Alien Species Commission and specialized Technical Advisory Groups to support science-based decision-making and coordinated implementation of IAS management measures (Official Gazette, 2026).

b) National Monitoring Programmes:

- **TurIST - Turkish National Invasive Alien Species Data and Information System (2024):** The Turkish National Invasive Alien Species Data and Information System (TurIST), developed by the Ministry of Agriculture and Forestry, is the national database for recording, monitoring and reporting invasive alien species (IAS) in marine, terrestrial and inland freshwater ecosystems. The system currently includes 177 invasive alien species (106 marine, 56 terrestrial, 13 freshwater and 2 amphibious species) and supports early warning, risk assessment, and the development of management and control plans. As part of the Marine Invasive Alien Species Project (MARIAS), Türkiye's National Invasive Alien Species Data and Information System has been established. The system is designed to support the monitoring, management, and prevention of invasive alien species in both aquatic and terrestrial environments (<https://turist.tarimorman.gov.tr/>).
- **Integrated Marine Pollution Monitoring Programme (2014-present):** Coordinated by the Ministry of Environment, Urbanization and Climate Change, this national programme conducts regular monitoring of Türkiye's marine waters. Monitoring activities include physicochemical parameters, contaminants, plankton, benthic habitats, fish, seagrass meadows, and other biological quality elements. It represents the country's most comprehensive marine environmental monitoring programme for assessing the ecological status of marine ecosystems (MEUCC, 2025, 2026, 2025a).
- **MaRDA Project (Marine Monitoring and Reporting Development Project):** Funded under the IPA III Programme, the Marine Monitoring and Reporting Development Project (MaRDA) aims to align Türkiye's marine monitoring and reporting system with the European Union Marine Strategy Framework Directive (MSFD 2008/56/EC). The project focuses on strengthening national capacity through the adoption of online and autonomous monitoring technologies, improved data management, and enhanced national and international reporting.
- **BlackSea4Fish (GFCM project) (2016):** Coordinated by the General Fisheries Commission for the Mediterranean (GFCM), the BlackSea4Fish Programme supports scientific cooperation for the sustainable management of fisheries in the Black Sea. The programme promotes stock assessments, monitoring of commercially important species (anchovy, sprat, horse mackerel, turbot, whiting, red mullet), invasive alien species (*Rapana venosa*), threatened species (piked dogfish) and regional scientific data sharing among

NEXT Black Sea Basin

the six Black Sea coastal countries. BlackSea4Fish has five main outputs: improving scientific knowledge for sustainable fisheries management; improving knowledge of small-scale and recreational fisheries; assessing and reducing illegal, unreported and unregulated (IUU) fishing; monitoring and reducing discards and bycatch of vulnerable species; and strengthening cooperation, communication and the sharing of project results among Black Sea stakeholders (<https://www.fao.org/gfcm/activities/fisheries/cooperation/blacksea4fish/en/>).

- The Regional Research Programmes on Rapa Whelk (established in 2018) and Piked Dogfish (established in 2021) are implemented under the BlackSea4Fish project to support sustainable fisheries management in the Black Sea. The Piked Dogfish Programme improves knowledge of the species' biology and population dynamics to support regional stock assessments, conservation measures, and bycatch mitigation. The Rapa Whelk Programme, focuses on stock assessment, biological data collection, and the sustainable management of *Rapana venosa*.

2.2. Bulgaria

2.2.1. Species Diversity in the Black Sea of Bulgaria:

The ichthyofauna of the Bulgarian Black Sea coast comprises a total of 154 species belonging to 56 families (Table 8). The most species-rich families are Gobiidae (25 species) and Sparidae (15 species). If all inhabitants of transitional waters, such as estuaries and coastal lagoons, are included, this number would be considerably higher, as only a small part of these species have been recorded in the marine environment. The present report considers only those species that have been documented within the marine waters of the Bulgarian sector of the Black Sea.

A total of 27 species of the ichthyofauna can be categorized as Ponto-Caspian relicts. This group includes representatives of the family Acipenseridae, part of the clupeid fishes (Clupeidae and Alosidae), as well as certain species from the families Gobiidae and Syngnathidae, and other taxa whose distribution is linked to the historical evolution of the Ponto-Caspian basin. These species are the autochthonous component of the Black Sea ichthyofauna, formed under conditions of prolonged geological isolation and a specific hydrological regime.

The largest proportion of the contemporary ichthyofauna of the Bulgarian Black Sea coast is represented by the so-called Mediterranean immigrants (a total of 110 species). These are species of boreal-Atlantic and Mediterranean origin that have entered the Black Sea during various stages of its paleogeographic and hydrological development. Their number have increased markedly following the re-establishment of the connection with the Mediterranean Sea during the Holocene, which created conditions for gradual colonization and establishment of new species. In recent years, an acceleration of this process, known as Mediterraneanization has been observed, characterized by an increased rate of penetration and establishment of Mediterranean species in the Black Sea. This has led to the continuous recording of new representatives of the Mediterranean fauna, including thermophilic and subtropical taxa. The primary driver of this trend can be identified as global climate change, and in particular the

NEXT Black Sea Basin

increase in sea water temperature, especially during the winter months, which reduces the thermal barrier for the successful overwintering and reproduction of thermophilic species in the Black Sea (Table 8).

A smaller proportion of the fish species recorded in the waters of the Bulgarian Black Sea coast are of primary freshwater origin. These comprise a total of 11 species, inhabiting transitional waters, from which they may enter the marine environment under certain conditions.

Table 8. Species composition, origin, habitat, fisheries, ecological, and conservation status of the Bulgarian Black Sea ichthyofauna.

Abbreviations used. Origin: AL - alien species; FRW - freshwater species; MI - Mediterranean immigrant; PCR - Ponto-Caspian relict. Habitat: BEN - benthic; COA - coastal; DEM - demersal; EST - estuarine; PEL - pelagic. Fisheries status: BYC - bycatch; COM - commercially important species; N-COM - non-commercial species; PRO - prohibited. Ecological status: INC - increasing; STA - stable; DEC - decreasing; RAR - rare; FLU - fluctuating; DD - data deficient; EXT - extinct. Conservation status: EX - extinct; CR - critically endangered; EN - endangered; VU - vulnerable; NT - near threatened; LC - least concern; DD - data deficient. II, IV, V - Annexes II, IV, and V of the Habitats Directive. The taxonomic classification of fish species follows Froese & Pauly (2026).

Species/family	Orig in	Habi tat	Fisheries status	Ecological status	IUCN	DIR 92/43	Red book
Squalidae							
<i>Squalus acanthias</i>	MI	PEL	COM	DEC	VU A2bd		
<i>Squalus blainville</i>	MI	PEL	N-COM	RAR	DD		
Rajidae							
<i>Raja clavata</i>	MI	BEN	COM	DD	NT A2bd		
Dasyatidae							
<i>Dasyatis pastinaca</i>	MI	BEN	BYC	STA	VU A2bd		
Acipenseridae							
<i>Acipenser gueldenstaedtii</i>	PCR	DEM	PRO	DEC	CR A2bcde	II	CR
<i>Acipenser ruthenus</i>	PCR	DEM	PRO	DEC	CR A2be	V	CR
<i>Acipenser stellatus</i>	PCR	DEM	PRO	DEC	CR A2bcde	II	CR
<i>Acipenser sturio</i>	MI	DEM	PRO	EXT	CR A2cde	II, IV	EX
<i>Huso huso</i>	PCR	DEM	PRO	DEC	CR A2bcd	II	CR
Anguillidae							
<i>Anguilla anguilla</i>	MI	DEM	PRO	DEC	CR A2bd+4bd		EN
Congridae							
<i>Conger conger</i>	MI	DEM	N-COM	RAR	LC		
Alosidae							
<i>Alosa fallax</i>	MI	PEL	BYC	RAR	LC	II, V	
<i>Alosa immaculata</i>	PCR	PEL	COM	DEC	LC	II, V	VU
<i>Alosa maeotica</i>	PCR	PEL	BYC	DEC	LC	II, V	EN

NEXT Black Sea Basin

Species/family	Orig in	Habitat	Fisheries status	Ecological status	IUCN	DIR 92/43	Red book
<i>Alosa tanaica</i>	PCR	PEL	BYC	DEC	LC	II, V	
<i>Sardina pilchardus</i>	MI	PEL	BYC	FLU	LC		
Dorosomatidae							
<i>Sardinella aurita</i>	MI	PEL	BYC	INC	LC		
Ehiravidae							
<i>Clupeonella cultriventris</i>	PCR	COA	N-COM	DEC	LC		EN
Clupeidae							
<i>Sprattus sprattus</i>	MI	PEL	COM	STA	LC		
Engraulidae							
<i>Engraulis encrasicolus</i>	MI	PEL	COM	STA	LC		
Cyprinidae							
<i>Carassius gibelio</i>	AL	EST	N-COM	INC	LC		
<i>Cyprinus carpio</i>	FRW	EST	N-COM	FLU	LC		CR
Leuciscidae							
<i>Alburnus mandrensis</i>	FRW	EST	N-COM	DEC	EN		EN
<i>Alburnus schischkovi</i>	FRW	EST	N-COM	DEC	NT B1b(iii)		EN
<i>Leucaspius delineatus</i>	FRW	EST	N-COM	FLU	LC		VU
<i>Petroleuciscus borysthenticus</i>	FRW	EST	N-COM	FLU	LC		EN
<i>Rutilus frisii</i>	FRW	EST	N-COM	DEC	LC		CR
<i>Rutilus rutilus</i>	FRW	EST	N-COM	FLU	LC		
<i>Scardinius erythrophthalmus</i>	FRW	EST	N-COM	FLU	LC		
<i>Vimba vimba</i>	FRW	EST	N-COM	FLU	LC		
Salmonidae							
<i>Oncorhynchus mykiss</i>	AL	PEL	N-COM	RAR	LC		
<i>Salmo labrax</i>	PCR	PEL	BYC	RAR	LC		CR
Gaidropsaridae							
<i>Gaidropsarus mediterraneus</i>	MI	BEN	BYC	STA	Not Evaluated		
Merlucciidae							
<i>Merluccius merluccius</i>	MI	DEM	BYC	RAR	LC		
Zeidae							
<i>Zeus faber</i>	MI	DEM	N-COM	RAR	DD		
Gadidae							
<i>Merlangius merlangus</i>	MI	DEM	COM	STA	LC		
Ophidiidae							
<i>Ophidion rochei</i>	MI	BEN	BYC	STA	DD		
Odontobutidae							

NEXT Black Sea Basin

Species/family	Orig in	Habi tat	Fisheries status	Ecological status	IUCN	DIR 92/43	Red book
<i>Perccottus glenii</i>	AL	DEM	N-COM	RAR	LC		
Gobiidae							
<i>Aphia minuta</i>	MI	PEL	N-COM	STA	LC		
<i>Babka gymnotrachelus</i>	PCR	EST	N-COM	STA	LC		
<i>Benthophiloides brauneri</i>	PCR	EST	N-COM	RAR	LC		EX
<i>Chromogobius quadrivittatus</i>	MI	BEN	N-COM	DD	LC		
<i>Gobius buccichi</i>	MI	BEN	N-COM	DD	LC		
<i>Gobius cruentatus</i>	MI	BEN	N-COM	RAR	LC		
<i>Gobius cobitis</i>	MI	BEN	BYC	STA	LC		
<i>Gobius niger</i>	MI	BEN	N-COM	STA	LC		
<i>Gobius ophiocephalus</i>	MI	BEN	BYC	STA	LC		VU
<i>Gobius paganellus</i>	MI	BEN	N-COM	DD	LC		
<i>Knipowitschia cf. caucasica</i>	PCR	EST	N-COM	STA	LC		
<i>Knipowitschia longicaudata</i>	PCR	EST	N-COM	EXT	LC		CR
<i>Mesogobius batrachocephalus</i>	PCR	BEN	COM	DEC	LC		
<i>Neogobius fluviatilis</i>	PCR	EST	N-COM	STA	LC		
<i>Neogobius melanostomus</i>	PCR	BEN	COM	FLU	LC		
<i>Pomatoschistus bathi</i>	MI	BEN	N-COM	RAR	LC		
<i>Pomatoschistus marmoratus</i>	MI	BEN	N-COM	STA	LC		
<i>Pomatoschistus minutus</i>	MI	BEN	N-COM	DD	LC		
<i>Ponticola cephalargoides</i>	PCR	BEN	BYC	DD	DD		
<i>Ponticola eurycephalus</i>	PCR	BEN	COM	FLU	LC		
<i>Ponticola kessleri</i>	PCR	EST	N-COM	RAR	LC		
<i>Ponticola ratan</i>	PCR	BEN	N-COM	DD	LC		
<i>Ponticola syrman</i>	PCR	BEN	N-COM	EXT	LC		EX
<i>Proterorhinus marmoratus</i>	PCR	BEN	N-COM	RAR	NT B1ab(iii)+2ab(iii)		
<i>Proterorhinus semilunaris</i>	PCR	EST	N-COM	STA	LC		
Pomacentridae							
<i>Chromis chromis</i>	MI	COA	N-COM	INC	LC		
Mugilidae							

NEXT Black Sea Basin

Species/family	Origin	Habitat	Fisheries status	Ecological status	IUCN	DIR 92/43	Red book
<i>Chelon auratus</i>	MI	PEL	COM	STA	NT A2cd+4cd		
<i>Chelon labrosus</i>	MI	PEL	BYC	RAR	NT A2cd+4cd		
<i>Chelon ramada</i>	MI	PEL	BYC	RAR	NT A2cd+4cd		
<i>Chelon saliens</i>	MI	PEL	COM	STA	NT A2cd+4cd		
<i>Mugil cephalus</i>	MI	PEL	COM	STA	LC		
<i>Planiliza haematocheilus</i>	AL	PEL	BYC	RAR	Not Evaluated		
Blenniidae							
<i>Aidablennius sphynx</i>	MI	BEN	N-COM	STA	LC		
<i>Blennius ocellaris</i>	MI	BEN	N-COM	STA	LC		
<i>Coryphoblennius galerita</i>	MI	BEN	N-COM	DD	LC		
<i>Parablennius sanguinolentus</i>	MI	BEN	N-COM	STA	LC		
<i>Parablennius tentacularis</i>	MI	BEN	N-COM	STA	LC		
<i>Parablennius zvonimiri</i>	MI	BEN	N-COM	STA	LC		
<i>Salaria pavo</i>	MI	BEN	N-COM	STA	LC		
Gobiesocidae							
<i>Diplecogaster bimaculata</i>	MI	BEN	N-COM	DD	LC		
<i>Lepadogaster candolii</i>	MI	BEN	N-COM	DD	LC		
<i>Lepadogaster lepadogaster</i>	MI	BEN	N-COM	DD	LC		
Atherinidae							
<i>Atherina boyeri</i>	MI	PEL	BYC	STA	LC		
<i>Atherina hepsetus</i>	MI	PEL	BYC	RAR	Not Evaluated		
Belonidae							
<i>Belone belone</i>	MI	PEL	COM	INC	LC		
Poeciliidae							
<i>Gambusia holbrooki</i>	AL	EST	N-COM	DD	LC		
Echeneidae							
<i>Echeneis naucrates</i>	MI	PEL	N-COM	RAR	LC		
Carangidae							
<i>Lichia amia</i>	MI	PEL	N-COM	RAR	LC		
<i>Naucrates ductor</i>	MI	PEL	N-COM	RAR	LC		
<i>Pseudocaranx dentex</i>	MI	PEL	BYC	RAR	LC		
<i>Trachinotus ovatus</i>	MI	PEL	BYC	RAR	LC		
<i>Trachurus trachurus</i>	MI	PEL	BYC	RAR	LC		
<i>Trachurus mediterraneus</i>	MI	PEL	COM	STA	LC		
Sphyraenidae							

NEXT Black Sea Basin

Species/family	Orig in	Habi tat	Fisheries status	Ecological status	IUCN	DIR 92/43	Red book
<i>Sphyraena sphyraena</i>	MI	PEL	N-COM	RAR	LC		
Xiphiidae							
<i>Xiphias gladius</i>	MI	PEL	N-COM	RAR	NT A2bd		
Scophthalmidae							
<i>Scophthalmus rhombus</i>	MI	BEN	BYC	DD	LC		
<i>Scophthalmus maximus</i>	MI	BEN	COM	DEC	LC		EN
Pleuronectidae							
<i>Platichthys flesus</i>	MI	BEN	BYC	STA	LC		
Bothidae							
<i>Arnoglossus kessleri</i>	MI	BEN	N-COM	DD	DD		
Soleidae							
<i>Pegusa nasuta</i>	MI	BEN	BYC	STA	LC		
Syngnathidae							
<i>Hippocampus guttulatus</i>	MI	COA	N-COM	STA	DD		
<i>Nerophis ophidion</i>	MI	COA	N-COM	DEC	LC		EN
<i>Syngnathus abaster</i>	MI	COA	N-COM	STA	LC		
<i>Syngnathus schmidtii</i>	PCR	PEL	N-COM	DD	EN A2bcd+3cd+4b cd		
<i>Syngnathus tenuirostris</i>	MI	COA	N-COM	DD	DD		
<i>Syngnathus typhle</i>	MI	COA	N-COM	STA	LC		
<i>Syngnathus variegatus</i>	PCR	COA	N-COM	DD	DD		
Callionymidae							
<i>Callionymus risso</i>	MI	BEN	N-COM	STA	LC		
<i>Callionymus pusillus</i>	MI	BEN	N-COM	STA	LC		
Scombridae							
<i>Euthynnus alletteratus</i>	MI	PEL	BYC	RAR	LC		
<i>Sarda sarda</i>	MI	PEL	COM	FLU	LC		
<i>Scomber scombrus</i>	MI	PEL	COM	FLU	LC		CR
<i>Scomber colias</i>	MI	PEL	COM	FLU	LC		
<i>Thunnus thynnus</i>	MI	PEL	BYC	RAR	EN A1bd		
Ammodytidae							
<i>Gymnammodytes cicerelus</i>	MI	BEN	N-COM	STA	LC		
Trachinidae							
<i>Trachinus draco</i>	MI	BEN	N-COM	STA	LC		
Uranosopidae							
<i>Uranoscopus scaber</i>	MI	BEN	N-COM	INC	LC		

NEXT Black Sea Basin

Species/family	Origin	Habitat	Fisheries status	Ecological status	IUCN	DIR 92/43	Red book
Labridae							
<i>Coris julis</i>	MI	COA	N-COM	RAR	LC		
<i>Ctenolabrus rupestris</i>	MI	COA	N-COM	RAR	LC		
<i>Symphodus roissali</i>	MI	COA	N-COM	STA	LC		
<i>Symphodus cinereus</i>	MI	COA	N-COM	STA	LC		
<i>Symphodus ocellatus</i>	MI	COA	N-COM	STA	LC		
<i>Symphodus tinca</i>	MI	COA	N-COM	STA	LC		
Mullidae							
<i>Mullus barbatus</i>	MI	BEN	COM	STA	LC		
Centrarchidae							
<i>Lepomis gibbosus</i>	AL	EST	N-COM	DD	LC		
Serranidae							
<i>Serranus cabrilla</i>	MI	COA	N-COM	RAR	LC		
<i>Serranus hepatus</i>	MI	COA	N-COM	RAR	LC		
<i>Serranus scriba</i>	MI	COA	N-COM	RAR	LC		
Percidae							
<i>Sander lucioperca</i>	FRW	EST	BYC	RAR	LC		
Pomatomidae							
<i>Pomatomus saltatrix</i>	MI	PEL	COM	FLU	LC		
Scorpaenidae							
<i>Scorpaena notata</i>	MI	BEN	N-COM	RAR	LC		
<i>Scorpaena porcus</i>	MI	BEN	BYC	STA	LC		
Sebastidae							
<i>Sebastes schlegelii</i>	AL	COA	N-COM	INC	Not Evaluated		
Triglidae							
<i>Chelidonichthys lucerna</i>	MI	BEN	BYC	STA	LC		
Gasterosteidae							
<i>Gasterosteus aculeatus</i>	MI	COA	N-COM	STA	LC		VU
<i>Pungitius platygaster</i>	PCR	EST	N-COM	RAR	LC		CR
Moronidae							
<i>Dicentrarchus labrax</i>	MI	COA	BYC	RAR	NT A2bcde		
Sciaenidae							
<i>Sciaena umbra</i>	MI	COA	BYC	STA	NT		
<i>Umbrina cirrosa</i>	MI	COA	BYC	STA	VU A2b		
Sparidae							
<i>Boops boops</i>	MI	COA	N-COM	RAR	LC		
<i>Dentex dentex</i>	MI	DEM	N-COM	INC	VU A2bd		
<i>Diplodus vulgaris</i>	MI	COA	N-COM	INC	LC		
<i>Diplodus sargus</i>	MI	COA	N-COM	RAR	LC		
<i>Diplodus annularis</i>	MI	COA	N-COM	INC	LC		
<i>Diplodus puntazzo</i>	MI	COA	N-COM	INC	LC		

NEXT Black Sea Basin

Species/family	Orig in	Habitat	Fisheries status	Ecological status	IUCN	DIR 92/43	Red book
<i>Lithognathus mormyrus</i>	MI	COA	N-COM	INC	LC		
<i>Oblada melanurus</i>	MI	COA	N-COM	RAR	LC		
<i>Pagellus erythrinus</i>	MI	COA	N-COM	RAR	LC		
<i>Sarpa salpa</i>	MI	COA	N-COM	RAR	LC		
<i>Sparus aurata</i>	MI	COA	N-COM	RAR	LC		
<i>Spicara smaris</i>	MI	DEM	BYC	INC	LC		
<i>Spicara maena</i>	MI	DEM	BYC	INC	LC		
<i>Spicara flexuosum</i>	MI	DEM	N-COM	RAR	Not Evaluated		
<i>Spondylisoma cantharus</i>	MI	COA	N-COM	RAR	LC		
Lophiidae							
<i>Lophius piscatorius</i>	MI	BEN	N-COM	RAR	LC		

2.2.1.1. General Status of Offshore and Coastal Species

The majority of the Black Sea ichthyofauna is composed of species inhabiting open waters. These comprise a total of 100 species and can be classified as pelagic, benthic, and demersal fish. The largest share is represented by benthic species, with a total of 46 species. A smaller number (38 species) are pelagic, while only 16 species can be defined as demersal.

In terms of their fisheries status, 20 of the open-water species are considered commercially valuable resource species. Among them, the most economically important are the sprat (*Sprattus sprattus*), anchovy (*Engraulis encrasicolus*), horse mackerel (*Trachurus mediterraneus*), bluefish (*Pomatomus saltatrix*), bonito (*Sarda sarda*), and red mullet (*Mullus barbatus*). Some commercial species exhibit fluctuating economic importance due to interannual variability in their population sizes, such as bluefish, bonito, and the two mackerel species. The populations of four of the resource species are considered to be declining: the spiny dogfish (*Squalus acanthias*), Pontic shad (*Alosa immaculata*), toad goby (*Mesogobius batrachocephalus*), and turbot (*Scophthalmus maximus*). The only commercial species with an increasing population is the garfish (*Belone belone*), while the populations of the remaining species are considered stable. A total of eight commercially important species also have an assigned conservation status. Five species are included in the IUCN Red List of Threatened Species: the spiny dogfish (*S. acanthias*) and bluefish (*P. saltatrix*) are categorized as Vulnerable, while the thornback ray (*Raja clavata*), salema (*Sarpa salpa*), and gilt-head bream (*Sparus aurata*) are classified as Near Threatened. The Pontic shad (*A. immaculata*) is included in Annexes II and V of the Habitats Directive (Directive 92/43/EEC), as well as in the Bulgarian Biological Diversity Act, and is listed in the Red Data Book of Bulgaria in the category Vulnerable. The turbot (*Scophthalmus maximus*) and the Black Sea mackerel are also included in the Red Data Book, categorized respectively as Endangered and Critically Endangered.

NEXT Black Sea Basin

A total of 33 marine fish species are classified as coastal inhabitants. The majority of them have no commercial importance; however, three species occasionally occur in catches as bycatch: the European seabass (*Dicentrarchus labrax*), brown meagre (*Sciaena umbra*), and shi drum (*Umbrina cirrosa*). With regard to their ecological status, the populations of only six coastal species are considered to be increasing. These include the damselfish (*Chromis chromis*), the invasive Korean rockfish (*Sebastes schlegelii*), and four species from the family Sparidae (*Diplodus vulgaris*, *D. annularis*, *D. puntazzo*, and *Lithognathus mormyrus*). In contrast, two species exhibit declining populations (*Clupeonella cultriventris* and *Nerophis ophidion*), while for two additional species there are insufficient data to determine their ecological status. Thirteen species are categorized as rare, and ten have stable populations (Table 1). Three coastal species are included in the IUCN Red List: two of them (*D. labrax* and *S. umbra*) are classified as **Near Threatened**, and one (*U. cirrosa*) as **Vulnerable**. Another three species are listed as Data Deficient (*Hippocampus guttulatus*, *Syngnathus tenuirostris*, and *S. variegatus*). Three species are also included in the **Red Data Book of Bulgaria**: one species (*Gasterosteus aculeatus*) is categorized as **Vulnerable**, and two species (*C. cultriventris* and *N. ophidion*) as **Endangered**.

2.2.1.2. Planktonic species diversity in the Black Sea of Bulgaria:

It has been established that the number of phytoplankton species observed in the Black Sea waters has increased over the years. During the first decade of the 21st century, twice as many species were recorded compared to the 1980s—from a list of 700 species in 1978 (The Black Sea, 1978) to 1621 confirmed and 48 unconfirmed species in the Black Sea Phytoplankton Checklist (BSPC Editorial Board, 2012).

In Bulgarian marine waters, the number of observed phytoplankton species has also increased—from 230 species during the period 1954-1980 to 544 species during 1980-2005 (Nesterova et al., 2008). According to data from the long-term expeditions of the Institute of Fish Resources - Varna (1992-2024), a total of **604 phytoplankton species** and forms have been recorded in Bulgarian marine and brackish waters (Varna and Beloslav Lakes) up to 2024, distributed across 21 taxonomic classes (Bacillariophyceae, Dinophyceae, Chlorophyceae, Euglenophyceae, Cryptophyceae, Cyanophyceae, Dictyochophyceae, Prasinophyceae, Prymnesiophyceae, Trebouxiophyceae, Chlorophyta incertae sedis, Chrysophyceae, Chlorodendrophyceae, Craspedophyceae, Dinoflagellata incertae sedis, Euglenoidea, Haptophyta incertae sedis, Pyramimonadophyceae, Synurophyceae, Xanthophyceae, Zygnematophyceae). A large part of them (500) have been published in the Atlas of the Phytoplankton in the Black Sea (<https://phytoplanktonblacksea.com/en/>) (Klisarova and Gerdzhikov, 2012).

The change in the number of recorded phytoplankton species is attributed both to the increased sampling frequency and the expansion of the monitoring scheme, as well as to improved microscopy techniques (Moncheva and Kamburska, 2002). The factors influencing the dynamics of phytoplankton communities are also shifting. Furthermore, the accelerated introduction of non-indigenous/exotic species via ballast waters is further altering the species composition (Klisarova, D., 2014).

NEXT Black Sea Basin

Studies on phytoplankton communities in Bulgarian marine waters have shown that certain species occur in almost every third sample, the so-called frequently occurring species (Table 9).

Table 9. Frequency of occurrence of phytoplankton species developing in Bulgarian marine waters, 2008-2010 (Gerdzhikov, 2014)

No	Taxon	Species	Frequency of occurrence (%)
1	Dinophyceae	<i>Gymnodinium</i> sp. Stein, 1878	100%
2	Cryptophyceae	<i>small Flagellathes</i>	100%
3	Dinophyceae	<i>Peridinium</i> sp. Ehrenberg, 1832	64.46%
4	Dinophyceae	<i>Prorocentrum cordatum</i> (Ostenfeld, 1901) Dodge, 1975 (syn. (from Gomez, 2005) = <i>E. cordata</i> Ostenfeld, <i>E. pyriformis</i> Schiller 1928, <i>P. minimum</i> (Pavillard 1916) Schiller 1931)	64.05%
5	Prymnesiophyceae	<i>Gephyrocapsa huxleyi</i> (Lohmann) P.Reinhardt, 1972 (Syn. <i>Emiliana huxleyi</i> (Lohmann) Hay & Mohler, 1967)	61.78%
6	Dinophyceae	<i>Gymnodinium agiliforme</i> Schiller, 1928	46.69%
7	Dinophyceae	<i>Scrippsiella trochoidea</i> (Stein, 1883) Balech ex Loeblich III, 1965 (syn. <i>Peridinium trochoideum</i> (Stein, 1883) Lemmermann, 1910)	44.63%
8	Bacillariophyceae	<i>Pseudo-nitzschia delicatissima</i> (P.T. Cleve, 1897) Heiden, 1928	43.18%
9	Bacillariophyceae	<i>Proboscia alata</i> (Brightwell) Sundström, 1986 (syn. <i>Rhizosolenia alata</i> Brightwell, 1858)	38.43%
10	Bacillariophyceae	<i>Cyclotella caspia</i> Grunow, 1878	37.19%
11	Dinophyceae	<i>Prorocentrum micans</i> Ehrenberg, 1833	35.12%
12	Bacillariophyceae	<i>Skeletonema costatum</i> (Greville) Cleve, 1873	34.50%
13	Chlorophyceae	<i>Chlorophyceae</i> sp. Wille, 1884	32.23%
14	Dinophyceae	<i>Gyrodinium spirale</i> (Bergh, 1881) Kofoed & Swezy, 1921	29.96%
15	Dinophyceae	<i>Heterocapsa triquetra</i> (Ehrenberg, 1840) Stein, 1883	26.24%
16	Bacillariophyceae	<i>Navicula</i> sp. Bory de Saint-Vincent, 1822	25.62%
17	Bacillariophyceae	<i>Dactyliosolen fragilissimus</i> (Bergon) Hasle in Hasle & Syvertsen, 1996 (syn. <i>Rhizosolenia fragilissima</i> Bergon, 1903)	24.79%
18	Bacillariophyceae	<i>Cerataulina pelagica</i> (Cleve) Hendey, 1937 (syn. <i>Cer. bergonii</i> H.Perag.)	24.17%
19	Cyanophyceae	<i>Merismopedia</i> sp. Meyen, 1839	22.31%
20	Cryptophyceae	<i>Chroomonas</i> sp. Hansgirg, 1885	22.11%
21	Bacillariophyceae	<i>Chaetoceros curvisetus</i> P.T. Cleve, 1889	21.28%

NEXT Black Sea Basin

22	Dictyochophyceae	<i>Apedinella radians</i> (Lohmann) Campbell, 1973 (Syn. <i>Apedinella spinifera</i> (Throndsen) Throndsen, 1971)	20.45%
23	Euglenophyceae	<i>Eutreptia lanowii</i> Steuer, 1904	20.04%
24	Cryptophyceae	<i>Leucocryptos marina</i> (Braarud) Butcher, 1967 (syn. <i>Bodo marina</i> Braarud, 1935; <i>Chilomonas marina</i> (Braarud, 1935) Halldal, 1953)	19.42%
25	Dinophyceae	<i>Lessardia elongata</i> Saldarriaga et F.J.R.Taylor, 2003	19.01%
26	Bacillariophyceae	<i>Nitzschia tenuirostris</i> Mer., 1902	19.01%
27	Bacillariophyceae	<i>Chaetoceros</i> sp. Ehrenberg, 1844	18.80%
28	Bacillariophyceae	<i>Pseudosolenia calcar-avis</i> (Schultze, 1858) Sundström, 1986 (syn. <i>Rhizosolenia calcar-avis</i> Schultze, 1858)	16.74%
29	Dinophyceae	<i>Glenodinium</i> sp. Ehrenberg, 1836	16.53%
30	Bacillariophyceae	<i>Thalassionema nitzschioides</i> (Grunow) Mereschkowsky, 1902 (Syn. <i>Thalassionema nitzschioides</i> (Grunow, 1862) Van Heurck, 1896)	15.08%
31	Dinophyceae	<i>Glenodinium paululum</i> Lindemann, 1928	14.67%
32	Bacillariophyceae	<i>Pseudo-nitzschia seriata</i> (P.T. Cleve, 1883) H. Peragallo in H. & M. Peragallo, 1900 (syn. <i>Nitzschia seriata</i> P.T. Cleve, 1883)	14.46%
33	Dinophyceae	<i>Prorocentrum compressum</i> (Bailey, 1850) Abé ex Dodge, 1975 (syn. <i>Exuviaella compressa</i> (Bailey) Ostensfeld, 1899)	14.26%
34	Bacillariophyceae	<i>Thalassiosira parva</i> Proshkina-Lavrenko, 1955	14.26%
35	Dinophyceae	<i>Oblea rotunda</i> (Lebour) Balech ex Sournia, 1973	12.81%
36	Dinophyceae	<i>Protoperidinium brevipes</i> (Paulsen, 1908) Balech, 1974 (Syn. <i>Peridinium brevipes</i> Paulsen, 1908)	11.36%
37	Dinophyceae	<i>Gymnodinium variabile</i> Herdman, 1924	10.95%
38	Bacillariophyceae	<i>Chaetoceros simplex</i> Ostensfeld, 1901	10.74%
39	Dinophyceae	<i>Cochlodinium adriaticum</i> Schiller, 1933 (Syn. <i>Gyrodinium adriaticum</i> Schiller, 1928)	9.71%
40	Dinophyceae	<i>Tripos furca</i> (Ehrenberg) F.Gómez, 2013 (Syn. <i>Ceratium furca</i> (Ehrenberg) Claparède & Lachmann, 1859)	8.88%
41	Dinophyceae	<i>Gymnodinium najadeum</i> Schiller, 1928	8.26%
42	Dinophyceae	<i>Gymnodinium wulffii</i> Schiller, 1933	7.85%
43	Cryptophyceae	<i>Rhodomonas</i> sp. Karsten, 1898	7.85%
44	Prasinophyceae	<i>Pyramimonas</i> sp. Schmarda, 1849	7.85%
45	Craspedophyceae	<i>Bicosta spinifera</i> (Throndsen) Leadbeater, 1978 (Syn. <i>Salpingoeca spinifera</i> Throndsen, 1970)	7.64%
46	Euglenophyceae	<i>Eutreptia</i> sp. Perty, 1852	7.64%

NEXT Black Sea Basin

47	Bacillariophyceae	<i>Chaetoceros insignis</i> Protskina-Lavrenko, 1955	7.44%
48	Euglenophyceae	<i>Eutreptiella</i> sp. A.da Cunha, 1914	7.44%
49	Prymnesiophyceae	<i>Coccolithus</i> sp. E.H.L.Schwarz, 1894	7.44%
50	Dinophyceae	<i>Peridinium pusillum</i> (Pénard, 1891) Lemmermann, 1901 (Syn. <i>Peridinium umbonatum</i> F.Stein, 1883)	7.23%
51	Dinophyceae	<i>Durinskia agilis</i> (Kofoid & Swezy) Saburova, Chomérat & Hoppenrath, 2012 (Syn. <i>Gymnodinium agile</i> Kofoid & Swezy, 1921)	7.23%
52	Chlorophyta incertae sedis	<i>Poropila dubia</i> Schiller, 1925	7.02%
53	Prymnesiophyceae	<i>Acanthoica quattropsina</i> Lohmann, 1903	7.02%
54	Bacillariophyceae	<i>Chaetoceros compressus</i> Lauder, 1864	6.82%
55	Dinophyceae	<i>Protoperidinium pellucidum</i> Bergh, 1882	6.61%
56	Dinophyceae	<i>Protoperidinium steinii</i> (Jørgensen, 1899) Balech, 1974	6.61%
57	Bacillariophyceae	<i>Thalassiosira anguste-lineata</i> (A.Schmidt) G.Fryxell & Hasle, 1977	6.61%
58	Bacillariophyceae	<i>Ditylum brightwellii</i> (T.West) Grunow, 1885	6.61%
59	Dinophyceae	<i>Gonyaulax spinifera</i> (Claparède & Lachmann, 1859) Diesing, 1866	6.40%
60	Dinophyceae	<i>Akashiwo sanguinea</i> (K.Hirasaka) G.Hansen & Ø.Moestrup, 2000 (Syn. <i>Gymnodinium splendens</i> Lebour, 1925; <i>Gymnodinium sanguineum</i> Hirasaka, 1922)	5.99%
61	Cyanophyceae	<i>Oscillatoria</i> sp. Vaucher ex Gomont, 1892	5.99%
62	Euglenophyceae	<i>Eutreptiella</i> sp. A.da Cunha, 1914	5.99%
63	Dinophyceae	<i>Triplos fusus</i> (Ehrenberg) F.Gómez, 2013 (Syn. <i>Ceratium fusus</i> (Ehrenberg, 1834) Dujardin, 1841)	5.79%
64	Prymnesiophyceae	<i>Syracosphaera</i> sp. Lohmann, 1902	5.79%
65	Bacillariophyceae	<i>Leptocylindrus minimus</i> Gran, 1915	5.58%
66	Bacillariophyceae	<i>Cyclotella meneghiniana</i> Kützing, 1844	5.58%
67	Bacillariophyceae	<i>Coscinodiscus granii</i> Gough, 1905	5.58%
68	Dinophyceae	<i>Minuscula bipes</i> (Paulsen) Lebour, 1925	5.37%
69	Dinophyceae	<i>Diplopsalis lenticula</i> Bergh 1882 (Syn. <i>Glenodinium lenticula</i> Pouchet 1883; <i>Peridiniopsis lenticula</i> (Bergh) Starmach)	5.17%
70	Cyanophyceae	<i>Phormidium bulgaricum</i> (Komárek) Anagnostidis & Komárek 1988 (Syn. <i>Oscillatoria bulgarica</i> Komárek, 1956)	4.75%
71	Bacillariophyceae	<i>Nitzschia closterium</i> (Ehrenberg) W. Smith, 1853 (syn. <i>Cylindrotheca closterium</i> (Ehrenberg) Reimann & J.C.Lewin)	4.55%
72	Bacillariophyceae	<i>Skeletonema subsalsum</i> (Cleve-Euler) Bethge, 1928	4.34%

NEXT Black Sea Basin

73	Bacillariophyceae	<i>Chaetoceros affinis</i> Lauder, 1864	4.34%
74	Euglenophyceae	<i>Eutreptia viridis</i> Perty, 1852	4.34%
75	Bacillariophyceae	<i>Thalassiosira antiqua</i> (Grunow) Cleve (syn. <i>Thalassiosira antiqua</i> var. <i>septata</i> Pr.-Lavr., 1955(syn. Accepted in AlgaeBase as <i>Thalassiosira oestrupii</i> (Ostenfeld) Hasle 1972)	3.93%
76	Bacillariophyceae	<i>Thalassiosira nana</i> Lohmann, 1908	3.72%
77	Euglenophyceae	<i>Euglena viridis</i> (O.F.Muller) Ehrenberg, 1832	3.72%
78	Dinophyceae	<i>Gonyaulax minima</i> Matzenauer, 1933	3.31%
79	Bacillariophyceae	<i>Chaetoceros lorenzianus</i> v. <i>solitarius</i> Proshkina-Lavrenko, 1955	3.31%
80	Dinophyceae	<i>Pronoctiluca pelagica</i> Fabre-Domergue, 1889	3.10%
81	Dinophyceae	<i>Lingulodinium polyedra</i> (F.Stein) J.D.Dodge 1989 (Syn. <i>Gonyaulax polyedra</i> F. Stein, 1883)	3.10%
82	Trebouxiophyceae	<i>Oocystis</i> sp. Nägeli ex A.Braun, 1855	3.10%
83	Dinophyceae	<i>Gymnodinium flavum</i> Kofoid & Swezy, 1921	2.89%
84	Dinophyceae	<i>Peridinium breve</i> Paulsen, 1907 (syn. <i>Protoperidinium pyriforme</i> (Paulsen 1907) Balech, 1974; <i>Protoperidinium breve</i> (Paulsen 1907) Balech)	2.89%
85	Bacillariophyceae	<i>Chaetoceros socialis</i> H.S.Lauder, 1864	2.89%
86	Bacillariophyceae	<i>Chaetoceros rigidus</i> Ostenfeld, 1901	2.89%
87	Bacillariophyceae	<i>Coscinodiscus</i> sp. Ehrenberg, 1839	2.89%
88	Dinophyceae	<i>Dinophysis sacculus</i> Stein, 1883	2.69%
89	Dinophyceae	<i>Prorocentrum scutellum</i> Schröder, 1900	2.69%
90	Dinophyceae	<i>Gymnodinium simplex</i> (Lohmann) Kofoid & Swezy, 1921	2.69%
91	Bacillariophyceae	<i>Halamphora coffeaeformis</i> (Agardh) Levkov, 2009 (Syn. <i>Amphora coffeaeformis</i> (C.Agardh) Kützinger, 1844)	2.69%
92	Dinophyceae	<i>Polykrikos schwarzii</i> Bütschli, 1873	2.48%
93	Chlorophyceae	<i>Platymonas</i> sp. G.S.West, 1916	2.48%
94	Prasinophyceae	<i>Pachysphaera</i> sp. Ostenfeld, 1899	2.48%
95	Dinophyceae	<i>Protoperidinium granii</i> (Ostenfeld, 1906) Balech, 1974	2.07%
96	Dinophyceae	<i>Protoperidinium divergens</i> (Ehrenberg, 1840) Balech, 1974	2.07%
97	Dinophyceae	<i>Cochlodinium</i> sp. Schütt, 1896	2.07%
98	Bacillariophyceae	<i>Detonula confervacea</i> (Cleve) Gran, 1900 (syn. <i>Detonula cystifera</i> Gran., 1900; <i>Lauderia confervacea</i> P.T. Cleve, 1896)	2.07%
99	Cryptophyceae	<i>Cryptomonas</i> sp. Ehrenberg, 1831	2.07%
100	Euglenophyceae	<i>Eutreptiella gymnastica</i> Throndsen 1969	2.07%
101	Dinophyceae	<i>Gyrodinium</i> sp. Kofoid & Swezy, 1921	1.86%
102	Bacillariophyceae	<i>Nitzschia</i> sp. Hassall, 1845	1.86%
103	Bacillariophyceae	<i>Pleurosigma elongatum</i> W. Smith, 1852	1.86%

NEXT Black Sea Basin

104	Bacillariophyceae	<i>Thalassiosira angulata</i> (W.Gregory) Hasle, 1978 (Syn. <i>Thalassiosira decipiens</i> (Grunow) E.G.Jørgensen, 1905)	1.86%
105	Euglenophyceae	<i>Euglena</i> sp. Ehrenberg, 1830	1.86%
106	Dinophyceae	<i>Gyrodinium lachryma</i> (Meunier, 1910) Kofoed et Swezy, 1921	1.65%
107	Dinophyceae	<i>Triplos muelleri</i> Bory de Saint-Vincent, 1826 (Syn. <i>Ceratium tripos</i> (O.F.Müller) Nitzsch, 1817)	1.65%
108	Bacillariophyceae	<i>Achnanthes longipes</i> C.Agardh, 1824	1.65%
109	Bacillariophyceae	<i>Thalassiosira rotula</i> Meunier, 1910	1.65%
110	Bacillariophyceae	<i>Leptocylindrus danicus</i> P.T. Cleve, 1889	1.65%
111	Dinophyceae	<i>Dinophysis rotundata</i> Claparède & Lachmann, 1859 (syn. <i>Phalacroma rotundatum</i> Kofoed and Michener, 1911)	1.45%
112	Dinophyceae	<i>Protoperidinium conicum</i> (Gran) Balech, 1974	1.45%
113	Dinophyceae	<i>Dinophysis acuta</i> Ehrenberg, 1841	1.45%
114	Bacillariophyceae	<i>Synedra</i> sp. Ehrenberg, 1830	1.45%
115	Bacillariophyceae	<i>Nitzschia closterium</i> (Ehrenberg) W. Smith, 1853	1.45%
116	Trebouxiophyceae	<i>Trochiscia multispinosa</i> (Möbius) Lemmermann	1.45%
117	Dinophyceae	<i>Protoperidinium conicoides</i> (Paulsen 1905) Balech, 1973	1.24%
118	Dinophyceae	<i>Dinophysis caudata</i> Saville-Kent, 1881	1.24%
119	Bacillariophyceae	<i>Cocconeis scutellum</i> Ehrenberg, 1838	1.24%
120	Chlorophyceae	<i>Golenkinia radiata</i> Chodat, 1894	1.24%
121	Cyanophyceae	<i>Cyanophyceae</i> sp. Schaffner, 1909	1.24%
122	Euglenophyceae	<i>Phacus</i> sp. Dujardin, 1841	1.24%
123	Dinophyceae	<i>Peridinium quinquecorne</i> Abe, 1927 (syn. <i>Protoperidinium quinquecorne</i> (Abé) Balech, 1974)	1.03%
124	Dinophyceae	<i>Dinophysis acuminata</i> Claparède & Lachmann, 1859	1.03%
125	Bacillariophyceae	<i>Chaetoceros densus</i> (Cleve) Cleve, 1899	1.03%
126	Bacillariophyceae	<i>Nitzschia incerta</i> (Grunow) M.Peragallo, 1903 (Syn. <i>Nitzschia reversa</i> W.Smith, 1853; <i>Nitzschia lorenziana</i> var. <i>incerta</i> Grunow)	1.03%
127	Bacillariophyceae	<i>Licmophora</i> sp. C. Agardh, 1827	1.03%
128	Bacillariophyceae	<i>Melosira moniliformis</i> (O.F.Müller) C.Agardh, 1824	1.03%
129	Chlorophyceae	<i>Scenedesmus incrassatulus</i> Bohlin, 1897	1.03%
130	Dinophyceae	<i>Protoperidinium subinerme</i> (Paulsen) Loeblich III, 1969	0.83%
131	Dinophyceae	<i>Gonyaulax</i> sp. Diesing, 1866	0.83%

NEXT Black Sea Basin

132	Dinophyceae	<i>Gonyaulax grindleyi</i> Reinecke, 1967 (Syn. <i>Protoceratium reticulatum</i> (Claparède & Lachmann, 1859) Bütschli, 1885)	0.83%
133	Bacillariophyceae	<i>Paralia sulcata</i> (Ehrenberg) P.T. Cleve, 1873 (Syn. <i>Melosira sulcata</i> (Ehrenberg) Kützinger, 1844)	0.83%
134	Bacillariophyceae	<i>Chaetoceros septentrionalis</i> Oestrup, 1895	0.83%
135	Bacillariophyceae	<i>Chaetoceros peruvianus</i> Brightwell, 1856	0.83%
136	Chlorophyceae	<i>Monoraphidium arcuatum</i> (Korshikov) Hindák, 1970 (Syn. <i>Ankistrodesmus arcuatus</i> Korshikov)	0.83%
137	Chlorophyceae	<i>Scenedesmus quadricauda</i> (Turpin) Brébisson in Brébisson & Godey 1835 (Syn. Accepted in Algaebase is <i>Desmodesmus quadricaudatus</i> (Turpin) Hegewald)	0.83%
138	Chlorophyceae	<i>Monoraphidium convolutum</i> (Corda) Komárková-Legnerová, 1969 (Syn. <i>Ankistrodesmus convolutus</i> Corda, 1838)	0.83%
139	Dinophyceae	<i>Amphidinium</i> sp. Claparède & Lachmann, 1859	0.62%
140	Dinophyceae	<i>Alexandrium monilatum</i> (J.F.Howell,1953) Balech, 1995	0.62%
141	Dinophyceae	<i>Cladopyxis</i> sp. Stein, 1883	0.62%
142	Dinophyceae	<i>Amphidinium crassum</i> Lohmann, 1908	0.62%
143	Dinophyceae	<i>Gymnodinium neapolitanum</i> Schiller, 1928	0.62%
144	Chlorophyceae	<i>Chlamydomonas</i> sp. Ehrenberg, 1833	0.62%
145	Dictyochophyceae	<i>Distephanus speculum</i> (Ehrenberg) Haeckel, 1887	0.62%
146	Dinophyceae	<i>Protoperidinium bulla</i> (Meunier ,1910) Balech 1974 (Syn. <i>Peridinium bulla</i> A.F.Meunier)	0.41%
147	Dinophyceae	<i>Exuviaella</i> sp. Cienkowski, 1881 (syn. Accepted in WoRMS (2013) is <i>Prorocentrum</i> Ehrenberg,1834)	0.41%
148	Dinophyceae	<i>Glenodinium foliaceum</i> F.Stein 1883	0.41%
149	Dinophyceae	<i>Amphidinium longum</i> Lohmann, 1908	0.41%
150	Dinophyceae	<i>Protoperidinium achromaticum</i> (Levander 1902) Balech, 1974 (Syn. <i>Peridinium achromaticum</i> Levander, 1902)	0.41%
151	Bacillariophyceae	<i>Achnanthes brevipes</i> C.A. Agardh, 1824	0.41%
152	Bacillariophyceae	<i>Thalassiosira baltica</i> (Grunow) Ostensfeld, 1901	0.41%
153	Bacillariophyceae	<i>Surirella gemma</i> Ehrenberg, 1839 (syn. Accepted in WoRMS as <i>Petrodictyon gemma</i> (Ehrenberg) D.G. Mann in Round, Crawford & Mann, 1990)	0.41%
154	Bacillariophyceae	<i>Grammatophora marina</i> (Lyngbye) Kützinger, 1844	0.41%

NEXT Black Sea Basin

155	Bacillariophyceae	<i>Licmophora Ehrenbergii</i> (Kutz.) Grun., 1867	0.41%
156	Bacillariophyceae	<i>Chaetoceros similis</i> Cleve, 1896	0.41%
157	Bacillariophyceae	<i>Navicula cancellata</i> Donkin, 1872	0.41%
158	Bacillariophyceae	<i>Chaetoceros wighamii</i> Brightwell, 1856	0.41%
159	Bacillariophyceae	<i>Eunotia</i> sp. Ehrenberg, 1837	0.41%
160	Cyanophyceae	<i>Spirulina subsalsa</i> Oerstedt ex Gomont, 1892	0.41%
161	Chlorophyceae	<i>Scenedesmus</i> sp. Meyen, 1829	0.41%
162	Chlorophyceae	<i>Phacotus</i> sp. Perty, 1852	0.41%
163	Chlorophyceae	<i>Ankistrodesmus longissimus</i> (Lemmermann) Wille	0.41%
164	Chlorophyceae	<i>Ankistrodesmus</i> sp. Corda, 1838	0.41%
165	Chrysophyceae	<i>Dinobryon</i> sp. Ehrenberg, 1834	0.41%
166	Chrysophyceae	<i>Dinobryon balticum</i> (Schütt) Lemmermann, 1900 (Syn. <i>Dinobryon pellucidum</i> Levander, 1894)	0.41%
167	Euglenophyceae	<i>Phacus longicauda</i> (Ehrenberg) Dujardin, 1841	0.41%
168	Prymnesiophyceae	<i>Phaeocystis pouchetii</i> (M.P. Hariot, 1892) G. Lagerheim, 1896	0.41%
169	Trebouxiophyceae	<i>Dictyosphaerium chlorelloides</i> (Nauman) Komárek & Perman, 1978 (Syn. <i>Dictyosphaerium simplex</i> Korschikov)	0.41%
170	Zygnematophyceae	<i>Mesotaenium</i> sp. Nägeli, 1849	0.41%
171	Dinophyceae	<i>Protoperidinium depressum</i> (Bailey) Balech, 1974 (Syn. <i>Peridinium depressum</i> , Bailey, 1855)	0.21%
172	Dinophyceae	<i>Amphidinium lacustre</i> Stein, 1883	0.21%
173	Dinophyceae	<i>Amphidinium extensum</i> Wulff, 1916	0.21%
174	Dinophyceae	<i>Phalacroma minutum</i> Cleve, 1900 (syn. <i>Dinophysis elongata</i> (Jørgensen, 1923) Abé vel Balech, 1967; <i>Dinophysis minuta</i> (Cleve, 1900) Balech, 1967)	0.21%
175	Dinophyceae	<i>Gymnodinium adriaticum</i> (Schmarda) Kofoid & Swezy, 1921	0.21%
176	Dinophyceae	<i>Peridinium bulla</i> Meunier, 1910 (syn. <i>Protoperidinium bulla</i> (Meunier 1910) Balech 1974)	0.21%
177	Dinophyceae	<i>Gyrodinium fusiforme</i> Kofoid & Swezy, 1921 (syn. Accepted as <i>Gyrodinium fusus</i> (Meunier, 1910) Akselman, 1985)	0.21%
178	Dinophyceae	<i>Gyrodinium pellucidum</i> (Wulff) Schiller, 1933	0.21%
179	Dinophyceae	<i>Hemidinium nasutum</i> F.Stein, 1883	0.21%
180	Dinophyceae	<i>Prorocentrum balticum</i> (Lohmann) Loeblich, 1970 (Syn. <i>Exuviaella baltica</i> Lohmann, 1908; <i>Prorocentrum pomoideum</i> Bursa, 1959)	0.21%
181	Dinophyceae	<i>Gymnodinium grammaticum</i> (Pouchet) Kofoid & Swezy, 1921	0.21%
182	Dinophyceae	<i>Dinophysis hastata</i> Stein, 1883	0.21%

NEXT Black Sea Basin

183	Dinophyceae	<i>Protoperidinium crassipes</i> (Kofoid, 1907) Balech, 1974	0.21%
184	Dinophyceae	<i>Glenodinium dinobryonis</i> (Woloszynska) Schiller 1937 (syn. Accepted in Algae Base as <i>Peridiniopsis dinobryonis</i> (Woloszynska) Bourrelly 1968)	0.21%
185	Dinophyceae	<i>Cochlodinium citron</i> Kofoid et Swezy, 1921	0.21%
186	Dinophyceae	<i>Gymnodinium catenatum</i> L.W.Graham, 1943	0.21%
187	Dinophyceae	<i>Protoperidinium marie-lebouriae</i> (Paulsen) Balech 1974	0.21%
188	Dinophyceae	<i>Protoperidinium abei</i> (Paulsen) Balech, 1974	0.21%
189	Dinophyceae	<i>Gonyaulax apiculata</i> (Pénard, 1891) Entz, 1904	0.21%
190	Dinophyceae	<i>Oxyrrhis marina</i> Dujardin, 1841	0.21%
191	Dinophyceae	<i>Scrippsiella hangoei</i> (J.Schiller) J.Larsen, 1995 (Syn. <i>Peridinium hangoei</i> J.Schiller, 1935; <i>Peridinium gracile</i> E.Lindemann, 1924)	0.21%
192	Dinophyceae	<i>Gymnodinium uberrimum</i> (G.J.Allman) Kofoid & Swezy, 1921	0.21%
193	Dinophyceae	<i>Gymnodinium fuscum</i> (Ehrenberg, 1834) Stein, 1883	0.21%
194	Dinophyceae	<i>Heterocapsa rotundata</i> (Lohmann, 1908) G.Hansen, 1995 (Syn. <i>Massartia rotundata</i> (Lohmann) Schiller, 1933; <i>Katodinium rotundatum</i> (Lohmann) Loeblich III, 1965)	0.21%
195	Dinophyceae	<i>Glenodinium oculatum</i> Stein, 1883 (syn. Accepted in AlgaeBase is <i>Peridiniopsis oculatum</i> (F.Stein) Bourrelly, 1968)	0.21%
196	Bacillariophyceae	<i>Chaetoceros anastomosans</i> Grunov, 1885	0.21%
197	Bacillariophyceae	<i>Pleurosigma</i> sp. W.Smith, 1852	0.21%
198	Bacillariophyceae	<i>Thalassiosira antarctica</i> Comber, 1896 (Syn. <i>Thalassiosira fallax</i> Meunier, 1910)	0.21%
199	Bacillariophyceae	<i>Rhoicosphenia marina</i> (W. Sm.) M. Schmidt (Syn. <i>Rhoicosphenia curvata</i> var. <i>marina</i> Grun)	0.21%
200	Bacillariophyceae	<i>Amphora inflexa</i> (Brébisson ex Kützing) H.L. Smith	0.21%
201	Bacillariophyceae	<i>Chaetoceros subtilis</i> Cleve, 1896	0.21%
202	Bacillariophyceae	<i>Campylodiscus</i> sp. C. G. Ehrenberg ex F. T. Kützing, 1844	0.21%
203	Bacillariophyceae	<i>Chaetoceros teres</i> Cleve, 1896	0.21%
204	Bacillariophyceae	<i>Coscinosira oestrupii</i> Ostefeld, 1900 (syn. <i>Thalassiosira oestrupii</i> (Ostefeld) Hasle)	0.21%
205	Bacillariophyceae	<i>Chaetoceros borgei</i> Lemmerman, 1904 (accepted in WoRMS is syn. <i>Chaetoceros muelleri</i> Lemmermann, 1898)	0.21%
206	Bacillariophyceae	<i>Chaetoceros danicus</i> Cleve, 1889	0.21%

NEXT Black Sea Basin

207	Bacillariophyceae	<i>Nitzschia longissima</i> (Brébisson) Ralfs, 1861	0.21%
208	Bacillariophyceae	<i>Amphora</i> sp. Ehrenberg ex Kützing, 1844	0.21%
209	Bacillariophyceae	Bacillariophyceae spp.	0.21%
210	Bacillariophyceae	<i>Chaetoceros scabrosus</i> Proskina-Lavrenko	0.21%
211	Chlorophyceae	<i>Hypnomonas</i> sp. Korshikov, 1926	0.21%
212	Chlorophyceae	<i>Tetrastrum heteracanthum</i> (Nordstedt) Chodat 1895	0.21%
213	Chlorophyceae	<i>Eudorina</i> sp. Ehrenberg ex Ralfs, 1832	0.21%
214	Chlorophyceae	<i>Scenedesmus obliquus</i> (Turpin) Kützing, 1833 (Syn. Accepted in Algaebase is <i>Acutodesmus obliquus</i> (Turpin) Hegewald & Hanagata 2000)	0.21%
215	Chlorophyceae	<i>Treubaria schmidlei</i> (Schröder) Fott & Kováčik, 1975 (Syn. <i>Treubaria varia</i> Tiffany & Ahlstrom, 1931)	0.21%
216	Chlorophyceae	<i>Scenedesmus protuberans</i> F.E.Fritsch & M.F.Rich 1929 (Syn. Accepted in Algaebase is <i>Desmodesmus protuberans</i> (F.E.Fritsch & M.F.Rich) E.Hegewald 2000)	0.21%
217	Chlorophyceae	<i>Monoraphidium griffithii</i> (Berkeley) Komárková-Legnerová (syn. <i>Ankistrodesmus acicularis</i> (A. Braun) Korshikov, 1953)	0.21%
218	Cyanophyceae	<i>Phormidium</i> sp. Kützing ex Gomont, 1892	0.21%
219	Cyanophyceae	<i>Merismopedia elegans</i> A.Braun ex Kützing, 1849	0.21%
220	Prymnesiophyceae	<i>Phaeocystis globosa</i> Scherffel, 1899	0.21%
221	Trebouxiophyceae	<i>Trochiscia</i> sp. Kützing, 1834	0.21%
222	Trebouxiophyceae	<i>Dictyosphaerium pulchellum</i> H.C.Wood, 1873	0.21%
223	Zygnematophyceae	<i>Closterium</i> sp. Nitzsch ex Ralfs, 1848	0.21%

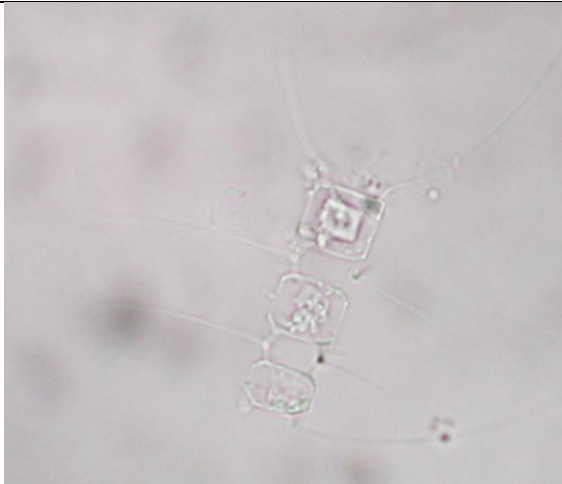
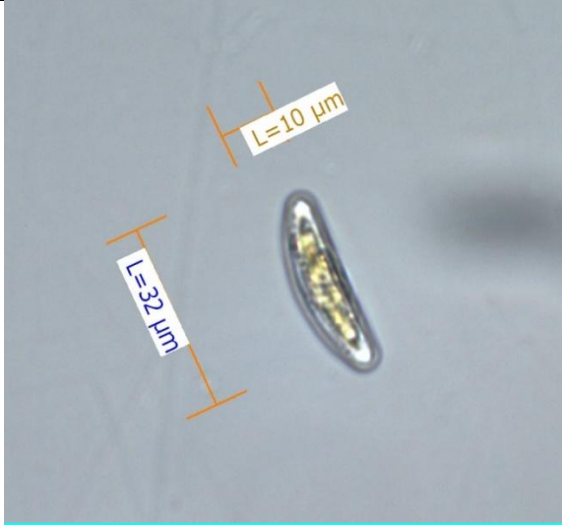
Frequently occurring phytoplankton species represent only a small proportion of the total number recorded over a given period of time. For example, of the 223 species observed during 2008-2010, only 38 phytoplankton species had a 90% frequency of occurrence. The remaining 185 species occurred in less than 10% of the samples. In other words, only 17% of the species recorded in this study were observed regularly, while the remaining 83% of the phytoplankton taxonomic composition were detected relatively less frequently (Table 9; Table 10).

NEXT Black Sea Basin

Table 10. Microphotographs of frequently occurring phytoplankton species off the Bulgarian coast (images-Klisarova&Gerdzhikov) (from source:<https://phytoplanktonblacksea.com/en/>).

	<p>Diatoms <i>Pseudo-nitzschia delicatissima</i> (long cells arranged in a chain) and <i>Coscinodiscus granii</i> (large single discoid cells) (https://phytoplanktonblacksea.com)</p>
	<p>Diatom <i>Pseudo-nitzschia delicatissima</i> (long cells arranged in a chain), euglenophyte <i>Eutreptia lanowii</i> and diatom <i>Proboscia alata</i> (long cylindrical cells) (https://phytoplanktonblacksea.com)</p>
	<p>Prymnesiophyceae <i>Gephyrocapsa huxleyi</i> (Syn. <i>Emiliana huxleyi</i>) (https://phytoplanktonblacksea.com)</p>
	<p>Diatom <i>Chaetoceros affinis</i> (https://phytoplanktonblacksea.com)</p>

NEXT Black Sea Basin

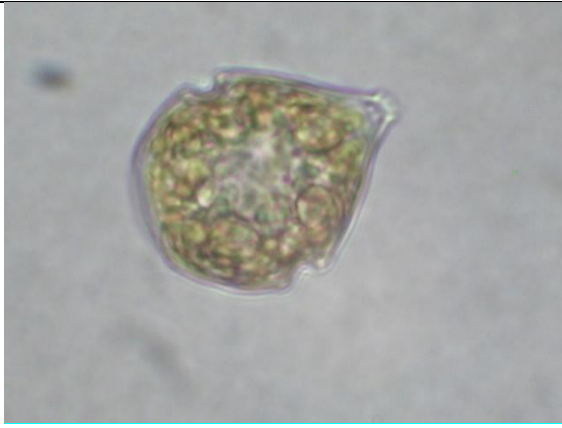
	<p>Diatom <i>Chaetoceros compressus</i> (https://phytoplanktonblacksea.com)</p>
	<p>Diatom <i>Halamphora coffeiformis</i> (https://phytoplanktonblacksea.com)</p>
	<p>Diatom <i>Skeletonema costatum</i> (https://phytoplanktonblacksea.com)</p>

NEXT Black Sea Basin

	<p>Diatom <i>Cyclotella caspia</i> ~12x6 μm (https://phytoplanktonblacksea.com)</p>
	<p>Diatom <i>Leptocylindrus danicus</i> (https://phytoplanktonblacksea.com)</p>
	<p>Diatom <i>Navicula</i> spp. and <i>Synedra</i> spp. (https://phytoplanktonblacksea.com)</p>

NEXT Black Sea Basin

	<p>Diatom <i>Thalassiosira rotula</i> (https://phytoplanktonblacksea.com)</p>
	<p>Dinoflagellate <i>Protoperidinium pellucidum</i> (https://phytoplanktonblacksea.com)</p>
	<p>Dinoflagellate <i>Prorocentrum cordatum</i> (syn. <i>Pr. minimum</i>) (https://phytoplanktonblacksea.com)</p>

	<p>Dinoflagellate <i>Scrippsiella trochoidea</i> (https://phytoplanktonblacksea.com)</p>
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Another part of phytoplankton are the rare species, which can play a fundamental role in shaping ecosystem dynamics by influencing community diversity, structure, and stability (Laraib et al., 2024).

In the last five years (2020-2024), the development of several dozen rare phytoplankton species (43) has been recorded in Bulgarian marine waters, among which dinoflagellates predominate:

Class Dinophyceae (20 species) - *Amphidinium crassum* Lohmann, 1908; *Amphidinium lacustre* Stein, 1883; *Ceratium hirundinella* (O.F.Müller) Dujardin, 1841; *Glenodinium danicum* Paulsen, 1907; *Gonyaulax apiculata* (Pénard, 1891) Entz, 1904; *Gonyaulax digitale* (Pouchet) Kofoed, 1911; *Gonyaulax polygramma* Stein, 1883; *Gonyaulax scrippsae* Kofoed, 1911; *Gymnodinium rhomboides* Schütt, 1895; *Gyrodinium lachryma* (Meunier, 1910) Kofoed et Swezy, 1921; *Gyrodinium pellucidum* (Wulff) Schiller, 1933; *Peridinium goslaviense* Wotoszyńska 1916; *Peridinium hangoei* J.Schiller 1935; *Peridinium pseudolaeve* M.Lefèvre, 1926; *Prorocentrum gracile* F. Schut, 1895; *Prorocentrum lima* (Ehrenberg) F.Stein 1878 (syn. *Exuviaella marina* var. *Lima* (Ehrenberg) Schiller 1931); *Protoperidinium monovelum* (Abé, 1936) Balech, 1974; *Protoperidinium pallidum* (Ostenfeld, 1899) Balech, 1973, *Pyrophacus horologicum* Stein, 1883; *Spatulodinium pseudonociluca* (Pouchet) J.Cachon & M.Cachon, 1968;

Class Bacillariophyceae (18 species) - *Campylodiscus thuretii* var. *lineolatus* Proschkina-Lavrenko, 1955; *Chaetoceros abnormis* Proschkina-Lavrenko, 1953; *Chaetoceros densus* (Cleve) Cleve, 1899; *Chaetoceros laciniosus* F.Schütt, 1895; *Chaetoceros scabrosus* Proschkina-Lavrenko; *Chaetoceros subtilis* Cleve, 1896; *Chaetoceros tortissimus* Gran, 1900; *Chaetoceros abnormis* Proshkina-Lavrenko, 1953; *Grammatophora marina* (Lyngbye) Kützing, 1844; *Grammatophora oceanica* Ehrenberg, 1840; *Hemiaulus hauckii* Grunow ex Van Heurck, 1882; *Leptocylindrus mediterraneus* (H.Peragallo) Hasle 1975; *Navicula cancellata* Donkin, 1872; *Pleurosigma rigidum* W.Smith, 1853; *Striatella interrupta* (Ehrenberg) Heiberg, 1863; *Striatella unipunctata* (Lyngbye) C. Agardh, 1830; *Synedra crystallina* (C.Agardh) Kützing, 1844; *Thalassiosira baltica* (Grunow) Ostenfeld, 1901;

NEXT Black Sea Basin

Class Chlorophyceae (2 species) - *Monoraphidium griffithii* (Berkeley) Komárková-Legnerová, 1969; *Pandorina* sp. Bory, 1826;

Class Euglenophyceae (2 species) - *Euglena acus* (O.F.Müller) Ehrenberg, 1830; *Phacus longicauda* (Ehrenberg) Dujardin, 1841;

Class Cyanophyceae - *Spirulina* sp. Turpin ex Gomont, 1892;

Under the influence of climatic and anthropogenic factors, significant changes in the diversity of flora and fauna have been recorded in the Black Sea (Shiganova and Ozturk, 2010). In 2009, a list was published containing a total of 52 phytoplankton species, most of which occur in Bulgarian waters (35), while only 9 (in Romanian waters) and 6 species (in Turkish waters) were identified. By 2017, the number of established non-native species had already increased to 64 (Black Sea Non-Indigenous Species, 2017). The typical sites of first appearance of non-native phytoplankton species are coastal and shelf waters (List of Non-Native Species from the Black Sea).

Zooplankton groups

The zooplankton species, studied along the Bulgarian Black Sea sector belongs to 4 groups: microzooplankton (tintinids), meso-, macro- and ichthyoplankton. The most important for food chain are copepods, which were affected enormously by invasive species *Mnemiopsis leidyi* (Table 11).

Table 11. Main zooplankton groups, studied in the Bulgarian Black Sea sector

No	Groups	species
1.	PROTOZOA-MASTIGOPHORA	<i>Noctiluca scintillans</i> Macartney Kofoid & Swezy, 1921
2.	METAZOA-COPEPODA	<i>Acartia (Acartiura) clausi</i> Giesbrecht, 1889
3.		<i>Acartia (Acanthacartia) tonsa</i> Dana, 1849
4.		<i>Calanus euxinus</i> Hulsemann, 1991
5.		<i>Calanus euxinus</i> Hulsemann, 1991
6.		<i>Pseudocalanus elongatus</i> Boeck, 1865
7.		<i>Paracalanus parvus parvus</i> (Claus, 1863)
8.		<i>Centropages ponticus</i> Karavaev, 1895
9.		<i>Oithona similis</i> Claus, 186
10.		<i>Oithona nana</i>
11.		<i>Oithona davisae</i> Ferrari F.D. & Orsi, 1984
12.		<i>Pontella mediterranea</i> Claus, 1863
13.		<i>Anomalocera patersonii</i>
14.	APPENDICULARIA	<i>Oikopleura (Vexillaria) dioica</i> Fol, 1872
15.	BIVALVIA	Bivalvia Larvae

NEXT Black Sea Basin

16.	BRANCHIOPODA	<i>Evadne spinifera</i> P.E.Müller, 1867
17.		<i>Penilia avirostris</i> Dana, 1849
18.		<i>Pseudevadne tergestina</i> Claus, 1877
19.		<i>Pleopis polyphemoides</i> Leuckart, 1859
20.	GASTROPODA	Gastropod Larvae
21.	CIRRIPIEDIA	Amphibalanus larvae
22.	CHAETOGNATA	<i>Parasagitta setosa</i> (J. Müller, 1847)
23.	MALACOSTRACA	Decapoda Larvae
24.		Isopoda larvae
25.	POLYCHAETA	Polychaeta larvae
26.	CTENOPHORA	<i>Pleurobrachia pileus</i> O. F. Müller, 1776
27.		<i>Mnemiopsis leidyi</i> A. Agassiz, 1865
28.		<i>Bolinopsis vitrea</i> L. Agassiz, 1860
29.	SCYPHOZOA	<i>Aurelia aurita</i> Linnaeus, 1758
30.		<i>Rhizostoma pulmo</i> Macri, 1778

The primary habitat of *T. truncatus ponticus* is the littoral zone along the entire continental shelf (at depths between 6 and 200 m). Secondary habitats include offshore waters and shallow coastal areas less than 6 m deep. The distribution of *D. delphis ponticus* covers almost the entire sea, with the species occurring predominantly in deep, offshore waters (Sanchez-Cabanes et al., 2017). Its primary habitat is the open sea (depths exceeding 200 m), while the littoral zone along the continental shelf represents a secondary habitat. The species *Ph. phocoena relicta* prefers shallow waters with lower temperatures (Sanchez-Cabanes et al., 2017), with its primary habitat being the littoral zone. It is less frequently encountered in offshore waters (depths over 200 m) and in the shallowest parts of the sea.

The primary habitats of *Monachus monachus* were rocky shores and coastal caves. Along the Bulgarian Black Sea coast, the species was distributed around Cape Kaliakra, Cape Maslen Nos, and the Strandzha coastal region (Golemanski et al., 2011).

According to the **Marine Strategy Framework Directive (MSFD)**, the abundance and density of cetacean species in the Black Sea are as follows:

Bottlenose dolphin (*T. truncatus ponticus*): Coastal and shelf zone - 4 861 individuals; 0,70 ind./km² (ship-based survey); open sea - 10 162 individuals; 0,36 ind./km² (aerial survey).

Common dolphin (*D. delphis ponticus*): Coastal and shelf zone - 5 019 individuals; 0,72 ind./km² (ship-based survey); open sea - 23 580 individuals; 0,84 ind./km² (aerial survey).

Harbour porpoise (*Ph. phocoena relicta*): Coastal and shelf zone - 1 003 individuals; 0,14 ind./km² (ship-based survey); open sea - 9 960 individuals; 0,35 ind./km² (aerial survey).

NEXT Black Sea Basin

A study conducted in 2013 (Studies for Carrying Out the Common Fisheries Policy: Adverse Fisheries Impacts on Cetacean Populations in the Black Sea) estimated cetacean density and abundance (Birkun et al., 2015) as follows:

- *T. truncatus ponticus* - 0,28 ind./km² and 9 947 individuals;
- *D. delphis ponticus* - 0,87 ind./km² and 30 737 individuals;
- *Ph. phocoena relicta* - 0,24 ind./km² and 8 539 individuals.

Based on ship- and aerial-based field surveys conducted in the Bulgarian Black Sea waters during 2014-2015 (project “**Field studies on species distribution/assessment of the conservation status of species and habitats across the country - Phase I**”), the density and absolute abundance of the species were estimated (Mihaylov et al., 2015) as follows:

- *T. truncatus ponticus* - 0,03 ind./km² and 1 057 individuals;
- *D. delphis ponticus* - 0,23 ind./km² and 8 207 individuals;
- *Ph. phocoena relicta* - 0,14 ind./km² and 4 886 individuals.

According to aerial survey results from the ACCOBAMS Survey Initiative (within the CeNoBS project, 2019), the population parameters were:

- *T. truncatus ponticus* - 0,24 ind./km² and 10 262 individuals;
- *D. delphis ponticus* - 0,33 ind./km² and 14 231 individuals;
- *Ph. phocoena relicta* - 1,14 ind./km² and 48 924 individuals.

The most recent large-scale monitoring project conducted in 2023 (“**Study and mapping of the distribution of habitat types, species habitats and their populations, and assessment of their conservation status in the marine waters of the Republic of Bulgaria**”) reported the following results (Delov et al., 2024):

- *T. truncatus ponticus* - 0,30 ind./km² and 9 738 individuals;
- *Ph. phocoena relicta* - 0,21 ind./km² and 6 756 individuals.

All marine mammals are included in the IUCN Red List. Three species (*M. monachus*, *D. delphis*, and *Ph. phocoena*) are classified as Vulnerable, while *T. truncatus* is categorized as Endangered. All three cetacean species are listed in Annexes II and IV of the Habitats Directive (Directive 92/43/EEC) and the corresponding Bulgarian Biological Diversity Act. In the Red Data Book of Bulgaria, the bottlenose dolphin and harbour porpoise are categorized as Vulnerable, while the Mediterranean monk seal is listed as Extinct.

2.2.2. Native, endemic, and threatened species

Native species are represented by Ponto-Caspian relicts and the mediterranean species invided Black Sea through the Bosphoros from Mediterranean Sea (6 000-7 000 years ago). Nowadays,

NEXT Black Sea Basin

Ponto-caspian relicts are concentrated mainly in the coastal lakes. In the sea are found only few of them, like as *Cardiophilus baeri* G.O. Sars, 1896 and *Pontogammarus maeoticus* (Sovinskij, 1894) from Amphipoda, some representatives of Mysida, Cumacea and other crustacean groups, and Nematoda, Ostracoda and Copepoda as well.

It is known that bioinvasions have had a significant impact on the Black Sea ecosystem, especially at the end of the 20th century (TDA, 2007).

Some of the non-native/alien species are invasive and have adapted to the conditions of the Black Sea, occurring regularly along the Bulgarian coast. Such examples include the diatom *Pseudosolenia calcar-avis* (Figure 8) and the dinoflagellates *Alexandrium monilatum* (Figure 9) and *Gymnodinium uberrimum* (Figure 10) (Klisarova, 2014).

Additionally, other non-native phytoplankton species have been regularly encountered in small quantities along the Bulgarian coast over the years, such as: *Chaetoceros tortissimum* Gran, 1900; *Scrippsiella trochoidea* (Stein) (Loeblich III, 1976); *Skeletonema subsalsum* (A. Cleve) Bethge, 1928; *Spatulodinium pseudonociluca* (Pouchet) J. and M. Cachon 1968; *Pronociluca pelagica* Fabre-Domerque, 1889; *Poropila dubia* Schiller, 1925 (Vergr., 1911-1914); *Apedinella spinifera* Thronsen, 1971; and *Distephanus speculum f. octonarius* (Ehrenberg) S. Locker & E. Martini. These species are included in the list of alien species in the TDA (2007) but have not been classified as invasive."

A total of 27 species of the ichthyofauna of the Bulgarian Black Sea coast can be classified as Ponto-Caspian relicts (Table 1). These represent an autochthonous component of the Black Sea ichthyofauna, formed under conditions of historical isolation and the specific hydrological regime of the Black Sea and Caspian basin, and may be regarded as endemic to the region.

According to their ecological status, three of the species can currently be considered extinct. These include *Acipenser nudiventris*, whose historical presence along the Bulgarian coast remains uncertain, as well as the gobies *Ponticola syrman* and *Knipowitschia longicaudata*. Eight of the relict species are characterized by declining populations (Table 1), while four species are classified as rare: *Salmo labrax*, *Benthophiloides brauneri*, *Ponticola kessleri*, and *Pungitius platygaster*. Among these, *B. brauneri* is found only in Shabla Lake, whereas *S. labrax* is occasionally recorded along the Bulgarian coast as isolated individuals in late winter and early spring. The species *P. kessleri* and *P. platygaster* are rare inhabitants of estuarine and lagoonal waters.

Most of the Ponto-Caspian relict species have an assigned conservation status. All sturgeon species inhabiting the Black Sea are included in the IUCN Red List in the category Critically Endangered. The species *Syngnathus schmidtii* is classified as Endangered, while *Proterorhinus marmoratus* is listed as Near Threatened. All clupeid species of the genus *Alosa* are included in Annexes II and V of the Habitats Directive (Directive 92/43/EEC) and, accordingly, in the Bulgarian Biological Diversity Act.

NEXT Black Sea Basin

A total of 12 relict species are included in the Red Data Book of Bulgaria, three of which are categorized as Extinct: *A. nudiventris*, *B. brauneri*, and *P. syrman*. Six species are classified as Critically Endangered (*Acipenser gueldenstaedtii*, *A. ruthenus*, *A. stellatus*, *Huso huso*, *S. labrax*, *Kn. longicaudata*, and *P. platygaster*), two species as Endangered (*Alosa maeotica* and *C. cultriventris*), and *A. immaculata* is categorized as Vulnerable.

Among the species of Mediterranean origin recorded in the Bulgarian Black Sea waters, a total of 17 species are included in various categories of the IUCN Red List. Two of them (*Acipenser sturio* and *Anguilla anguilla*) are classified as Critically Endangered, while one species (*Thunnus thynnus*) is categorized as Endangered. A total of four species are listed as Vulnerable (*S. acanthias*, *D. pastinaca*, *Dentex dentex*, and *U. cirrosa*), while nine additional species are classified as Near Threatened. From the same group, two species (*A. sturio* and *Alosa fallax*) are included in Annexes II and V of the Habitats Directive (Directive 92/43/EEC) and, accordingly, in the Bulgarian Biological Diversity Act.

A total of seven species of Mediterranean origin are included in the Red Data Book of Bulgaria. One of them (*A. sturio*) is categorized as Extinct, and one (*S. scombrus*) as Critically Endangered. Three species are classified as Endangered (*A. anguilla*, *S. maximus*, and *N. ophidion*), while two are categorized as Vulnerable (*Gobius ophiocephalus* and *G. aculeatus*).

Among the species of primary freshwater origin recorded in the Bulgarian Black Sea waters, two species can be characterized as local endemics - the shemayas *Alburnus mandrensis* and *Alburnus schischkovi*. Two other species (*Petroleuciscus borysthenticus* and *Rutilus frisii*) are characterized by a restricted circum-Pontic distribution. The two shemaya species are also included in the IUCN Red List, categorized respectively as Endangered and Near Threatened. A total of six freshwater species are included in the Red Data Book of Bulgaria. The wild form of *Cyprinus carpio* and *R. frisii* are classified as Critically Endangered, while *A. mandrensis*, *A. schischkovi*, and *P. borysthenticus* are categorized as Endangered. The sunbleak (*Leucaspius delineatus*) is listed as Vulnerable.

All three cetacean species are represented in the Black Sea by endemic subspecies: the Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*), the Black Sea common dolphin (*Delphinus delphis ponticus*), and the Black Sea harbour porpoise (*Phocoena phocoena relicta*).

2.2.1.4. Benthic Species Diversity

Based on recent and hystorical information, the total number of marine and marine-brakish zoobenthos species along the Bulgarian Black Sea sector was estimated at 1059 (Hubenov, 2025). Largest number of species was established for the groups Nematoda, Rotifera, Annelida, Arthropoda and Mollusca. The current list of species (Table 12) differs from the established for the non-eutrophicated period, due to a number of changes in the ecological environment in the last 100 years. First of them was the increased level of eutrophication, reducing the populations of species susceptible to oxidative stress. Secondly the emergence of invasive species with large ecological plasticity, which negatively affected the populations of native species. In example rapa whelk destroyed the populations of the native oyster and the black mussel along the

NEXT Black Sea Basin

Bulgarian Black Sea coast. As a result of climate change and often human activities, the number of new non indigenous species has increased significantly. With the implementation of molecular genetic methods, the taxonomic status of many species had been changed.

Table 12. List of main groups zoobenthic species studied along the Bulgarian Black Sea coast

PHYLUM, CLASS	Family	Latin name	Synonyms
ANNELIDA, POLYCHAETA	Phyllodocidae	<i>Phyllodoce maculata</i> (Linnaeus, 1767)	
	Phyllodocidae	<i>Phyllodoce mucosa</i> Örsted, 1843	
	Phyllodocidae	<i>Phyllodoce lineata</i> (Claparede, 1870)	
	Phyllodocidae	<i>Phyllodoce laminosa</i> Savigny, 1818	
	Phyllodocidae	<i>Genetyllis tuberculata</i> (Bobretzky, 1868)	Phyllodoce
	Phyllodocidae	<i>Nereiphylla rubiginosa</i> (Saint-Joseph, 1888)	Phyllodoce
	Phyllodocidae	<i>Nereiphylla paretii</i> Blainville, 1828	Phyllodoce
	Phyllodocidae	<i>Nereiphylla nana</i> Saint-Joseph, 1906	Phyllodoce
	Phyllodocidae	<i>Eulalia viridis</i> (Johnston, 1829)	Phyllodoce
	Phyllodocidae	<i>Eumida sanguinea</i> (Örsted, 1843)	Eulalia
	Phyllodocidae	<i>Pterocirrus macroceros</i> (Grube, 1860)	Sige, Eulalia
	Phyllodocidae	<i>Pterocirrus limbatus</i> Claparede, 1868	Eulalia
	Phyllodocidae	<i>Mysta picta</i> (Quatrefages, 1865)	Eteone
	Phyllodocidae	<i>Pseudomystides limbata</i> (Saint-Joseph, 1888)	Mystides
	Phyllodocidae	<i>Hesionura coineau</i> (Laubier, 1962)	Eteonides, Mystides
	Polynoidae	<i>Acholoe squamosa</i> (Delle Chiaje, 1827)	
	Polynoidae	<i>Harmothoe extenuata</i> (Grube, 1840)	Lagisca
	Polynoidae	<i>Harmothoe imbricata</i> (Linnaeus, 1767)	
	Polynoidae	<i>Harmothoe impar</i> (Johnston, 1839)	

NEXT Black Sea Basin

	Polynoidae	<i>Harmothoe reticulata</i> (Claparède, 1870)	
	Polynoidae	<i>Malmgreniella lunulata</i> (Delle Chiaje, 1830)	
	Polynoidae	<i>Polynoe scolopendrina</i> Savigny, 1822	
	Polynoidae	<i>Paralepidonotus indicus</i> (Kinberg, 1856)	
	Sigalionidae	<i>Pholoe inornata</i> Johnston, 1839	<i>Ph. synophthalmica</i>
	Sigalionidae	<i>Sthenelais boa</i> (Johnston, 1833)	Sigalion
	Sigalionidae	<i>Pisione remota</i> (Southern, 1914)	
	Amphinomidae	<i>Chloeia venusta</i> Quatrefages, 1865	
	Hesionidae	<i>Hesione pantherina</i> Risso, 1826	
	Microphthalmdae	<i>Hesionides arenaria</i> Friedrich, 1937	
	Microphthalmdae	<i>Microphthalmus fragilis</i> Bobretzky, 1870	
	Microphthalmdae	<i>Microphthalmus szcelkowi</i> Metschnikow, 1865	
	Microphthalmdae	<i>Microphthalmus similis</i> Bobretzky, 1870	
	Pilargidae	<i>Synelmis rigida</i> (Fauvel, 1919)	
	Pilargidae	<i>Sigambra constricta</i> (Southern, 1921)	
	Pilargidae	<i>Sigambra tentaculata</i> (Treadwell, 1914)	Ancistrosyllis
	Syllidae	<i>Myrianida prolifera</i> (O.F. Müller, 1788)	Autolytus prolifer
	Syllidae	<i>Xenosyllides violacea</i> Perajaslawzewa, 1891	
	Syllidae	<i>Haplosyllis spongicola</i> (Grube, 1855)	Syllis
	Syllidae	<i>Syllis gracilis</i> Grube, 1840	
	Syllidae	<i>Syllis hyalina</i> Grube, 1863	
	Syllidae	<i>Syllis prolifera</i> Crohn, 1852	
	Syllidae	<i>Syllis variegata</i> Grube, 1860	
	Syllidae	<i>Syllis cornuta</i> Rathke, 1843	
	Syllidae	<i>Syllis amica</i> Quatrefages, 1865	

NEXT Black Sea Basin

	Syllidae	<i>Syllis armillaris</i> (O.F. Muller, 1776)	
	Syllidae	<i>Amblyosyllis spectabilis</i> (Johnston in Baird, 1861)	Amblyosyllis, <i>Pterosyllis formosa</i>
	Syllidae	<i>Streptosyllis varians</i> Webster & Benedict, 1887	
	Syllidae	<i>Syllides longocirratus</i> (Ørsted, 1845)	
	Syllidae	<i>Neopetitia amphophthalma</i> (Siewing, 1956)	Petitia
	Syllidae	<i>Salvatoria clavata</i> (Claparède, 1863)	Grubea
	Syllidae	<i>Salvatoria limbata</i> (Claparède, 1868)	Grubea
	Syllidae	<i>Salvatoria tenuicirrata</i> (Claparède, 1864)	Grubea
	Syllidae	<i>Syllides longocirratus</i> (Ørsted, 1845)	S. longocirrata
	Syllidae	<i>Sphaerosyllis bulbosa</i> Southern, 1914	
	Syllidae	<i>Sphaerosyllis hystrix</i> Claparède, 1863	
	Syllidae	<i>Nudisyllis pulligera</i> (Krohn, 1852)	Pyonosyllis
	Syllidae	<i>Trypanosyllis zebra</i> (Grube, 1860)	
	Syllidae	<i>Pseudosyllis brevipennis</i> Grube, 1863	<i>Trypanosyllis coeliaca</i>
	Syllidae	<i>Exogone naidina</i> Ørsted, 1845	<i>E. gemmifera</i> , <i>Paedophylax claviger</i>
	Chrysopetalidae	<i>Vigtorniella zaikai</i> (Kisseleva, 1992)	
	Nereididae	<i>Nereis pelagica</i> Linnaeus, 1758	
		<i>Nereis rava</i> Ehlers, 1864	
		<i>Nereis zonata</i> Malmgren, 1867	
		<i>Eunereis longissima</i> (Johnston, 1840)	Nereis
		<i>Alitta succinea</i> (Frey & Leuckart, 1847)	Neanthes, Nereis
		<i>Neanthes fucata</i> (Savigny, 1820)	Nereis
		<i>Perinereis cultifera</i> (Grube, 1840)	

NEXT Black Sea Basin

		Platynereis dumerili (Audouin & Milne-Edwards, 1834)	Nereis
		Namanereis pontica (Borbretzky, 1872)	N. quadriticeps, Lycastopsis
		Websterinereis glauca (Claparede, 1870)	Leptonereis
		Composetia costae (Grube, 1840)	Nereis (Ceratoneis) costae
		Hediste diversicolor (O.F. Müller, 1776)	
	Nephtyidae	Micronephtys longicornis (Perejaslavl'tseva, 1891)	Micronephtys stammeri
		Nephtys ciliata (Müller, 1788)	
		Nephtys cirrosa (Ehlers, 1868)	
		Nephtys hombergii Savigny in Lamarck, 1818	
		Nephtys hystrix McIntosh, 1900	
		Nephtys longosetosa Oersted, 1842	
		Nephtys paradoxa Malmgren, 1874	
		Nephtys incisa Malmgren, 1865	
	Sphaerodoridae	Sphaerodoridium clapedii (Greeff, 1866)	Sphaerodorum
	Sphaerodoridae	Sphaerodorum gracilis (Rathke, 1843)	Ephesia
	Glyceridae	Glycera alba (O. F. Müller, 1776)	
		Glycera capitata Örsted, 1842	
		Glycera tridactyla Schmarda, 1861	Glycera convoluta
		Glycera fallax Quatrefages, 1850	Glycera gigantea
		Glycera tessellata Grube, 1840	
		Glycera unicornis Savigny in Lamarck, 1818	G. rouxii
	Goniadidae	Goniadella bobrezkii (Annenkova, 1929)	Goniada

NEXT Black Sea Basin

	Eunicidae	<i>Eunice vittata</i> (Delle Chiaje, 1828)	
	Eunicidae	<i>Lysidice ninetta</i> Audouin & Milne-Edwards, 1833	
	Eunicidae	<i>Lysidice unicornis</i> (Grube, 1840)	Nematonereis
		<i>Drilonereis filum</i> (Claparède, 1868)	
	Dorvilleidae	<i>Protodorvillea kefersteini</i> (McIntosh, 1869)	Staurocephalus
	Dorvilleidae	<i>Dorvillea rubrovittata</i> (Grube, 1855)	<i>Staurocephalus rubrovittatus</i>
	Dorvilleidae	<i>Schistomeringos neglecta</i>	Staurocephalus
	Dorvilleidae	<i>Schistomeringos rudolphi</i> (Delle Chiaje, 1828)	Staurocephalus
	Orbiniidae	<i>Orbinia latreillii</i> (Audouin & Milne-Edwards, 1833)	Aricia
	Orbiniidae	<i>Orbinia sertulata</i> (Savigny, 1822)	Aricia cuvieri
	Orbiniidae	<i>Naineris laevigata</i> (Grube, 1855)	Nainereis laevigata (Grube, 1855)
	Orbiniidae	<i>Protoaricia capsulifera</i> (Bobretzky, 1870)	Theostoma
	Spionidae	<i>Malacoceros girardi</i> Quatrefages, 1843	Scolecopsis
	Spionidae	<i>Malacoceros tetracerus</i> (Schmarda, 1861)	Scolecopsis ciliata
	Spionidae	<i>Malacoceros fuliginosus</i> (Claparède, 1868)	Scolecopsis fuliginosa
	Spionidae	<i>Scolecopsis (Scolecopsis) squamata</i> (O.F. Muller, 1806)	Scolecopsis squamata, Nerine cirratulus
	Spionidae	<i>Scolecopsis (Scolecopsis) cantabra</i> (Rioja, 1918)	Nerinides
	Spionidae	<i>Scolecopsis tridentata</i> (Southern, 1914)	<i>Pseudomalacoceros tridentata</i> , Nerinides, Parascolecopsis
	Spionidae	<i>Laonice cirrata</i> (M. Sars, 1851)	
	Spionidae	<i>Aonides oxycephala</i> (Sars, 1862)	
	Spionidae	<i>Aonides paucibranchiata</i> Southern, 1914	A. ornatus

NEXT Black Sea Basin

	Spionidae	<i>Microspio mecznikowiana</i> (Claparède, 1868)	<i>Microspio mecznikowianus</i> (Claparede, 1868)
	Spionidae	<i>Spio filicornis</i> (O. F. Müller, 1776)	
	Spionidae	<i>Spio multioculata</i> Rioja, 1919	
	Spionidae	<i>Spio decorata</i> Bobretzky, 1870	<i>Spio decoratus</i>
	Spionidae	<i>Pygospio elegans</i> Claparède, 1863	
	Spionidae	<i>Pseudopolydora antennata</i> (Claparede, 1868)	Polydora
	Spionidae	<i>Polydora ciliata</i> (Johnston, 1838)	
	Spionidae	<i>Polydora cornuta</i> Bosc, 1802	
	Spionidae	<i>Polydora websteri</i> Hartman in Loosanoff & Engle, 1943	
	Spionidae	<i>Dipolydora caulleryi</i> (Mesnil, 1897)	Polydora
	Spionidae	<i>Dipolydora quadrilobata</i> (Jacobi, 1883)	
	Spionidae	<i>Polydora limicola</i> Annenkova, 1934	
	Spionidae	<i>Prionospio cirrifera</i> Wirén, 1883	
	Spionidae	<i>Streblospio shrubsolii</i> (Buchanan, 1890)	
	Magelonidae	<i>Magelona papillicornis</i> F. Müller, 1858	
	Magelonidae	<i>Magelona rosea</i> Moore, 1907	
	Magelonidae	<i>Maea mirabilis</i> Johnston, 1865	<i>Magelona mirabilis</i> (Johnston, 1865)
	Paraonidae	<i>Paradoneis harpagonea</i> (Storch, 1967)	<i>Cirrophorus branchiatus</i> , <i>Paraonis fulgens</i>
	Paraonidae	<i>Paraonis fulgens</i> (Levinsen, 1883)	<i>Paradoneis fulgens</i> (Levinsen, 1884)
	Paraonidae	<i>Paradoneis lyra</i> (Southern, 1914)	
	Paraonidae	<i>Aricidea (Strelzovia) claudiae</i> Laubier, 1967	<i>A. claudiae</i> , <i>A. jeffreysii</i>
	Paraonidae	<i>Aricidea (Acmira) assimilis</i> Tebble, 1959	
	Paraonidae	<i>Levinsenia gracilis</i> (Tauber, 1879)	<i>Tauberia</i> , <i>Paraonis</i>

NEXT Black Sea Basin

	Cirratulidae	<i>Cirriformia tentaculata</i> (Montagu, 1808)	Auduinia
	Cirratulidae	<i>Caulleriella bioculata</i> (Keferstein, 1862)	Cirratulus, Heterocirrus
	Cirratulidae	<i>Chaetozone caputesocis</i> (Saint-Joseph, 1894)	Heterocirrus caputesocis
	Cirratulidae	<i>Aphelochaeta marioni</i> (Saint-Joseph, 1894)	Tharyx marioni
	Cirratulidae	<i>Chaetozone setosa</i> Malmgren, 1867	
	Cirratulidae	<i>Ctenodrilus serratus</i> (Schmidt, 1857)	
	Cirratulidae	<i>Timarete anchylochaeta</i> (Schmarda, 1861)	
	Cirratulidae	<i>Timarete dasylophius</i> (Marenzeller, 1879)	
	Cirratulidae	<i>Timarete filigera</i> (Delle Chiaje, 1828)	
	Opheliidae	<i>Ophelia bicornis</i> Savigny, 1918;	
	Opheliidae	<i>Ophelia limacina</i> (Rathke, 1843)	
	Opheliidae	<i>Polyophthalmus pictus</i> (Dujardin, 1839)	
	Capitellidae	<i>Notomastus latericeus</i> M. Sars, 1851	
	Capitellidae	<i>Notomastus profundus</i> (Eisig, 1887)	
	Capitellidae	<i>Notomastus lineatus</i> Claparede, 1870	
	Capitellidae	<i>Heteromastus filiformis</i> (Claparede, 1864)	
	Capitellidae	<i>Capitella capitata</i> (Fabricius, 1780)	
	Capitellidae	<i>Capitella minima</i> Langerhans, 1880	Capitomastus minimus
	Capitellidae	<i>Capitellethus dispar</i> (Ehlers, 1907)	
	Capitellidae	<i>Capitella giardi</i> (Mesnil, 1897)	Capitellides
	Parergodrilidae	<i>Stygocapitella subterranea</i> Knollner, 1934	
	Arenicoliidae	<i>Arenicola marina</i> (Linnaeus, 1758)	

NEXT Black Sea Basin

	Arenicoliidae	<i>Arenicolides branchialis</i> (Audouin & M.-Edwards, 1833)	
	Maldanidae	<i>Euclymene collaris</i> (Claparède, 1869)	Clymene, Praxylla
	Maldanidae	<i>Euclymene oerstedii</i> (Claparède, 1863)	Clymene
	Maldanidae	<i>Macroclymene santanderensis</i> (Rioja, 1917)	Clymene
	Maldanidae	<i>Euclymene palermitana</i> (Grube, 1840)	Clymene
	Maldanidae	<i>Leiochone leiopygos</i> (Grube, 1860)	L. clipeata, Clymenura
	Maldanidae	<i>Micromaldane ornithochaeta</i> Mesnil, 1897	
	Maldanidae	<i>Petaloproctus terricola</i> Quatrefages, 1866	Petaloproctus terricola
	Maldanidae	<i>Maldane glebifex</i> Grube, 1860	
	Oweniidae	<i>Owenia fusiformis</i> Delle Chiaje, 1842	
	Oweniidae	<i>Myriochele heeri</i> Malmgren, 1867	
	Sabellariidae	<i>Sabellaria taurica</i> (Rathke, 1837)	Amphitrite, Centrocorone
	Sabellariidae	<i>Sabellaria spinulosa</i> Leuckart, 1849	
	Sternaspidae	<i>Sternaspis scutata</i> (Ranzani, 1817)	
	Pectinariidae	<i>Pectinaria belgica</i> (Pallas, 1766)	
	Pectinariidae	<i>Lagis koreni</i> Malmgren, 1866	Pectinaria
	Pectinariidae	<i>Petta pusilla</i> Malmgren, 1866	
	Melinnidae	<i>Melinna palmata</i> Grube, 1870	
	Melinnidae	<i>Amphicteis gunneri</i> (M. Sars, 1835)	
	Ampharetidae	<i>Ampharete acutifrons</i> (Grube, 1860)	
	Ampharetidae	<i>Hypaniola kowalewskii</i> (Grimm, 1877)	
	Trichobranchidae	<i>Terebellides stroemii</i> Sars, 1835	
	Terebellidae	<i>Polycirrus caliendrum</i> Claparede, 1868	

NEXT Black Sea Basin

	Terebellidae	<i>Polycirrus pallidus</i> (Claparède, 1864)	
	Terebellidae	<i>Polycirrus aurantiacus</i> Grube, 1860	
	Terebellidae	<i>Polycirrus jubatus</i> Bobretzky, 1868	
	Terebellidae	<i>Polycirrus haematodes</i> (Claparede, 1864)	
	Terebellidae	<i>Amphitritides gracilis</i> (Grube, 1860)	Amphitrite gracilis
	Terebellidae	<i>Proclea graffii</i> (Langerhans, 1884)	
	Sternaspidae	<i>Sternaspis scutata</i> (Ranzani, 1817)	
	Sabelidae	<i>Potamilla torelli</i> Malmgren, 1866	
	Sabelidae	<i>Acromegalomma vesiculosum</i> (Montagu, 1813)	Branchioma
	Fabriciidae	<i>Fabricia stellaris</i> (Müller, 1774)	F. sabella (Ehrenberg, 1836)
	Fabriciidae	<i>Manayunkia caspica</i> Annenkova, 1929	
	Sabelidae	<i>Amphicorina armandi</i> (Claparède, 1864)	Oriopsis, Oridia
	Sabelidae	<i>Jasmineira caudata</i> Langerhans, 1880	
	Serpulidae	<i>Serpula vermicularis</i> Linnaeus, 1767	
	Serpulidae	<i>Hydroides norvegica</i> Gunnerus, 1768	
	Serpulidae	<i>Ficopomatus enigmaticus</i> (Fauvel, 1923)	Mercierella
	Serpulidae	<i>Vermiliopsis infundibulum</i> (Linnaeus, 1758)	
	Serpulidae	<i>Spirobranchus triqueter</i> (Linnaeus, 1758)	Pomatoceros, P. triquetroides
	Serpulidae	<i>Ditrupa arietina</i> (O.F. Muller, 1776)	
	Serpulidae	<i>Salmacina incrustans</i> Claparede, 1870	
	Serpulidae	<i>Janua heterostropha</i> (Montagu, 1803)	J. pagenstecheri, Spirorbis
	Serpulidae	<i>Pileolaria militaris</i> Claparède, 1870	Spirorbis

NEXT Black Sea Basin

ARCHIANNELIDA	Polygordiidae	<i>Polygordius lacteus</i> Schneider, 1868	P. neapolitanus ponticus, P. ponticus
	Protodrilidae	<i>Lindrilus flavocapitatus</i> (Uljanina, 1877)	Protodrilus flavocapitatus (Uljanin, 1877)
	Protodrilidae	<i>Megadrilus purpureus</i> (Schneider, 1868)	Protodrilus purpureus (Schneider, 1868)
	Saccocirridae	<i>Saccocirrus papillocercus</i> Bobretzky, 1872	
	Nerillidae	<i>Nerilla antennata</i> Schmidt, 1848	
	Dinophilidae	<i>Dimorphilus gyrotilatus</i> (O. Schmidt, 1857)	Dinophilus gyrotilatus O. Schmidt, 1857
	Dinophilidae	<i>Trilobodrilus heideri</i> Remane, 1925	
PHORONIDA	Phoronidae	<i>Phoronis psammophila</i> Cori, 1889	Phoronis euxinicola Selys-Longchamps, 1907
MOLLUSCA, POLYPLACOPHORA	Tonicellidae	<i>Lepidochitona caprearum</i> (Scacchi, 1836)	L. corrugata, Chiton poli, Middendorffia
	Tonicellidae	<i>Lepidochitona cinerea</i> (Linnaeus, 1767)	Chiton marginatus, Ch. variegatus
	Acanthochitonidae	<i>Acanthochitona crinita</i> (Pennant, 1777)	A. fascicularis
MOLLUSCA, GASTROPODA	Patellidae	<i>Patella ulyssiponensis</i> Gmelin, 1791	P. caerulea pontica, P. pontica, P. tarentina];
		<i>Patella caerulea</i> Linnaeus, 1758	
	Phasianellidae	<i>Tricolia pullus pullus</i> (Linnaeus, 1758)	Phasianella pontica
	Trochidae	<i>Steromphala adriatica</i> (R. A. Philippi, 1844)	Gibbula adriatica (Philippi, 1844), G. euxinica, G. deversa, Trochus
	Trochidae	<i>Steromphala albida</i> (Gmelin, 1791)	Gibbula albida (Gmelin, 1791), rochus fermonii
	Trochidae	<i>Steromphala divaricata</i> (Linnaeus, 1758)	Gibula divaricata (Linnaeus, 1758), Trochus
	Trochidae	<i>Steromphala adansonii</i> (Payraudeau, 1826)	Gibbula adansonii adansonii (Payraudeau, 1826)

NEXT Black Sea Basin

	Cerithiidae	<i>Bittium reticulatum</i> (da Costa, 1778)	Cerithium, Cerithium exile
	Cerithiidae	<i>Cerithidium submamillatum</i> (de Rayneval & Ponzi, 1854)	Bittium submamillatum, C. pusillum
	Cerithiidae	<i>Theridium vulgatum</i> (Bruguère, 1792)	Cerithium vulgatum, C. vulgatum ponticum, C. ponticum
LITTORINIMORPHA	Caecidae	<i>Caecum armoricum</i> de Folin, 1869	C. tenue, Brochina
	Caecidae	<i>Caecum trachea</i> (Montagu, 1803)	C. elegans, C. rugulosum
	Calyptraeidae	<i>Calyptrea chinensis</i> (Linnaeus, 1758)	
Caenogastropoda incertae sedis	Cerithiopsidae	<i>Cerithiopsis minima</i> (Brusina, 1865)	
	Cerithiopsidae	<i>Cerithiopsis tubercularis</i> (Montagu, 1803)	
TROCHIDA	Calliostomatidae	<i>Calliostoma granulatum</i> (Von Born, 1778)	
Caenogastropoda incertae sedis	Epitoniidae	<i>Epitonium turtonis</i> (Turton, 1819)	<i>Scalaria communis</i> , <i>S. tenuicostata</i>
	Epitoniidae	<i>Epitonium clathrus</i> (Linnaeus, 1758)	<i>Scalaria communis</i>
	Littorinidae	<i>Melarhappe neritoides</i> (Linnaeus, 1758)	Littorina
	Littorinidae	<i>Melarhappe neritoides</i> (Linnaeus, 1758)	
LITTORINIMORPHA	Rissoidae	<i>Rissoa membranacea</i> (Adams J., 1800)	R. oblonga, R. pontica, R. venusta
	Rissoidae	<i>Rissoa parva</i> (da Costa, 1778)	R. euxinica
	Rissoidae	<i>Rissoa splendida</i> Eichwald, 1830	
	Rissoidae	<i>Pusillina lineolata</i> (Michaud, 1832)	Rissoa
	Rissoidae	<i>Setia pulcherrima</i> (Jeffreys, 1848)	<i>Setia turriculata</i> Monterosato, 1884
	Rissoidae	<i>Setia valvatoidea</i> (Milaschewitsch, 1909)	
	Truncatellidae	<i>Truncatella subcylindrica</i> (Linnaeus, 1767)	
	Triphoridae	<i>Marshallora adversa</i> (Montagu, 1803)	<i>Trifora obesula</i> , <i>T. perversa</i> var. <i>parva</i>
NEOGASTROPODA	Muricidae	<i>Rapana venosa</i> (Valenciennes, 1846)	<i>R. bezoar</i> , <i>R. thomasi</i>

NEXT Black Sea Basin

	Muricidae	<i>Trophonopsis muricatus</i> (Montagu, 1803)	T. brevatus, Trophon
	Muricidae	<i>Trophonopsis breviata</i> (Jeffreys, 1882)	
	Buccinidae	<i>Neptunea arthritica</i> (Valenciennes, 1858)	
	Nassariidae	<i>Tritia neritea</i> (Linnaeus, 1758)	<i>Cyclope neritea</i>
	Nassariidae	<i>Tritia pellucida</i> (Risso, 1826)	<i>Cyclope, C. donovani, Cyclonassa kamischensis</i>
	Nassariidae	<i>Tritia reticulata</i> (Linnaeus, 1758)	Nassarius reticulatus (Linnaeus, 1758)
	Nassariidae	<i>Tritia incrassata</i> (Ström, 1768)	Nassarius incrassatus (Ström, 1768)
	Nassariidae	<i>Tritia nitida</i> (Jeffreys, 1867)	Nassarius nitidus (Jeffreys, 1867)
	Mangeliidae	<i>Bela nebula</i> (Montagu, 1803)	Cythara fuscata, Mangelia, Raphitona
	Mangeliidae	<i>Mangelia costata</i> (Pennant, 1777)	M. pontica, M. taeniata, Cythara
	Omalogyridae	<i>Omalogyra atomus</i> (Philippi, 1841)	Homalogyra, Truncatella
	Omalogyridae	<i>Ammonicera fischeriana</i> (Monterosato, 1869)	Homalogyra
	Pyramidellidae	<i>Parthenina emaciata</i> (Brusina, 1866)	Chrysallida emaciata, Turbonilla
	Pyramidellidae	<i>Parthenina indistincta</i> (Montagu, 1808)	
	Pyramidellidae	<i>Spiralina alpinoligustica</i> (Sacco, 1892)	Chrysallida incerta (Milaschewitsh, 1916), Ch. brusinae, Odostomia, Parthenia
	Pyramidellidae	<i>Parthenina interstincta</i> (J. Adams, 1797)	Chrysallida interstincta, Ch. obtusa, Parthenina tenuistriata
	Pyramidellidae	<i>Parthenina terebellum</i> (R. A. Philippi, 1844)	Chrysallida terebellum, Parthenina costulata, Odostomia
	Pyramidellidae	<i>Parthenina emaciata</i> (Brusina, 1866)	Chrysallida emaciata
	Pyramidellidae	<i>Auristomia erjaveciana</i> (Brusina, 1869)	Odostomia erjaveciana
	Pyramidellidae	<i>Brachystomia eulimoides</i> (Hanley, 1844)	Odostomia eulimoides, O.

NEXT Black Sea Basin

			<i>novegradensis</i> , <i>O. pallida</i>
	Pyramidellidae	<i>Brachystomia scalaris</i> (MacGillivray, 1843)	<i>O. albella</i> , <i>O. rissoiformis</i>
	Pyramidellidae	<i>Odostomia plicata</i> (Montagu, 1803)	
	Pyramidellidae	<i>Brachystomia scalaris</i> (MacGillivray, 1843)	<i>Odostomia scalaris</i>
	Pyramidellidae	<i>Eulimella acicula</i> (Philippi, 1836)	<i>E. laevis</i> , <i>Belonidium</i> , <i>Odostomia</i>
	Pyramidellidae	<i>Noemiamea dolioliformis</i> (Jeffreys, 1848)	<i>Odostomia</i>
	Pyramidellidae	<i>Turbonilla acuta</i> (Donovan, 1804)	<i>Turbonilla delicata</i> , <i>Odostomia</i>
	Pyramidellidae	<i>Turbonilla pusilla</i> (Philippi, 1844)	
	Murchisonellidae	<i>Ebala pointeli</i> (de Folin, 1868)	<i>Anisocycla</i> , <i>Eulimella</i> , <i>Turbonilla</i>
CEPHALASPIDEA	Retusidae	<i>Retusa umbilicata</i> (Montagu, 1803)	<i>Cylichna umbilicata</i>
	Retusidae	<i>Retusa umbilicata</i> (Montagu, 1803)	<i>C. strigella</i> , <i>C. variabilis</i> , <i>Retusa</i>
	Retusidae	<i>Retusa truncatula</i> (Bruguière, 1792)	<i>R. truncatula</i> opima, <i>Bulla</i> , <i>Cylichna</i>
ELLOBIIDA	Ellobiidae	<i>Myosotella myosotis</i> (Draparnaud, 1801)	<i>Alexia</i> , <i>Auricula</i> , <i>Ovtella</i>
	Limapontiidae	<i>Calliopaea bellula</i> (Orbigny, 1837)	<i>Stiliger</i>
	Limapontiidae	<i>Limapontia capitata</i> (O. F. Müller, 1774)	
NUDIBRANCHIA	Tergipedidae	<i>Tergipes tergipes</i> (Forskål, 1775)	
	Trinchesiidae	<i>Tenellia adspersa</i> Nordmann, 1845	
	Embletoniidae	<i>Embletonia pulchra</i> (Alder & Hancock 1844)	
Caenogastropoda incertae sedis	Epitoniidae	<i>Epitonium clathrus</i> (Linnaeus, 1758)	<i>Epitonium commune</i> (Lamarck, 1822)
	Hydrobiidae	<i>Hydrobia acuta</i> (Draparnaud, 1805)	
	Corambidae	<i>Corambe obscura</i> (Verrill, 1870)	<i>Doridella</i>
MOLLUSCA, BIVALVIA, Arcida	Noetiidae	<i>Striarca lactea</i> (Linnaeus, 1758)	(<i>Galactella</i>) <i>lactea</i>
	Arcidae	<i>Anadara kagoshimensis</i> (Tokunaga, 1906)	<i>A. inaequalvis</i> , <i>Cunearca cornea</i> , <i>Scapharca</i>

NEXT Black Sea Basin

MOLLUSCA, BIVALVIA, Mytilida	Mytilidae	<i>Mytilaster lineatus</i> (Gmelin, 1791)	<i>M. lineatus pontica</i> , <i>M. minimus</i> , <i>M. monterosatoi</i>
	Mytilidae	<i>Mytilus galloprovincialis</i> Lamarck, 1819	<i>M. edulis galloprovincialis</i>
	Modiolidae	<i>Modiolus adriaticus</i> Lamarck, 1819,	<i>Modiola adriatica</i> , <i>Gibbomodiola</i>
		<i>Modiolus barbatus</i> (Linnaeus, 1758)	
	Modiolidae	<i>Modiolula phaseolina</i> (Philippi, 1844)	<i>Modiola phaseolina</i> , <i>Modiolus phaseolinus</i>
	Modiolidae	<i>Arcuatula senhousia</i> (W. H. Benson, 1842)	
MOLLUSCA, BIVALVIA, Pectinida	Pectinidae	<i>Flexopecten glaber</i> (Linnaeus, 1758)	<i>F. glaber ponticus</i> , <i>Chlamys glabra</i> , <i>Pecten glaber</i> var. <i>pontica</i> , <i>P. pontica</i>
	Pectinidae	<i>Flexopecten flexuosus</i> (Poli, 1795)	
	Anomiidae	<i>Anomia ephippium</i> Linnaeus, 1758	
MOLLUSCA, BIVALVIA, OSTREIDA	Ostreidae	<i>Ostrea edulis</i> Linnaeus, 1758	
	Ostreidae	<i>Magallana gigas</i> (Thunberg, 1793)	
MOLLUSCA, BIVALVIA, LUCINIDA	Lucinidae	<i>Lucinella divaricata</i> (Linnaeus, 1758)	<i>Divaricella divaricata</i>
MOLLUSCA, BIVALVIA, GALEOMMATIDA	Lasaeidae	<i>Hemilepton nitidum</i> (W. Turton, 1822)	<i>Kellia compressa</i> , <i>Erycina nitida</i>
	Lasaeidae	<i>Kellia suborbicularis</i> (Montagu, 1803)	
	Lasaeidae	<i>Kurtiella bidentata</i> (Montagu, 1803)	<i>Mysella bidentata</i> (Montagu, 1803)
MOLLUSCA, BIVALVIA, CARDIIDA	Cardiidae	<i>Acanthocardia paucicostata</i> (G. B. Sowerby, 1834)	
	Cardiidae	<i>Acanthocardia tuberculata</i> (Linnaeus, 1758)	
	Cardiidae	<i>Cerastoderma glaucum</i> (Poiret, 1789)	<i>C. edule</i> , <i>Cardium edule</i> , <i>C. clodiense</i> , <i>C. lamarckii</i>
	Cardiidae	<i>Parvicardium exiguum</i> (Gmelin, 1791)	<i>Cardium exiguum</i>
	Cardiidae	<i>Papillicardium papillosum</i> (Poli, 1791)	<i>Cardium fasciatum</i> , <i>C. simile</i>
	Tellinidae	<i>Gastrana fragilis</i> (Linnaeus, 1758)	<i>Tellina fragilis</i> <i>Psammobia</i>

NEXT Black Sea Basin

	Tellinidae	<i>Moerella donacina</i> (Linnaeus, 1758)	<i>Tellina donacina</i> Linnaeus, 1758, <i>Angulus donacinus</i> (Linnaeus, 1758)]
	Tellinidae	<i>Fabulina fabula</i> (Gmelin, 1791)	<i>Tellina fabula</i> ; <i>T. fabula</i> var. <i>propinqua</i> ; <i>Angulus fabula</i> Moerella
	Tellinidae	<i>Macomangulus tenuis</i> (da Costa, 1778)	<i>Tellina tenuis</i> , <i>T. Exigua</i> , <i>Angulus exiguus</i> ; <i>A. tenuis</i> ; Moerella
	Tellinidae	<i>Moerella distorta</i> Poli, 1791	<i>T. distorta</i>
	Donacidae	<i>Donax trunculus</i> Linnaeus, 1758	<i>D. julianae</i> ; <i>D. trunculus julianae</i>
	Donacidae	<i>Donax semistriatus</i> Poli, 1795	<i>Donax fabagella</i> <i>Donax venustus</i>
	Semelidae	<i>Abra alba</i> (W. Wood, 1802)	<i>A. alba occitanica</i> , <i>A. alba</i> var. <i>pontica</i> , <i>Syndesmya alba</i> , <i>Syndosmya occitanica</i>
	Semelidae	<i>Abra prismatica</i> (Montagu, 1808)	<i>A. fragilis</i> , <i>A. milachewichi</i> , <i>A. nitida</i> , <i>Syndesmya fragilis</i> , <i>S. fragilis</i>
	Semelidae	<i>Abra nitida</i> (O.F. Müller, 1776)	
	Semelidae	<i>Abra segmentum</i> (Récluz, 1843)	<i>A. ovata</i> , <i>Erycina ovata</i> , <i>Syndesmya ovata</i> , <i>Syndosmya segmentum</i>
MOLLUSCA, BIVALVIA, VENERIDA	Mactridae	<i>Spisula subtruncata</i> (da Costa, 1778)	<i>Mactra subtruncata</i> var. <i>triangula</i> , <i>M. triangula</i>
	Mactridae	<i>Spisula solida</i> (Linnaeus, 1758)	
	Mesodesmatidae	<i>Donacilla cornea</i> (Poli, 1795)	<i>Mesodesma cornea</i>
	Veneridae	<i>Gouldia minima</i> (Montagu, 1803)	<i>Circe minima</i> , <i>Venus minima</i>
	Veneridae	<i>Pitar rudis</i> (Poli, 1795)	<i>Meretrix rudis</i> var. <i>ochropicta</i> , <i>Venus ochropicta</i> , <i>Cytherea rudis</i>
	Veneridae	<i>Irus irus</i> (Linnaeus, 1758)	<i>Venerupis irus</i>
	Veneridae	<i>Chamelea gallina</i> (Linnaeus, 1758)	<i>Venus gallina</i> ; <i>Chione gallina corrugatula</i>

NEXT Black Sea Basin

	Veneridae	<i>Polititapes aureus</i> (Gmelin, 1791)	<i>Paphia aurea</i> ; <i>Polititapes petalina</i> ; <i>Venus petalina</i> ; <i>Tapes aureus</i> var. <i>rugata</i> Bucquoy; <i>T. rugatus</i> ; <i>T. Proclivis discrepans</i> ; <i>T. lineatus</i>
	Veneridae	<i>Petricola lithophaga</i> (Retzius, 1788)	
	Veneridae	<i>Venus casina</i> Linnaeus, 1758	
	Veneridae	<i>Mactra stultorum</i> (Linnaeus, 1758)	
ADAPEDONTA	Solenidae	<i>Solen marginatus</i> Pulteney, 1799	<i>S. vagina</i> ; <i>S. marginatus</i> var. <i>pontica</i>
MYIDA	Myidae	<i>Mya arenaria</i> Linnaeus, 1758	<i>M. truncata</i>
	Corbulidae	<i>Lentidium mediterraneum</i> (O. G. Costa, 1829)	<i>Corbulomya maeotica</i> ; <i>Corbula mediterranea</i>
	Pholadidae	<i>Pholas dactylus</i> Linnaeus, 1758	
	Pholadidae	<i>Barnea candida</i> (Linnaeus, 1758)	<i>B. candida pontica</i> ; <i>Pholas candidus</i>
	Teredinidae	<i>Teredo navalis</i> Linnaeus, 1758	
	Teredinidae	<i>Nototeredo norvegica</i> (Spengler, 1792)	<i>Teredo utriculus</i>
ANOMALODESMATA	Thraciidae	<i>Thracia phaseolina</i> (Lamarck, 1818)	<i>T. papyracea</i>
CIRRIPIEDIA		<i>Amphibalanus eburneus</i> (Gould, 1841)	
		<i>Chthamalus stellatus</i> (Poli, 1795)	
		<i>Euraphia depressa</i> (Poli, 1795)	
		<i>Verruca spengleri</i> Darwin, 1854	
OSTRACODA		<i>Paracypris complanata</i> (Brady & Robertson, 1869)	
		<i>Aurila convexa</i> (Baird, 1850)	
		<i>Rectobuntonia subulata</i> (Ruggieri, 1954)	
		<i>Bythocythere turgida</i> G.O. Sars, 1866	

NEXT Black Sea Basin

	Leptocytheridae	Callistocythere crispata (Brady, 1868)	
	Leptocytheridae	Leptocythere (Callistocythere) diffusa (Müller, 1894) Schornikov, 1966	Callistocythere diffusa (G.W. Mueller, 1894)
		Callistocythere mediterranea (G.W. Mueller, 1894)	
	Trachyleberididae	Carinocythereis carinata (Roemer, 1838)	
	Trachyleberididae	Costa edwardsii (Roemer, 1838)	
		Costa runcinata (Baird, 1850)	
	Cytherideidae	Cyprideis torosa (Jones, 1850)	
		Cyprinotus inaequalis Bronstein, 1928	
		Cythereis amnicola (G.O. Sars, 1887)	
	Trachyleberididae	Hiltermannicythere rubra pontica (Dubowsky, 1939)	Cythereis rubra pontica Dubowsky, 1939
	Cytherideidae	Cytheridea acuminata (Bosquet, 1852)	
		Cytherois vitrea (G.O. Sars, 1866)	
	Cytheromatidae	Cytheroma karadagiensis Dubowsky, 1939	
	Cytheromatidae	Cytheroma variabilis G.W. Mueller, 1894	
	Loxoconchidae	Cytheromorpha fuscata (Brady, 1869)	
		Cytheropteron rotundatum G.W. Mueller, 1894	
		Eucythere prava Brady & Robertson, 1869	
	Cytheruridae	Hemicytherura bulgarica (Klie, 1937)	Eucytherura bulgarica Klie, 1937
		Euphilomedes interpuncta (Baird, 1850)	
		Hemicytherura videns (G.W. Mueller, 1894)	
	Cyprididae	Heterocypris incongruens (Ramdohr, 1808)	

NEXT Black Sea Basin

		Heterocypris salina (Brady, 1886)	
		Leptocythere fabaeformis (G.W. Mueller, 1894)	
	Leptocytheridae	Leptocythere macallana (Brady & Robertson, 1869)	
	Leptocytheridae	Leptocythere multipunctata (Seguenza, 1942)	
	Leptocytheridae	Leptocythere ramosa (Rome, 1942)	
		Leptocythere rara (G.W. Mueller, 1894)	
		Limnocythere inopinata (Baird, 1850)	
		Loxoconcha bairdi (G.W. Mueller, 1894)	
		Loxoconcha elliptica Brady, 1868	
		Loxoconcha globosa Schornikov, 1965	
		Loxoconcha granulata G.O. Sars, 1866	
		Loxoconcha pontica Klie, 1937	
		Loxoconcha rhomboidea (Fischer, 1855)	
		Microcythere longiantennata Marinov, 1962	
		Microcythere varnensis Marinov, 1962	
		Microcytherura nigrescens G.W. Mueller, 1894	
		Paracypris polita G.O. Sars, 1866	
		Paradoxostoma abbreviatum G.O. Sars, 1866	
MYSIDA	Mysidae	Paramysis (Metamysis) ullskyi Czerniavsky, 1882	
	Mysidae	Diamysis bahirensis (G.O. Sars, 1877)	
		Diamysis mecznikovi (Czerniavsky, 1882)	
		Diamysis pengoi (Czerniavsky, 1882)	

NEXT Black Sea Basin

		<i>Gastrosaccus sanctus</i> (Van Beneden, 1861)	
		<i>Hemimysis anomala</i> G.O. Sars, 1907	
		<i>Hemimysis serrata</i> Bacescu, 1938	
		<i>Leptomysis lingvura</i> (G. O. Sars, 1866)	
		<i>Leptomysis truncata</i> (Heller, 1863)	
		<i>Limnomysis benedeni</i> Czerniavsky, 1882	
		<i>Mesopodopsis slabberi</i> (van Beneden, 1861)	
		<i>Paramysis agigensis</i> Bacescu, 1940	
		<i>Paramysis arenosa</i> (G.O. Sars, 1877)	
		<i>Paramysis (Paramysis) baeri</i> Czerniavsky, 1883	
		<i>Paramysis (Paramysis) bakuensis</i> G.O. Sars, 1895	
		<i>Paramysis (Serrapalpis) kosswigi</i> Bacescu, 1948	
		<i>Paramysis (Longidentia) kroyeri</i> (Czerniavsky, 1882)	
		<i>Paramysis (Serrapalpis) lacustris</i> (Czerniavsky, 1882)	<i>Paramysis (Serrapalpis) lacustris tanaitica</i> Martinov, 1924
		<i>Paramysis (Pseudoparamysis) pontica</i> Bacescu, 1940	
		<i>Siriella jaltensis</i> Czerniavsky, 1868	
CUMACEA	Bodotriidae	<i>Bodotria arenosa mediterranea</i> (Stener, 1938)	
	Nannastacidae	<i>Cumella (Cumella) limicola</i> G.O. Sars, 1879	
	Nannastacidae	<i>Cumella (Cumella) pygmaea euxinica</i> Bacescu, 1950	
	Bodotriidae	<i>Cumopsis goodsir</i> (Van Beneden, 1861)	
	Leuconidae	<i>Eudorella truncatula</i> (Bate, 1856)	

NEXT Black Sea Basin

	Bodotriidae	<i>Iphinoe elisae</i> Bacescu, 1950	
	Bodotriidae	<i>Iphinoe maeotica</i> (Sowinsky, 1894)	
	Bodotriidae	<i>Iphinoe tenella</i> G.O. Sars, 1878	
	Bodotriidae	<i>Iphinoe elisae</i> Băcescu, 1950	
	Nannastacidae	<i>Nannastacus euxinicus</i> Bacescu, 1951	
	Pseudocumatidae	<i>Pseudocuma</i> (<i>Pseudocuma</i>) <i>ciliatum</i> G.O. Sars, 1879	
	Pseudocumatidae	<i>Pseudocuma</i> (<i>Pseudocuma</i>) <i>longicorne</i> (Bate, 1858)	
	Pseudocumatidae	<i>Pseudocuma</i> (<i>Stenocuma</i>) <i>cercarioides</i> G.O. Sars 1894	
	Pseudocumatidae	<i>Pseudocuma</i> (<i>Stenocuma</i>) <i>graciloides</i> G.O. Sars, 1894	
	Pseudocumatidae	<i>Pseudocuma</i> (<i>Stenocuma</i>) <i>laeve</i> G.O. Sars, 1914	
	Pseudocumatidae	<i>Pterocuma pectinatum</i> (Sowinsky, 1893)	
	Pseudocumatidae	<i>Pterocuma rostratum</i> (G.O. Sars, 1894)	
	Pseudocumatidae	<i>Pterocuma sowinskyi</i> (G.O. Sars, 1894)	
	Pseudocumatidae	<i>Schizorhamphus eudorelloides</i> (G.O. Sars, 1894)	
	Pseudocumatidae	<i>Schizorhamphus scabriusculus</i> (G.O. Sars, 1894)	
	Pseudocumatidae	<i>Volgacuma telmatophora</i> Derzhavin, 1912	
TANAIDACEA	Apseudidae	<i>Apseudopsis ostroumovi</i> Bacescu & Carausu, 1947	
	Apseudidae	<i>Apseudopsis acutifrons</i> (Sars, 1882)	
	Leptocheliidae	<i>Heterotanais oerstedii</i> (Krøyer, 1842)	
	Leptocheliidae	<i>Chondrochelia savignyi</i> (Kroyer, 1842)	<i>Leptochelia savignyi</i>
	Leptocheliidae	<i>Leptochelia mergellinae</i> Smith, 1906	
	Pseudotanaidae	<i>Pseudotanais borceai</i> Bacescu, 1960	

NEXT Black Sea Basin

	Tanaididae	<i>Tanais dulongii</i> (Audouin, 1826)	
ISOPODA	Cymothoidae	<i>Anilocra physodes</i> (Linnaeus, 1758)	
	Bopyridae	<i>Bopyrina ocellata</i> (Czerniavsky, 1868)	
	Bopyridae	<i>Bopyrissa diogeni</i> (Popov, 1927)	
	Sphaeromatidae	<i>Cymodoce tattersalli</i> Torelli, 1929	
	Sphaeromatidae	<i>Cymodoce erythraea</i> euxinica Bacescu, 1958	
	Sphaeromatidae	<i>Dynamene bicolor</i> (Rathke, 1837)	
	Sphaeromatidae	<i>Dynamene bidentata</i> (Adams, 1800)	
	Sphaeromatidae	<i>Lekanesphaera hookeri</i> (Leach, 1814)	
	Gnathiidae	<i>Elaphognathia bacescoi</i> (Kussakin, 1969)	
	Gnathiidae	<i>Gnathia oxyuraea</i> (Lilljeborg, 1855)	
	Gnathiidae	<i>Halophiloscia couchii</i> (Kinahan, 1858)	
	Cirolanidae	<i>Eurydice dollfusi</i> Monod, 1930	
	Cirolanidae	<i>Eurydice pontica</i> (Czerniavsky, 1868)	
	Cirolanidae	<i>Eurydice racovitzai</i> Bacescu, 1949	
	Cirolanidae	<i>Eurydice spinigera</i> Hansen, 1890	
	Cirolanidae	<i>Eurydice valkanovi</i> Bacescu, 1949	
	Idoteidae	<i>Idotea balthica</i> (Pallas, 1772)	
	Idoteidae	<i>Idotea ostroumovi</i> Sowinsky, 1895	
	Janiridae	<i>Jaera (Jaera) hopeana</i> Costa, 1853	
	Janiridae	<i>Jaera (Jaera) nordmanni</i> (Rathke, 1836)	
	Janiridae	<i>Jaera (Jaera) sarsi</i> Vulkanov, 1936	
	Ligiidae	<i>Ligia italica</i> Fabricius, 1798	
	Limnoriidae	<i>Limnoria tuberculata</i> Sowinsky, 1884	

NEXT Black Sea Basin

	Cymothoidae	<i>Mothocya taurica</i> (Czerniavsky, 1868)	
	Bopyridae	<i>Parathelges racovitzai</i> R. Codreanu, 1940	
AMPHIPODA	Gammaridae	<i>Amathillina cristata</i> G.O. Sars, 1894	
	Ampeliscidae	<i>Ampelisca diadema</i> (A. Costa, 1853)	
	Ampeliscidae	<i>Ampelisca pseudospinimana</i> Bellan-Santini & Kaim-Malka, 1977	
	Ampeliscidae	<i>Ampelisca pseudosarsi</i> Bellan-Santini & Kaim-Malka, 1977	
	Ampithoidae	<i>Pleonexes gammaroides</i> Spence Bate, 1857	Ampithoe gammaroides
	Ampithoidae	<i>Pleonexes helleri</i> (Karaman, 1975)	Ampithoe helleri
	Ampithoidae	<i>Ampithoe ramondi</i> Audouin, 1826	
	Calliopiidae	<i>Apherusa bispinosa</i> (Bate, 1857)	
	Calliopiidae	<i>Apherusa chiereghinii</i> Giordani-Soika, 1950	
	Atylidae	<i>Nototropis guttatus</i> Costa, 1853	
	Atylidae	<i>Nototropis massiliensis</i> (Bellan-Santini, 1975)	Atylus massiliensis
	Bathyporeiidae	<i>Bathyporeia guilliamsoniana</i> (Bate, 1857)	
	Ampithoidae	<i>Biancolina algicola</i> Della Valle, 1893	
	Caprellidae	<i>Caprella acanthifera</i> Leach, 1814	
	Caprellidae	<i>Caprella acanthifera</i> discrepans Carausu, 1941	
	Caprellidae	<i>Caprella danilevskii</i> Czerniavski, 1868	
	Caprellidae	<i>Caprella liparotensis</i> Haller, 1879	
	Caprellidae	<i>Caprella mytis</i> Mayer, 1890	
	Caprellidae	<i>Caprella rapax</i> Mayer, 1890	
	Behningiellidae	<i>Cardiophilus baeri</i> G.O. Sars, 1896	

NEXT Black Sea Basin

		<i>Chelura terebrans</i> Philippi, 1839	
	Corophiidae	<i>Chelicorophium maeoticum</i> (Sowinsky, 1898)	<i>Corophium maeoticum</i>
	Corophiidae	<i>Chelicorophium nobile</i> (G.O. Sars, 1895)	<i>Corophium nobile</i>
	Corophiidae	<i>Corophium orientale</i> Schellenberg, 1928	
	Corophiidae	<i>Chelicorophium robustum</i> (G.O. Sars, 1895)	<i>Corophium robustum</i>
	Corophiidae	<i>Chelicorophium sowinskyi</i> (Martynov, 1924)	<i>Corophium sowinskyi</i>
	Ampithoidae	<i>Cymadusa crassicornis</i> (A. Costa, 1857)	
	Dexaminidae	<i>Dexamine spinosa</i> (Montagu, 1813)	
	Gammaridae	<i>Dikerogammarus haemobaphes</i> (Eichwald, 1841)	
	Gammaridae	<i>Dikerogammarus villosus</i> (Sowinsky, 1894)	
	Gammaridae	<i>Pectenogammarus foxi</i> (Schellenberg, 1928)	<i>Echinogammarus foxi</i>
	Gammaridae	<i>Chaetogammarus ischnus</i> (Stebbing, 1899)	<i>Echinogammarus ischnus</i>
	Gammaridae	<i>Pectenogammarus olivii</i> (H. Milne Edwards, 1830)	<i>Echinogammarus olivii</i>
	Gammaridae	<i>Chaetogammarus placidus</i> (G.O. Sars, 1896)	<i>Echinogammarus placidus</i>
	Gammaridae	<i>Chaetogammarus warpachowskyi</i> (G.O. Sars, 1894)	<i>Echinogammarus warpachowskyi</i>
	Ischyroceridae	<i>Erichthonius punctatus</i> (Bate, 1857)	<i>Erichthonius difformis</i>
	Ischyroceridae	<i>Erichthonius difformis</i> Milne-Edwards, 1830	
	Pontogammaridae	<i>Pontogammarus maeoticus</i> (Sovinskij, 1894)	<i>Euxinia maeoticus</i> (Sowinsky 1894)
	Pontogammaridae	<i>Pontogammarus sarsi</i> (Sowinsky, 1898)	<i>Euxinia sarsi</i> (Sowinsky, 1898)
	Pontogammaridae	<i>Pontogammarus weidemanni</i> (G.O. Sars, 1896)	<i>Euxinia weidemanni</i>
	Gammarellidae	<i>Gammarellus carinatus</i> (Rathke, 1843)	

NEXT Black Sea Basin

	Gammarellidae	<i>Gammarellus angulosus</i> (Rathke, 1843)	
	Gammaridae	<i>Gammarus aequicauda</i> (Martynov, 1931)	
	Gammaridae	<i>Gammarus crinicornis</i> Stock, 1966	
	Gammaridae	<i>Gammarus duebeni</i> Liljeborg, 1852	
	Gammaridae	<i>Gammarus insensibilis</i> Stock, 1966	
	Gammaridae	<i>Gammarus pulex</i> (Linnaeus, 1758)	
	Gammaridae	<i>Gammarus subtypicus</i> Stock, 1966	
	Gammaridae	<i>Gammarus zaddachi</i> Sexton, 1912	
	Gammaridae	<i>Marinogammarus marinus</i> (Leach, 1816)	Echinogammarus
	Phoxocephalidae	<i>Harpinia dellavallei</i> Chevreux, 1910	
	Hyalidae	<i>Apohyale crassipes</i> (Heller, 1866)	<i>Hyale crassipes</i>
	Hyalidae	<i>Protohyale (Protohyale) dollfusi</i> (Chevreux, 1911)	<i>Hyale dollfusi</i>
	Hyalidae	<i>Protohyale (Protohyale) schmidtii</i> (Heller, 1866)	<i>Hyale schmidtii</i>
	Hyalidae	<i>Apohyale perieri</i> (Lucas, 1846)	<i>Hyale perieri</i>
	Hyalidae	<i>Hyale pontica</i> Rathke, 1837	
	Ischyroceridae	<i>Jassa marmorata</i> (Holmes, 1903)	
	Ischyroceridae	<i>Plumulojassa ocia</i> (Spence Bate & Westwood, 1862)	<i>Jassa ocia</i>
	Corophiidae	<i>Leptocheirus pilosus</i> Zaddach, 1844	
	Corophiidae	<i>Medicorophium runcicorne</i> (Della Valle, 1893)	
	Megaluropidae	<i>Megaluropus agilis</i> Hoeck, 1889	
	Photidae	<i>Megamphopus cornutus</i> Norman, 1869	
	Melitidae	<i>Melita palmata</i> (Montagu, 1804)	
	Aoridae	<i>Microdeutopus algicola</i> Della Valle, 1893	
	Aoridae	<i>Microdeutopus anomalus</i> (Rathke, 1843)	

NEXT Black Sea Basin

	Aoridae	<i>Microdeutopus gryllotalpa</i> A. Costa, 1853	
	Aoridae	<i>Microdeutopus versiculatus</i> (Bate, 1856)	
	Aoridae	<i>Microprotopus longimanus</i> Chevreux, 1887	
	Oedicerotidae	<i>Deflexilodes gibbosus</i> (Chevreux, 1888)	<i>Monoculodes gibbosus</i>
	Lysianassidae	<i>Nannonyx goesii</i> (Boeck, 1871)	<i>N. goesi</i>
	Lysianassidae	<i>Nannonyx propinquus</i> Chevreux, 1911	
ARTHROPODA, MALACOSTRACA, DECAPODA	Alpheidae	<i>Alpheus dentipes</i> Guérin-Méneville, 1832	
	Alpheidae	<i>Athanas nitescens</i> (Leach, 1814)	
	Hippolytidae	<i>Hippolyte leptocerus</i> (Heller, 1863)	
	Hippolytidae	<i>Hippolyte sapphica</i> D'Udekem d'Acoz, 1993	
	Crangonidae	<i>Crangon crangon</i> (Linnaeus, 1758)	
	Crangonidae	<i>Philocheras fasciatus</i> (Risso, 1816)	
	Crangonidae	<i>Philocheras trispinosus</i> (Hailstone, 1835)	
	Palaemonidae	<i>Palaemon adspersus</i> Rathke, 1837	
	Palaemonidae	<i>Palaemon elegans</i> Rathke, 1837	
	Palaemonidae	<i>Palaemon macrodactylus</i> Rathbun, 1902	
	Palaemonidae	<i>Palaemon serratus</i> (Pennant, 1777)	
	Processidae	<i>Processa edulis</i> (Risso, 1816)	
	Porcellanidae	<i>Pisidia bluteli</i> (Risso, 1816)	<i>Porcellanides, Porcellana longimana</i>
	Diogenidae	<i>Diogenes ponticus</i> (Kessler, 1861)	<i>Diogenes pugilator</i> (Roux, 1829)
	Diogenidae	<i>Clibanarius erythropus</i> (Latreille, 1818)	
	Nephropidae	<i>Homarus gammarus</i> (Linnaeus, 1758)	
	Callianassidae	<i>Gilvossius candidus</i> (Olivi, 1792)	<i>Pestarella candida</i>

NEXT Black Sea Basin

	Callianassidae	<i>Necallianassa truncata</i> (Giard et Bonnier, 1890) [	
	Grapsidae	<i>Pachygrapsus marmoratus</i> (Fabricius, 1787);	
	Grapsidae	<i>Planes minutus</i> (Linnaeus, 1758)	
	Varunidae	<i>Eriocheir sinensis</i> (H. Milne Edwards, 1854)	
	Varunidae	<i>Brachynotus gemmellari</i> (Rizza, 1839)	
	Varunidae	<i>Brachynotus sexdentatus</i> (Risso, 1827)	
	Eriphiidae	<i>Eriphia verrucosa</i> (Forskål, 1775)	
	Inachidae	<i>Macropodia longirostris</i> (Fabricius, 1775)	
	Inachidae	<i>Macropodia rostrata</i> (Linnaeus, 1761)	
	Pilumnidae	<i>Pilumnus hirtellus</i> (Linnaeus, 1761)	
	Pirimelidae	<i>Sirpus ponticus</i> Vereshchaka, 1989	
	Carcinidae	<i>Carcinus aestuarii</i> Nardo, 1847	<i>C. maenas</i> , <i>C. mediterraneus</i>
	Carcinidae	<i>Portumnus latipes</i> (Pennant, 1777)	
	Polybiidae	<i>Polybius depurator</i> (Linnaeus, 1758)	Macropipus, Portunus
	Polybiidae	<i>Polybius navigator</i> (Herbst, 1794)	<i>L. arcuatus</i> , Macropipus, Portunus
	Polybiidae	<i>Polybius vernalis</i> (Risso, 1827)	<i>Portunus holsatus</i> , Macropipus
	Portunidae	<i>Callinectes sapidus</i> Rathbun, 1896	
	Panopeidae	<i>Rhithropanopeus harrisii</i> (Gould, 1841)	<i>R. harrisii tridentatus</i>
	Panopeidae	<i>Eurypanopeus depressus</i> (Smith, 1869)	
	Xanthidae	<i>Xantho poressa</i> (Olivi, 1792)	<i>X. hydrophilus</i> , <i>X. rivulosus</i>
	Upogebiidae	<i>Upogebia pusilla</i> (Petagna, 1792)	
	Pirimelidae	<i>Pirimela denticulata</i> (Montagu, 1808)	
	Lysmatidae	<i>Lysmata seticaudata</i> (Risso, 1816)	

NEXT Black Sea Basin

	Nephropidae	<i>Homarus gammarus</i> (Linnaeus, 1758)	
ECHINODERMATA	Amphiuridae	<i>Amphiura stepanovi</i> Djakonov, 1954	<i>Amphiura stepanovi</i> Chernyavskii, 1861
	Synaptidae	<i>Leptosynapta inhaerens</i> (O.F. Müller, 1776)	
	Cucumariidae	<i>Stereoderma kirchsbergii</i> (Heller, 1868) Panning, 1949	
TUNICATA	Asciidiidae	<i>Asciidiella aspersa</i> (Müller, 1776)	
	Styelidae	<i>Botryllus schlosseri</i> (Pallas, 1766)	
	Didemnidae	<i>Diplosoma listerianum</i> (Milne-Edwards, 1841)	
	Cionidae	<i>Ciona intestinalis</i> (Linnaeus, 1767)	
	Molgulidae	<i>Eugyrioides adriaticus</i> Drasche, 1884	<i>Eugyra adriatica</i> Drasche, 1884
	Molgulidae	<i>Molgula appendiculata</i> Heller, 1877	
	Molgulidae	<i>Molgula euprocta</i> Drasche, 1884	

2.2.3. Key Ecosystems and Habitats

2.2.3.1. Pelagic zone / Open waters

This zone represents a specific habitat encompassing the entire water column, from the surface to the seabed - in the open sea and large bays. In the Black Sea this zone is populated down to 100 m, due to presence of anoxic zone below. It forms the basis of trophic chains, as the main plankton communities are concentrated here, underpinning food web interactions in the Black Sea. The zone is characterized by pronounced seasonal thermal and gas stratification, the presence of marine currents, and distinct seasonal processes.

Of all species recorded in the Bulgarian Black Sea waters, 38 are classified as pelagic inhabitants. This group includes key secondary consumers - zooplanktivorous, relatively small species such as sprat, anchovy, horse mackerel, sand smelt (*Atherina* spp.), as well as mullets and other clupeid fishes. Predatory species typical of this habitat include bonito, bluefish, garfish, tunas, and mackerels, as well as apex predators such as the spiny dogfish.

A total of 15 species are identified as demersal inhabitants of this zone. These include all sturgeon species, the European eel (*A. anguilla*), the conger eel (*Conger conger*), as well as species such as common dentex (*D. dentex*), whiting (*Merlangius merlangus*), picarels (*Spicara* spp.), and the relatively rare Black Sea species John Dory (*Zeus faber*) and European hake (*Merluccius merluccius*).

NEXT Black Sea Basin

2.2.3.2. Benthic habitats

The definition of Directive 92/43/EEC on the conservation of natural habitats and wild flora and fauna (the Habitats Directive) stated that "natural habitat" are terrestrial or aquatic areas defined on the basis of geographical, abiotic and biotic features, wholly or partly natural.

This zone encompasses all bottom areas of the shelf area. It is characterized by a variety of substrates, depending on geographical conditions, which in turn determine the diversity of species assemblages.

Of the total 153 recorded fish species, 46 are classified as benthic. This large group includes all rays, gobies (with the exception of *Aphia minuta*), blennies, clingfishes, dragonets, red mullet, greater weever, scorpionfish, stargazers, as well as all flatfishes such as turbot, flounder, and sole.

Six of these benthic species can be considered resource species, as they have commercial importance for industrial fisheries in Bulgaria. These are *R. clavata*, *M. batrachocephalus*, *N. melanostomus*, *P. eurycephalus*, *S. maximus*, and *M. barbatus*.

2.2.3.3. Coastal Habitats

In the Bulgarian Black Sea waters, the following main key habitats can be identified up to 100-150 m of depth, where start the anoxic zone (lacking life).

This zone encompasses a variety of habitats within the coastal area of the Bulgarian shoreline. It includes seagrass meadows (*Zostera marina* and *Z. noltei*), which form dense underwater vegetation in shallow bays and sheltered areas and is included in EUNIS list as habitat type MB548 - Black Sea seagrass meadows on lower infralittoral sands' (EUNIS, 2019). Functionally, they stabilize sediments, reduce water turbidity, and increase oxygen levels through photosynthesis. They also represent key habitats for juvenile stages of various fish and invertebrate species. Typical inhabitants include pipefishes, various blennies and wrasses, as well as some gobies such as *G. ophiocephalus*.

Coastal seagrass meadows identified by Petrova-Karajova (1982) in 1978-79 were also located during the current survey, despite the increased eutrophication pressures and overall degradation of benthic habitats in the western Black Sea during the 1980s and early 1990s. Recent investigations estimated the total habitat coverage along the Bulgarian Black Sea coast to 916.9 ha, of which only 17.9 ha are in man-made sheltered environments (harbours) (Berov et al., 2022). Same authors concluded that the main share 52% (411 ha) of the total are distributed seagrass bed is in front of Burgas and Sarafovo. In addition they mentioned other large meadows in front of Pomorie, Sunny Beach, Poda, Otmanli, Sozopol Bay and Sv. Vlas (Southern Black Sea area). Uzunova (2010) reported 69 zoobenthic species, belonging to four groups: Polychaeta, Mollusca, Crustacea and Varia for this habitat. Dzhembekova et al., (2026) found that metazoan assemblages in seagrass habitats are more significant habitat-related in community composition and detection frequency, with taxa being detected more frequently than in bare sand environments.

NEXT Black Sea Basin

Another important habitat type consists of **macroalgal belts** formed by brown, green, and red algae, developing primarily on rocky and stony substrates in the coastal zone. These create a mosaic structure of the seabed, enhancing biodiversity and providing a food base for numerous organisms. They often serve as shelter for juvenile fish at early developmental stages and benthic species. Typical inhabitants include various blennies and small gobies.

Based on historical and contemporary algological studies 42 new described taxa and 78 threatened algae were reported by Dimitrova et al. (2018). *Cystoseira* communities (*Cystoseira barbata*, *C. Agardh* and *C. crinita* f. *bosporica*) are the most widespread algal species presenting perfect living conditions to oxifil species like as crustatians. They were severely affected by the period of increased anthropogenic eutrophication in the Black Sea in the 1980s, but recent studies of Berov et al. (2012) proved their recovery to the level of pre-eutrophication period in the early 1980s, but with a significant decrease in the depth of occurrence of the studied communities.

Mussel beds represent a specific habitat type composed mainly of *Mytilus galloprovincialis*, forming dense aggregations on hard or mixed substrates. As filter feeders, mussels increase water clarity. They also accumulate organic matter and provide shelter and substrate for a wide range of invertebrates and fish species.

Rocky reefs and underwater rock formations located in coastal areas of the Black Sea are highly important, species-rich habitats. These natural hard substrates, often characterized by high heterogeneity and microrelief, support diverse communities of sessile organisms (sponges, mollusks, algae) and are crucial for feeding and reproduction of many coastal fish species. Typical inhabitants include various blennies, gobies, seabasses, shi drum, brown meagre, and representatives of the family Sparidae.

Coastal sandy habitats are widely distributed along the Bulgarian coast. They are characterized by dynamic conditions driven by waves and currents and play an important role in coastal sediment balance. Typical inhabitants include gobies of the genera *Pomatoschistus* and *Knipowitschia*, flounders, soles, weever fishes, dragonets, and other benthic species.

2.2.3.4. Transitional Waters

This group of habitats includes all estuaries and coastal lagoons, i.e., zones of mixing between freshwater and marine waters with a pronounced salinity gradient. They are characterized by high biological productivity and often serve as nursery areas for larvae and juvenile stages of various fish species, particularly mullets. These habitats are highly sensitive to pollution, hydromorphological alterations, and development. Salinity frequently varies within wide limits depending on water exchange. Typical inhabitants of transitional waters include sticklebacks, certain species of pipefishes and gobies, as well as various fish species of primary freshwater origin.

2.2.3. National Inventories and Monitoring

Black Sea commercial fisheries in Bulgaria are managed within the framework of the EU Common Fisheries Policy (CFP) and the regional measures of the General Fisheries Commission for the Mediterranean (GFCM) for GSA 29 (Black Sea). Relatively comprehensive data are available on catches, fleet capacity, as well as from various scientific studies.

The main national institutions responsible for data collection and management are the Ministry of Agriculture and Food (MAF), which ensures policy coordination of the sector and interaction with European structures under the Operational Programme for Fisheries, and the Executive Agency for Fisheries and Aquaculture (EAFA) - a subordinate body of MAF and the national competent authority for policy implementation, administration of registers, and licensing. EAFA also acts as the primary coordinator for the collection of technical, biological, and economic fisheries data under the EU Data Collection Framework (DCF).

The Directorate-General for Maritime Affairs and Fisheries (DG MARE) is a department within the European Commission responsible for the Common Fisheries Policy (CFP), the EU's maritime policy, sustainable management of fishery resources, and international fisheries agreements. In the Black Sea context, DG MARE develops regulations and technical measures, coordinates the implementation of quotas and control mechanisms for Total Allowable Catch (TAC), and provides the framework and technical infrastructure for DCF data reporting, as well as for the evaluation of work plans and annual reports.

The Joint Research Centre (JRC) is the scientific body of the European Commission that provides scientific and technical support for policy development, data analysis and modeling, and methodological frameworks for data collection and validation. In the field of fisheries, the JRC coordinates the technical aspects of the DCF, supports scientific expert groups, and develops tools for stock assessment, economic analysis, and data quality control.

The Institute of Fish Resources - Varna (IFR), the Institute of Oceanology - Bulgarian Academy of Sciences (IO-BAS), as well as other units of the Bulgarian Academy of Sciences (BAS), conduct scientific research and monitoring of the marine environment and biota. Some of these institutions participate in various national and international projects related to fisheries and the sustainable use of fishery resources, as well as in the harmonization of biological data with European infrastructures.

Other major projects and initiatives related to Black Sea fisheries and catch data include:

BlackSea4Fish is a regional initiative of the GFCM under FAO, launched in 2016 and aimed at the sustainable management of fishery resources in the Black Sea (GSA 29). Its main objectives are to improve the scientific basis and harmonize methodologies for data collection. The initiative supports regional research and enhances stock assessments for key commercial species, while also promoting regional cooperation and the exchange of data and expertise. It provides assistance to national institutions in implementing regional measures and operates through scientific working groups, regional workshops, and joint analyses. In Bulgaria, BlackSea4Fish improves access to regional scientific data and strengthens the participation of

NEXT Black Sea Basin

national scientists and experts in stock assessments, thereby supporting the sustainable management of key resources.

The State of Mediterranean and Black Sea Fisheries (SoMFi) is an official periodic report of the GFCM under FAO, providing a scientific assessment of the status of fishery resources, fishing fleets, and stock management in the Mediterranean and Black Sea. Its primary objective is to deliver a consolidated, science-based evaluation of major fish stocks. For the Black Sea (GSA 29), SoMFi provides regionally comparable indicators of stock status, tracks the effects of implemented quotas, evaluates the progress of the BlackSea4Fish initiative, and identifies priorities for reducing overfishing and improving data quality. It serves as the principal scientific and analytical reference for strategic fisheries management decisions in the region.

ANEMONE (Assessment and Monitoring of the Black Sea Ecosystems) is an international project funded under the EU Black Sea Basin Cross-Border Cooperation (CBC) programme. It brings together scientific institutions and organizations from Black Sea countries to improve monitoring and assessment of marine ecosystems. Although not exclusively focused on fisheries, ANEMONE is directly relevant to fisheries management, as it provides data on habitat conditions and trophic interactions and supports the Ecosystem Approach to Fisheries (EAF).

TIMMOD (Transboundary Integrated Management and Monitoring of Marine Resources and Ecosystems in the Black Sea Basin) is another international project funded under the EU Black Sea Basin CBC programme. Its main objective is to enhance transboundary coordination in the monitoring and management of marine resources and ecosystems in the Black Sea.

All these resources provide extensive data on catches, fishing effort, and fleet capacity. The fishing vessel register supplies information on fleet technical characteristics, including gross tonnage, engine power, vessel length classes, and licenses for specific fishing gears or target resources. These data enable assessment of fleet structural dynamics, analysis of fishing capacity, and comparison between capacity and actual fishing effort. Combined with catch data, this information supports the evaluation of fishing pressure and the potential risk of overexploitation.

Within the European Data Collection Framework (DCF), information is compiled on economic indicators, including revenues, operating costs, employment, value added, and profitability by fleet segment. These data are reported to the European Commission and analyzed within the expert processes of the Scientific, Technical and Economic Committee for Fisheries (STECF). Economic data are essential for assessing socio-economic sustainability and for balancing biological and economic objectives in fisheries and resource management.

Data from scientific research constitute a key component in assessing the status of fishery resources. In the Black Sea, deep-water trawl and acoustic surveys are conducted, often in a regionally coordinated framework. Methodologies are harmonized at the regional level through initiatives such as BlackSea4Fish and scientific bodies within the GFCM. The aim is to ensure

NEXT Black Sea Basin

comparable data on relative biomass and abundance, which serve as standard parameters for stock assessment and the development of indicators.

Some marine fish species are subject to monitoring within the framework of the National Biodiversity Monitoring System (NBMS). It represents a comprehensive mechanism for tracking and summarizing long-term changes in the biodiversity of the Republic of Bulgaria. The existing monitoring methodology provides information on the status and long-term trends in the populations of the following species subject to monitoring:

- *Engraulis encrasicolus* (Linnaeus, 1758)
- *Sprattus sprattus* (Linnaeus, 1758)
- *Trachurus mediterraneus* (Steindachner, 1868)
- *Atherina boyeri* Risso, 1810
- *Alosa immaculata* (Benett, 1835)
- *Alosa maeotica* (Grimm, 1901)
- *Alosa tanaica* (Grimm, 1901)
- *Gobius ophiocephalus* (Pallas, 1814)
- *Neogobius melanostomus* (Pallas, 1814)
- *Mesogobius batrachocephalus* (Pallas, 1814)
- *Scophthalmus maeoticus* (Linnaeus, 1758)
- *Syngnathus abaster* (Risso, 1827)

All data obtained from the monitoring of these species are stored in the Information System of NBMS. This system has been developed in accordance with the requirements of Article 115, paragraph 1, items 10 and 11 of the Biological Diversity Act, and aims to ensure comprehensive and reliable information from field monitoring within the NBMS, to support policy decision-making for biodiversity conservation in Bulgaria. The Executive Environment Agency (ExEA), as a body under the Ministry of Environment and Water (MoEW), is responsible for the development, maintenance, and operation of national environmental information systems. Within the NBMS, the ExEA plays a central role as the operator and administrator of the Information System.

The management of transitional waters (estuaries and coastal lagoons) is organized and implemented by the Black Sea Basin Directorate (BSBD), a regional authority under the Ministry of Environment and Water, responsible for water management in the Black Sea River Basin District of Bulgaria. The Directorate's activities are based on the requirements of the Water Act and the EU Water Framework Directive (2000/60/EC). The BSBD defines the boundaries and typology of transitional water bodies, including their classification according to hydromorphology, salinity, and ecological characteristics. This typology serves as the basis for ecological status assessment and the determination of reference conditions. The Directorate participates in the assessment of transitional waters through the analysis of biological indicators (phytoplankton, macrophytes, macrozoobenthos, and fish), physicochemical parameters, and chemical pollution. Monitoring data are collected within the framework of the National Water Monitoring System, with part of the data provided by the Executive Environment Agency (ExEA).

NEXT Black Sea Basin

Transitional waters are included among the water bodies assessed and managed under the River Basin Management Plans (RBMPs).

Despite the large volume of available resources and data in the field of fisheries and fishery resources, as well as the substantial information generated through scientific projects and studies, a number of knowledge gaps remain. Significant gaps are observed in reporting and in the incomplete coverage of data on catches and fishing effort, particularly in small-scale coastal fisheries. The small size of vessels, the seasonal nature of activities, and the use of multiple fishing gears complicate the development of a unified data system. The same applies to recreational fisheries, where available catch data are very limited.

There is a need to develop robust systems for data collection and quantitative assessment of catches, as well as to design pilot self-reporting tools that can be integrated into the DCF framework. Data on bycatch of cetaceans, sharks, sturgeons, and other vulnerable groups remain highly limited, especially for passive fishing gears. Additionally, there is a lack of sufficiently detailed spatial data on fishing pressure, particularly for small vessels that are not equipped with tracking systems. This constrains comprehensive assessment of cumulative impacts within marine spatial planning and the implementation of the Marine Strategy Framework Directive (MSFD). The use of ecosystem models and climate scenarios in management decision-making is also limited, despite the increasing importance of factors such as rising sea temperatures and processes such as eutrophication and hypoxia.

It is necessary to expand electronic catch reporting systems and integrate mobile applications for small-scale and recreational fisheries, combined with clear protocols for validation and quality control of incoming data. The expansion of fisheries observer programs and the implementation of electronic monitoring systems (REM) are particularly important, especially in fisheries with a high risk of bycatch of protected species.

With regard to marine mammals, several large-scale studies and monitoring efforts have been conducted in recent years. In 2014-2015, data were collected under the project “Field studies on species distribution/assessment of the conservation status of species and habitats across the country - Phase I,” Activity 6 “Field observations of cetaceans: *Tursiops truncatus*, *Phocoena phocoena*, and *Delphinus delphis* in the Bulgarian Exclusive Economic Zone of the Black Sea,” implemented by ExEA under the Operational Programme “Environment” 2007-2013.

During the period 2013-2020, various vessel-based surveys were conducted in the coastal (territorial and shelf) waters of Bulgaria in the Black Sea. These were part of initiatives and projects of the Institute of Oceanology - BAS (e.g., ISMEIMP project for national monitoring under the MSFD) and the NGO “Green Balkans” (including dolphin photo-identification projects, pilot studies in Natura 2000 sites “Strandzha” and “Ropotamo,” and regular monitoring of cetacean abundance and density in Bulgarian territorial waters). Additional activities have supported the implementation of the Marine Strategy for the Black Sea, including the

NEXT Black Sea Basin

establishment of a regional system for cetacean monitoring and underwater noise monitoring (CeNoBS, 2019).

2.3. Romania

The biota (flora and fauna) of the Black Sea reflects the general processes that have historically influenced the sea's ecosystem. The species are divided into five distinct groups based on their origins and adaptation to the marine environment. The composition of the Black Sea's living organisms is structured into the following groups (Table 13).

Table 13. Group of species and living habitats

Group	Defining characteristics	Habitat/salinity preference
Pontian relics	The most ancient species; their presence trace back to the Black Sea's history (Pontus being an old name for the sea).	Inhabit waters with low salinity .
Boreal - Atlantic relics	Marine species originating from cold northern seas.	Predominantly found in the deep layers of the sea.
Mediterranean species	The most numerous components, comprising up to 80% of the total fauna.	Thrive in warm, saline waters , typically residing in the upper layers .
Freshwater species	Introduced via river discharges.	Observed in seawater primarily during periods of maximum river run-off .
Alien species	Populations that have become established after being introduced through various human-mediated routes.	Varies by introduced species.

The overall species richness of the Black Sea is notably lower than that of the adjacent Mediterranean Sea. The current number of species in the Black Sea represents approximately one-third of the Mediterranean total, a ratio that has remained relatively stable despite recent absolute population changes.

- Mediterranean Sea diversity: approximately 10,000 species.
- Black Sea diversity: approximately 3,700 species.

2.3.1. Species diversity and their role in the food web

Biodiversity in the Black Sea plays a fundamental role in maintaining ecological balance, regulating energy flow, and sustaining ecosystem functions. The food web in the Romanian

NEXT Black Sea Basin

marine area includes a wide array of species with different ecological roles, from primary producers to top predators. The Black Sea hosts a diverse assemblage of marine life, including:

Fish: anchovy (*Engraulis encrasicolus*), sprat (*Sprattus sprattus*), horse mackerel (*Trachurus mediterraneus ponticus*), turbot (*Scophthalmus maeoticus*), red mullet (*Mullus ponticus*), whiting (*Merlangius merlangus*), spiny dogfish (*Squalus acanthias*).

Marine mammals: harbour porpoise (*Phocoena phocoena relicta*), bottlenose dolphin (*Tursiops truncatus ponticus*), common dolphin (*Delphinus delphis ponticus*).

Seabirds: great cormorant (*Phalacrocorax carbo*), yellow-legged gull (*Larus michahellis*), little tern (*Sternula albifrons*).

Benthic invertebrates: Mediterranean mussel (*Mytilus galloprovincialis*), various polychaetes, crustaceans, and mollusks.

Plankton species: diatoms (*Coscinodiscus*, *Chaetoceros*), dinoflagellates (*Ceratium*), copepods (*Acartia clausi*, *Calanus euxinus*).

Offshore species, particularly pelagic fish like anchovy and sprat, show signs of recovery due to improved management, though seasonal overfishing persists. Coastal and benthic communities have experienced higher degradation, especially near industrialized and eutrophic zones. Seabirds and marine mammals face pressure from habitat loss, bycatch, and pollution. While some populations remain stable, others show declining trends, reflecting cumulative human impacts. In recent years, monitoring programs have highlighted growing disparities between well-protected areas and unmanaged coastal stretches, where disturbance, nutrient inputs, and habitat modification continue to hinder natural regeneration. These contrasting patterns suggest that conservation efforts are effective when implemented consistently, yet the broader ecosystem remains vulnerable to fluctuations in fishing pressure, climate-driven changes, and ongoing coastal development (Table 14).

Fish species identified at the Romanian coast in the past 10 years

NEXT Black Sea Basin

		<i>Proterorhinus marmoratus</i>	Tubenose goby	Least Concern (LC)
		<i>Gobius niger</i>	Black goby	Least Concern (LC)
		<i>Gobius cobitis</i>	Giant goby	Least Concern (LC)
		<i>Aphia minuta</i>	Transparent goby	Not Evaluated (NE)
	Labridae	<i>Symphodus rostratus</i>	Pointed-snout wrasse	Least Concern (LC)
		<i>Symphodus cinereus</i>	Grey wrasse	Least Concern (LC)
		<i>Symphodus ocellatus</i>	Ocellated wrasse	Least Concern (LC)
		<i>Symphodus roissali</i>	Five-spotted wrasse	Least Concern (LC)
		<i>Symphodus tinca</i>	Peacock wrasse	Least Concern (LC)
		<i>Sprattus sprattus</i>	European sprat	Least Concern (LC)
		<i>Clupeonella cultriventris</i>	Black Sea sprat	Least Concern (LC)
		<i>Alosa immaculata</i>	Pontic shad, Danube shad	Vulnerable (VU)
Clupeiformes	Clupeidae	<i>Alosa tanaica</i>	Azov shad	Least Concern (LC)
		<i>Alosa maeotica</i>	Black Sea shad	Least Concern (LC)
	Engraulidae	<i>Engraulis encrasicolus</i>	European anchovy	Least Concern (LC)
Gadiformes	Gadidae	<i>Merlangius merlangius</i>	Whiting	Least Concern (LC)
		<i>Gaidropsarus mediterraneus</i>	Shore rockling	Not Evaluated (NE)

NEXT Black Sea Basin

	Moronidae	<i>Dicentrarchus labrax</i>	European seabass	Least Concern (LC)
	Mullidae	<i>Mullus barbatus</i>	Black goby	Least Concern (LC)
		<i>Mullus surmuletus</i>	Red mullet	Least Concern (LC)
	Pomatomidae	<i>Pomatomus saltatrix</i>	Bluefish	Vulnerable (VU)
	Sciaenidae	<i>Sciaena umbra</i>	Brown meagre	Near Threatened (NT)
	Scombridae	<i>Scomber scombrus</i>	Atlantic mackerel	Vulnerable (VU)
		<i>Sarda sarda</i>	Atlantic bonito	Least Concern (LC)
	Sparidae	<i>Diplodus puntazzo</i>	Sharp snout bream	Least Concern (LC)
	Trachinidae	<i>Trachinus draco</i>	Greater weever	Least Concern (LC)
	Uranoscopidae	<i>Uranoscopus scaber</i>	Stargazer	Least Concern (LC)
	Soleidae	<i>Pegusa lascaris</i>	Sand sole	Least Concern (LC)
	Pleuronectidae	<i>Platichthys flesus</i>	European flounder	Least Concern (LC)
	Scophthalmidae	<i>Scophthalmus maeoticus</i>	Black Sea turbot	Not Evaluated (NE)
Ophidiiformes	Ophidiidae	<i>Ophidion rochei</i>	Cuskeel, Roche's snake blenny	Data Deficient (DD)
Rajiformes	Rajidae	<i>Dasyatis pastinaca</i>	Common stingray	Data Deficient (DD)
		<i>Raja clavata</i>	Thornback ray	Near Threatened (NT)
Salmoniformes	Salmonidae	<i>Salmo labrax</i>	Black Sea trout	Least Concern (LC)
Scorpeniformes	Scorpaenidae	<i>Scorpaena porcus</i>	Black scorpionfish	Least Concern (LC)

NEXT Black Sea Basin

		<i>Scorpaena notata</i>	Small red scorpionfish	Least Concern (LC)
	Triglidae	<i>Chelidonichthys lucerna</i>	Tub gurnard	Least Concern (LC)
Squaliformes	Squalidae	<i>Squalus acanthias</i>	Picked dogfish, Spiny dogfish	Vulnerable (VU)
Syngathiformes	Syngnathidae	<i>Hippocampus guttulatus</i>	Long-snouted seahorse	Data Deficient (DD)
		<i>Syngnathus schmidt</i>	Schmidt's pipefish	Data Deficient (DD)
		<i>Syngnathus tenuirostris</i>	Narrow-snouted pipefish	Data Deficient (DD)
		<i>Syngnathus typhle</i>	Broadnosed pipefish	Least Concern (LC)
		<i>Syngnathus variegatus</i>	Thickly snouted pipefish	Data Deficient (DD)
		<i>Nerophis ophidion</i>	Straightnose pipefish	Least Concern (LC)

NEXT Black Sea Basin

For a deeper understanding of ecological value, the following section provides details on 15 fish species as follows:

1. Beluga (*Huso huso*)

Family: Acipenseridae; **Genus:** *Huso*.

The Beluga sturgeon is an anadromous and demersal species native to the Caspian, Black, and Adriatic Seas. It is the largest freshwater fish in the world, with a robust, elongated body covered in five longitudinal rows of bony scutes. The snout is broad and conical, with four barbels in front of a protrusible mouth used for bottom feeding. Coloration is grayish to dark brown dorsally, fading to pale yellowish-white ventrally. This long-lived species is highly migratory, ascending major rivers to spawn, and is renowned for producing Beluga caviar (Figure 6). **Maximum length:** 9 m; **Maximum weight:** >1150 kg.



Figure 6. *Huso huso*

2. Russian sturgeon (*Acipenser gueldenstaedti*)

Family: Acipenseridae; **Genus:** *Acipenser*.

The Russian sturgeon is an anadromous and demersal species native to the Black, Caspian, and Azov Seas, migrating upstream into large rivers for spawning. It has a robust, spindle-shaped body covered with five rows of bony scutes, and a moderately long, rounded snout with four sensory barbels located closer to the mouth. Coloration is dark gray to brown dorsally, with lighter flanks and a pale ventral side. This long-lived species feeds primarily on benthic invertebrates and small fish and is highly prized for its roe, which is processed into high-quality caviar (Figure 7). **Maximum length:** 1.4 m;



Figure 7. *Acipenser gueldenstaedti*

3. Garfish (*Belone belone*)

Family: Belonidae; **Genus:** *Belone*

This pelagic, needle-shaped fish is widely distributed in the eastern Atlantic, Mediterranean, and Black Seas. It has an elongated, slender body with a long, beak-like snout armed with sharp teeth. Its coloration is bluish-green on the back with silvery flanks and a whitish belly, providing camouflage in open water. Garfish is an active predator, feeding mainly on small fish and crustaceans, and forms schools in coastal and offshore waters. Its bones are characteristically green due to the presence of biliverdin (Figure 8).

Maximum length: 95 cm; **Maximum weight:** ~1.3 kg.



Figure 8. *Belone belone*

4. Sprat (*Sprattus sprattus*)

Family: Clupeidae; **Genus:** *Sprattus*.

This small pelagic fish is widely distributed in the northeastern Atlantic, Mediterranean, and Black Seas, where it forms dense schools in coastal and offshore waters. It has a slender, laterally compressed body, a terminal mouth, and large eyes, with a silvery coloration on the flanks and a bluish-green back. This species is an important forage fish, feeding primarily on zooplankton, and serves as a key prey item for larger fish, seabirds, and marine mammals. It plays a central role in the Black Sea food web and supports significant commercial fisheries (Figure 9).

Maximum length: 16 cm; **Maximum weight:** ~30 g.



Figure 9. *Sprattus sprattus*

NEXT Black Sea Basin

5. Black Sea shad (*Alosa maeotica*)

Family: Clupeidae; **Genus:** *Alosa*.

This species closely resembles the Danube shad but exhibits a more laterally compressed body, a straighter and smoother abdominal profile, and a less pronounced keel. The eyes are large with thick eyelids, and the teeth are well-developed. Dorsal coloration is bluish-green, transitioning to silvery hues along the flanks and belly (Figure 10). **Maximum length:** 33 cm; **Maximum weight:** ~400 g.

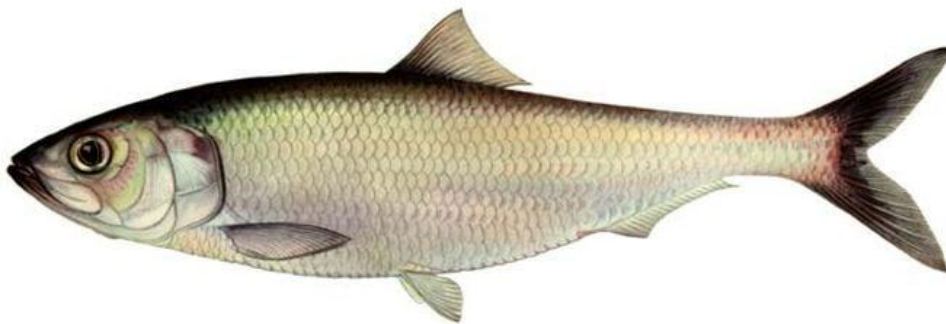


Figure 10. *Alosa maeotica*

6. Anchovy (*Engraulis encrasicolus*)

Family: Engraulidae; **Genus:** *Engraulis*.

This small pelagic species is characterized by a slender, elongated body, a silvery lateral stripe, and a large mouth extending beyond the eyes, with a slightly projecting lower jaw. It forms dense schools in surface waters and plays a key role as forage fish for many marine predators. Dorsal coloration is bluish-green, with silvery flanks and a whitish belly (Figure 11). **Maximum length:** 20 cm; **Maximum weight:** 50 g



Figure 11. *Engraulis encrasicolus*

7. Round goby (*Neogobius melanostomus*)

Family: Gobiidae; **Genus:** *Neogobius*.

This small demersal fish is native to the Black Sea and Caspian Sea basins, inhabiting sandy, rocky, or shell-covered bottoms in coastal and freshwater habitats. It has a robust, cylindrical

NEXT Black Sea Basin

body, a blunt head with large eyes, and fused pelvic fins forming a suction disc. Its coloration is mottled gray-brown with darker blotches, providing camouflage against the substrate. The species is highly adaptable, feeding on mollusks, crustaceans, and small fish, and males guard nests during spawning. It has become invasive in parts of Europe and North America, impacting native fish communities (Figure 12).

Maximum length: 25 cm; **Maximum weight:** ~250 g

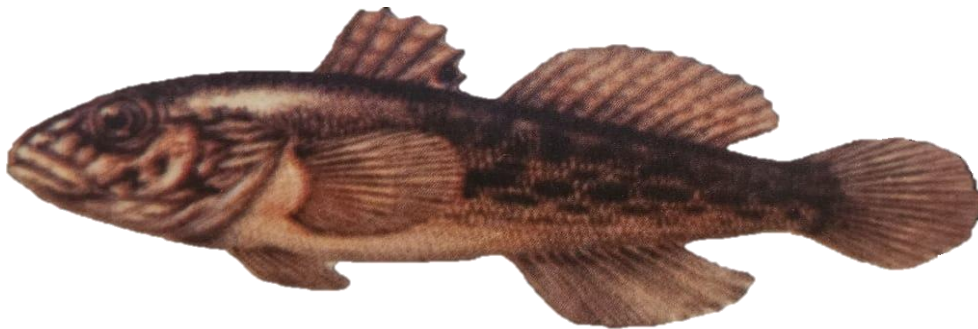


Figure 12. *Neogobius melanostomus*

8. Atlantic mackerel (*Scomber scombrus*)

Family: Scombridae; **Genus:** *Scomber*.

This pelagic, schooling fish is widely distributed in the North Atlantic and Black Sea, including Romanian waters. It has a robust, elongated, almost cylindrical body covered with small scales, and a large scaleless head. The mouth is terminal, large, and oblique, with small teeth; a distinct triangular notch is present behind the upper jaw. The lateral line runs in a zigzag pattern, and the species lacks a swim bladder, allowing rapid vertical movement. Its coloration is metallic blue-green on the back with numerous dark, wavy transverse stripes, silvery flanks with rosy reflections, and a white belly. It is a fast-swimming predator, feeding mainly on small fish and zooplankton, and forms dense schools that migrate seasonally (Figure 13).

Maximum length: 30 cm; **Maximum weight:** 30-700 g.



Figure 13. *Scomber scombrus*

9. Spiny dogfish (*Squalus acanthias*)

Family: Squalidae; **Genus:** *Squalus*.

A formidable predator found throughout seas and oceans. The head is streamlined and well-adapted for high-speed pursuits, allowing it to cut through the water like a torpedo when chasing prey. The body exhibits a **bluish-gray coloration**, with the back and flanks marked by a variable pattern of **bluish or white spots**. The ventral surface is **pale whitish-yellow** (Figure 14).

Maximum length: 150 cm; **Weight range:** 6-13 kg.



Figure 14. *Squalus acanthias*

10. Broad-nosed pipefish (*Syngnathus typhle*)

Family: Syngnathidae; **Genus:** *Syngnathus*.

This demersal fish inhabits shallow coastal waters, seagrass meadows, and algal beds throughout the eastern Atlantic, Mediterranean, and Black Seas. It has an elongated, slender body with a long tubular snout and a broad head, providing excellent camouflage among vegetation. The species is an ambush predator, feeding on small crustaceans and zooplankton, and males carry fertilized eggs in a brood pouch until hatching. Its coloration ranges from greenish to brownish hues, matching surrounding habitats (Figure 15).

Maximum length: 35 cm; **Maximum weight:** 5 g.

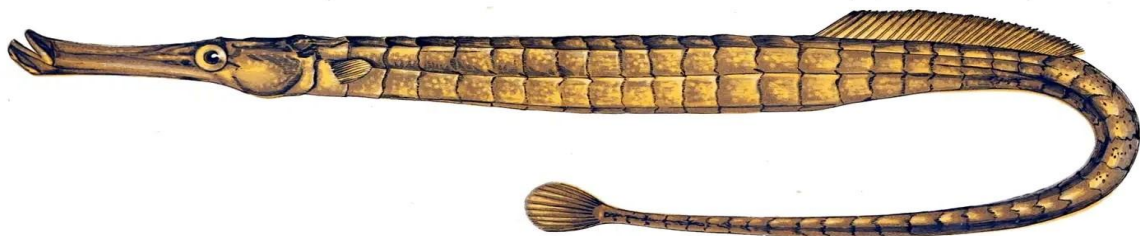


Figure 15. *Syngnathus typhle*

NEXT Black Sea Basin**11. Tub gurnard (*Chelidonichthys lucerna*)****Family:** Triglidae; **Genus:** *Chelidonichthys*

The tub gurnard is a demersal fish found in the Black Sea, Mediterranean, and eastern Atlantic, inhabiting sandy and muddy bottoms at depths of 20-200 m. It has a reddish body, a bony head, and large, brightly colored pectoral fins with blue-green markings, used both for display and for sensing prey. The species feeds mainly on crustaceans, mollusks, and small fish (Figure 16).

Maximum length: 75 cm; **Maximum weight:** 6 kg.



Figure 16. *Chelidonichthys lucerna*

12. Black Sea turbot (*Scophthalmus maeoticus*)**Family:** Scophthalmidae; **Genus:** *Scophthalmus*.

This demersal flatfish is endemic to the Black Sea and Sea of Azov, inhabiting sandy and muddy seabeds at depths of 20-100 m. It has a rounded, highly compressed body with both eyes on the left side, a scaleless skin covered with bony tubercles, and a large mouth adapted for ambushing prey. Its coloration is mottled brown or gray, providing excellent camouflage on the seabed. This species is a top benthic predator, feeding on fish, crustaceans, and other invertebrates, and is of high commercial importance (Figure 17).

Maximum length: 85 cm; **Maximum weight:** 12 kg.



Figure 17. *Scophthalmus maeoticus*

NEXT Black Sea Basin**13. Flathead grey mullet (*Mugil cephalus*)****Family:** Mugilidae; **Genus:** *Mugil*.

This coastal pelagic fish is widely distributed in temperate and tropical waters worldwide, inhabiting estuaries, lagoons, and shallow coastal areas over sandy or muddy bottoms. It has an elongated, cylindrical body covered with large scales, a blunt head with a small terminal mouth, and two well-separated dorsal fins. Its coloration is silvery-gray with darker longitudinal stripes along the sides, allowing it to blend into coastal waters. This species is an opportunistic omnivore, feeding mainly on detritus, algae, macroinvertebrates, and organic matter filtered from sediments, and is of significant commercial and aquaculture importance (Figure 18).

Maximum length: 75 cm; **Maximum weight:** 12 kg.



Figure 18. *Mugil cephalus*

14. Thornback ray (*Raja clavata*)**Family:** Rajidae; **Genus:** *Raja*.

This benthic ray species is one of the most common rays in the Black Sea, including the Romanian coastal zone. It inhabits sandy, muddy, or gravelly bottoms, usually between 10 and 60 m deep, but can occur down to about 300 m. The body is rhomboid with broad, pointed pectoral fins, a short snout, and a long tail lined with rows of sharp thorns. The dorsal surface is brown or gray, mottled with pale and dark spots for camouflage, while the underside is pale (Figure 19).

Maximum length: 150 cm **Maximum weight:** 8 kg.



Figure 19. *Raja clavata*

15. Common stingray (*Dasyatis pastinaca*)

Family: Dasyatidae; **Genus:** *Dasyatis*.

This demersal stingray is widely distributed in the eastern Atlantic, Mediterranean, and Black Sea, including the Romanian coast. It inhabits sandy, muddy, or mixed substrates in shallow coastal waters, often between 5 and 60 m deep. Its body is diamond-shaped with rounded corners, a smooth dorsal surface, and a long, whip-like tail equipped with one or more venomous spines used for defense. The dorsal coloration is uniform brown or gray, while the underside is pale (Figure 20).

Maximum length: 200 cm; **Maximum weight:** 16 kg.



Figure 20. *Dasyatis Pastinaca*

Native, Endemic, and Threatened Species

In this ecosystem, numerous native and regionally distinct species occur, with fish and marine mammals representing key examples:

The Black Sea supports a wide range of native species that have adapted to its brackish waters and semi-enclosed conditions. Among fish, native representatives include anchovy (*Engraulis*

NEXT Black Sea Basin

encrasicolus), sprat (*Sprattus sprattus*), red mullet (*Mullus barbatus ponticus*), and the commercially important turbot (*Scophthalmus maeoticus*). The basin also hosts naturally occurring shark species such as the spiny dogfish (*Squalus acanthias*).

1. Red mullet (*Mullus Barbatus*)

Family: Mullidae; **Genus:** Mullus

This demersal fish is widely distributed in the eastern Atlantic, the Mediterranean Sea, and the Black Sea, including coastal areas of the Black Sea basin. It inhabits sandy, muddy, or gravel bottoms on the continental shelf, usually at depths of about 15-30 m but sometimes reaching depths of up to 300 m. The body is elongated and laterally compressed, with a short, steep snout and a small mouth positioned on the underside of the head. Two long barbels on the chin act as sensory organs used to detect prey on the seabed. The coloration is generally reddish-pink with a silvery belly and pale yellow fins. It feeds mainly on small benthic invertebrates such as worms, crustaceans, and mollusks (Figure 21).

Maximum length: 30 cm; **Maximum weight:** 1 kg

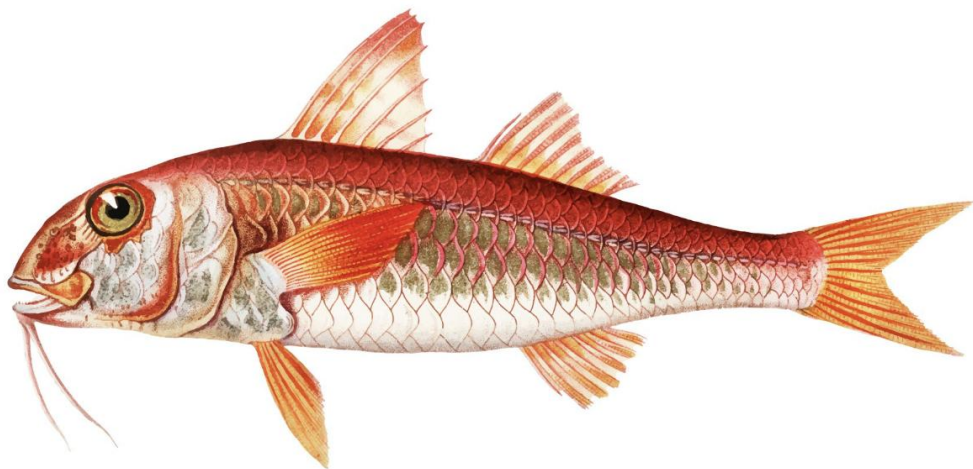


Figure 21. Mullus Barbatus

Native marine mammals are represented by three cetaceans: the harbour porpoise, the bottlenose dolphin, and the common dolphin – all occurring as distinct Black Sea subspecies. In addition, benthic communities include native mussels (*Mytilus galloprovincialis*) and various polychaetes, crustaceans, and mollusks that form essential components of coastal ecosystems. Planktonic communities, dominated by diatoms, dinoflagellates, and copepods, also play a crucial role in sustaining the region's overall productivity.

NEXT Black Sea Basin

2. Mediterranean Mussel (*Mytilus galloprovincialis*)

Family: Mytilidae; Genus: *Mytilus*

This marine bivalve is native to the Mediterranean Sea, the Black Sea, and parts of the eastern Atlantic, although it has been introduced to many regions worldwide through shipping and aquaculture. It commonly inhabits rocky coasts, harbours, estuaries, and other hard substrates in the intertidal zone and shallow coastal waters, usually down to about 40 m depth. The species forms dense colonies and attaches firmly to rocks or other surfaces using strong byssal threads. Its shell consists of two equal valves that are smooth and wedge-shaped, typically dark blue, brown, or almost black, sometimes with violet hues. Mediterranean mussels are filter feeders that consume phytoplankton and suspended organic particles from the water (Figure 22).

Maximum length: 15 cm; Typical size: 5-8 cm

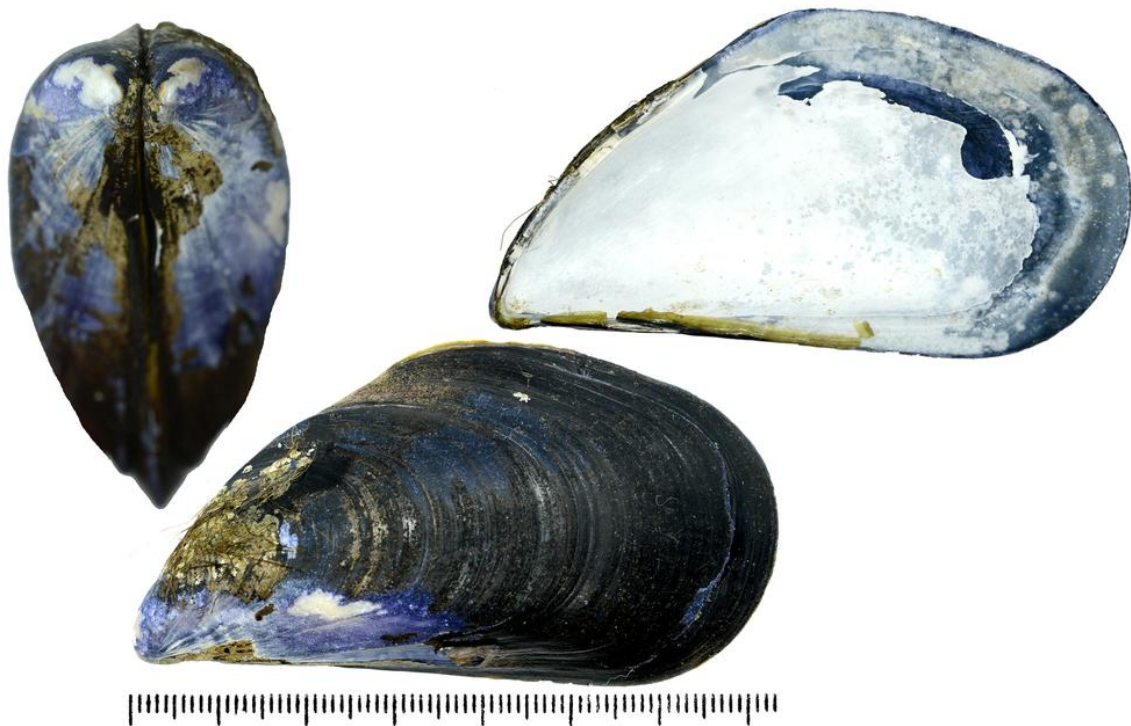


Figure 22. *Mytilus galloprovincialis*

Threatened and endemic species of the Black Sea in Romanian waters highlight the ecosystem's vulnerability and the urgent need for strong conservation measures. Among marine vertebrates, all three Black Sea cetaceans – the harbour porpoise (*Phocoena phocoena relicta*), the common dolphin (*Delphinus delphis ponticus*), and the bottlenose dolphin (*Tursiops truncatus ponticus*) – are endemic subspecies and face increasing pressure from bycatch, pollution, and habitat degradation. Several native sturgeon species, including the beluga, the stellate sturgeon, and the Russian sturgeon, are now critically endangered due to overfishing, poaching, and the disruption of natural spawning routes. Within benthic communities, certain endemic mollusks and crustaceans adapted to the Black Sea's low-salinity environment are threatened by invasive

NEXT Black Sea Basin

species and environmental changes. Together, these endangered and endemic species serve as key indicators of the ecological health of Romania's marine ecosystems and underscore the need for continued protection and restoration efforts.

3. Harbour porpoise (*Phocoena phocoena relicta*)

Family: Phocoenidae; **Genus:** Phocoena.

This small marine mammal is present in the Black Sea, where a distinct subspecies, *Phocoena phocoena relicta*, occurs. It inhabits coastal and shelf waters and is often found in relatively shallow areas. The body is small and robust, with a rounded head lacking a distinct beak and a small triangular dorsal fin positioned slightly behind the middle of the back. Its coloration is dark grey on the dorsal side, becoming lighter on the sides and white on the underside. Harbour porpoises are usually observed alone or in small groups and feed mainly on small fish, as well as crustaceans and cephalopods (Figure 23).

Maximum length: 1.8 m; **Maximum weight:** about 90 kg.



Figure 23. *Phocoena phocoena relicta*

4. Common dolphin (*Delphinus delphis ponticus*)

Family: Delphinidae; **Genus:** Delphinus

In the Black Sea, the common dolphin occurs as a distinct population often referred to as *Delphinus delphis ponticus*. This energetic and highly social marine mammal has a slender body with a moderately long rostrum (beak) and a tall, curved dorsal fin. The coloration typically features a striking hourglass pattern on the sides, with a dark grey back, lighter grey flanks, and a pale or white belly, along with buffy-tan or yellowish panels near the front of the body. Common dolphins are usually seen in large groups and are known for their acrobatic behavior, including leaps and riding bow waves (Figure 24).

Maximum length: 2.4 m; **Maximum weight:** about 150 kg.



Figure 24. *Delphinus delphis ponticus*

5. Bottlenose dolphin (*Tursiops truncatus ponticus*)

Family: Delphinidae; **Genus:** Tursiops

In the Black Sea, bottlenose dolphins are represented by a distinct subspecies, *Tursiops truncatus ponticus*. This marine mammal inhabits coastal and continental shelf waters, including bays, lagoons, and estuaries, but can also occur offshore. It has a robust, streamlined body with a short, well-defined beak and a tall, curved dorsal fin located near the middle of the back. The coloration is generally dark grey to bluish-grey on the back, lighter on the sides, and pale grey or white on the belly. Bottlenose dolphins are usually observed in small groups and feed mainly on fish and other marine animals such as crustaceans and molluscs (Figure 25).

Maximum length: 3.2 m; **Maximum weight:** about 200 kg



Figure 25. *Tursiops truncatus ponticus*

The introduction of non-native species has significantly altered trophic interactions:

***Mnemiopsis leidyi*:** Disrupts zooplankton populations and fish recruitment.

NEXT Black Sea Basin

Veined rapa whelk (*Rapana venosa*): competes with native benthic mollusks and preys on bivalves, modifying benthic food webs.

These alien species have caused cascading ecological impacts and contributed to the decline of native biodiversity.

Commercial fisheries in the Black Sea rely heavily on a few key species:

- Pelagic: anchovy, sprat, horse mackerel.
- Demersal: turbot, red mullet, whiting, spiny dogfish.
- Invertebrates: Mediterranean mussel.

These species not only support local economies but also serve as vital links in the food web, transferring energy from plankton to higher trophic levels such as marine mammals and seabirds. Overexploitation of these stocks threatens ecosystem stability.

6. Comb jelly (*Mnemiopsis leidyi*)

Family: Mnemiidae; **Genus:** Mnemiopsis

Mnemiopsis leidyi is a species of comb jelly (ctenophore) commonly found in marine and brackish waters. It has a transparent, gelatinous body that resembles a jellyfish but belongs to a different animal group. The body is oval or walnut-shaped and laterally compressed, with eight rows of ciliated plates called “combs” that help the organism move through the water. These comb rows can reflect light and sometimes produce a green glow at night. The species has two large oral lobes used to capture prey such as zooplankton, fish eggs, and larvae. It inhabits coastal waters, bays, estuaries, and shallow seas, where it can form large populations in the plankton. Originally native to the western Atlantic Ocean, it was introduced to the Black Sea through ship ballast water and spread rapidly in this region (Figure 26).

Maximum length: about 10-12 cm



Figure 26. *Mnemiopsis leidyi*

NEXT Black Sea Basin

7. *Rapana venosa*

Family: Muricidae; Genus: *Rapana*

Rapana venosa is a large predatory marine gastropod commonly found in coastal and shelf waters, including sandy and rocky seabeds and shallow marine habitats. This sea snail has a heavy, globose shell with a short conical spire and a large body whorl. The shell surface shows spiral ridges and often dark vein-like patterns. Its coloration varies from grey to reddish-brown, while the inside of the shell aperture is usually bright orange or yellow. This species is carnivorous and feeds mainly on other molluscs, especially bivalves such as mussels, oysters, and clams. It is native to the western Pacific Ocean but has spread to other regions, including the Black Sea, where it has become a common and sometimes invasive species (Figure 27).

Maximum shell length: about 16-18 cm



Figure 27. *Rapana venosa*

2.3.2. Key Ecosystems and Habitats

1. Pelagic habitats

The pelagic zone of the Black Sea refers to the open-water column extending from the surface down to the depth where sunlight is insufficient for photosynthesis. Unlike benthic areas, it is structured dynamically by the water column itself rather than the seabed. This expansive zone supports a wide range of organisms—including phytoplankton, zooplankton, and free-swimming fish—all of which are essential for marine food webs and nutrient cycling.

NEXT Black Sea Basin

Along Romania's coast, the pelagic zone is dominated by planktonic communities that form the foundational trophic level of the marine food web.

- **Phytoplankton dynamics:** Species such as *Coscinodiscus*, *Chaetoceros*, and *Ceratium* serve as primary producers, exhibiting distinct seasonal changes in abundance and composition. Recent monitoring (2019-2023) indicates that while occasional algal blooms still occur, they are generally less intense than the severe, eutrophication-driven blooms observed in the late 20th century. This shift reflects a broader transformation in phytoplankton structure and localized improvements in nutrient management (Silkin et al., 2021).
- **Zooplankton and invasive pressures:** Zooplankton, including copepods (*Acartia clausi*, *Calanus euxinus*) and cladocerans, act as the primary food source for larval and small pelagic fish. However, the ecosystem remains vulnerable to the invasive ctenophore *Mnemiopsis leidyi*, which historically altered the pelagic food web. By aggressively preying on zooplankton, fish eggs, and larvae, *M. leidyi* indirectly impacts the recruitment and stock viability of commercially important species, such as the European anchovy (*Engraulis encrasicolus*) and sprat (*Sprattus sprattus*) (Kideys, 1994; Langmead et al., 2009).

2. Pelagic Fish and Ecosystem Health

The upper trophic levels of the Romanian Black Sea rely heavily on the stability of these planktonic foundations.

- **Key species:** Significant pelagic fish species include the Atlantic mackerel (*Scomber scombrus*), a migratory predator that transfers energy between trophic levels, and the bluefish (*Pomatomus saltatrix*), which acts as a top-down regulator of prey populations.
- **Driving pressures:** The overall health and resilience of the pelagic ecosystem are heavily dependent on a delicate balance of nutrient levels, seasonal fluctuations in temperature and salinity, and the mitigation of anthropogenic pressures. Factors such as nutrient runoff, pollution, and historic overfishing have drastically altered the pelagic food web in recent decades, necessitating ongoing conservation and socio-ecological management strategies (Langmead et al., 2009).

a. Coscinodiscus

Family: Coscinodiscaceae; **Genus:** Coscinodiscus

Coscinodiscus is a genus of marine centric diatoms commonly found in oceans and coastal waters around the world. These microscopic algae are part of the phytoplankton community and play an important ecological role as primary producers in aquatic ecosystems. Cells are typically circular and disc-shaped, showing radial symmetry and a highly ornamented silica cell wall (frustule). The valve surface is usually flat or slightly convex and covered with numerous regularly arranged pores (areolae) radiating from the center. Species of this genus often contain several discoid chloroplasts that allow them to perform photosynthesis. Members of *Coscinodiscus* can occur as solitary cells and are an important food source for various marine organisms (Figure 28).

NEXT Black Sea Basin

Maximum diameter: up to about 500 μm



Figure 28. *Coscinodiscus*

b. Chaetoceros

Family: Chaetocerotaceae; **Genus:** Chaetoceros

Chaetoceros is a genus of centric marine diatoms widely distributed in oceans and coastal waters around the world. These microscopic algae are an important component of marine phytoplankton and play a significant role in primary production and marine food webs. Cells are typically rectangular in side view and elliptical to circular in valve view, and they are surrounded by a silica cell wall (frustule). A distinctive feature of this genus is the presence of four long, thin bristles called setae that extend from the corners of each cell. These setae often interlock with those of neighbouring cells, forming chains or colonies of varying lengths. Species of *Chaetoceros* perform photosynthesis and commonly occur in the upper sunlit layers of the water column, where they may form large plankton blooms and serve as food for many marine organisms such as copepods and other zooplankton (Figure 29).

Maximum cell size: about 2-85 μm diameter



Figure 29. *Chaetoceros*

c. Ceratium

Family: Ceratiaceae; **Genus:** *Ceratium*

Ceratium is a genus of unicellular dinoflagellate algae commonly found in marine and freshwater environments around the world. These microscopic organisms are an important component of plankton communities and contribute to primary production in aquatic ecosystems. Cells are typically elongated and asymmetrical, with a distinctive armoured covering composed of plates forming the cell wall (theca). A characteristic feature of this genus is the presence of horn-like projections: usually one anterior horn and two or three posterior horns, which help the cells remain suspended in the water. Species of *Ceratium* contain chromatophores with yellow, brown, or green pigments used for photosynthesis and possess two flagella that allow them to move through the water. Some species can form large blooms and may contribute to red tide events in marine environments (Figure 30).

Maximum length: about 20-200 µm.



Figure 30. *Ceratium*

d. *Acartia clausi*

Family: Acartiidae; **Genus:** *Acartia*

Acartia clausi is a species of small marine copepod commonly found in coastal and shelf waters, including bays, estuaries, and brackish environments. This microscopic crustacean is an important component of zooplankton communities and plays a key role in marine food webs. The body is elongated and transparent, divided into several segments, and equipped with long antennae and swimming appendages that allow the organism to move through the water. A characteristic feature of this species is a row of small spines located at the rear margin of the metasome. *Acartia clausi* feeds mainly on phytoplankton and small suspended particles, acting as a suspension feeder, and it is an important food source for fish larvae and other marine organisms. The species is distributed mainly in coastal regions of the northeastern Atlantic Ocean, the Mediterranean Sea, and the Black Sea (Figure 31).

Maximum length: about 1-1.5 mm



Figure 31. *Acartia clausi*

e. *Calanus euxinus*

Family: Calanidae; **Genus:** Calanus

Calanus euxinus is a species of marine copepod widely distributed in the pelagic waters of the Black Sea and the Sea of Marmara. This small crustacean is an important component of the zooplankton community and represents a major part of the zooplankton biomass in these regions. The body is elongated and segmented, with long antennae and swimming appendages that help the organism move through the water column. The species contains large lipid reserves that serve as an energy source and allow it to survive periods of low food availability. *Calanus euxinus* feeds mainly on phytoplankton and other microscopic particles and is a key food source for many fish species, especially small pelagic fish and fish larvae. Because of its abundance and ecological role, it is considered one of the most important species in the Black Sea marine food web (Figure 32).

Maximum length: about 3.5-3.7 mm



Figure 32. *Calanus euxinus*

f. Bluefish (*Pomatomus saltatrix*)

Family: Pomatomidae; **Genus:** Pomatomus

Pomatomus saltatrix is a marine pelagic fish commonly found in temperate and subtropical coastal waters around the world, including the Mediterranean Sea and the Black Sea. It inhabits coastal and offshore waters, often near beaches, rocky headlands, and estuaries, and may occasionally enter brackish environments. The body is elongated and streamlined, with a large mouth and strong jaws lined with sharp, conical teeth. The coloration is typically greenish-blue or steel-blue on the back, fading to silvery on the sides and belly. This species usually forms schools, especially when young, and is known as a fast and aggressive predator that feeds mainly on smaller fish, as well as crustaceans and cephalopods. Because of its predatory behavior and wide distribution, it plays an important role in marine food webs and is also valued in commercial and recreational fisheries (Figure 33).

Maximum length: about 120-130 cm; **Maximum weight:** about 14 kg

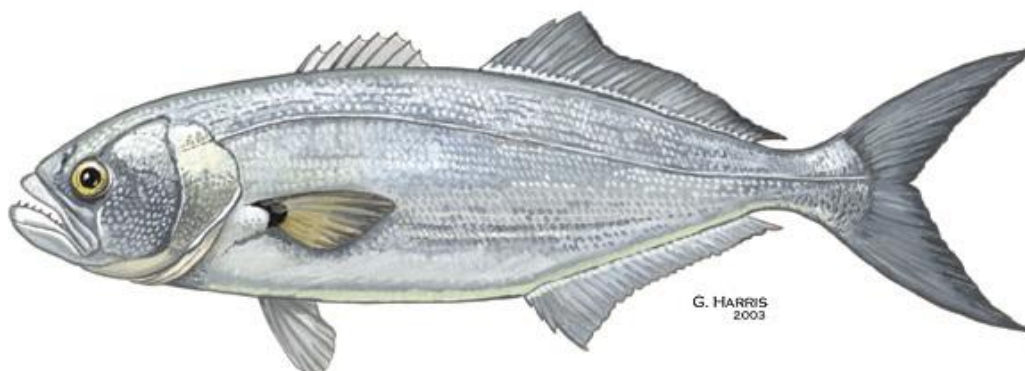


Figure 33. Bluefish (*Pomatomus saltatrix*)

NEXT Black Sea Basin

3. Benthic habitats

The benthic zone encompasses the seabed, including sediment surfaces and sub-surface layers. It supports organisms living on, in, or near the seabed, such as benthic invertebrates, demersal fish, and sessile species. Benthic habitats are crucial for nutrient cycling, sediment stabilization, and providing feeding grounds for higher trophic levels. Romania's benthic habitats are highly diverse, ranging from sandy and muddy substrates to rocky outcrops and seagrass (*Zostera marina*). These habitats host benthic invertebrates such as polychaetes, mollusks, and crustaceans, as well as juvenile demersal fish, all contributing to ecosystem function and energy transfer. Key benthic species include turbot (*Scophthalmus maeoticus*), a top demersal predator; red mullet (*Mullus ponticus*), a benthic forager contributing to nutrient cycling; and benthic bivalves (*Mytilus galloprovincialis*), filter-feeders that improve water quality and provide habitat for microfauna. Diversity and abundance vary with substrate type and human disturbance. Recent studies identified seven distinct habitats along the Romanian Black Sea coast, with communities often dominated by polychaetes and crustaceans in terms of density and mollusks in terms of biomass. Multivariate biotic indices, such as M-AMBI(n), are used to assess the cumulative impact of anthropogenic pressures, including eutrophication, pollution, and physical disturbance from fishing.

a. Eelgrass (*Zostera marina*)

Family: Zosteraceae; **Genus:** *Zostera*

Zostera marina is a marine flowering plant commonly known as eelgrass, widely distributed in temperate and subarctic coastal waters of the Northern Hemisphere. It grows submerged in shallow marine environments such as bays, estuaries, lagoons, and sheltered coastal areas, where it forms dense underwater meadows. The plant has long, narrow, ribbon-like leaves that are bright to dark green and arise from creeping rhizomes that anchor it in sandy or muddy sediments. These rhizomes allow the plant to spread across the seabed and form extensive beds. Eelgrass performs photosynthesis and plays an important ecological role by stabilizing sediments, improving water quality, and providing habitat and nursery grounds for many fish, crustaceans, and other marine organisms (Figure 34).

Maximum leaf length: up to about 1-2 m.

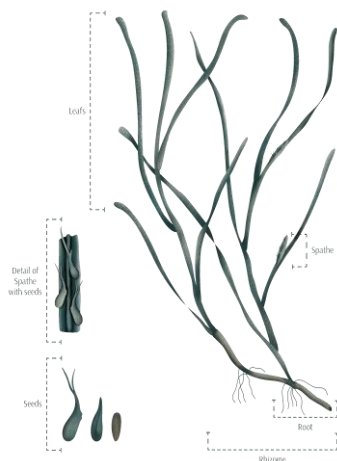


Figure 34. *Zostera marina*

2.3.3. National Inventories and Monitoring

National inventories and monitoring programs are essential tools for understanding, conserving, and managing marine biodiversity. These programs systematically document species composition, abundance, and distribution, as well as the condition of habitats and ecological processes. By collecting both biotic data—covering species from plankton and invertebrates to fish and marine mammals—and abiotic data, including water quality, salinity, temperature, and nutrient levels, monitoring programs provide a holistic understanding of ecosystem health and dynamics.

Continuous monitoring allows the detection of long-term trends and seasonal variations, as well as the early identification of ecological disturbances, such as pollution events, habitat degradation, climate-induced changes, or the introduction of invasive species. These programs form the foundation for evidence-based management, enabling policymakers to establish conservation priorities, evaluate the effectiveness of protective measures, and adjust strategies when necessary.

National inventories also play a crucial role in creating baseline datasets for research and assessment. By maintaining detailed and standardized records, countries can compare ecological data across regions and over time, facilitating regional collaboration and integration into international marine biodiversity assessments. Such integration is particularly important in semi-enclosed seas like the Black Sea, where cross-border cooperation is necessary to monitor shared marine resources effectively and implement coordinated conservation measures.

Moreover, monitoring programs contribute to a better understanding of ecosystem resilience and the interdependence of species within food webs. By tracking changes in species populations, reproductive success, and habitat condition, these inventories provide insights into ecosystem functioning and the potential consequences of human impacts, including overfishing, coastal development, and pollution.

In addition to informing management and conservation policies, national inventories and monitoring initiatives enhance public awareness and scientific knowledge. The collected data support research, education, and outreach programs, promoting the sustainable use of marine resources while ensuring that biodiversity conservation objectives are met. Ultimately, robust monitoring and inventories are indispensable for safeguarding marine ecosystems, maintaining ecological balance, and supporting long-term sustainability in the face of ongoing environmental pressures.

In Romania, the implementation of these critical monitoring goals is largely coordinated by the National Institute for Marine Research and Development "Grigore Antipa" (NIMRD). Serving as the technical operator of the national marine monitoring network, NIMRD systematically tracks physical, chemical, and biological parameters to meet the strict obligations of the EU Marine Strategy Framework Directive (MSFD) and the Water Framework Directive (WFD). The biological components continuously monitored include phytoplankton, zooplankton, phytobenthos, and

NEXT Black Sea Basin

macrobenthos, which function as vital bioindicators. These multi-trophic assessments allow researchers to evaluate whether the Romanian marine waters are achieving Good Environmental Status (GES) by analyzing biodiversity thresholds, species abundance, and the structural integrity of marine food webs (Nicolaev & Zaharia, 2020).

Recently, NIMRD's monitoring programs have significantly evolved to address complex regional challenges and historical data gaps. For example, assessment protocols have been expanded beyond the coastal and transitional zones—which are heavily influenced by the nutrient inputs of the Danube River—to encompass deeper offshore waters. Extending systematic monitoring into these offshore regions provides a much-needed integrated assessment of hazardous substance contamination and ecological health across the broader Romanian marine ecosystem, contributing directly to basin-wide MSFD compliance (Oros et al., 2024). Furthermore, the national inventory actively categorizes a wide array of anthropogenic pressures that threaten the semi-enclosed Black Sea basin. By utilizing standardized WFD and MSFD methodologies, researchers map pollution sources, physical habitat loss, hydrocarbon introductions, and the proliferation of non-indigenous species. This rigorous inventory allows for the prioritization of specific environmental pressures under various management scenarios, ensuring that local policymakers can implement adaptive and targeted conservation strategies (Lazar et al., 2024). The comprehensive data gathered through both coastal and offshore monitoring expeditions is synthesized annually in the *Report on the State of the Romanian Marine and Coastal Environment*. This document not only serves as the definitive baseline for national conservation policies but also feeds directly into the European Environmental Agency's broader assessments, ensuring that the ecological dynamics of the Romanian Black Sea are accurately represented in international marine governance.

Transboundary cetacean monitoring programs:

Because highly mobile apex predators do not adhere to geopolitical boundaries, national biodiversity inventories in Romania heavily rely on collaborative, cross-border monitoring efforts. A prominent example is the continuous assessment of the three endemic and threatened cetacean species in the region: the Black Sea harbour porpoise (*Phocoena phocoena relicta*), the bottlenose dolphin (*Tursiops truncatus ponticus*), and the common dolphin (*Delphinus delphis ponticus*). Protecting these species requires basin-wide strategies, as their movements are tightly linked to the seasonal migrations of pelagic fish stocks and varying environmental conditions across the semi-enclosed sea.

Coordinated by the Romanian NGO Mare Nostrum alongside a consortium of institutional partners, projects like CeNoBS (in synergy with the ACCOBAMS Survey Initiative) have executed the most extensive aerial surveys of marine megafauna in the Black Sea basin to date. By employing internationally validated line-transect distance-sampling methodologies, researchers assessed cetacean abundance and distribution across the territorial waters of Romania, Bulgaria, Ukraine, Turkey, and Georgia simultaneously.

NEXT Black Sea Basin

Covering over 7,000 kilometers of survey transects, these flights established critical baseline data for Descriptor 1 (Biodiversity) of the Marine Strategy Framework Directive (MSFD). The surveys revealed stark differences in species distribution; for instance, bottlenose dolphins were observed in significantly lower numbers compared to harbour porpoises and common dolphins, underscoring their heightened vulnerability to habitat degradation and prey depletion (Paiu et al., 2021; Popov et al., 2024). Furthermore, the simultaneous recording of marine litter and maritime traffic during these flights provided a holistic view of the overlapping anthropogenic pressures these cetaceans face.

While aerial and vessel-based visual surveys provide excellent spatial coverage, they are inherently limited by daylight, weather conditions, and high operational costs. To overcome these constraints, the **BlackCeTrends** initiative introduced advanced Passive Acoustic Monitoring (PAM) utilizing next-generation **F-POD** (Full waveform capture Pod) dataloggers along the Romanian coast.

Deployed at key coastal stations—including shallow-water habitats near Mamaia, Constanța, Agigea, and Mangalia—these autonomous devices continuously scan for the high-frequency echolocation clicks of cetaceans. The F-PODs are uniquely capable of processing millions of audio samples per second, isolating the narrow-band high-frequency (NBHF) clicks characteristic of harbour porpoises from the broadband clicks of dolphins. This technology allows researchers to collect thousands of hours of unbiased data across all four seasons (Paiu et al., 2023).

By analyzing the inter-click intervals and "foraging buzzes" captured by the F-PODs, marine biologists can identify diurnal feeding patterns and seasonal residency that visual surveys miss. This continuous tracking is especially vital in nutrient-rich but heavily trafficked areas, such as the coastal waters influenced by the Danube River plume. Ultimately, integrating acoustic telemetry with visual inventories enables Romania to evaluate the impact of underwater noise (MSFD Descriptor 11), accurately map critical habitats, and design targeted mitigation strategies to reduce incidental bycatch in regional fisheries (Gol'din et al., 2021; Mare Nostrum, 2024).

Benthic habitat and Marine Protected Area (MPA) assessment:

Monitoring the integrity of benthic communities is another critical component of Romania's national inventory, particularly within the expanding Natura 2000 network. Because benthic organisms are largely sessile or possess limited mobility, they cannot escape localized environmental changes. As a result, they act as highly reliable bioindicators that reflect long-term environmental conditions and the cumulative impact of anthropogenic stressors.

Research institutes such as the National Institute of Marine Geology and Geo-ecology (GeoEcoMar) and NIMRD conduct regular, high-resolution evaluations of sensitive seabed habitats. Modern inventories have moved beyond traditional SCUBA diving transects and grab sampling; today, researchers employ advanced remote sensing technologies, including multibeam echosounders, side-scan sonar, and Remotely Operated Vehicles (ROVs). These tools

NEXT Black Sea Basin

allow for precise bathymetric mapping and the non-destructive visual assessment of biogenic structures and deep-water benthic cover across the Romanian shelf (Teacă et al., 2020).

A primary focus of these monitoring efforts is the preservation of rare and highly structured habitats, such as the *Cystoseira* (recently taxonomically updated to genera such as *Gongolaria* and *Ericaria*) macroalgal canopy reefs and the submerged rocky landscapes of the Vama Veche - 2 Mai Marine Reserve. These canopy-forming algae serve as "ecosystem engineers," providing essential nursery grounds, oxygen, and shelter for numerous marine species. However, they are highly susceptible to reduced water transparency and eutrophication. Monitoring initiatives track the decline or potential recovery of these phytobenthic communities, while also quantifying the impact of invasive species. For example, continuous assessments monitor the predatory veined rapa whelk (*Rapana venosa*), documenting its structural alteration of the native mussel beds (*Mytilus galloprovincialis*) that naturally filter coastal waters (Micu et al., 2019). To ensure these benthic assessments are robust and standardized across geopolitical borders, national initiatives are closely integrated with regional collaborative projects such as MISIS (MSFD Guiding Improvements in the Black Sea Integrated Monitoring System) and ANEMONE (Assessing the vulnerability of the Black Sea marine ecosystem to human pressures). These transboundary projects have been instrumental in harmonizing benthic sampling methodologies and adopting unified biotic indices—such as the Black Sea-specific AMBI (AZTI Marine Biotic Index). By calculating these indices, researchers can quantitatively categorize the "Seafloor Integrity" (MSFD Descriptor 6) of different coastal sectors (Begun et al., 2021).

Ultimately, the comprehensive data yielded by these benthic inventories provides the necessary scientific evidence to justify the expansion of MPAs and the designation of new Sites of Community Importance (SCIs), such as the marine areas of Cape Tuzla and Mangalia. Furthermore, detailed spatial mapping of sensitive habitats is crucial for maritime spatial planning and the enforcement of stricter regional fishing regulations, including the restriction of bottom-disturbing fishing gears (like bottom trawls and dredges) in ecologically vulnerable zones, thereby supporting the long-term resilience of the Romanian coastal ecosystem.

Integrating research innovations: DOORS, BRIDGE-BS, and MSFD evolution:

The monitoring landscape in the Romanian Black Sea is continuously evolving, moving beyond localized, independent assessments toward highly integrated, pan-European frameworks. This shift is largely driven by large-scale Horizon 2020 research initiatives designed to consolidate fragmented marine data into accessible, predictive models that support both biodiversity conservation and sustainable blue growth.

Horizon 2020 flagships: DOORS and BRIDGE-BS:

Two of the most prominent flagship initiatives directly impacting Romanian marine biodiversity monitoring are the DOORS (Developing Optimal and Open Research Support for the Black Sea) and BRIDGE-BS (Advancing Black Sea Research and Innovation to Support Blue Growth) projects.

NEXT Black Sea Basin

Running concurrently, these programs aim to operationalize the Black Sea Strategic Research and Innovation Agenda (SRIA) by enhancing capacity and standardizing methodologies across all riparian states.

- **DOORS** was coordinated by the Romanian institute GeoEcoMar, DOORS focuses on integrating existing marine observing systems—such as those maintained by national institutes and EuroGOOS—into a unified "System of Systems." A critical innovation introduced through DOORS is the foundational framework for the Black Sea Digital Twin Ocean. By harmonizing biotic and abiotic data across international borders, DOORS provides the vital digital infrastructure required to model complex ecosystem responses to pollution and climate change, directly upgrading national monitoring capabilities (DOORS Consortium, 2024).
- **BRIDGE-BS:** operating in synergy with DOORS, BRIDGE-BS focuses on developing sophisticated predictive tools capable of assessing the compounding impacts of multi-stressors. Because the Black Sea is heavily impacted by climate-induced hypoxia, nutrient overloading, and overfishing, BRIDGE-BS utilizes an ecosystem-based management approach to map how these stressors alter biodiversity and ecosystem services. By translating raw monitoring data into actionable scenarios, BRIDGE-BS bridges the gap between scientific observations and the regulatory frameworks needed to maintain a "safe operating space" for coastal communities (BRIDGE-BS, 2025).

The data, modelling tools, and collaborative networks established by initiatives like DOORS, BRIDGE-BS, and ANEMONE continuously feed into the regulatory backbone of Romania's marine management: the Marine Strategy Framework Directive (MSFD) monitoring program. Historically, Romania's MSFD reporting relied heavily on retrospective assessments—measuring parameters after an environmental change had occurred. However, bolstered by these Horizon 2020 innovations, the national MSFD program is becoming highly proactive. Recent updates to the national monitoring framework emphasize real-time data acquisition, high-frequency continuous observations, and rigorous cross-border intercalibration of biological indicators (such as zooplankton biomass and phytoplankton bloom dynamics). By leveraging transboundary predictive models, Romania can now forecast the cumulative outcomes of anthropogenic stressors across all 11 MSFD Qualitative Descriptors. This evolutionary step ensures that national inventories do not merely record the state of the Black Sea, but actively simulate future scenarios—allowing policymakers to implement adaptive, preemptive conservation measures that safeguard marine biodiversity against rapidly changing environmental dynamics (Oros et al., 2024).

Enhancing monitoring through regional and cross-border programs:

In addition to flagship Horizon 2020 initiatives, Romania's marine inventory and monitoring capabilities are heavily supported by targeted cross-border cooperation programs and European data networks. These projects focus on specific environmental pressures—such as pollution dispersion, invasive species, and spatial conflicts—ensuring that monitoring data translates into practical, cross-regional management tools.

NEXT Black Sea Basin

To address the increasing spatial overlap between human activities and vulnerable marine habitats, Romania and Bulgaria have collaborated extensively through the **MARSPLAN-BS** (Cross-Border MARitime Spatial PLANning in the Black Sea) projects, funded by the European Maritime and Fisheries Fund (EMFF).

With NIMRD serving as a key scientific partner, MARSPLAN-BS created the first institutional framework for cross-border maritime spatial planning between the two EU member states in the Black Sea. By integrating biodiversity monitoring data with maps of human activities (such as aquaculture, maritime transport, and energy infrastructure), the project established detailed spatial inventories. These inventories are vital for minimizing the ecological footprint of the "Blue Economy" on sensitive benthic habitats and marine protected areas in the transboundary coastal zone.

Modern monitoring in Romania increasingly relies on integrating traditional sampling with remote sensing and automated predictive technologies to track environmental shifts in real-time.

- **EO4SIBS (Earth Observation Data for Science and Innovation in the Black Sea):** Supported by the European Space Agency (ESA), this project enhances the monitoring of the Black Sea's surface parameters. By utilizing satellite data to track sea surface temperature, chlorophyll-*a* concentrations, and coastal currents, EO4SIBS helps Romanian researchers detect the early onset of harmful algal blooms (eutrophication) and map the large-scale spatial distribution of phytoplankton, providing critical early-warning data for maintaining Good Environmental Status (GES).
- **SYROCO (System for Romanian Coastal Monitoring):** Jointly developed by Romanian scientific networks and NIMRD under the Copernicus Marine Service framework, SYROCO acts as a high-resolution early warning system. It specifically tracks the dispersion of land-based pollutants—such as nutrient run-off and microbiological contaminants—within the coastal zone. This tool is crucial for protecting local aquaculture and coastal biodiversity from sudden pollution events. Monitoring the introduction and spread of non-indigenous and invasive species is one of the most pressing challenges for Black Sea biodiversity.
- **The IASON Project:** Funded under the ENI CBC Black Sea Basin Programme, IASON (Invasive Alien Species Observatory and Network Development) specifically targets the assessment of climate-induced risks to biodiversity in the Black Sea's deltaic protected areas, particularly the Danube Delta. By establishing a joint observatory network with partners in Romania, Ukraine, and Georgia, the project monitors how climate change facilitates the establishment of invasive alien species, providing crucial data for regional risk assessment.
- **EMODnet (European Marine Observation and Data Network):** To ensure that national inventories are accessible and standardized, Romanian institutes are heavily integrated into EMODnet. NIMRD acts as a regional leader for the Black Sea in *EMODnet Chemistry* and contributes extensively to *EMODnet Biology* and *Bathymetry*. By continuously uploading local monitoring data regarding heavy metals, marine litter, and species abundance into this centralized European database, Romania ensures that the ecological

NEXT Black Sea Basin

state of its marine environment contributes to global ocean governance and large-scale biodiversity assessments.

THREATS TO BIODIVERSITY

3.1. Türkiye

3.1.1. Overfishing and IUU Fishing

Overfishing has become one of the most significant anthropogenic pressures affecting marine ecosystems worldwide. It occurs when fish are harvested at a rate that exceeds their natural capacity for growth, reproduction, and population recovery. Under such conditions, fish stocks gradually decline, age and size structures are altered, reproductive potential decreases, and the long-term sustainability of fisheries is compromised. The Black Sea is particularly vulnerable to overfishing due to its semi-enclosed nature, limited water exchange with adjacent seas, and relatively low biological resilience. Throughout the last several decades, increasing fishing capacity, technological advancements, and expanding market demand have substantially intensified fishing pressure on commercially valuable species. Unlike natural environmental fluctuations, overfishing directly alters the structure and functioning of marine ecosystems. Declines in predator populations modify trophic interactions, reduce biodiversity, and affect ecosystem stability. Consequently, the impacts of excessive fishing extend far beyond target species and influence the overall ecological integrity of the Black Sea.

The ecological effects: The ecological effects of overfishing are manifested through several interconnected processes that influence marine ecosystem structure and function.

- a) **Decline in Fish Stock Biomass:** Continuous harvesting reduces the biomass of exploited populations. As spawning stocks decline, reproductive output decreases, limiting the capacity of fish populations to replenish themselves. Over time, recruitment becomes insufficient to compensate for fishing mortality, resulting in progressive stock depletion.
- b) **Changes in Population Structure:** Fishing activities generally target larger and older individuals because of their higher commercial value. Consequently, populations become dominated by younger and smaller fish. This shift reduces reproductive success because larger females typically produce significantly more eggs with higher survival rates than smaller individuals.
- c) **Alteration of Marine Food Webs:** Commercial fisheries frequently target top predators such as bluefish (*Pomatomus saltatrix*) and bonito (*Sarda sarda*). The reduction of these predators disrupts trophic interactions, leading to increased abundance of lower trophic-level species while altering the ecological balance of the ecosystem. This process, commonly referred to as "fishing down the food web," has been documented in numerous marine ecosystems worldwide and represents one of the principal ecological consequences of excessive fishing pressure.

NEXT Black Sea Basin

- d) Loss of Biodiversity: Persistent fishing pressure may result in local declines or even regional disappearance of vulnerable species. Reduced species diversity weakens ecosystem resilience, making marine communities less capable of recovering from additional environmental disturbances such as climate change, pollution, or invasive species.
- e) Habitat Degradation: Certain fishing methods, particularly bottom trawling, may cause physical damage to benthic habitats. Disturbance of seabed communities negatively affects benthic organisms, nursery grounds, and essential fish habitats, ultimately reducing ecosystem productivity.

Socioeconomic Impacts: The consequences of overfishing extend beyond ecological degradation and directly affect fisheries-dependent communities. Declining fish stocks reduce catch per unit effort (CPUE), forcing fishers to spend more time, fuel, and operational costs to harvest the same quantity of fish. This reduces economic efficiency and threatens the long-term viability of commercial fisheries. In addition, fluctuations in fish availability influence seafood markets, processing industries, export revenues, and employment opportunities throughout the fisheries sector. Sustainable fisheries management is therefore essential not only for biodiversity conservation but also for ensuring food security and maintaining the economic stability of coastal communities.

Sustainable Fisheries Management and Current Regulatory Framework

Transition toward Science-Based Fisheries Management : The increasing pressure on marine fish stocks in the Black Sea has highlighted the necessity of implementing more effective and science-based fisheries management strategies. During the past decade, Türkiye has progressively shifted from conventional fisheries regulations toward management approaches that incorporate stock assessments, ecosystem considerations, and adaptive decision-making.

The principal objective of contemporary fisheries management is not merely to maximize catches but to ensure that fish populations remain capable of sustaining long-term ecological functions while continuing to provide economic and social benefits.

In this context, Türkiye has introduced several regulatory measures designed to protect commercially important fish stocks, reduce fishing mortality, and improve the sustainability of marine fisheries.

Total Allowable Catch (TAC) System: One of the most significant developments in recent fisheries management has been the implementation of the **Total Allowable Catch (TAC)** system for selected commercial species, particularly anchovy. Under the TAC approach, annual harvest limits are determined according to scientific stock assessments rather than solely by fishing capacity or market demand. This management strategy aims to ensure that total removals remain within biologically sustainable limits while allowing fish populations sufficient opportunity to reproduce and replenish. The introduction of TAC represents an important step toward precautionary and science-based fisheries management in the Black Sea.

NEXT Black Sea Basin

Minimum Landing Size: Minimum landing size regulations constitute another fundamental conservation measure. These regulations prohibit the harvest of individuals below specified legal sizes, thereby allowing fish to reach sexual maturity and reproduce at least once before becoming vulnerable to commercial fishing. For species such as anchovy, bluefish, horse mackerel, and turbot, compliance with minimum landing size regulations contributes significantly to maintaining spawning biomass and improving long-term stock productivity. However, the effectiveness of these measures depends largely on enforcement, monitoring, and stakeholder compliance.

Seasonal Closures and Protected Areas: Seasonal fishing closures are widely recognized as one of the most effective management tools for protecting fish during spawning periods. By temporarily restricting fishing activities, these closures allow adult fish to reproduce successfully and support natural recruitment processes. In addition to temporal restrictions, certain ecologically sensitive areas may be designated as fisheries protection zones where fishing activities are either prohibited or strictly regulated. These spatial management measures contribute to habitat conservation, biodiversity protection, and long-term stock recovery.

Fishing Gear Regulations: Technical regulations governing fishing gear are intended to improve selectivity and minimize unwanted ecological impacts. Restrictions concerning mesh size, gear design, fishing depth, and operational methods help reduce the capture of juvenile fish and non-target species while minimizing habitat disturbance. Particularly in demersal fisheries, restrictions on bottom trawling contribute to the conservation of benthic ecosystems and essential fish habitats.

Ecosystem-Based Fisheries Management: Modern fisheries management increasingly adopts the principles of **Ecosystem-Based Fisheries Management (EBFM)**. Unlike traditional single-species management, EBFM considers ecological interactions among species, habitat integrity, biodiversity conservation, environmental variability, and climate change. Within the Black Sea ecosystem, ecosystem-based management is particularly important because changes affecting one commercially important species may influence multiple trophic levels and ecosystem processes. Consequently, sustainable fisheries management should integrate biological, ecological, economic, and social dimensions into a comprehensive decision-making framework.

Policy Recommendations: The future of Black Sea fisheries depends on maintaining a balance between ecological sustainability and socioeconomic development. Science-based decision-making, effective governance, regional cooperation, and responsible resource use are essential for ensuring that marine living resources continue to provide ecological, economic, and social benefits for future generations. The following policy recommendations are proposed to improve the long-term sustainability of Black Sea fisheries.

NEXT Black Sea Basin

- Strengthen Science-Based Fisheries Management
- Improve Monitoring, Control, and Surveillance
- Expand Ecosystem-Based Fisheries Management
- Protect Critical Habitats
- Reduce Juvenile Fish Harvest
- Promote Sustainable Fishing Technologies
- Enhance Regional Cooperation
- Address Climate Change Impacts
- Support Sustainable Aquaculture
- Final Statement

Evaluation of the Turkish Fishing Fleet: The fishing fleet constitutes one of the most important components determining the harvesting capacity of marine fisheries. In Turkey, significant technological developments have occurred in commercial fishing activities over the past twenty-five years. Although the total number of registered fishing vessels has gradually declined, the overall fishing capacity has continued to increase due to improvements in vessel size, engine power, electronic navigation systems, fish-finding technologies, and fishing gear efficiency (Figure 35).

Consequently, the number of fishing vessels alone is no longer an adequate indicator of fishing pressure. Modern fisheries assessments increasingly emphasize **fishing effort**, which integrates vessel characteristics, fishing duration, engine power, and technological capability.

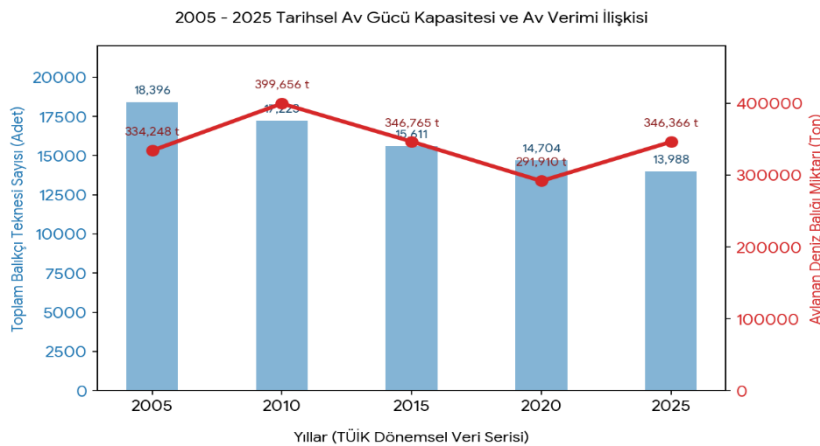


Figure 35. Changes in the number of fishing vessels and marine capture production in Türkiye (2000-2025).

Fishing Capacity and Technological Development: Technological innovation has substantially improved the efficiency of commercial fisheries. Modern fishing vessels are equipped with

NEXT Black Sea Basin

advanced sonar systems, GPS navigation, echo sounders, radar, satellite communication systems, hydraulic hauling equipment, and sophisticated fish detection technologies. These innovations have significantly increased catch efficiency while reducing the time required to locate fish schools. As a result, fishing mortality has increased even in periods when the number of vessels remained stable or declined. From a fisheries management perspective, technological advancement may therefore lead to "**hidden increases in fishing effort**," where actual harvesting pressure rises despite reductions in fleet size.

Catch per Unit Effort: One of the most widely used indicators for evaluating fish stock status is **Catch Per Unit Effort (CPUE)**. CPUE represents the quantity of fish harvested per standardized unit of fishing effort and is commonly used as an indirect indicator of stock abundance. A declining CPUE generally suggests that fish populations are becoming less abundant, requiring greater fishing effort to obtain equivalent catches. Conversely, stable or increasing CPUE values may indicate relatively healthy stock conditions, provided that fishing technology and operational practices remain comparable. Although CPUE has limitations, particularly when technological efficiency changes over time, it remains one of the most valuable indicators for long-term fisheries assessments.

Relationship between Fishing Capacity and Stock Decline: The data presented in Figure 7 indicate that reductions in fleet size have not necessarily resulted in lower fishing pressure. Improvements in vessel efficiency have largely compensated for the decrease in vessel numbers, allowing the fleet to maintain—or in some cases increase—its harvesting capacity. Meanwhile, marine capture production has exhibited considerable interannual variability together with a long-term tendency toward reduced stock availability for several commercially important species. This pattern suggests that **technological capacity has increased more rapidly than the natural productivity of fish populations**, creating an imbalance between harvesting pressure and the biological capacity of fish stocks to replenish themselves (Daskalov, 2002).

General Status of Commercial Fish Stocks: An analysis of fisheries statistics covering the last twenty-five years reveals that commercially important fish stocks in the Black Sea have experienced substantial changes. While some small pelagic species have exhibited temporary increases in abundance, many economically valuable species have shown long-term declining trends. These patterns indicate that the observed fluctuations are not merely the result of natural environmental variability but also reflect increasing fishing pressure, changes in ecosystem structure, and the cumulative effects of climate-related processes. Figures-7 and 8 demonstrate that the composition of marine catches has changed considerably over time, suggesting an increasing dependence of Turkish fisheries on a limited number of commercially dominant species (Figure 36).

NEXT Black Sea Basin

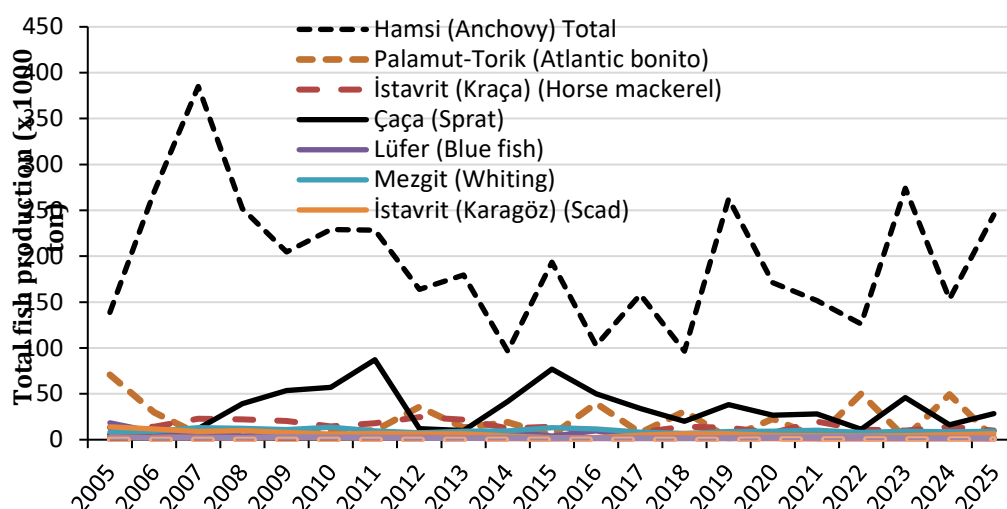


Figure 36. Annual catches of major commercial fish species in the Black Sea.

a) European Anchovy (*Engraulis encrasicolus*): The European anchovy is the dominant pelagic fish species in the Black Sea and represents the most economically valuable component of Turkish marine fisheries. Long-term catch statistics reveal pronounced interannual fluctuations accompanied by an overall declining trend. Marine capture production decreased from approximately **280,000 tonnes** in the early 2000s to **153,175 tonnes** in 2024. Several interacting factors contribute to this decline, including excessive fishing pressure, harvesting of juvenile individuals before reaching sexual maturity, environmental variability, and changes in plankton productivity associated with climate change. Given its ecological importance and economic value, the sustainable management of anchovy stocks remains one of the highest priorities for Black Sea fisheries management. A substantial proportion of the harvested anchovy is not destined for direct human consumption but is instead processed by the fishmeal and fish oil industry. For example, 170,000 tonnes of anchovy harvested in 2007, 179,513 tonnes in 2019, and 186,530 tonnes in 2023 were diverted to fishmeal and fish oil production rather than entering the human food supply. This practice intensifies ecological pressure on a key forage species at the base of the marine food web, thereby increasing the risk of cascading effects throughout the Black Sea ecosystem (Figure 37).

NEXT Black Sea Basin

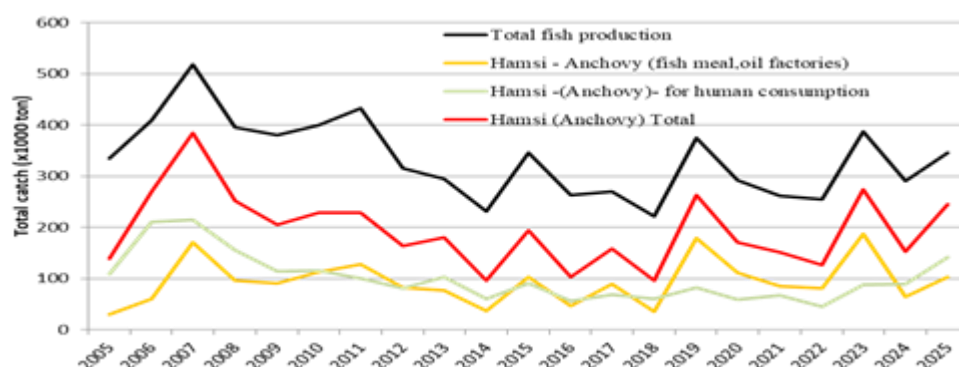


Figure 37. Long-term trends of commercially important fish species (2000-2025).

b) Atlantic Bonito (*Sarda sarda*): Atlantic bonito populations display substantial year-to-year fluctuations that largely reflect migratory behaviour and environmental conditions. Consequently, exceptionally high catches recorded in individual years should not be interpreted as evidence of long-term stock recovery. Instead, long-term monitoring is required to distinguish between temporary recruitment events and genuine improvements in stock abundance. Variability in bonito catches is influenced by sea surface temperature, prey availability, migration routes, and fishing pressure.

c) Bluefish (*Pomatomus saltatrix*): Bluefish occupies a high trophic level within the Black Sea ecosystem and plays a key ecological role as a top predator. Over recent decades, the abundance of bluefish has declined considerably. Intensive fishing pressure, particularly the harvesting of immature individuals, has reduced spawning biomass and limited the stock's capacity for natural recovery. The decline of apex predators may also trigger trophic imbalances, affecting the abundance and distribution of lower trophic-level species throughout the ecosystem.

d) Sprat (*Sprattus sprattus*): Unlike several commercially valuable species, sprat catches have increased during certain periods. However, this increase should not necessarily be interpreted as evidence of improving ecosystem health. Instead, it largely reflects a redistribution of fishing effort toward alternative target species, particularly during periods of reduced anchovy availability. Growing demand from the fishmeal and fish oil industries has further intensified exploitation of sprat resources. Without appropriate management measures, similar declines may eventually occur in sprat populations.

e) Horse Mackerel (*Trachurus mediterraneus*): Horse mackerel represents another commercially important pelagic species within the Black Sea ecosystem. Long-term fisheries statistics indicate a gradual reduction in catches, suggesting increasing fishing pressure and possible declines in stock abundance. The observed trend highlights the need for multispecies management approaches rather than concentrating conservation efforts exclusively on anchovy stocks.

f) Turbot (*Scophthalmus maximus*): Turbot is among the highest-value demersal fish species inhabiting the Black Sea. Because of its relatively slow growth, late sexual maturity, and low reproductive capacity, the species is particularly vulnerable to overexploitation. Bottom trawling, illegal fishing, and habitat degradation have all contributed to long-term declines in turbot populations. Existing regulations concerning minimum landing size, seasonal closures, and fishing restrictions represent important conservation measures; however, sustained enforcement and scientific monitoring remain essential for stock recovery.

Structural Changes in Fisheries Production

Türkiye's fisheries sector has undergone a profound structural transformation over the past twenty-five years. While marine capture fisheries have shown considerable annual fluctuations and an overall tendency toward stagnation, aquaculture production has expanded continuously and has become the primary driver of growth in total fisheries production. Figure-9 illustrates the long-term trends in marine capture fisheries, inland fisheries, aquaculture production, and total fisheries output (Figure 38).

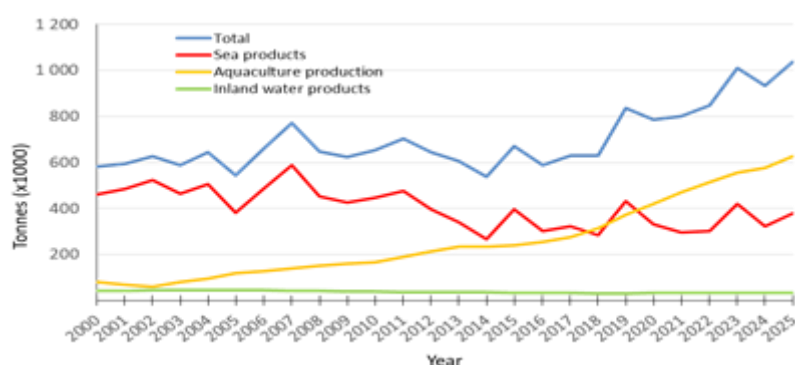


Figure 38. Trends in Turkish fisheries production by production sector (2000-2025)

Trends in Marine Capture Fisheries: Marine capture fisheries continue to constitute an important component of Türkiye's seafood production. However, catch statistics reveal substantial year-to-year variability together with long-term signs of increasing pressure on natural fish stocks. Marine capture production reached relatively high levels during the mid-2000s but subsequently exhibited considerable fluctuations. These variations reflect the combined influence of environmental conditions, recruitment success, fishing pressure, and management measures. Although certain years recorded relatively high landings, long-term trends indicate that capture fisheries have become increasingly dependent on a limited number of pelagic species, particularly anchovy (*Engraulis encrasicolus*).

Interpretation of Total Fisheries Production: The continuous increase in total fisheries production should not automatically be interpreted as evidence of recovering marine fish stocks. A considerable proportion of this growth originates from aquaculture rather than

NEXT Black Sea Basin

improvements in wild fish populations. Consequently, aggregate production statistics may create a misleading impression if marine capture and aquaculture production are evaluated together without distinction. For fisheries management purposes, these production sectors should therefore be analyzed separately to accurately assess the status of natural marine resources.

Illegal, Unreported and Unregulated (IUU) Fishing: IUU fishing threatens marine biodiversity, livelihoods, and food security. In the Black Sea, it is a major threat to fish stocks and marine biodiversity, particularly turbot, anchovy, and rapa whelk.

Historically, the Black Sea has offered a rich system, particularly in terms of small pelagic species such as anchovy (*Engraulis encrasicolus*). However, today this productive structure is under serious pressure due to increasing human activities. Current data reveals that the Black Sea is now under intense “anthropogenic stress,” and this pressure threatens the ecosystem balance.

Biodiversity in the Black Sea has shown a dramatic decline in the last few decades. The decline in the number of commercially important species from over 20 in the 1970s to just 5-6 today is one of the most concrete indicators of this transformation. This process has not only been limited to species loss but has also altered the functioning of the ecosystem. Scientific modeling reveals a significant decrease in total biomass between 1995 and 2021. The observed decrease in anchovy stocks, in particular, indicates that fish are being caught before reaching reproductive maturity. This weakens the stocks' capacity to regenerate and reduces the ecosystem's resilience. The simplification of food webs makes the system more vulnerable to external shocks.

Fishing pressure exceeding the natural regeneration capacity of fish stocks leads to both ecological and economic problems in the long term. The decrease in size and stock reduction observed in anchovy stocks in recent years is a clear indication of this pressure. Catching fish before they reach reproductive age seriously threatens the sustainability of stocks. The main consequences of overfishing are the following:

- Decrease in fish stocks
- Decrease in average fish size
- Changes in species composition
- Instability in fishing revenues

This creates a serious contradiction between short-term economic gain and long-term ecosystem health. In addition to overfishing, illegal, unregistered, and unregulated fishing (IUU) is a significant factor increasing pressure on the Black Sea ecosystem. Common illegal activities along the Black Sea coast include:

- Fishing during prohibited periods (especially April 15 - August 31)

NEXT Black Sea Basin

- Use of small mesh nets
- Large-scale fishing in coastal areas
- Underreporting or misrepresenting catch quantities

These practices, particularly the fishing of juvenile fish, prevent stock replenishment and increase the risk of long-term collapse.

- Habitat Destruction and Ghost Fishing: One of the most devastating effects of illegal fishing is a process called "ghost fishing." Nets lost or abandoned at sea continue to fish uncontrollably for years, causing the death of numerous marine creatures.
- The semi-enclosed nature of the Black Sea further exacerbates the effects of this type of pollution. In addition, bottom trawling methods such as trawling and dredging destroy the seabed, eliminating breeding and growth areas.
- These habitat losses severely limit the ecosystem's capacity for self-renewal.
- Trophic Cascade and Invasive Species: Overfishing leads to chain reactions affecting not only target species but also the entire ecosystem. The decline of top-level predator species creates imbalances at the lower levels of the food chain. This situation particularly facilitates the spread of invasive species. One of the most striking examples in the Black Sea is the invasion of *Mnemiopsis leidyi* (comb jellyfish). This organism consumes fish eggs and larvae, preventing stock recovery and putting significant pressure on the ecosystem.
- Socioeconomic Dimension: Ecological problems in the Black Sea also have significant socioeconomic consequences. Overfishing and illegal fishing negatively impact the incomes of small-scale fishermen while increasing competition with industrial fishing.
- Depletion of stocks leads to rising fish prices and increased risks to food security. In the long term, this process threatens the sustainability of the fishing sector.
- Transformation in Fisheries Management in Türkiye: Fishing activities in Türkiye are regulated by the Ministry of Agriculture and Forestry. Significant changes have occurred in the management approach in recent years.
- With the widespread adoption of digital monitoring systems:
 - Vessel Monitoring Systems (VMS)
 - AI-supported inspections
 - Comprehensive field controls
 are actively used. In addition:
 - Species-based quota applications
 - Minimum size limits
 - Seasonal fishing bans.

are subject to stricter enforcement.

Furthermore, practices such as supporting small-scale fishermen and ghost net cleaning stand out as important steps towards sustainability.

NEXT Black Sea Basin

- i) Global Perspective and New Approaches: Combating overfishing and illegal fishing has become a global priority. International agreements, technological advancements, and market-based mechanisms play a significant role in this fight.

In particular:

- The Treaty on the High Seas (BBNJ)
- Satellite and AI-supported monitoring systems
- Sustainability certifications

These tools aim to make fishing activities more transparent and sustainable.

3.1.2. Pollution and Eutrophication

Pollution from land-based sources—including agricultural runoff, industrial waste, untreated sewage, and maritime activities—introduces a complex mix of contaminants into the marine environment. Among the most concerning pollutants are heavy metals (mercury, cadmium, lead), persistent organic pollutants (POPs), hydrocarbons, and plastic debris.

Eutrophication, caused primarily by excessive nitrogen and phosphorus inputs, remains a chronic problem, especially near river mouths. It triggers seasonal algal blooms that reduce oxygen levels, decrease water transparency, and disrupt food web dynamics—from phytoplankton and zooplankton to fish and top predators. Microplastics are increasingly found in zooplankton, fish, and seabirds, while larger plastic debris causes entanglement and ingestion incidents in marine mammals and turtles, further endangering biodiversity (Mee, 2006).

3.1.3. Habitat Loss and Degradation

The Black Sea ecosystem is widely recognized as one of the most environmentally stressed regional seas, where multiple anthropogenic pressures converge and interact. Major threats include overfishing (both legal and illegal), pollution and eutrophication, habitat loss and degradation, biological invasions, and the growing influence of climate change and ocean acidification. These pressures do not operate in isolation, rather, they produce cumulative and often synergistic impacts on biodiversity and ecosystem functioning. Among them, habitat loss and degradation represent a central mechanism through which ecological integrity is eroded, affecting both coastal and offshore systems.

The Black Sea supports a mosaic of marine and coastal habitats, ranging from seagrass meadows and macroalgal beds to wetlands, lagoons and deltaic systems. However, prolonged exposure to anthropogenic activity has placed these habitats under sustained stress. A defining feature of habitat degradation in the region is coastal squeeze where expanding urban infrastructure meet rising sea levels and natural shoreline dynamics. The six riparian countries, Türkiye, Bulgaria, Romania, Ukraine, Russia and Georgia have concentrated a large proportion of their population and economic activity along the coast. Major metropolitan and port cities of demographic pressure. With an estimated 17 million inhabitants in the coastal zone, urban expansion has intensified land-use change, infrastructure developmental degradation.

NEXT Black Sea Basin

The physical alteration of coastal and marine habitats is another significant threat to biodiversity. Infrastructure development—including port expansion, dredging, beach nourishment, and coastal protection structures—leads to habitat fragmentation and the loss of critical benthic ecosystems.

Seagrass meadows (*Zostera spp.*), shallow soft-bottom areas, and nursery habitats for juvenile fish are particularly affected. These habitats play a crucial role in sheltering, feeding, and spawning for a wide range of marine species. Once degraded or removed, they are difficult to restore and contribute to long-term declines in biodiversity and ecosystem resilience.

Coastal Reclamation and Urbanization: Historically, much of the Black Sea coastline was characterized by natural and relatively undisturbed landscapes. However, since the mid-20th century particularly from the 1960s onward coastal zones have undergone rapid transformation into highly modified anthropogenic environments. Urbanization, tourism infrastructure, and industrial development have resulted in the direct conversion of natural habitats into built environments. This transition is expected to continue, with projections identifying coastal urban growth as a persistent long-term pressure.

Population distribution is strongly skewed toward coastal areas, amplifying environmental stressors. High-density urban generates significant pollutant loads through untreated or insufficiently treated wastewater, solid waste disposal, and nutrient enrichment. Land-change analyses, particularly along the northern coast of Istanbul, demonstrate substantial increases in agricultural and residential land at the expense of forests and natural open areas. Such changes reduce the buffering capacity of terrestrial ecosystems, allowing greater fluxes of nutrients and contaminants into coastal waters.

Infrastructure development has further accelerated habitat loss. The construction of coastal highways, ports, and urban expansions had led to the fragmentation and, in many cases, complete removal of intertidal and shallow marine habitats. In the eastern Black Sea, linear urbanization combined with large-scale transportation projects has significantly altered the coastal morphology around southeastern Black Sea coastal area. Documented impacts include habitat loss, biodiversity decline, increased erosion, and widespread land reclamation infilling.

Coastal reclamation defined as the conversion of shallow marine and intertidal zones into terrestrial land represents one of the most irreversible forms of habitat destruction. These are critical ecological interfaces, function as nursery grounds for fish, feeding habitat for seabirds, and transitional zones supporting high productivity. Their removal leads to a disproportionate loss of ecosystem services. Additionally, port operations introduce chronic disturbances such as dredging, anchoring and contamination from hydrocarbons and heavy metals, further degrading habitat quality.

At the basin scale, shoreline dynamic has also been significantly altered. Long-term analyses indicate an average erosion rate of approximately -1.7 m per year, with localized hotspot

NEXT Black Sea Basin

exceeding 1 m annually, particularly in deltaic regions such as Danube, Kızılırmak, and Yeşilırmak. Engineering interventions including seawall, groins, and breakwater while designed to mitigate erosion, often disrupted sediment transport processes and exacerbate habitat degradation by simplifying coastal geomorphology.

Eutrophication and Benthic Habitat Collapse: Eutrophication has been one of the most pervasive drivers of habitat degradation in the Black Sea, particularly during the 1970s and 1980s. The expansion of intensive agriculture across the drainage basin especially within the catchments of the Danube, Dnieper, and Dniester rivers led to massive nutrient inputs into the sea. These inputs fundamentally altered water quality and ecosystem structure.

The ecological mechanism is well established: excess nitrogen and phosphorus stimulate phytoplankton blooms, reducing water clarity and limiting light penetration to the seabed. As algal biomass decomposes, microbial respiration depletes dissolved oxygen, generating hypoxic or anoxic conditions commonly referred to as “dead zones.” These conditions are particularly severe on the northwestern shelf and result in large-scale mortality of benthic organisms and the collapse of demersal fish populations.

Eutrophication also drives community-level phase shifts. Structurally complex, perennial species are replaced by opportunistic, fast-growing algae with lower ecological value. Sensitive taxa such as *Phyllophora crispa*, *Cystoseira*, and *Zostera marina* have declined, while eutrophic-tolerant species proliferate. This transition reduces habitat complexity and weakens trophic linkages.

Degradation of Important Marine Habitats: Seagrass meadows, primarily formed by *Zostera marina* and *Zostera noltii*, are among the most valuable coastal habitats in the Black Sea region. They provide essential nursery grounds, stabilize sediments, improve water quality, and contribute to carbon sequestration. However, these systems are highly sensitive to reduced light availability and physical disturbance. Eutrophication-induced turbidity, epiphytic algal overgrowth, coastal construction, and bottom trawling have collectively driven significant declines. Once degraded, seagrass systems may shift to unvegetated states, with limited potential for natural recovery due to reinforcing feedback mechanisms.

Rocky reef habitats, historically dominated by canopy-forming macroalgae such as *Cystoseira*, have also experienced substantial degradation. These habitats provide three-dimensional structure that supports diverse invertebrate and fish assemblages. Their replacement by low-complexity algal mats represents a marked decline in ecological functionality.

The collapse of reef-forming bivalve communities further illustrates the scale of habitat loss. Native oyster reefs formed by *Ostrea edulis* have largely disappeared due to overexploitation, pollution, and predation by the invasive gastropod *Rapana venosa*. Similarly, declines in mussel beds, particularly *Mytilus galloprovincialis*, have reduced natural water filtration capacity and destabilized benthic food webs.

Coastal wetlands, lagoons, and delta systems especially the Danube Delta represent biodiversity hotspots and critical ecological buffers. Despite partial protection under international frameworks, these systems continue to face pressures from land conversion, hydrological alteration, and resource exploitation. Upstream damming has reduced sediment supply and altered salinity gradients, undermining ecological resilience. Smaller wetlands across the basin have experienced even greater losses, often being converted to aquaculture or drained for agriculture and urban development.

3.1.4. Invasive Alien Species

Invasive alien species pose a growing ecological threat by disrupting native communities and altering ecosystem dynamics.

The comb jelly (*Mnemiopsis leidyi*) preys heavily on zooplankton and fish larvae, competing with commercially important species such as anchovy and sprat. Its proliferation has contributed to significant fish stock declines in the past.

The veined rapa whelk (*Rapana venosa*), a predatory gastropod, consumes native bivalves and outcompetes local mollusk species, restructuring benthic communities and reducing native biodiversity. These invasions often lead to long-term changes in species composition, food web interactions, and habitat functionality.

The Black Sea is highly vulnerable to biological invasions because of its relatively low biodiversity, the presence of vacant ecological niches, and intensive maritime transport. Many invasive alien species have been introduced through ships' ballast water and have successfully established populations. Common characteristics of successful invaders include high tolerance to changes in temperature and salinity, early sexual maturity, high fecundity, rapid growth, long lifespan, and the ability to survive under poor environmental conditions. These traits enable them to adapt quickly, spread rapidly, and outcompete native species.

Several invasive species have caused major ecological changes in the Black Sea ecosystem. Among the most important are the rapa whelk (*Rapana venosa*), the comb jelly (*Mnemiopsis leidyi*), and its predator *Beroe ovata*. Other invasive species recorded in the region include the Pacific oyster (*Magallana gigas*), the blue crab (*Callinectes sapidus*), the blood cockle (*Anadara inaequalis*), most of which were introduced via ballast water.

Rapa Whelk (*Rapana venosa*): The rapa whelk is native to the Sea of Japan, Yellow Sea, and East China Sea. It was accidentally introduced into the Black Sea through ballast water in the 1940s, with the first record reported in 1946. *Rapana venosa* is characterized by strong ecological fitness, including high fecundity, early sexual maturity, rapid growth, longevity, and broad tolerance to variations in salinity, temperature, water pollution, and low dissolved oxygen. These life-history and physiological traits are typical characteristics of a successful marine invader. Its successful establishment in the Black Sea has been facilitated by the absence of major natural predators, limited competition, the availability of vacant ecological niches, relatively low native biodiversity, and an abundance of suitable prey. Together, these

NEXT Black Sea Basin

ecosystem characteristics have significantly enhanced the invasion success and subsequent spread of *R. venosa* throughout the Black Sea. Rapa whelk caused severe declines in native bivalve populations through intensive predation. Chukhchin (1984) attributed the near extinction of the native oyster (*Ostrea edulis*), scallop (*Pecten ponticus*), and Mediterranean mussel (*Mytilus galloprovincialis*) in the Gudaut region to predation by *R. venosa*.

To date, no significant native predators of adult *R. venosa* have been observed in the Black Sea, although laboratory studies have shown that the invasive blue crab (*Callinectes sapidus*) can prey on small juvenile stages.

The major ecological impacts of *R. venosa* include:

- Decline of native bivalve populations through intense predation;
- Alteration of benthic food webs;
- Competition with native species for food and habitat;
- Reduction in biodiversity and ecosystem functioning.

Warty Comb Jelly (*Mnemiopsis leidyi*): *Mnemiopsis leidyi* is a carnivorous ctenophore native to the western Atlantic Ocean. It was introduced into the Black Sea through ballast water from ships arriving from the eastern coast of North America during the early 1980s. In the Black Sea, individuals typically reach 40-180 mm in length. Like other ctenophores, *M. leidyi* is a simultaneous hermaphrodite, allowing a single individual to establish a new population under favorable conditions. Combined with its rapid reproduction and high feeding capacity, this characteristic contributed to its explosive population growth.

The invasion of *M. leidyi* had severe ecological and economic consequences, particularly during the late 1980s when Black Sea anchovy (*Engraulis encrasicolus*) stocks collapsed. The species affected fisheries through three primary mechanisms:

Predation on fish eggs and larvae, with grazing rates estimated to remove up to 70% of total ichthyoplankton in shelf waters. Intensive consumption of zooplankton, the primary food source for many commercially important fish species, resulting in food limitation and reduced fish recruitment. Large blooms followed by mass mortality, leading to the accumulation of dead ctenophores and mucus on the seabed, which contributed to oxygen depletion (anoxia) and further degradation of pelagic and benthic ecosystems.

Overall, invasive alien species have become one of the major drivers of biodiversity loss in the Black Sea. By altering food webs, reducing native populations, modifying ecosystem structure, and affecting fisheries, species such as *Rapana venosa* and *Mnemiopsis leidyi* have fundamentally transformed the ecological balance of the region.

3.1.5. Abandoned, Lost or Discarded Fishing Gear (ALDFG)

Abandoned, lost, or otherwise discarded fishing gear (ALDFG) also referred to as a “ghost gear”, is widely recognised as one of the most ecologically harmful forms of marine litter (Consoli et al., 2019). Unlike most anthropogenic debris, fishing gear is specially designed to capture and

NEXT Black Sea Basin

kill marine organisms and can continue to trapping and killing wildlife long after it has been abandoned or lost by fishers (Mcfayden et al., 2009; Gilman, 2015; FAO, 2019; 2024; Kaykaç et al., 2014). In the Black Sea, a semi-enclosed basin characterised by limited water exchange, connected to the Mediterranean only through the narrow Turkish Straits System and significant land-based inputs from across six countries (Bulgaria, Georgia, Romania, Russia, Türkiye, and Ukraine), benthic marine litter has accumulated to critical levels (Dağtekin et al., 2026; Vaspremeanu & Golumbeanu, 2018; Terzi et al., 2020; Eryaşar et al., 2021). A recent standardized survey conducted along the Turkish Black Sea coast reported a mean benthic litter density of 639 ± 54 items/km², with plastic materials including fishing nets, lines, and ropes, accounting for 77% of the total composition (Dağtekin et al., 2026; Gajanur and Jaafar, 2022; Macfadyen et al., 2009). Globally, it is estimated that over 6.4 million tons of ALDFG and other capture fisheries litter enter the ocean each year, posing persistent threats to marine biodiversity, fisheries productivity, and coastal ecosystems (Richardson et al., 2019; Bilgin et al., 2018).

The Black Sea's susceptibility to marine litter accumulation is strongly influenced by its unique hydrodynamic characteristics. The basin-wide cyclonic Rim Current promotes the eastward transport of floating debris, resulting in pronounced accumulation zones along the eastern coastline (Lebedev et al., 2020; Dağtekin et al., 2025). In addition, mesoscale circulation features, including the Sinop and Batumi coastal eddies, function as efficient retention mechanisms that trap suspended fishing gear and other floating debris, creating localized pollution hotspots. Vertical distribution patterns are also shaped by the basin's hydrography. Recent studies have shown that benthic litter abundance reaches its highest levels at depths of 50-75 m, where the permanent pycnocline acts as a density barrier that slows the downward transport of plastics and other materials with densities similar to seawater. Consequently, these materials remain suspended for longer periods before settling, leading to enhanced litter accumulation within this depth interval (Dağtekin et al., 2026).

Abandoned, lost, or otherwise discarded fishing gear (ALDFG) threatens Black Sea biodiversity through multiple ecological pathways. First, entanglement and ghost fishing occur when derelict fishing gear continues to function as originally intended, indiscriminately capturing a wide range of marine organisms. Entrapped animals frequently die from starvation, exhaustion, injury, or predation, while their carcasses attract scavengers and predators that may also become entangled, perpetuating a self-sustaining cycle of mortality (Gilman et al., 2015). Second, habitat degradation results from the physical interaction of ALDFG with benthic habitats. Lost fishing gear can abrade the seabed, smother benthic communities, and alter habitat structure, thereby reducing ecosystem integrity (Rossi et al., 2017). Evidence from other regions containing structurally complex benthic ecosystems, such as marine animal forests, demonstrates that derelict longlines and nets can entangle, break, and remove habitat-forming corals and sponges, leading to substantial losses in biodiversity and ecosystem functioning. Third, ALDFG affects a broad range of taxonomic groups. Although species-specific assessments for the Black Sea remain limited, global evidence indicates that more than 950 marine species have been impacted by marine litter, with fish, marine mammals, seabirds, sea

NEXT Black Sea Basin

turtles, and benthic invertebrates among the most vulnerable taxa (Gunasekaran et al., 2024). These findings suggest that continued ALDFG accumulation poses a significant threat to the

ALDFG in the Black Sea is closely associated with the region's most economically important demersal fishery, namely bottom-set gill nets and trammel nets targeting turbot (*Scophthalmus maeoticus*). These fisheries constitute one of the principal sources of ALDFG generation and are a major contributor to persistent ghost fishing in the basin (Radu & Anton, 2014; Zaharieva et al., 2020). Among the documented ecological impacts, the most severe concerns the endemic Black Sea harbour porpoise (*Phocoena phocoena relicta*), which is classified as Endangered on the IUCN Red List. Observer-based monitoring programs conducted in the Bulgarian and Romanian turbot fisheries have consistently identified harbour porpoises as the predominant cetacean bycatch in bottom-set gillnets, with lower numbers of Black Sea bottlenose dolphins (*Tursiops truncatus ponticus*) and Black Sea common dolphins (*Delphinus delphis ponticus*) also recorded (Radu and Anton, 2014; Zaharieva et al., 2020) (Figure 39). These findings highlight the dual ecological threat posed by both actively fished and derelict gill nets, which continue to cause mortality of vulnerable cetacean populations through incidental capture and ghost fishing.

Beyond direct mortality, ALDFG contributes to long-term ecosystem degradation through both physical and chemical pathways. First, it acts as a persistent source of microplastic pollution. Synthetic fishing gear, primarily composed of polyamide and polyethylene, gradually fragments through mechanical abrasion, ultraviolet exposure, and environmental weathering, generating large quantities of microplastics that accumulate in benthic habitats (Battisti et al., 2019; Gilman et al., 2022; Thomas et al., 2023). These particles are readily ingested by benthic invertebrates, fish, and other marine organisms, facilitating their transfer through the food web and increasing the potential for bioaccumulation and biomagnification. Second, ALDFG poses chemical and biological risks. As plastics degrade, they can release additives and adsorb persistent organic pollutants and trace metals from the surrounding environment, which may subsequently be transferred to organisms following ingestion. In addition, derelict fishing gear provides surfaces for the development of complex microbial biofilms, including potentially pathogenic microorganisms, thereby increasing the risk of disease transmission and physiological stress in habitat-forming species and other marine biota.

Effective management of ALDFG in the Black Sea requires a combination of standardized monitoring, proactive recovery strategies, and efficient reporting systems. **First**, standardized monitoring protocols are essential for accurately assessing the spatial distribution and abundance of seafloor litter. The adoption of harmonized bottom-trawl survey methodologies, such as MEDITS/iBOTS, enables consistent detection and quantification of benthic marine litter, providing robust datasets to support regional assessments and evidence-based policy development (Dağtekin et al., 2026). **Second**, targeted removal programs can substantially reduce accumulated marine litter. Commercial bottom-trawl fleets represent an important resource for litter retrieval, with studies estimating that fleets operating in the central and western Black Sea could remove more than 90 tonnes of benthic litter during a single fishing

NEXT Black Sea Basin

season while conducting routine fishing activities (Lee et al., 2006; Spengler and Costa, 2008; Eryaşar et al., 2014; Dağtekin et al., 2025). **Third**, rapid reporting and retrieval systems are needed to minimize the persistence of lost fishing gear. Implementing a Reporting, Response, and Retrieval (RRR) framework, similar to that adopted in the Salish Sea, would encourage fishers to report gear losses within 24 hours, enabling timely recovery operations and reducing the likelihood of prolonged ghost fishing and long-term ALDFG accumulation (Drinkwin et al., 2023).



Figure 39 A dolphin entangled with ALDFG on the coast of Sürmene Trabzon Türkiye (Captured during BlackNETs Project)

3.1.6. Climate Change

Climate change related global warming has led to a notable rise in sea surface temperature (SST) across the world's oceans and seas, with an estimated rise of 0.93°C since the late 19th century (Fox-Kemper et al., 2019). In recent decades, the rate of SST warming has accelerated, with the last decade (2010-2019) exhibiting a rate approximately 4.5 times higher than the long-term trend (Garcia-Soto et al., 2021). As a result, marine heatwaves (MHWs), defined as prolonged, anomalously warm SSTs, and have become more frequent and intense across various regions (Hobday et al., 2016, Pearce and Feng, 2013). MHWs are largely attributed to long-term ocean warming, with some contribution from internal climate variability (Oliver, 2018). These extreme events have severe ecological and economic impacts, including harmful algal blooms, coral bleaching, and mass mortality of marine organisms, with repercussions for fisheries, aquaculture, and tourism (Cavole et al., 2016). Significant SST warming trends have been reported in the basins. In the Black Sea, the basin averaged SST increased by $0.09^{\circ}\text{C}/\text{year}$ between 1982 and 1991 (Ginzburg et al., 2004), nearly twice the rate observed in the Mediterranean Sea (Belkin, 2009). The Aegean Sea experienced a warming trend of $0.045^{\circ}\text{C}/\text{year}$ from 1985 to 2008, accelerating to $0.06^{\circ}\text{C}/\text{year}$ from 2003 to 2019 based on satellite derived SSTs (García-Monteiro et al., 2022). In situ measurements near the Dardanelles Strait suggest a slightly lower SST trend of $0.035^{\circ}\text{C}/\text{year}$, likely due to the influence of colder Black Sea inflows (Shaltout and Omstedt, 2014). While no comprehensive SST or MHW studies exist for the Marmara Sea, warming trends are expected, given the observed trends in adjacent basins. The only MHW focused study in the Black Sea found that most of , marine heatwaves (MHW) occurred between 2010 and 2020 with durations ranging from 10 to 22 days and frequencies between 1.2 and 2.4 events/year. Both frequency and duration have shown

NEXT Black Sea Basin

significant increasing trends, with rates of 1.4 events/decade and 2.8 days/decade, respectively. Limited research exists on the variability of MHWs in the Mediterranean and Black Sea and their connection to large-scale climate patterns. The El Niño Southern Oscillation (ENSO) a major driver of global ocean-atmosphere interactions, influences SST anomalies in the Mediterranean and Black Sea (Figure 40). In the Black Sea, MHW events have been linked to different ENSO phases. The North Atlantic Oscillation (NAO), which reflects atmospheric mass shift between the Azores High and the Icelandic Low, is a key driver of North Atlantic climate variability. A negative NAO phase is associated with milder and wetter conditions over southern Europe and the Black Sea (Oguz et al., 2006).

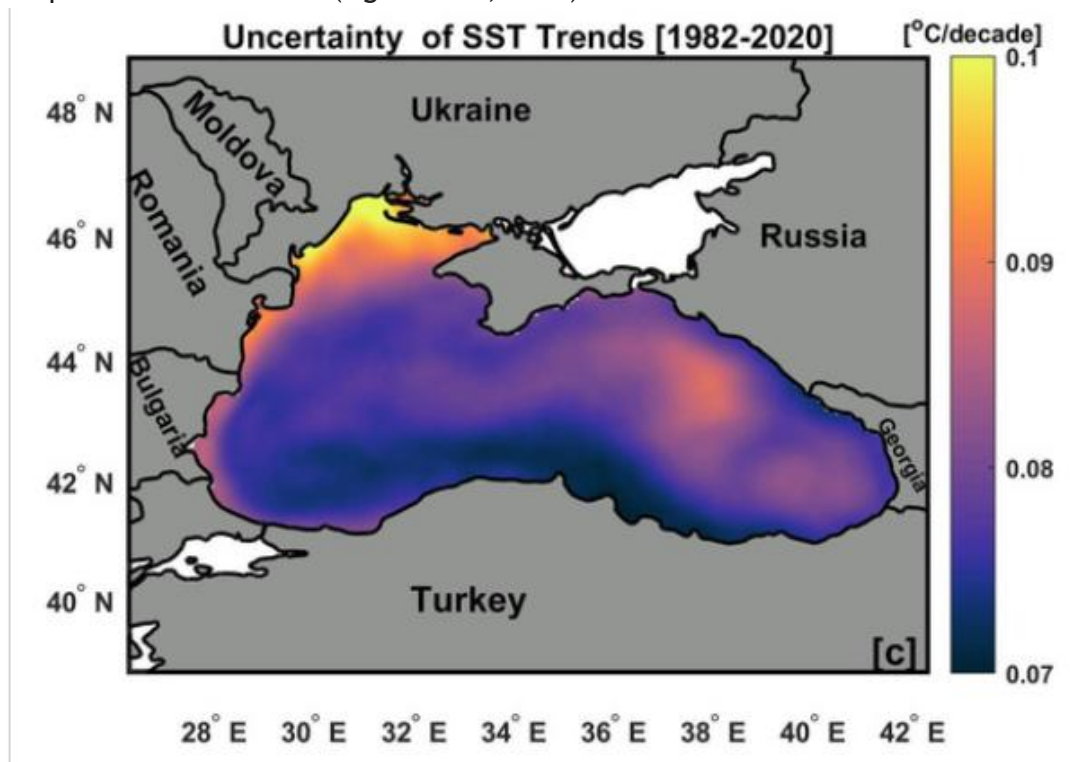


Figure 40. Spatial map of the Black Sea SST uncertainty from 1982 to 2020 (Mohamed et al, 2022)

The Black Sea is undergoing rapid physical changes driven by atmospheric warming and shifting hydrological balances. Sea surface temperatures (SST) have exhibited a persistent warming trend of approximately 0.64°C per decade over the last twenty years, with total increases reaching $2.0\text{-}2.5^{\circ}\text{C}$ in some subregions (Valcheva, N., et al., 2026). This warming is not confined to the surface; high-resolution modeling indicates that heat is penetrating to depths of up to 700 meters (Ilıcak and Tutak, 2025).

Furthermore, the sea level is rising at a rate of approximately 1.04 mm per year, a process influenced significantly by regional hydrological factors such as river inflow and evaporation, as well as global mass redistribution (Wen et al., 2025). The Black Sea has its own cycles of water level fluctuations. Concurrently, reduced freshwater input and increased evaporation

NEXT Black Sea Basin

are driving a trend toward increased salinity, which further alters the sea's density stratification (Ilıcak and Tutak, 2025). For example, since the late 1990s, the level of the Black Sea has dropped by an average of 1cm. This may be due to global climate change - the warmer the sea is, the more water evaporates from its surface. In addition, the warmer and drier the year is, the less water reaches the sea from the rivers flowing into it. The river flows into the Black Sea is much less than 100 years ago. This is because most of the water volume of the Dnieper, Bug, Dniester and Danube is channelled to field irrigation for agriculture purposes. As the temperature rises, in land water consumption increases, while its runoff from the upstream decreases. Heating water in shallow coastal areas can reduce the solubility of oxygen in water. Whole spots of "dead water" (anoxic zones) are formed, where the oxygen saturation is too low for the survival of fish, crabs and shellfish, and they die in big numbers. With a decrease in river flow into the Black Sea and an increase in ocean levels, salinity in the Black Sea may increase, which means that the Black Sea will become more attractive for settlement by inhabitants from the Mediterranean. Each year, more Mediterranean species swim occasionally into the Black Sea (Alexandrov, et al, 2020).

Sea level rise has become a danger of global warming; firstly, glaciers are melted and thus add water to the world's oceans, and secondly, water expands when heated. So, Odesa and other cities of the Black Sea basin could share the fate of drowned Olbia, though it may take a few thousand years. However, against the background of the Black Sea level rise tendency, which is consistent with water level rise in the rest of the world's oceans (0.1-0.2 cm/year), the Black Sea has its own water level fluctuation cycles. Thus, every year the Black Sea's deficit of water to compensate for evaporation increases, and the waters become more saline. Such a salination (compounded by warming) makes the Black Sea more attractive and available for occupation by flora and fauna of the Mediterranean Sea. Every year, more and more Mediterranean species push into the Black Sea. This process is called 'mediterraneanisation', which means that the Black Sea becomes similar to the Mediterranean. The heating of water in the shallow coastal regions can cause lower solubility of oxygen in water, which can give rise to areas of 'dead water', wherein the concentration of oxygen is too low for fish, crabs, and clams to breathe, they perished masse, literally suffocating. Further, climate change influences the hydro sulphuric layer of the Black Sea and is considered to be one of the main reasons for the progressive rise of anoxic layers towards the surface. For now, the mechanism of this influence has been scarcely investigated and scientists still cannot say for sure how exactly the warming determines the rise of the hydrogen sulphide level, and find it difficult to foretell the behaviour of this layer in future. Studies of this issue are one of the most urgent tasks in the field of Black Sea exploration (Aleksandrov, B., et al, 2020). The unique semi enclosed Black Sea has its own cycles of water level fluctuations. With a decrease in river flow into the Black Sea and an increase in ocean levels, salinity in the Black Sea may increase, which means that the Black Sea will become more attractive for settlement by inhabitants from the Mediterranean (URL1, 2026). General effect of the climate change on the Black sea water masses and ecosystems are given at Table 15.

NEXT Black Sea Basin

Table 15. Climate change effects on Black Sea water masses and Ecosystem

Climate Vector	Primary Direct Effect	Secondary Biodiversity Impact
Rising Water Temperature	Shrinking/Loss of Cold Intermediate Layer (CIL)	Decline in native cold-water species (turbot, sprat etc.)
Increased Stratification	Shoaling of the hydrogen-sulfide (H ₂ S) boundary	Shrinking vertical habitat for fish and zooplankton
Warming and Salinity Shifts	Bosphorus migration barrier weakening	"Mediterranisation"; surge of non-indigenous warm-water species
Extreme Heatwaves	Eutrophication & low dissolved oxygen spikes	Toxic algal blooms, massive fish/mussel die-offs

3.8.1. Climate Change Vanishing Habitable Zones

The Black Sea's unique meromictic structure—where oxygenated surface waters are permanently separated from deeper, toxic hydrogen sulfide layers—makes it exceptionally vulnerable (Lecrenier and Camero, 2016; Stanev et al., 2019). Warmer water naturally holds less dissolved oxygen. Deoxygenation is seen as surface layers warm and stratification intensifies, the boundary between the top oxygenated water and the deep hydrogen-sulfide rich anoxic layer rises closer to the surface. This shrinks the thin "habitable zone" available for cold-water marine organisms, crowding fish populations into narrower vertical strips. The habitable oxic boundary shoaled from 140 meters in 1955 to just 90 meters in 2015, representing a loss of over 40% of the sea's habitable volume (Capet et.al, 2016). The Black Sea Cold Intermediate Layer (CIL) is Lossing. The CIL, a vital perennial water mass, is warming at an accelerated rate of roughly 0.05 °C per year (Stanev et al., 2019). Projections suggest that under high-emission scenarios, the CIL could completely disappear after 2040, removing a critical ventilation mechanism for the upper water masses (İlıcak and Tutak, 2026; Ozkan and Tutak, 2016). Simulations of the Black Sea surface temperature (SST) up to 2100 project a total average temperature will increase of 5.1 °C by the end of the century. Historical data from 1982 to 2015 show an observed warming rate of 0.64 °C per decade, mirroring high-emission climate scenarios. Past Warming Rate Recorded a fast increase of 0.64 °C per decade between 1982 and 2015 (Sakalli and Başusta, 2018).

3.8.2. Climate Change Effect on Marine Biodiversity

These environmental shifts are triggering profound ecological reorganizations of the "Mediterranization", "Invasive Alien Species" and "Native Species Declines". As the Black Sea getting warmer and becomes saltier, Mediterranean fish, crustaceans species etc., and various new plankton are migrating northward and settling in the basin (Aleksandrov, 2020, Kldiashvili, N., 2025). Also, anthropogenic activities, such as ballast water discharge, have introduced invasive species like the predatory jelly (*Mnemiopsis leidyi*), which caused catastrophic collapses in native fish stocks by consuming eggs and larvae (Erdoğan, et Al.2009; Aleksandrov, 2020). Increased temperatures and deoxygenation threaten the survival of cold-water and sensitive native species, such as sturgeon, turbot, and Black Sea salmon, many of which are now endangered (Aleksandrov, 2020; Radulescu, V., 2021). Under climate changing effect,

NEXT Black Sea Basin

warm-water species like anchovies (*Engraulis encrasicolus*), sardines, and certain cephalopods are shifting their migration paths and expanding northward. But cold-water native species like sprat (*Sprattus sprattus*), whittings, and turbot face habitat loss, reduced reproductive success, and shrinking population ranges. Higher temperatures combined with agricultural nutrient runoff fuel severe seasonal blooms of toxic cyanobacteria, dinoflagellates, and opportunists like comb jellies (*Mnemiopsis leidyi* and *Beroe ovata*). These blooms outcompete native plankton, can clogging the food web (Pauly et al., 1998; Polat and Ergun, 2008). Benthic habitats, such as *Zostera* (seagrass) and *Cystoseira* (brown algae) beds, provide critical nursery grounds for young fish and invertebrates. Rising temperatures, sea-level shifts, and decreased water clarity from algal blooms lead to widespread die-offs of these foundational habitats. Some endemic species of the Black Sea marine mammals (the Black Sea harbour porpoise, bottlenose dolphin, and common dolphin) face reduced prey availability as fish schools alter their seasonal migration routes to escape warming coastal areas (ÇŞB, 2026).

3.8.3. Climate Change Effect on Fisheries and Socio-Economic Consequences:

Climate change acts as a "multiplier" for existing pressures like overfishing and pollution (Erdoğan, et al., 2009, Radulescu, V., 2021). European anchovy stocks, which are central to the region's food web and economy, are displaying altered migration and schooling patterns due to rising water temperatures, leading to shorter and less predictable fishing seasons ((Erdoğan, et al., 2009; Kldiashvili , N., 2025). Modeling indicates an overall temporal degradation of the ecosystem, with significant decreasing trends in the biomass of most commercially exploited species since the mid-1990s (Serpetti, et al., 2025). Continued warming correlates directly with disruptions in marine life, including the sharp decline of southern Black Sea fish stocks like anchovies after 1993 (Sakalli and Başusta, 2018).

3.2. Bulgaria

The biodiversity of the Bulgarian Black Sea is under significant, compound pressure from anthropogenic activities (Dineva, 2015) and environmental changes. The ecosystem is uniquely sensitive due to its high degree of isolation, significant stratification, and the fact that the most part of its volume is anoxic. The main threats include severe eutrophication, habitat loss due to coastal development, and climate change-induced warming.

3.2.1. Overfishing and Illegal Fishing

During the second half of the 20th century, the intensification of industrial fishing in the Black Sea led to a significant increase in total catches, reaching a peak in the 1980s (over 800000 t annually for the entire basin). Following this peak, a collapse of part of the fish stocks was observed, accompanied by a shift in dominant species (Daskalov et al., 2007). During this period, there was a marked decline in high predators such as mackerel, bonito, bluefish, and dolphins, while at the same time the biomass of small pelagic species such as sprat and anchovy increased, exerting stronger pressure on zooplankton. This led to reduced consumption on phytoplankton and an increase in its biomass, resulting in more frequent and intense blooms, decreased water transparency, and hypoxic events in coastal areas.

NEXT Black Sea Basin

Overfishing and unregulated fishing can act as central drivers of large-scale structural transformations in fish communities and the entire ecosystem. At present, an additional concern is “hidden mortality,” resulting from unreported catches, lost fishing gear (so-called “ghost fishing”), and bycatch of non-target, often rare or endangered species. To control overfishing, a number of fisheries restrictions have been introduced in Bulgaria. One of the main measures is the implementation of catch quotas for certain species, as part of the EU Common Fisheries Policy (CFP). The key instrument is the TAC system, under which overall catch limits are allocated as national quotas among EU Member States. Annual fishing quotas are adopted by the Council of the EU based on proposals from the European Commission (DG MARE), informed by scientific advice from STECF and regional scientific bodies. In the Black Sea, management is also coordinated by the GFCM. At the national level, quotas are administered by EAFA in accordance with the Fisheries and Aquaculture Act.

In the Bulgarian Black Sea waters, quotas are applied for turbot and sprat. For turbot, management measures include a national quota allocated among vessels, limits on fishing days, minimum landing size, and closed seasons. Sprat is also subject to annually determined national quotas. For species such as anchovy, horse mackerel, gobies, and others, quotas are not applied, but they are regulated through seasonal closures, minimum size limits, and technical (e.g., mesh size) and spatial restrictions.

Overfishing currently represents a major threat to populations of key commercial species in the Black Sea, including sprat, anchovy, horse mackerel, bonito, and bluefish, necessitating the implementation of effective management measures. Migratory species are particularly vulnerable, especially those that do not reproduce in the Bulgarian sector but are exploited there, such as species of the genus *Alosa*. The excessive removal of mature individuals reduces reproductive potential and limits population recovery.

Illegal fishing (poaching) remains a major threat to sturgeon populations. Although less visible in the Black Sea itself, sturgeons are frequently caught as bycatch. This also applies to other species such as the spiny dogfish, European eel, tunas, and the three cetacean species.

At present, one of the main threats to cetaceans in the Black Sea is incidental capture in fishing gear (bycatch), which represents the primary source of anthropogenic mortality. The bottlenose dolphin and harbour porpoise frequently enter coastal waters and ports, making them more vulnerable to bycatch and other human-related incidents. Bycatch of harbour porpoise is of particular concern.

During a vessel-based survey conducted in Bulgaria in 2010-2011, a total of 982 turbot gillnets (88,4 km) were examined, and 21 cetaceans were recorded - 19 harbour porpoises and two bottlenose dolphins.

In the period 2014-2018, data collected from fishing crews aboard 31 vessels during fishing operations recorded bycatch of cetaceans in turbot gillnets along the entire Bulgarian Black Sea coast. A total of 1 336,6 km of bottom-set gillnets were monitored, with 413 cetaceans recorded (Zaharieva et al., 2020). Between 2019 and 2021, monitoring of cetacean bycatch in turbot gillnets in the northern and southern Black Sea covered 340,8 km of nets, resulting in the identification of 183 cetaceans: 176 harbour porpoises, 4 bottlenose dolphins, and 3 common dolphins (Popov, D., Green Balkans NGO, 2020).

3.2.2. Pollution and Eutrophication

The Black Sea is a semi-enclosed basin with a specific hydrographic structure and highly restricted water exchange with the Mediterranean Sea through the Bosphorus. It is characterized by strong vertical stratification, with approximately 90% of its volume containing hydrogen sulfide. These features make it particularly vulnerable to environmental pressures such as eutrophication.

Sources and Types of Pollution: The Bulgarian Black Sea is considered polluted (Dineva, 2011a), with major contributors including:

- Large rivers that empty into the northwestern Black Sea shelf (Danube, Dniester, Bug, Dnieper), with a major contribution of the Danube River (Dineva, 2013b; Lazar et al., 2024). This is historically the most serious problem for the Bulgarian Black Sea. The pathway of Danube transformed waters along the Bulgarian coast seasonally shifts and passes at a different distance offshore (Dineva, 2005).
- Oil spills and residual discharges from shipyards and port activities in Burgas and Varna.
- Agricultural runoff carrying nitrite and nitrate compounds from river systems.
- Plastic waste and improperly managed coastal garbage, which accumulate along the shoreline. Because of poor waste management, microplastics are now widespread in Bulgarian waters, entering the food chain of marine mammals and fish.
- Sewage effluents from malfunctioning treatment plants near the coast.

These pollutants degrade water quality, disrupt physiological processes in marine organisms, and contribute to long term habitat degradation. Along the Bulgarian coast, substantial pollution inputs also originate from rivers and urbanized areas. Coastal lagoons and lakes such as Varna Lake and Burgas Lake are particularly vulnerable to eutrophication due to limited water exchange with the sea and high levels of industrial and domestic pollution. The Beloslav-Varna lake system's current is a strong anthropogenic factor for the southern area of the Varna Bay (Dineva, 2021).

Studies about the Bulgarian Black Sea have confirmed trace levels of arsenic, mercury, and lead in fish and mussels, although most remained within permissible limits (CO-EDP, VisionRI, 2025).

Eutrophication is recognized as one of the major threats to the Bulgarian Black Sea ecosystem and is one of the best-documented environmental problems in the Black Sea. Excessive nutrient inputs—primarily inorganic nitrogen and phosphorus—stimulate phytoplankton blooms, reduce water transparency, and lead to hypoxia. The direct effect on phytoplankton includes stimulating the growth of dinoflagellates at the expense of diatoms, whose numbers decrease. In the 1950s and 1960s, peridinians formed 18.8% of the phytoplankton biomass (Ivanov, 1967). From the 1970s onward, they accounted for up to 55% (Nesterova, 1987). Extensive water blooms can lead to monocultures with mass development of 2-3 microalgal species, usually dinoflagellates, reaching ‘bloom’ concentrations (Biological Diversity in the Black Sea, 1997). During monospecific blooms, 2-6 species grow in enormous concentrations, which leads to a permanent reduction of species diversity, with the few non-blooming species represented only by single specimens (Velikova and Petrova, 1999). The main source of nutrient input is the large riverine discharge from major European rivers, including the Danube, Dnieper, and Dniester. The Bulgarian Black Sea is especially vulnerable due to riverine inputs (Dineva, 2011b), coastal urbanization (Stanchev, et al. 2015), and intensive maritime activity (Sala-Pérez et al., 2020). Understanding the combined effects of these stressors is critical for safeguarding biodiversity and ensuring sustainable resource use. The Danube basin alone covers an area of approximately 817 000 km² and transports substantial amounts of nitrogen and phosphorus to the western Black Sea. During the 1970s and 1980s, concentrations of nitrates and phosphates in the northwestern Black Sea increased significantly due to intensive agriculture, industrialization, and expanding urbanization.

Ecological Consequences

- Algal blooms reduce light penetration and alter primary productivity (Dineva, 2021) and often leading to hypoxic events in coastal areas. This process was further intensified by the introduction of the ctenophore *Mnemiopsis leidyi* and by overfishing of predatory fish species such as bluefish, bonito, and the spiny dogfish. Increased primary production leads to the accumulation of organic matter, whose decomposition consumes dissolved oxygen, creating hypoxic conditions in bottom waters. These conditions can cause mass mortality of benthic organisms and fish. Large-scale hypoxic events were recorded in the 1980s in the northwestern Black Sea, affecting tens of thousands of square kilometers of shelf ecosystems (Mee et al., 2005).
- Oxygen depletion in upper layers threatens fish and benthic communities.
- Hydrogen sulphide accumulation in deeper layers—already the world’s largest H₂S reserve—limits habitable zones and increases vulnerability to disturbances.
- Chemical pollution, including contamination by microplastics, heavy metals, and pesticides, represents a serious problem in the Black Sea, particularly for apex predators such as cetaceans, as these substances bioaccumulate through the food web. This can lead to immunosuppression, reproductive impairment, and increased juvenile mortality. Studies have reported significantly elevated concentrations of toxic heavy metals in harbour porpoises from the northern Black Sea (Evtimova et al., 2019).

NEXT Black Sea Basin

In addition to nutrients, various contaminants, including heavy metals, petroleum products, and persistent organic pollutants enter the marine environment. These substances can accumulate in sediments and bioaccumulate in marine organisms, especially top predators. Sediment analyses from the western Black Sea have revealed increased concentrations of metals such as cadmium, lead, and mercury, particularly near industrial and port areas (EEA, 2019).

These processes collectively reduce biodiversity, alter species composition, and destabilize food webs.

3.2.3. Habitat Loss and Degradation

The coastal zone is subject to significant anthropogenic pressure associated with pollution, urbanization, tourism, port infrastructure, hydromorphological alterations of the shoreline, and intensive use of coastal resources. This results in substantial loss of natural habitats, fragmentation of aquatic ecosystems, and changes in coastal environmental conditions. Such pressures often alter sediment transport and hydrodynamic regimes, potentially leading to erosion or sediment accumulation and, consequently, changes in the structure of benthic ecosystems (EEA, 2019). Climate driven changes in temperature and nutrient dynamics are projected to cause substantial habitat losses for commercially important fish species such as anchovy, red mullet, horse mackerel, turbot, and whiting. Model projections for 2030-2040 and 2090-2100 show considerable declines in suitable habitats under both low and high emission scenarios (Gül et al., 2025).

Coastal wetlands and transitional waters are among the most vulnerable ecosystems along the Black Sea coast. Alterations in the hydrological regime through the construction of canals, dikes, and other hydraulic structures disrupt the natural exchange between marine and freshwater systems and, together with pollution, may lead to significant ecological changes and overall ecosystem degradation. A typical example is Varna Lake and Beloslav Lake, which have undergone substantial transformation following the construction of connecting canals to the Black Sea, as well as urbanization and industrialization in their surrounding areas.

Other highly threatened and sensitive habitats along the Black Sea coast include mussel beds and seagrass meadows. These represent key habitats for many benthic invertebrates and fish species. They are particularly vulnerable to mechanical disturbances such as dredging, bottom trawling, construction of underwater infrastructure, and other human activities. The destruction of such biogenic structures leads to reduced structural integrity of benthic habitats and a significant decline in biodiversity, as they play a crucial ecological role by providing shelter and feeding grounds for numerous fish, crustaceans, and mollusks, stabilizing sediments, and reducing seabed erosion.

Seagrass meadows also play an important role in carbon sequestration in marine sediments, making them a key component of so-called “blue carbon” ecosystems (Waycott et al., 2009). However, reduced water transparency due to eutrophication and increased sedimentation has led to a significant decline in the extent of *Zostera* meadows, as these plants require sufficient

NEXT Black Sea Basin

light for photosynthesis. In the long term, the degradation of these key habitats results in a decline in the ecosystem services they provide, including biodiversity support, sediment stabilization, and the maintenance of fishery productivity.

In recent years, offshore exploration for oil and natural gas in the Bulgarian Black Sea waters has emerged as a potential threat to cetacean populations. Additional pressures include military activities and exercises, where high-frequency emissions and noise pollution from naval vessels may negatively affect cetacean behavior (Bilyavsky, 1998).

3.2.4. Invasive Alien Species:

The International Union for Conservation of Nature (IUCN) defines invasive alien species as animals, plants, or other organisms introduced by humans outside their natural range that negatively impact native biodiversity, human economies, or well-being.

In the last 30 years, an unusual form of pollution from ships has seriously damaged the Black Sea ecosystem. This is the introduction of non-native species that are accidentally transported from another part of the Ocean, adapt successfully and develop rapidly because they usually have no natural enemies to limit their population. The problem is caused mainly by ships discharging their ballast water near the Black Sea coast. Ballast water is the water that a ship takes on board for additional stability after unloading, often in some remote part of the world. Non-native invasive species are considered the greatest threat to marine biodiversity, coastal economies and human health. Ballast water is a major vector for this bioinvasion. (Klisarova, 2014).

Under the influence of climatic and anthropogenic factors, significant changes in the diversity of flora and fauna have been recorded in the Black Sea (Shiganova and Ozturk, 2010). In 2009, a list was published containing a total of 52 phytoplankton species, most of which occur in Bulgarian waters (35), while only 9 (in Romanian waters) and 6 species (in Turkish waters) were identified. By 2017, the number of established non-native species had already increased to 64 (Black Sea Non-Indigenous Species, 2017). The typical sites of first appearance of non-native phytoplankton species are coastal and shelf waters (List of Non-Native Species from the Black Sea) (Table 5).

Mediterraneanization—the influx of species from the Mediterranean—continues to reshape Black Sea biodiversity. Invasive species such as *Mnemiopsis leidyi* have historically caused trophic collapses, and ongoing introductions threaten native fish and zooplankton communities. The transport of species through ships' ballast water (such as the veined rapana and the ctenophora *Mnemiopsis leidyi*) radically alters local habitats and displaces native species. Development of potentially toxic and harmful phytoplankton species, which in higher concentrations can cause toxin accumulation in mollusks and health problems in humans.

During the past 20 years, a total of 24 potentially toxic (harmful) phytoplankton species have been identified in the Phytoplankton Laboratory of the Institute of Fish Resources - Varna, according to the standardized list (Moestrup et al., 2009). Among the potentially toxic species, the dominant ones include *Pseudo-nitzschia delicatissima*, *Pseudo-nitzschia seriata*,

NEXT Black Sea Basin

Prorocentrum cordatum, and *Halamphora coffeiformis* (C. Agardh) Mereschkowsky 1903: 54, 149 (as 'coffaeiformis'), depending on the observed season and water area.

Potentially toxic dinoflagellate species from the genera *Dinophysis*, *Gonyaulax*, and *Alexandrium* are often found in Bulgarian coastal waters (Petrova and Gerdzhikov, 2007; Petrova and Gerdzhikov, 2011). When the abundance and biomass of these species increase, there is a risk of toxin accumulation in commercially valuable mussel and fish species.

Nowadays many non-indigenous species were introduced in Black Sea waters, but only some of them adapted and increased their populations so to respond to term **invasive** - species associated with established species which are agents of change and threaten native biological diversity (IUCN, 2002) or with species that threaten the diversity or abundance of native species, the ecological stability of infested ecosystems, economic activities dependent on these ecosystems and/or human health (EPA, 2001). More recent data on invasive zooplankton and zoobenthos species reduced their number and recognized Băncilă et al. (2022) *M. leidy*, *B. ovata*, *F. enigmaticus*, *P. cornuta*, *D. quadrilobate*, *R. venosa*, *A. kagoshimensis* and *M. arenaria*. A total of **seven fish** species recorded in the Bulgarian Black Sea waters can be classified as invasive alien species. Five of them are of primary freshwater origin, inhabiting estuarine and lagoonal zones along the coast. These include the Prussian carp (*Carassius gibelio*), the eastern mosquitofish (*Gambusia holbrooki*), and the pumpkinseed (*Lepomis gibbosus*). In contrast, adult specimens of rainbow trout (*Oncorhynchus mykiss*) have been recorded at multiple locations along the Bulgarian coast in recent years. Their origin may be linked to aquaculture facilities in Krasnodar, near Sochi (Russia), where strong waves and stormy winds in late January 2022 damaged cage installations, resulting in the escape of 20 to 300 tonnes of adult individuals into the Black Sea. *Perccottus glenii* is another invasive species of freshwater origin recorded in the Bulgarian Black Sea waters, although it was initially misidentified as *Umbra krameri* (Raikov et al., 2012).

The two alien and invasive species of marine origin recorded in Bulgaria are *Planiliza haematocheila* and *Sebastes schlegelii*. The native range of *P. haematocheila* covers the northwestern Pacific Ocean (the Sea of Japan, the Yellow Sea, and the coastal waters of China and Korea). The species was intentionally introduced into the Azov - Black Sea basin in the 1970s for the purposes of aquaculture development and enhancement of fishery productivity (Borisenko & Chikhachev, 1991). Following a series of stockings, a stable, self-reproducing population was established in the Sea of Azov in the early 1980s, from where it subsequently spread throughout the Black Sea basin (Kostadinova, 2008). Due to its euryhaline nature, high ecological plasticity, and ability to inhabit coastal, lagoonal, and estuarine environments, *P. haematocheila* exhibits considerable invasive potential. Although the species had long been observed along the Bulgarian Black Sea coast, it was first officially reported by Dobrovolev et al. (2003). At present, there is no reliable evidence that the species reproduces along the Bulgarian Black Sea coast, and there is also a lack of data regarding its status, abundance, and catches.

NEXT Black Sea Basin

Sebastes schlegelii is a demersal species widely distributed in the northwestern Pacific Ocean along the coasts of China, Japan, and the Korean Peninsula. It was first recorded in the Black Sea in 2013 in the coastal waters of Crimea and has since been repeatedly observed, suggesting successful introduction. Its occurrence in the Black Sea is likely related either to transport via ballast waters or to the import and acclimatization of the Pacific oyster *Magallana gigas* as a potential aquaculture species (Karpova et al., 2021). Along the Bulgarian Black Sea coast, *S. schlegelii* was first recorded in 2022-2023, when a total of six specimens were documented in the areas of Varna and Kiten (Ivanova et al., 2024). At present, the species is being encountered with increasing frequency, with individuals recorded at various locations along the coast.

Of all alien and invasive species identified to date, only *Planiliza haematocheila* is part of the commercial catches as bycatch. The remaining species have no economic importance.

3.2.5. Climate Change and Ocean Acidification

Climate change is disrupting weather patterns and further increasing pressures on Europe's water resources and ecosystems (EEA, 2024). The EU Climate Risk Assessment highlights the need to address interconnected and compound risks (WE, 2026). This new Water Europe position paper on the climate adaptation framework argues that strengthening water management as a preventive adaptation measure lowers our vulnerability to the risks, while boosting public health and economic stability.

Climate change represents an increasingly important factor affecting the structure and functioning of marine ecosystems. Observations indicate that sea surface temperatures in the Black Sea have been rising in recent decades, increasing by approximately 0,8-1,2 °C since the mid-20th century (IPCC, 2021; EEA, 2022). This has led to shifts in the distribution of various fish species, as well as changes in the seasonal dynamics of plankton communities. Alterations in migration patterns and spawning periods have been observed in some species, such as anchovy and sprat, which are key components of Black Sea pelagic ecosystems (Kideys, 2002).

Marine heatwaves are becoming more common disrupting fish populations and altering sea currents. In addition, rising temperatures may facilitate the spread of certain invasive species, further altering the trophic structure of the ecosystem. Changes in the thermal regime of the Black Sea also intensify water column stratification, limiting vertical exchange of oxygen and nutrients between surface and deeper layers.

Another important aspect of climate change is ocean acidification, resulting from increased concentrations and dissolution of carbon dioxide in seawater, which alters carbonate chemistry and reduces pH (Kwiatkowski&Orr, 2018). Global estimates indicate that the average surface ocean pH has decreased by about 0,1 units since the beginning of the industrial era, corresponding to an approximately 30% increase in acidity (IPCC, 2019). Although the Black Sea is largely isolated from the global ocean and has specific hydrochemical characteristics, this process may have long-term negative effects on a range of organisms, particularly calcifying species such as certain planktonic organisms, mollusks, and other invertebrates. The Black Sea

NEXT Black Sea Basin

responds more quickly to global climate changes compared to the world ocean. The Bulgarian Black Sea becomes climate change affected area (Dineva, 2013a). Climate change mitigation has to include reducing the emission of greenhouse gases and enhancing their sinks, whereas adaptation refers to actions performed at local or regional scale to moderate negative effects of climate change (Dineva, 2013c). These changes disproportionately affect vulnerable species and may lead to permanent ecosystem disruption.

Surface water temperatures in the Bulgarian Black Sea have increased significantly over recent decades, altering species' metabolic rates, reproductive cycles, and migration patterns. Temperature sensitive species such as sturgeons are experiencing habitat loss and reduced reproductive success, contributing to population collapse. Long-term temperature changes are characterized by a positive statistically significant trend, with values of 0.6-0.7 °C per decade for annual air temperatures and 0.5 °C per decade for annual SST. The trend during the cold part of the year (November-April) is 0.8 °C per decade (both for air and sea surface temperatures) while in the warm part (May-October) the trend is 0.6-0.7 °C per decade (Klisarova et al., 2025).

The rising surface temperature (SST) proved to statistically significantly influence the decrease in the abundance of nano-phytoplankton (50.9%), the abundance and biomass of micro-phytoplankton (53%; 33.2%), the Bacillariophyceae (49.5%; 35.6%), and the biomass of the species of group "Other" (51.4%) (Klisarova et al., 2023). The decreasing total phosphorus (TP) has a significant influence on the decrease in the abundance and biomass of the diatoms and the biomass of group "Other". The decreasing dissolved inorganic nitrogen (DIN) significantly affects the decrease in the abundance and biomass of Dinophyceae (Klisarova et al., 2023). The analyses showed that rising temperatures had a leading role in the changes in the taxonomic and size structure of phytoplankton during the period 1992-2019 (Klisarova et al., 2023).

In the Black Sea, climate change may act cumulatively with other pressures such as eutrophication, overfishing, illegal fishing, and invasive alien species. Sea warming and acidification threaten food webs and the livelihood of communities that depend on the sea (Doney et al., 2009). In the long term, these combined processes may lead to significant alterations in ecosystem structure, including changes in trophic interactions, productivity, and the spatial distribution of fish and other marine organisms.

3.3. Romania

The Black Sea ecosystem along Romania's coastline is exposed to multiple interacting threats that undermine its biodiversity and ecological balance. These pressures rarely act in isolation; rather, they have cumulative and synergistic effects that degrade marine resilience. These include overfishing and illegal fishing, pollution and eutrophication, habitat degradation, invasive alien species, and the accelerating impacts of climate change and ocean acidification. Below is an overview of these key pressures affecting marine life in the region.

3.3.1. Overfishing and Illegal, Unreported, and Unregulated (IUU) Fishing

Overfishing remains one of the most severe threats to marine biodiversity in Romanian waters. Both demersal species (such as turbot *Scophthalmus maeoticus*, red mullet *Mullus ponticus*, and spiny dogfish *Squalus acanthias*) and small pelagic fish (like anchovy *Engraulis encrasicolus*, sprat *Sprattus sprattus*, and horse mackerel *Trachurus mediterraneus ponticus*) face intense and often unsustainable exploitation. Despite the implementation of regional quotas by the General Fisheries Commission for the Mediterranean (GFCM), the recovery of demersal stocks like turbot remains fragile. Illegal, unreported, and unregulated (IUU) fishing further exacerbates the decline of fish stocks, undermines conservation efforts, and damages sensitive habitats such as seagrass beds and soft-bottom areas through the use of destructive bottom-trawling gear or non-compliance with seasonal closures.

Moreover, bycatch from both legal and illegal operations poses a critical risk to marine mammals. The widespread use of bottom-set monofilament gillnets for turbot fishing is the primary cause of mortality for the Black Sea harbour porpoise (*Phocoena phocoena relicta*), with peak bycatch incidents occurring during their spring migrations. Dolphins (*Tursiops truncatus ponticus* and *Delphinus delphis ponticus*) are also frequently entangled, contributing to population declines and undermining the reproductive success of these apex predators (Paiu et al., 2021, 2024; GFCM, 2023).

3.3.2. Pollution and Eutrophication

Pollution from land-based sources introduces a complex mix of contaminants into the marine environment. Because the Black Sea drains a massive European catchment area—with the Danube River serving as the primary vector—the Romanian coast is highly susceptible to agricultural runoff, industrial waste, and untreated sewage. Among the most concerning pollutants are heavy metals, persistent organic pollutants (POPs), and hydrocarbons from maritime traffic.

Eutrophication, caused primarily by excessive nitrogen and phosphorus inputs, remains a chronic problem. While nutrient loads have decreased since the severe hypoxic crises of the 1980s, the shallow northwestern shelf is still prone to seasonal algal blooms. These blooms reduce water transparency, disrupt food web dynamics, and trigger localized hypoxia (oxygen depletion) in bottom waters, causing mass mortalities of benthic invertebrates and fish (Abaza et al., 2020). Furthermore, plastic pollution has emerged as a severe threat. The Danube River discharges thousands of tons of plastic waste annually into the Black Sea. Microplastics are now ubiquitously found in Romanian coastal sediments, zooplankton, and commercial fish species, while larger plastic debris causes fatal entanglement and ingestion incidents in marine mammals and seabirds (Pojar et al., 2021).

NEXT Black Sea Basin

3.3.3. Habitat Loss and Degradation

The physical alteration of coastal and marine habitats through "coastal squeeze" is significantly degrading biodiversity. Infrastructure development, port expansion at Constanța and Midia, dredging, and the construction of hard coastal protection structures lead to habitat fragmentation and the irreversible loss of critical benthic ecosystems.

A prominent contemporary example is the large-scale beach nourishment projects implemented along the Romanian coast (e.g., in Mamaia and Eforie) to combat coastal erosion. While necessary for shoreline protection, the extraction of massive volumes of offshore sand and its deposition on the coast physically smothers shallow soft-bottom communities. This severely impacts populations of native bivalves (such as *Donax trunculus* and *Chamelea gallina*) and destroys critical nursery habitats for juvenile fish. Once degraded or removed, these complex biological communities require years to recover, reducing the overall ecosystem resilience of the coastal zone (Micu et al., 2020).

3.3.4. Invasive Alien Species (IAS)

Due to extensive international shipping and ballast water discharges, invasive alien species pose a massive ecological threat by disrupting native communities and altering food webs.

A historical catastrophe occurred in the late 1980s with the accidental introduction of the comb jelly (*Mnemiopsis leidyi*). This highly adaptable ctenophore preyed heavily on zooplankton and pelagic fish larvae, outcompeting commercially important species like anchovy and sprat and contributing to the near-collapse of regional fisheries. The ecosystem only stabilized after the subsequent accidental introduction of another ctenophore, *Beroe ovata*, which specifically preys upon *M. leidyi* (Shiganova et al., 2019). In the benthic zone, the veined rapa whelk (*Rapana venosa*), a large predatory gastropod from the Pacific, has fundamentally restructured the ecosystem. By consuming native bivalves, it decimated the native oyster and mussel beds that serve as natural water filters. Paradoxically, the *Rapana* has now become Romania's most lucrative marine export, creating a complex management scenario where an invasive species sustains the local fishing economy while threatening native biodiversity.

3.3.5. Climate change and ocean acidification

Climate change compounds all other anthropogenic pressures and is fundamentally altering the physical and biological structure of the Black Sea. Key documented impacts include:

- **Rising sea temperatures:** Increasing sea surface temperatures (SST) influence plankton phenology (the timing of blooms) and force cold-water species, like sprat, deeper into the water column, altering predator-prey dynamics.
- **Deoxygenation and stratification:** The Black Sea is naturally anoxic below ~150 meters, but climate change is exacerbating this. Warmer winters have reduced the formation of the Cold Intermediate Layer (CIL), a critical water mass that ventilates the upper sea. Consequently, the boundary of the toxic, hydrogen sulfide-rich deep water is shoaling (rising closer to the surface), compressing the habitable space for all aerobic marine life (Capet et al., 2020).

NEXT Black Sea Basin

- **Benthic stress:** Increased thermal anomalies (marine heatwaves) induce severe physiological stress on sessile benthic organisms, leading to localized die-offs.
- **Ocean acidification:** Although ocean acidification is less studied in the Black Sea compared to open ocean systems, the absorption of excess atmospheric CO₂ lowers water pH. This is expected to severely affect calcifying organisms—such as mussels, oysters, and specific plankton species—weakening their shells and potentially altering the entire marine food web.

4. BLACK SEA FOOD PYRAMID

4.1. Türkiye

A food pyramid is a graphical representation of the trophic structure of an ecosystem. It illustrates the hierarchical organization of organisms according to their trophic level and depicts the flow of energy from primary producers through primary, secondary, and tertiary consumers to apex predators.

In the Black Sea ecosystem, the food pyramid reflects this sequential transfer of energy across trophic levels. As energy moves from one level to the next, only about 10% is transferred, while the remaining energy is lost through metabolic processes and heat. Consequently, biomass, organism abundance, and available energy progressively decrease from the base of the pyramid toward the apex predators.

4.1.1. Primary Producers (Phytoplankton and Seagrass)

Primary producers, also called autotrophs, are organisms that use photosynthesis to capture the Sun's energy and use it to synthesize glucose. Through photosynthesis, primary producers generate food for all other forms of marine life: a process called primary production. Primary producers include phytoplankton, algae, and marine plants.

The most important primary producers in the oceans are the phytoplankton: single-celled photosynthesizing organisms that float and drift near the ocean surface, in the euphotic zone; the region of enough sunlight for photosynthesis. From a systemic perspective, organisms that perform this function include various groups of eukaryotes. These groups, which vary with the trophic status of the aquatic environment, form the basis of primary production.

- a) Phytoplankton Groups: In the Black Sea, phytoplankton groups, which represent the primary producers at the base of the food pyramid, consist mainly of diatoms (class: Bacillariophyceae), dinoflagellates (class: Dinophyceae), green algae (class: Chlorophyceae), cyanobacteria (blue-green algae) (class: Cyanophyceae), silicoflagellates (class: Chrysophyceae), euglenoid flagellates (class: Euglenophyceae), and coccolithophores (class: Prymnesiophyceae) (Table 10).

NEXT Black Sea Basin

Table 16. Number of species belonging to phytoplankton groups identified in the Black Sea.

Phytoplanktonic Groups	Approximate number of species
Diatoms (Bacillariophyceae)	300
Dinoflagellat (Dinophyceae)	200
Green algae (Chlorophyta)	50-100
Cyanobacteria	30-50
Haptophyta, Cryptophyta, Euglenophyta	10-20

- b) Blue-Green Algae (Cyanophyceae): Blue-green algae are prokaryotic organisms that lack true plastids and nuclei (Cirik and Gökpınar, 1993). Due to the absence of a nucleus, they resemble bacteria (Davis, 1955). They can exist as single cells or in colonial forms. The most common morphological form is filamentous colonies. There is no division of labor among the cells within the colony. Most species are non-motile organisms (Davis, 1955). The pigments found in their cells are highly diverse. In addition to chlorophyll-a, chlorophyll-b, and phycocyanin pigments, they also contain β -carotene and xanthophylls. Their cell walls are composed of cellulose and pectin. They store reserved food materials produced as a result of assimilation in the form of glycogen. Planktonic Cyanophyceae species possess gas vesicles within their cells (Cirik and Gökpınar, 1993). Sexual reproduction is not observed in blue-green algae. Asexual reproduction occurs, especially in unicellular forms, through binary cell division. The formation of various types of spores has also been observed. In filamentous forms, resistant spores called akinetes are found between cells. They possess specialized transparent, thick-walled cells called heterocysts, which enable atmospheric nitrogen fixation. The presence and position of heterocysts in filamentous forms are important characteristics in algal taxonomy. The most common unicellular blue-green algal genus observed throughout the pelagic ecosystem of the Black Sea is *Synechococcus* spp. (Feyzioğlu et al., 2015) (Figure-41). These prokaryotic unicellular organisms, ranging in size from 0.8 to 1.5 μm , represent one of the most important components of primary production in aquatic ecosystems. *Synechococcus* spp. is also a major component of the microbial loop.

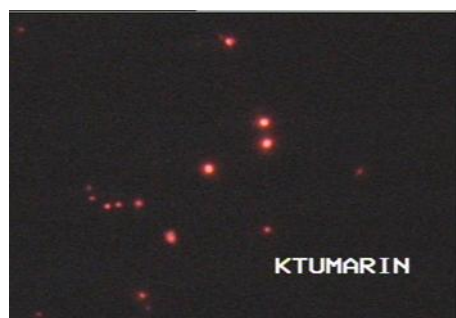


Figure 41. *Synechococcus* spp. observed in the Black Sea. (Photo: A.M. Feyzioğlu)

NEXT Black Sea Basin

- c) Green Algae (Chlorophyceae): Organisms belonging to this group exhibit a highly diverse range of morphological forms. They include motile and non-motile unicellular picoplanktonic forms, colonial forms, as well as multicellular filamentous algae with simple or branched structures and multinucleated thalli that may exceed one meter in length (Baydar, 1979; Valiela, 1995). Their cell walls are resistant and composed mainly of cellulose. The outer surface contains pectic substances, and calcium carbonate may also occur in some species. Chloroplasts may be single or multiple and exhibit a variety of morphologies, including star-shaped, cup-shaped, ribbon-like, and spiral forms. Chloroplasts contain chlorophyll-a and chlorophyll-b. Among carotenoid pigments, carotene and the xanthophyll pigment lutein are present (Baydar, 1979). Members of this class are generally autotrophic; however, heterotrophic colorless forms also occur. Starch is usually produced as a result of assimilation, and in addition to starch, lipids may also serve as storage compounds (Baydar, 1979). Asexual reproduction occurs through cell division in unicellular forms. Sexual reproduction, although not frequent in some species, may occur through isogamy, anisogamy, and oogamy. Following fertilization, the resulting zygote possesses a thick wall in freshwater species, whereas marine forms generally have a thin membrane. Germination occurs through mitotic division (Baydar, 1979). In the Black Sea ecosystem, species belonging to the group Chlorophyta are generally represented by thallus-forming algae distributed mainly in the coastal region, particularly within the infralittoral zone and the upper part of the circalittoral zone. Although this group is represented by a limited number of marine planktonic species, *Pyramimonas orientalis* may occasionally form blooms, particularly in enclosed areas and coastal waters (Feyzioğlu and Boran, 1997) (Figure 42).



Figure 42. *Pyramimonas orientalis* (<https://www.ccap.ac.uk/catalogue/>)

- d) Silicoflagellates (Chrysophyceae): Silicoflagellates are unicellular flagellated organisms. Their flagellum consists of a paraxial root and a motile part, while the second flagellum is present as a basal body. The flagellum produces sinusoidal movements, allowing the cell to move by pulling itself through the water. Cells may be naked or covered with a skeleton composed of cellulose and silica. In some species, a chitinous lorica is also present. They are typically yellow or yellowish-brown in color. Their chloroplasts may

NEXT Black Sea Basin

occur in numbers of three, six, or more. The main storage product is chrysolaminarin (a soluble β -1,3-glucan), although lipids may also serve as storage compounds. Their nutritional modes include phototrophy, mixotrophy, and heterotrophy. Silicoflagellates are generally distributed in cold, nutrient-rich waters. Planktonic species occur in both coastal and oceanic environments, and some species particularly prefer brackish water habitats (Tomas, 1993; Valiela, 1995). Although their contribution to primary productivity and energy flow within the food web is relatively limited, the most common silicoflagellate species observed in the Black Sea are *Dictyocha speculum* and *Octactis octonaria* (Figure 43).

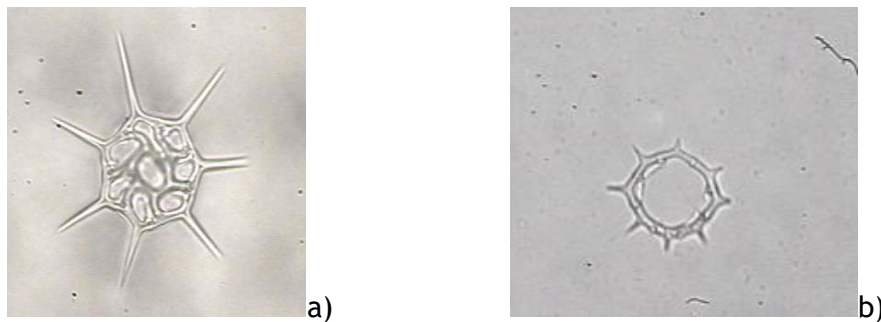


Figure 43. Some Silicoflagellates observed in the Black Sea. (A) *Dictyocha speculum*, (B) *Octactis octonaria* (Photo: A.M. Feyzioğlu)

- e) Cocolithophores (Prymnesiophyceae): Cocolithophores are unicellular organisms possessing two flagella. The flagella are located at the anterior end of the cell and are approximately equal in length. Cell sizes rarely exceed 30 μm , and most species are generally smaller than 10 μm . They may exhibit various morphological forms, including cylindrical, spherical, spinose, and oval shapes. Vegetative reproduction occurs through cell division. They generally possess chloroplasts containing parietal pyrenoids. Most species have two chloroplasts, which contain chlorophyll-a and chlorophyll-c. Their main storage products are the water-soluble carbohydrate-like compound chrysolaminarin and lipids. The most distinctive characteristic of cocolithophores is the presence of regularly arranged calcium carbonate plates covering the outer surface of the cells. These plates are called cocoliths. Due to their characteristic arrangement and morphology on the cell surface, cocoliths are widely used as important taxonomic features for the identification and classification of cocolithophore species. During bloom events, cocolithophores may cause visible changes in seawater color due to the high abundance of their calcified cells. They are mainly distributed in tropical and subtropical open ocean regions. In neritic environments, *Emiliana huxleyi* is one of the most abundant and widespread species (Figure VIII). Cocolithophores are also known to produce significant amounts of volatile sulfur compounds, which can readily enter the atmosphere in gaseous form (Tomas, 1993). They frequently form extensive blooms over large areas, particularly during spring periods (Figure 44).

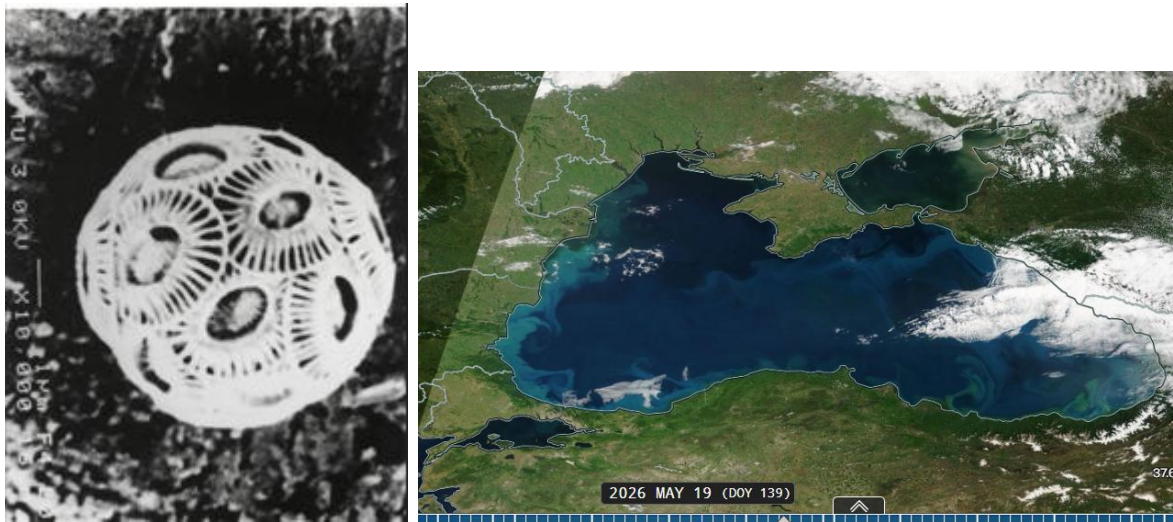


Figure 44. *Emiliania huxleyi* (Photo: A.M. Feyzioğlu) and *E. huxleyi* bloom along the Black Sea coast NASA (<https://worldview.earthdata.nasa.gov>)

- f) **Diatoms (Bacillariophyceae):** Diatoms are one of the most important algal groups in marine environments (Hasle, 1978) (Figure 45). The most distinctive characteristic of diatoms, which are abundant in coastal systems of temperate regions, upwelling areas, and high-latitude waters, is the presence of an external skeleton composed of silica (Kennish, 1994). The siliceous cell wall contains various secondary structures and ornamentations that are important for species identification. This cell wall, known as the frustule or theca, consists of two overlapping parts similar to the two halves of a box or a Petri dish. The larger and older upper part is called the hypotheca or hypovalve, whereas the smaller part is known as the epitheca or epivalve. The region where these two thecae overlap is called the girdle (Cirik and Gökpinar, 1993). Many marine diatoms are non-motile organisms and generally range in size from 10 to 200 μm . Due to the relatively high density of their siliceous shells, they tend to sink in the water column. Therefore, they have developed various morphological and physiological adaptations to maintain their position within the photic zone (Kennish, 1994). Immediately beneath the frustule lies a relatively thick layer of protoplasm containing chromatophores. The shape and number of chromatophores vary among species. The nucleus is generally located in the central region of the cell. The major pigments include chlorophyll-a, chlorophyll-c, β -carotene, fucoxanthin, and diadinoxanthin. The primary storage product is chrysolaminarin; diatoms do not produce starch. Photosynthetic products are mainly stored as lipid droplets within the cell (Cirik and Gökpinar, 1993). Diatoms reproduce through both asexual and sexual reproduction. During asexual reproduction, the cell divides parallel to the valve surface. After division, each daughter cell retains one valve, while the newly formed side remains without a valve. A new hypotheca is then formed within the existing valve of each daughter cell (Baydar, 1979). After several successive divisions, cells reach their minimum size. At this stage, the diatom loses its siliceous shell and increases in size until reaching the normal cell dimensions before forming new valves (Valiela, 1995). Under favorable environmental conditions, a single diatom cell may divide

NEXT Black Sea Basin

0.5-6 times per day (Kennish, 1994). During sexual reproduction, microsporulation produces small, biflagellated microspores lacking a silicified membrane. These microspores are motile and fuse to form a zygote, which develops into a normal-sized vegetative cell (Cirik and Gökpınar, 1993). Under unfavorable environmental conditions, when vegetative reproduction cannot continue, diatoms form resistant structures known as resting spores (Valiela, 1995) (Figure 45).

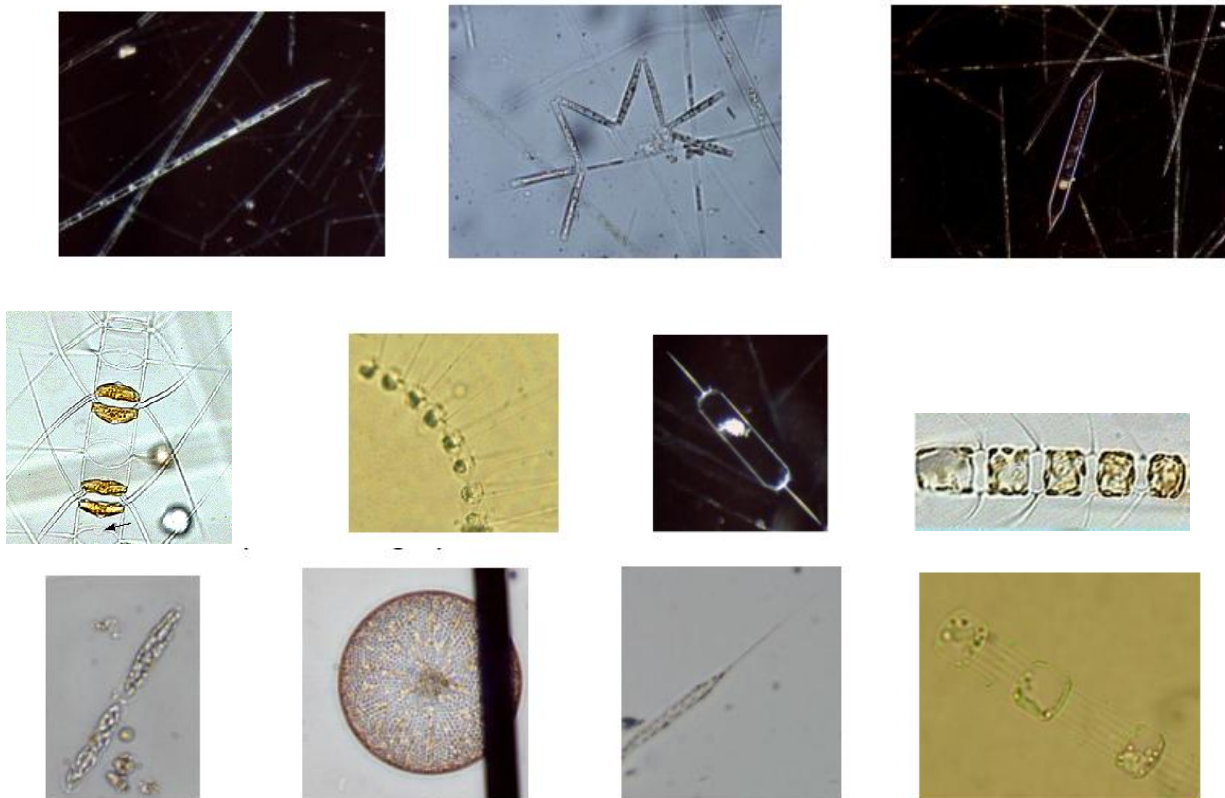


Figure 45. Some Diatom species observed in the Black Sea a) *Proboscia alata*, b) *Thallasionema nitzshiioides*, c) *Rhizosolenia calcar-avis* d) *Chaetoceros didymus*, e) *Chaetoceros curvisetus*, f) *Ditylum brightwelli*, g) *Chaetoceros compressus*, h) *Dactyliosolen fragilissimus*, i) *Coscinodiscus radiatus*, j) *Rhizosolenia hebetata*, k) *Skeletonema coctatum* respectively (Photo: A.M. Feyzioğlu)

g) **Dinoflagellates (Dinophyceae):** Dinoflagellates represent the second most important group of marine organisms after diatoms in terms of abundance and ecological significance (Davis, 1955) (Figure 46). Their sizes generally range from 5 μm to 2000 μm . A characteristic feature of dinoflagellates is the presence of two distinct grooves on the cell surface. From a zoological perspective, they have historically been classified within the protozoan group and included in the class Mastigophora. However, because many dinoflagellate species are photosynthetic, they are also considered algae (Baretta-Bekker et al., 1992). Many dinoflagellates possess a light-sensitive structure known as an eyespot

NEXT Black Sea Basin

(stigma), which is formed by the accumulation of photosensitive pigments (Davis, 1955). They contain a large nucleus surrounded by a double membrane located in the central region of the cell. The cytoplasm contains all major organelles characteristic of eukaryotic organisms (Spector, 1984). Dinoflagellates are widely distributed and abundant in marine and brackish-water environments, particularly in tropical and subtropical regions. They are typically unicellular organisms possessing two flagella. Based on their position, these flagella are classified as transverse and longitudinal flagella. They are located within specialized grooves on the cell surface called the cingulum (transverse groove) and sulcus (longitudinal groove), respectively (Kennish, 1994). Although planktonic dinoflagellates possess flagella, their movement is generally insufficient to overcome water currents, and they are largely transported by water movements (Valiela, 1995). The most common mode of reproduction in dinoflagellates is asexual reproduction through mitotic cell division. However, sexual reproduction has also been observed in many genera (Spector, 1984). Division rates are highly variable, and generation times depend strongly on environmental conditions (Kennish, 1994). Dinoflagellates exhibit diverse nutritional strategies, including holophytic, saprophytic, holozoic, and mixotrophic feeding modes (Davis, 1955). Some species are capable of phagotrophic feeding and can ingest entire prey cells. Certain species develop rhizoid structures to capture prey, while several dinoflagellate species act as predators on fish eggs. Others occur as parasites of metazoans and protozoans (Spector, 1984). The major pigments found in dinoflagellates include chlorophyll-a, chlorophyll-c, β -carotene, and the characteristic brown pigment peridinin. During bloom periods, dinoflagellates may cause seawater discoloration, changing the water color to reddish-brown due to the dominance of their brown pigments. This phenomenon is known as red tide. Metabolic products are stored mainly as starch and lipids (Spector, 1984). A large proportion of dinoflagellate species are capable of producing toxins. These toxins may cause mortality in fish, shellfish, and other marine organisms. Such effects become particularly pronounced during toxic red tide events (Kennish, 1994). Red tide events have recently been observed in the Black Sea, especially in coastal regions, where they are associated with blooms of *Noctiluca scintillans* (Kopuz et al., 2024). The most common dinoflagellate species observed in the Black Sea and coastal red tide events are presented in Figure XI. Compared with diatoms, dinoflagellates generally have slower division rates and longer generation times. Therefore, diatoms have a competitive advantage during the initial stages of phytoplankton blooms. As turbulence decreases and nutrients become depleted, diatoms tend to sink into deeper waters. In contrast, dinoflagellates can remain within the euphotic zone due to their flagellar movement. Consequently, dinoflagellates are generally more abundant during the later stages of phytoplankton succession (Spector, 1984) (Figure 47).

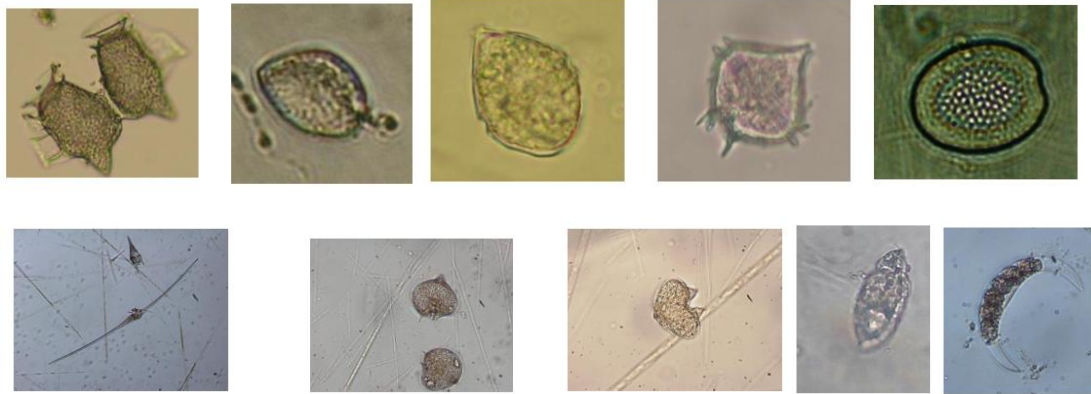


Figure 46. Some Dinoflagellata species observed in the Black Sea: a) *Dinophysis caudata*, b) *Prorocentrum micans* c) *Scripsiella trochoidea*, d) *Protoperidinium pallidum* e) *P. compressum* f) *Tripos fusus* ve *Tripos furca*, g) *Potoperidinium conicum*, h) *Protoperidinium depressum*, i) *Katodinium glaucum*, j) *Dissodinium pseudoluneata* respectively (Photo: A.M. Feyzioğlu)



Figure 47. a) *Noctiluca scintillans* and b-c) the red-tide event caused by *Noctiluca scintillans*. (Photo: A.M. Feyzioğlu)

Recent changes observed in the Black Sea ecosystem have revealed a decline in gelatinous zooplankton groups and an increase in the abundance of *Noctiluca scintillans*. Although *N. scintillans* is a unicellular organism, its relatively large cell size, comparable to that of small adult copepods and copepodites of larger copepod species, allows it to compete with copepods in terms of feeding strategies and resource utilization.

Previous studies have reported that the biomass of *N. scintillans* may exceed that of copepod communities. The frequent occurrence of *N. scintillans* blooms in coastal regions in recent years, together with the absence of effective predators at higher trophic levels, may result in the loss of energy transferred into the *Noctiluca*-dominated pathway from the food web.

Due to this diversion of energy away from traditional trophic pathways, *N. scintillans* has the potential to exert ecosystem-level impacts similar to those previously caused by *Mnemiopsis leidyi*. Such changes may ultimately influence important pelagic fish stocks, particularly commercially valuable species such as anchovy (*Engraulis encrasicolus*).

- h) Euglenoids (Euglenophyceae): Euglenoids are unicellular flagellated organisms. Their classification is relatively difficult because they exhibit both plant-like and animal-like characteristics (Şişli et al., 1972). They never form colonies. Pigmented species generally possess a single long flagellum, whereas non-pigmented species may have one, two, or three long flagella. Under unfavorable environmental conditions, the flagellum may disappear, and the cell becomes surrounded by a thick wall, transforming into a cyst form. Euglenoids possess an eyespot (stigma) and a contractile vacuole. Instead of a true cell wall, the outer rigidized layer of the cytoplasm functions as a protective covering and is known as the pellicle. The pellicle is generally striated or composed of small vesicular structures. Their photosynthetic pigments include chlorophyll-a, chlorophyll-b, and carotenoids. Chromatophores are green in color and may exhibit various shapes, including disc-shaped, rod-shaped, star-shaped, or ribbon-like forms. The main storage products formed as a result of assimilation are paramylon (a glucose polymer) and lipids (Aykulu, 1984). Reproduction generally occurs through simple cell division and is asexual. However, sexual reproduction has also been reported in several genera (Şişli et al., 1972). In the Black Sea, the most common euglenoid species observed in coastal regions, particularly in river mouths and enclosed ecosystems, is reported to be *Eutreptia lanowii* (Figure- 48).



Figure 48. The most common Euglena species *Eutreptia lanowii* (Photo: A.M. Feyzioğlu)

4.1.2. Primary Consumers (Zooplankton)

Organisms that cannot synthesize glucose are called heterotrophs. They must consume autotrophs or other heterotrophs for food. All marine animals are heterotrophs. Feeding relationships between organisms resemble webs, with different organisms feeding at different trophic levels, depending on what is available as a food source.

Copepods, Energy Flow, and Trophic Dynamics in the Black Sea: *Calanus euxinus* and *Acartia clausi* are among the most extensively studied copepod species in the Black Sea. Both species constitute the principal food source for commercially important fish such as anchovy (*Engraulis encrasicolus*) and horse mackerel (*Trachurus mediterraneus*) (Sirotenko and Sorokalit, 1979; Avşar, 1993; Sağlam and Yıldız, 2019). While *Acartia clausi* is commonly observed throughout the year, *C. euxinus* is primarily a deep-water species that reaches its highest abundance during winter and spring (İşinibilir et al., 2011; Yıldız and Feyzioğlu, 2014).

NEXT Black Sea Basin

Arashkevich et al. (1998) reported high egg production rates ($5\text{--}25$ eggs female⁻¹ day⁻¹) for *C. euxinus* during experiments conducted in the Black Sea in September-October 1996. They suggested that these elevated reproductive rates resulted from a shift in the feeding strategy of *C. euxinus* from herbivory toward carnivory, with ciliates and dinoflagellates constituting a substantial proportion of its diet. In contrast, Beşiktepe and Telli (2004) reported considerably lower egg production rates for *C. euxinus* during October 2000 and May 2001. Similarly, Üstün and Bat (2014) investigated the egg production of *Acartia clausi* during 2008 and found the highest reproductive rates in February.

A study conducted in 1995 demonstrated that adult female *Calanus euxinus* consumed approximately 14.5% of the primary production in April and 9.5% in September (Beşiktepe et al., 1998). Nevertheless, information describing how seasonal variations in food composition and nutritional quality affect the feeding activity and reproductive performance of Black Sea copepods remains limited.

The cyclopoid copepod *Oithona davisae*, a non-indigenous species that entered the Black Sea during the early 2000s and became established in the Eastern Black Sea after 2010, has become an important contributor to mesozooplankton biomass. Although *Calanus euxinus* remains the preferred prey of commercially important fish species such as anchovy, horse mackerel, and sprat, its abundance has declined considerably compared with the early 2000s.

In contrast, populations of small-bodied copepods have increased. While these smaller copepods may provide suitable prey for early fish larvae, the decline of larger copepod species reduces food availability for larger planktivorous fishes, including anchovy. The ongoing shift of phytoplankton communities toward pico- and nanophytoplankton favors small-bodied copepods feeding on these size fractions, particularly species belonging to the genera *Oithona* and *Acartia*, resulting in increased biomass of these taxa. Conversely, the decline of diatom populations is thought to have contributed to the reduced abundance of larger copepods such as *Calanus euxinus*.

Anchovy is a planktivorous fish whose diet consists primarily of copepods of the genus *Calanus*, together with larvae of Cirripedia and Mollusca. During feeding, anchovy performs diel vertical migrations, descending to depths of approximately 70-90 m during daylight hours and ascending toward coastal surface waters (10-40 m) at night. Anchovy competes for the same planktonic food resources with other pelagic fishes, including sprat, shad, and sardine, as well as with gelatinous zooplankton such as ctenophores and jellyfish (Örek et al., 2000; Sağlam and Yıldız, 2019).

Although species such as sprat are of lower commercial value than anchovy, they play a significant ecological role in resource partitioning and energy transfer within the Black Sea ecosystem. Population changes resulting from excessive fishing pressure and other environmental stressors may therefore alter the regulatory mechanisms controlling ecosystem energy flow.

Until the 1970s, the Black Sea ecosystem functioned primarily under bottom-up control, in which ecosystem processes were regulated mainly by plankton communities at lower trophic levels. During the last three decades, however, changes in fish stocks have shifted ecosystem regulation toward top-down control (Oğuz and Gilbert, 2007). This transition has favored opportunistic gelatinous organisms, particularly ctenophores and scyphozoan jellyfish.

These gelatinous predators compete directly with pelagic fish for the same planktonic prey and fundamentally altered energy transfer within the Black Sea during the late 1980s. Whereas the dominant trophic pathway had previously been "zooplankton → planktivorous fish," it shifted toward "zooplankton → *Mnemiopsis leidyi*", resulting in substantial reductions in fish stocks and considerable economic losses (BSC, 2009).

Furthermore, increasing nutrient inputs and organic matter enrichment have enhanced the importance of microbial food-web processes, leading to longer and more complex trophic pathways. Under these circumstances, effective ecosystem-based management requires a comprehensive understanding of food-web architecture, trophic interactions, and the magnitude and pathways of carbon and energy transfer within the ecosystem.

4.1.3. Secondary Consumers (Small Pelagic Fish)

Secondary consumers (trophic level 3) prey primarily on zooplankton and other primary consumers. This trophic level mainly includes anchovy (*Engraulis encrasicolus*), sprat (*Sprattus sprattus*), horse mackerel, some gelatinous organisms etc. These species feed primarily on zooplankton and transfer energy from primary consumers to higher trophic levels.

Among the secondary consumers, anchovy (*Engraulis encrasicolus*), sprat (*Sprattus sprattus*), and horse mackerel (*Trachurus mediterraneus*) feed mainly on zooplankton. Anchovy primarily consumes calanoid copepods and bivalve larvae, sprat feeds predominantly on calanoid copepods and chaetognaths (*Parasagitta setosa*), while horse mackerel mainly preys on decapod crustaceans and calanoid copepods (Sağlam and Yildiz, 2019).

- Convert plankton production into fish biomass with high ecological and commercial value.
- Serve as the main food source for larger predatory fish and marine mammals.
- Play a central role in the pelagic food web by transferring energy to higher trophic levels.
- The **anchovy** is considered a **keystone species** in the Black Sea because changes in its population can affect the entire food web.

4.1.4. Tertiary Consumers (Medium-Sized Pelagic and Benthic Fish)

Trophic Level 4 consists of medium- and large-sized predatory fish, including bluefish (*Pomatomus saltatrix*), Atlantic bonito (*Sarda sarda*), turbot (*Scophthalmus maximus*), whiting

NEXT Black Sea Basin

(*Merlangius merlangus euxinus*), Garfish (*Belone belone*), scorpionfish, ray species etc. These predators feed mainly on small pelagic fishes, helping to regulate their populations and maintain ecosystem balance. They also transfer energy from secondary consumers to apex predators and include many of the Black Sea's most commercially valuable fish species. Declines in these predators can disrupt the food web, leading to increases in small pelagic fish populations or, in some cases, blooms of gelatinous organisms such as jellyfish and comb jellies.

As a tertiary consumer, adult *Scorpaena porcus* feeds primarily on benthic crustaceans and fishes, including mud shrimp (*Upogebia pusilla*), red mullet (*Mullus barbatus*), harbour crabs, and seahorses (*Hippocampus spp.*), along with a variety of other benthic prey (Sağlam and Bascinar, 2008). Its diet reflects its role as an opportunistic ambush predator in coastal benthic ecosystems. As a tertiary consumer, adult *Belone belone euxini* feeds mainly on small pelagic fishes, while also consuming insects, mollusks, crustaceans, and isopods opportunistically (Kaya and Sağlam, 2017). As a tertiary consumer, adult *Dasyatis pastinaca* feeds mainly on crustaceans, particularly mud shrimp (*Upogebia pusilla*). It also preys on anchovy (*Engraulis encrasicolus*), red mullet (*Mullus barbatus ponticus*), harbour crab (*Liocarcinus depurator*), horse mackerel (*Trachurus mediterraneus*), Mediterranean shore crab (*Carcinus mediterraneus*), brown shrimp (*Crangon crangon*), and the clam *Venus gallina* (Sağlam et al 2010).

4.1.5. Apex Predators

Dolphins are apex predators (trophic level 5) at the top of the Black Sea food web and are important indicators of ecosystem health. There are three cetacean species inhabiting the Black Sea: the bottlenose dolphin (*Tursiops truncatus*), the common dolphin (*Delphinus delphis*), and the harbour porpoise (*Phocoena phocoena*). A decline in dolphin populations can disrupt the marine food web, reduce the sustainability of fisheries, and negatively affect the entire ecosystem. By preferentially feeding on weak, old, or diseased fish, dolphins help maintain healthier fish populations and support successful reproduction. Dolphins also play an important role in nutrient cycling. Their feces act as a natural fertilizer, releasing nutrients that stimulate the growth of phytoplankton, the microscopic plants that produce oxygen and form the base of the marine food web (Trites, 2019). The increase in phytoplankton supports zooplankton and small pelagic fish such as European anchovy (*Engraulis encrasicolus*), sprat (*Sprattus sprattus*), and horse mackerel (*Trachurus mediterraneus*), which are key species for the Black Sea ecosystem and fisheries.

By feeding at depth and defecating near the surface, dolphins transport nutrients from deeper waters to the sunlit upper layer, where most marine life occurs. This "nutrient pump" helps recycle essential nutrients and enhances primary productivity. In summary, dolphins are not only top predators but also key contributors to the ecological functioning and productivity of the Black Sea, supporting both biodiversity and sustainable fisheries. Harbour porpoise (*Phocoena phocoena*) fed mainly on anchovy (*Engraulis encrasicolus*), followed by whiting

NEXT Black Sea Basin

(*Merlangius merlangus*) and horse mackerel (*Trachurus mediterraneus*). Common dolphin (*Delphinus delphis*) primarily preyed on anchovy and horse mackerel (Bilgin et al 2018).

Changes in Trophic Structure: Imbalances and Cascading Effects: The Black Sea is semi-enclosed sea and virtually isolated, connected with the Mediterranean by small and narrow channel, Bosphorus and characterized by two large cyclonic gyres in eastern and western parts (Oguz et al., 2006). This two cyclonic cyres system separates the Black Sea as east and west Black Sea Region on Anatolian coast. Because of the enclosed basin characteristics, the pelagic ecosystem of the Black Sea is continuously changing at surprising rates (Soydemir et al., 2002). Existing environmental changes and their impact not only on phytoplankton but also zooplankton composition and fisheries is of great important (Uysal, 1996).

In the western part of the Black Sea, the species composition was shifted from diatoms to coccolithophores and dinoflagellates possibly owing to decrease in the dissolved silicate (Moncheva and Krastev 1997). Pennate diatom species were more copious before 2000 when compared to after 2000 species composition. Diatom and dinoflagellate ratio changed and dinoflagellate ratio increase. Diatom and dinoflagellate ratio was 52,88% and 33,65 % respectively before millennium. But after millennium this ratio observed as 44,12% and 44,18% for diatom and dinoflagellate respectively (Figure 49) (Feyzioglu, A. M and Seyhan, K., 2007). The reason for the increase in dinoflagellate ratio after 2000 may be due to the difference in the use of nitrogen and phosphorus ratio by diatom and dinoflagellates. Because low nitrogen to phosphorus (N:P) ratio (below the Red field ratio) was favorable for coccolithophore growth whereas the high N:P ratio and increased above the Redfield ratio stimulated the development of diatoms (Silkin et al 2014). The changing nutrient balance of the Black Sea, along with changes in the seawater temperature regime, has affected the dominance of phytoplankton species, and it has been reported that in the last 10 years, dinoflagellates, micro and nanoplankton phytoplankton species have become more dominant than diatom species (BSC, 2008).

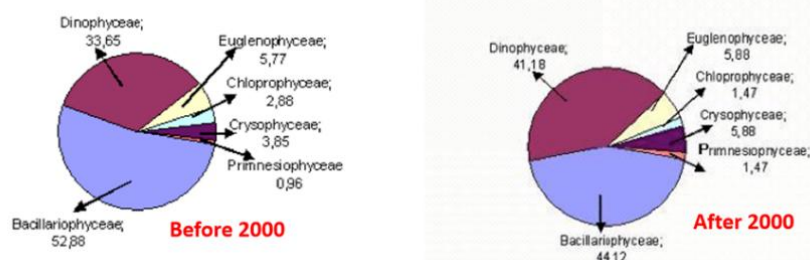


Figure 49. Ratio of main phytoplankton class living in Black Sea Anatolian coast

Ecosystem Dynamics of the Black Sea: Marine ecosystems provide direct and indirect benefits to human societies. However, degradation of healthy marine ecosystems may occur due to excessive fishing pressure, eutrophication, toxic pollutants, habitat loss, and other problems

NEXT Black Sea Basin

that are often associated with inadequate management practices (Nguyen, 2012). The Black Sea is an ecosystem that has experienced many of these environmental pressures. Considering its fundamental characteristics, the Black Sea has an average depth of approximately 1240 m and represents the largest anoxic basin in the world. Only a relatively thin upper layer, extending to approximately 150 m depth, contains dissolved oxygen, while the lower boundary of this oxygenated layer is defined as the Oxygen Minimum Zone (OMZ). The distribution of pelagic fauna in the Black Sea is largely restricted to this oxygenated upper layer above the OMZ (Beşiktepe et al., 1998).

Among the most important species within the Black Sea ecosystem are commercially valuable small pelagic fishes that occur in large schools, including anchovy (*Engraulis encrasicolus*), horse mackerel (*Trachurus mediterraneus*), and Atlantic bonito (*Sarda sarda*). Currently, approximately 76% of the fisheries production obtained through capture fisheries in Türkiye originates from the Black Sea, and anchovy fisheries account for approximately 85% of this production. Changes observed in anchovy fisheries and stock abundance over the last 50 years have resulted not only from fishing pressure but also from the synergistic effects of environmental factors, including eutrophication, climatic fluctuations, external species introductions, and internal ecosystem dynamics (Oğuz, 2010).

Small pelagic fishes generally feed on planktonic organisms. Their major prey items include copepods of the genus *Calanus*, as well as larvae of *Cirripedia* and *Mollusca*. For example, anchovy performs diel vertical migrations associated with feeding behavior, descending to deeper waters (70-90 m) during the daytime and moving toward coastal and surface waters (10-40 m) at night. Anchovy competes for food resources with other organisms and groups occupying similar trophic levels, including sprat, sardine, other planktivorous fishes, ctenophores, and jellyfish (Örek et al., 2000).

In addition to anchovy, other species such as sprat, although having lower commercial value, play important ecological roles in resource partitioning and energy transfer within the ecosystem. Changes in the populations of these species caused by excessive fishing pressure and environmental disturbances may alter the regulatory mechanisms controlling energy flow within the ecosystem.

Until the 1970s, the Black Sea ecosystem was primarily regulated by bottom-up control, in which ecosystem dynamics were governed mainly by lower trophic levels, particularly plankton communities. However, during the last three decades, changes in fish stocks have resulted in a shift toward regulation by higher trophic levels (top-down control) (Oğuz and Gilbert, 2007). A schematic representation of this transition is presented in Figure XIV.

The increasing influence of higher trophic levels has particularly favored opportunistic gelatinous organisms, including ctenophores and scyphozoan jellyfish. These organisms compete with pelagic fish for similar planktonic prey resources and altered the existing energy pathways of the Black Sea ecosystem during the late 1980s. While energy flow was previously dominated by the pathway “zooplankton-planktivorous fish,” it shifted toward “zooplankton-*Mnemiopsis leidyi*” following the introduction and population increase of this ctenophore

NEXT Black Sea Basin

(Figure 50). This alteration in energy transfer contributed to declines in fish stocks and resulted in substantial economic losses (BSC, 2009).

Furthermore, changes in nutrient availability and increases in organic matter inputs have enhanced the importance of microbial pathways, resulting in longer and more complex food webs. Under such conditions, effective ecosystem-based management requires detailed analyses of food web structure, trophic interactions, carbon cycling, and energy flow pathways and their magnitude within the ecosystem.

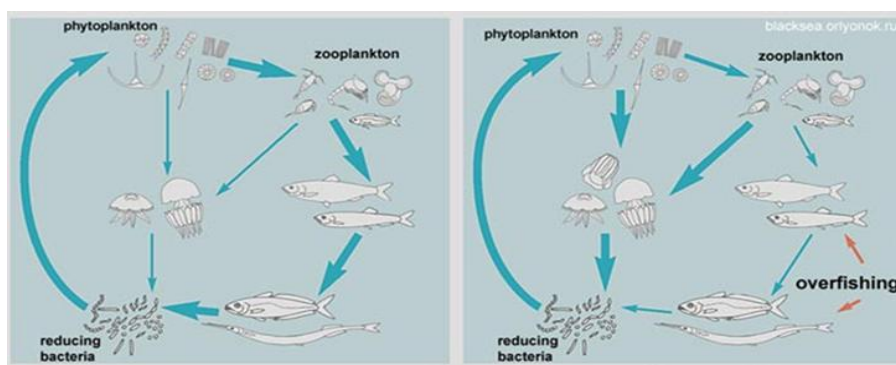


Figure 50. The changing Black Sea ecosystem (Source: <http://blacksea-education.ru/>)

4.2. Bulgaria

4.2.1. Primary Producers: Phytoplankton and Seagrass:

Phytoplankton diversity is extremely important for the stability and functioning of the marine ecosystem and biogeochemical cycles (Ptacnik et al., 2008; Moncheva et al., 2019). Phytoplankton reacts to anthropogenic impacts by alterations in species composition and abundance and the timing and duration of blooming events. The taxonomic composition and number of bloom-producing species differ between the Black Sea coastal area (44 species) (Moncheva et al., 1999).

Development of potentially toxic and harmful phytoplankton species, which in higher concentrations can cause toxin accumulation in mollusks and health problems in humans.

During the past 20 years, a total of 24 potentially toxic (harmful) phytoplankton species have been identified in the Phytoplankton Laboratory of the Institute of Fish Resources - Varna, according to the standardized list (Moestrup et al., 2009). Among the potentially toxic species, the dominant ones include *Pseudo-nitzschia delicatissima*, *Pseudo-nitzschia seriata*, *Prorocentrum cordatum*, and *Halamphora coffeiformis*, depending on the observed season and water area.

NEXT Black Sea Basin

Potentially toxic dinoflagellate species from the genera *Dinophysis*, *Gonyaulax*, and *Alexandrium* are often found in Bulgarian coastal waters (Petrova and Gerdzhikov, 2007; Petrova and Gerdzhikov, 2011). When the abundance and biomass of these species increase, there is a risk of toxin accumulation in commercially valuable mussel and fish species.

The seagrass plays important role in the benthic food pyramid by providing rich carbon sources for consumers at different trophic level, shelter for many invertebrate species, a spawning substrate for fish, sediment stabilization, nutrient cycling and mitigation to ocean acidification (Duarte 2000, Bergstrom et al., 2019)

4.2.2. Primary Consumers: Zooplankton and Benthic Invertebrates:

Zooplankton species are important link between primary producers and secondary consumers. At the time some of them, i.e. *Mnemiopsis leidyi*, might be considered as secondary consumers as they feed on fish eggs and other zooplankters. The conditions during eutrophication period were favorable for development of population of *M. leidyi* (Konsulov, Kamburska 1998). This resulted in decrease of mesozooplankton density and trophic limitation of planktivorous pelagic fishes, which caused structural changes in food chains, reflecting marine ecosystem functioning.

The planktonic ecosystem in the 1980s was dominated by the protozoan *Noctiluca scintillans* in the surface layer, affecting the abundance of all zooplankton components. *Noctiluca* density has reached extreme values exceeding 6.8 million individuals/l and wet biomass of 500 kg/m³ (Zaitsev and Alexandrov, 1998).

Benthic invertebrates are a key component in demersal fish diet, nutrient recycling and sediment-water interactions. The main threats on benthic species were eutrophication in 1980s of XXth century, leading to mass mortality of oxygen sensitive species as crabs and habitat destruction.

4.2.3. Secondary Consumers: Small Pelagic Fish: (anchovy, sprat, mullet species)

Small pelagic fish constitute an important group of secondary consumers in the Black Sea ecosystem. They occupy an intermediate trophic level in the food web, feeding primarily on zooplankton and thus linking primary consumers (zooplankton) with larger predatory fish, dolphins, and seabirds. In the Bulgarian sector of the Black Sea, the most important commercially significant representatives of this group, forming the bulk of the catches are the anchovy (*E. encrasicolus*), sprat (*S. sprattus*), and several mullet species from the family Mugilidae (mainly *Chelon auratus* and *C. saliens*).

Anchovy and sprat are among the most widespread and ecologically significant pelagic species in the Black Sea. They form large schools in coastal waters and feed mainly on zooplankton. These species play a key role in the trophic pyramid of the Black Sea ecosystem, as they serve as a primary food source for larger predatory fish such as bonito (*S. sarda*) and bluefish (*P. saltatrix*), as well as for dolphins (particularly the harbour porpoise) and various seabirds (e.g., *Phalacrocorax aristotelis*, *Puffinus yelkouan*, *Sterna sandvicensis*, among others). Their populations often exhibit significant interannual fluctuations, which are associated both with fishing pressure and with various environmental factors (Kideys, 2002).

NEXT Black Sea Basin

Mulletts (family Mugilidae) are also widely distributed along the Bulgarian coast and frequently inhabit coastal and transitional waters. They have a more diverse diet, including detritus, phytoplankton, zooplankton, and other organic matter, which distinguishes them to some extent from typical pelagic zooplanktivorous species. Nevertheless, they represent an important component of coastal food webs.

Other species of lesser or negligible commercial importance within this trophic group include juvenile horse mackerel (*T. mediterraneus*), sand smelt (*A. boyeri*), whiting (*M. merlangus*), clupeids from the family Alosidae, and some representatives of the family Sparidae (*Spicara spp.*).

As secondary consumers, small pelagic fish play a key role in the functioning of the Black Sea ecosystem. They facilitate the efficient transfer of energy from primary consumers to higher trophic levels and are essential for maintaining ecological balance in the marine environment. Some of these species, such as anchovy, sprat, and horse mackerel, are also of significant commercial importance, constituting a major proportion of Bulgaria's annual fish catches.

4.2.4. Higher Predators: Medium-Sized Pelagic and Benthic Fish: (bonito, mackerel, zander, etc.)

This group of fish occupies a higher trophic level in the Black Sea ecosystem and represents important predators within the marine food web. They feed primarily on small pelagic fish and thus play a key role in regulating populations at lower trophic levels. In the Bulgarian sector of the Black Sea, the most important representatives of this group include bonito (*S. sarda*), bluefish (*P. saltatrix*), horse mackerel (*T. mediterraneus*), garfish (*B. belone*), and mackerel (*S. scombrus*), as well as benthic species such as turbot (*S. maximus*) and thornback ray (*R. clavata*).

Bonito is a typical pelagic predator widely distributed in the Black Sea, forming large seasonal schools and undertaking migrations between different parts of the basin. It feeds mainly on small pelagic fish such as anchovy and sprat, as well as other small fish and crustaceans. Although its population size fluctuates considerably over time, bonito remains an important commercial species for Bulgarian Black Sea fisheries. This also applies to bluefish and, to a lesser extent, to horse mackerel and garfish.

Mackerel is another important pelagic predator that was historically widespread in the Black Sea, forming large populations and constituting a significant component of fishery resources. However, during the second half of the 20th century, its population declined dramatically, a trend associated both with overfishing and with ecosystem changes in the Black Sea (Daskalov, 2002).

Among benthic predatory fish, the most important representative is turbot, which feeds on various fish and large invertebrates inhabiting the near-bottom layer. It remains a valuable

NEXT Black Sea Basin

commercial species despite the declining trend in its population. Other representatives of this group include rays, which have considerably lower economic importance.

In transitional waters and Black Sea lagoons, the most significant predatory species is pikeperch (*Sander lucioperca*). It is an active predator feeding mainly on smaller fish and large crustaceans. Its presence is generally considered an indicator of relatively good ecological status in coastal ecosystems.

4.2.5. Apex Predators: Dolphins (Sharks were more common in the past):

Apex predators occupy the highest trophic levels in the Black Sea food web and play a key role in regulating the structure and functioning of the marine ecosystem. In the Bulgarian Black Sea waters, this group includes marine mammals (three cetacean species), as well as the spiny dogfish (*S. acanthias*).

Cetaceans in the Black Sea are represented by the Black Sea bottlenose dolphin (*Tursiops truncatus ponticus*), the Black Sea common dolphin (*Delphinus delphis ponticus*), and the harbour porpoise (*Phocoena phocoena relicta*). These predators feed primarily on pelagic fish such as anchovy, sprat, horse mackerel, and others.

The full **dietary spectrum** of the three species is presented below:

- *Tursiops truncatus ponticus*: *E. encrasicolus*, *M. merlangus*, *B. belone*, *M. cephalus*, *P. haematocheila*, *S. lucioperca*, *T. mediterraneus*, *M. barbatus*, *S. sarda*, *Gobius* spp., *S. porcus*, *S. maximus*.
- *Delphinus delphis ponticus*: *S. sprattus*, *A. immaculata*, *E. encrasicolus*, *M. merlangus*, *B. belone*, *S. schmidtii*, *S. typhle*, *P. saltatrix*, *T. mediterraneus*, *M. barbatus*, *S. sarda*.
- *Phocoena phocoena relicta*: *S. sprattus*, *A. immaculata*, *E. encrasicolus*, *M. merlangus*, *M. merluccius*, *A. boyeri*, *Gobiidae*.

Changes in Trophic Structure: Imbalances and Cascading Effects: Ecological studies indicate that a decline in apex predator populations may lead to so-called population outbreaks of lower trophic level species, resulting in significant changes in overall ecosystem structure (Daskalov, 2002).

In addition to marine mammals, apex predators in the Black Sea also include the spiny dogfish (*S. acanthias*), the only widely distributed shark species in the basin. This species primarily inhabits shelf and deeper coastal waters and feeds on fish, crustaceans, and other large invertebrates. It is characterized by slow growth, late sexual maturity, and low reproductive capacity, making it particularly vulnerable to fishing pressure (Compagno, 2001). The spiny dogfish is subject both to targeted fishing and bycatch in Black Sea fisheries. Regional fisheries statistics indicate that total catches of this species in the Black Sea reached peak levels during the period 1989-1995, when annual catches exceeded 1 200 - 1 300 t across the basin. In the Bulgarian waters, the highest catches were recorded in the early 2000s, with approximately

NEXT Black Sea Basin

126 t reported in 2001 (GFCM, 2012). Since then, a significant decline has been observed, with annual catches generally falling below 50 t over the past two decades and even lower in recent years. This decline in catches is indicative of a reduction in population size.

In recent years, sharks in Bulgarian Black Sea waters have been caught mainly as bycatch in gillnets, longlines, and trawl gear used for targeting sprat, turbot, and other commercial species. Targeted shark fishing using longlines is now rare. Consequently, actual catch volumes and population size are difficult to assess, as a large proportion of bycatch remains unreported (STECF, 2021).

The ecological importance of sharks and other apex predators, such as cetaceans, is considerable, as they contribute to maintaining the stability of marine ecosystems and regulating populations of lower trophic levels. Healthy populations of marine mammals and other apex predators are considered indicators of good environmental status, as these organisms are particularly sensitive to changes in prey availability, pollution, and other anthropogenic pressures.

Changes in trophic structure: Imbalances due to stock declines and loss of top predators:

Changes in the trophic structure of marine ecosystems typically manifest as a reduction in populations of predatory species at higher trophic levels, followed by an increase and dominance of species at lower levels of the food web. In the Black Sea, this process is generally driven by a combination of overfishing, eutrophication, invasive species such as *Mnemiopsis leidyi*, and climate-related changes, particularly rising water temperatures.

The depletion or drastic reduction of predators in the Black Sea leads to an increase in populations of small pelagic zooplanktivorous fish, which in turn exert greater pressure on zooplankton communities. This results in reduced grazing on phytoplankton, causing its excessive growth and contributing to increased eutrophication. Such processes were observed in the Bulgarian Black Sea waters during the 1970s and 1990s.

In the 1960s, a total of 26 fish species were targeted by commercial fisheries in the Bulgarian Black Sea waters, whereas by the 1980s, catches were dominated by approximately five key commercial species (sprat, anchovy, horse mackerel, turbot, and gobies). This shift indicates trophic downgrading of the food web and the collapse of pelagic predator populations, leading to changes in the structure of commercial catches. During this period, catches of mackerel, bonito, and bluefish declined dramatically, reducing predation pressure on small zooplanktivorous pelagic fish. A substantial decline was also recorded in the population of Black Sea horse mackerel. In 1985, catches reached 141 000 t, followed by a sharp decline to approximately 4 700 t by 1991, which has been attributed to food competition and the impact of the mass proliferation of *Mnemiopsis*.

Similarly dramatic declines have been observed in cetacean populations in the Black Sea, which were subject to industrial-scale hunting until bans were introduced in 1966. Estimates indicate

NEXT Black Sea Basin

that the harbour porpoise population had declined by more than 90% by the time the ban was implemented.

4.3. Romania

The marine ecosystem along Romania's Black Sea coast is structured as a trophic pyramid where energy and biomass flow upward from primary producers to apex predators. Ecologically, the Black Sea operates as a "wasp-waist" ecosystem—where a massive biomass of plankton at the bottom and a variety of predators at the top are linked by just a few highly abundant species of small pelagic fish in the middle. Human activities such as overfishing, eutrophication, and pollution have significantly altered this delicate structure, causing imbalances that disrupt ecosystem stability and resilience.

4.3.1. Primary Producers: Phytoplankton and Macrophytes

At the base of the food web are primary producers. In the pelagic zone, this level is overwhelmingly dominated by phytoplankton, particularly diatoms (e.g., *Skeletonema*, *Chaetoceros*) and dinoflagellates. Along the Romanian coast, phytoplankton production is heavily subsidized by the nutrient-rich freshwater plume of the Danube River, which drives intense seasonal blooms (Boicenco et al., 2020).

In shallow coastal areas, benthic macrophytes—such as *Zostera* (seagrasses) and canopy-forming brown algae like *Cystoseira* (recently reclassified as *Gongolaria*)—contribute significantly to primary production and provide critical three-dimensional habitat complexity. However, these benthic communities are highly vulnerable to decreased water transparency caused by eutrophication-driven turbidity, which limits the light available for photosynthesis and leads to habitat degradation.

4.3.2. Primary Consumers: Zooplankton and Benthic Invertebrates

Primary consumers form the vital link that transfers energy from microscopic algae to larger animals. The pelagic zooplankton community is driven by copepods (such as *Acartia clausi* and *Calanus euxinus*) and cladocerans. Crucially, in eutrophic conditions, the mixotrophic dinoflagellate *Noctiluca scintillans* often dominates zooplankton biomass, creating "red tides" that represent a dead-end in the food web because few organisms prey upon it.

On the seafloor, benthic invertebrates—such as native mussels (*Mytilus galloprovincialis*), amphipods, and polychaetes—graze on detritus and benthic microalgae. These filter feeders are the ecosystem's natural water purifiers and are essential for recycling nutrients back into the water column. However, localized bottom-water hypoxia and physical seabed disturbances frequently collapse these vulnerable benthic communities (Gomoiu, 2013).

4.3.3. Secondary Consumers: Small Pelagic Fish

NEXT Black Sea Basin

Small pelagic fish species form the narrow "wasp-waist" of the trophic pyramid. Species like the European anchovy (*Engraulis encrasicolus*), sprat (*Sprattus sprattus*), and various mullet species play an indispensable role by converting zooplankton biomass into prey for higher predators.

In recent decades, Romanian Black Sea fisheries have reported highly volatile catches of these foundational species. Their populations have been destabilized not only by direct overexploitation but also by direct resource competition with invasive gelatinous zooplankton (such as the comb jelly *Mnemiopsis leidyi*), which aggressively consume the exact same copepods the fish rely on (Oguz, 2017).

4.3.4. Higher Predators: Medium-sized Pelagic and Benthic Fish

Medium-sized predatory fish once played significant ecological roles by keeping small pelagic fish and benthic fauna in check. Pelagic hunters like bluefish (*Pomatomus saltatrix*), Atlantic bonito (*Sarda sarda*), and horse mackerel (*Trachurus mediterraneus ponticus*), along with valuable benthic predators like turbot (*Scophthalmus maeoticus*) and zander (*Sander lucioperca* in transitional waters), historically supported rich fisheries.

However, along the Romanian coast, these populations have been severely depleted. The historical loss of large migrating predators (such as bluefin tuna and swordfish, which ceased entering the Black Sea decades ago) shifted immense fishing pressure onto these medium-sized fish, destabilizing predator-prey dynamics and permanently altering the region's fisheries profile.

4.3.5. Apex Predators: Cetaceans and Elasmobranchs

At the very apex of the trophic pyramid, three species of cetaceans—the bottlenose dolphin (*Tursiops truncatus ponticus*), common dolphin (*Delphinus delphis ponticus*), and harbour porpoise (*Phocoena phocoena relicta*)—are the primary biological regulators of the Romanian Black Sea. By feeding on schools of medium and small fish, they cull sick individuals and regulate prey populations.

Historically, large sharks shared this apex role. Today, the spiny dogfish (*Squalus acanthias*) is the only resident shark species remaining in the region. Due to its slow growth rate, late maturity, and heavy historical exploitation for its meat and liver oil, the spiny dogfish population is highly degraded. Meanwhile, increasing dolphin mortality—driven by incidental bycatch in turbot gillnets, plastic ingestion, and epizootic diseases—raises grave concerns about the long-term sustainability of top-down control in the basin (Paiu et al., 2021).

Changes in Trophic Structure: "Jellyfication" and Cascading Effects

The dramatic ecological shifts observed in the Romanian Black Sea over the past fifty years represent one of the world's most documented examples of a marine trophic cascade. This cascade was not caused by a single event, but rather by a "perfect storm" of simultaneous top-down and bottom-up anthropogenic pressures that fundamentally rewired how energy flows through the ecosystem. Throughout the 1970s and 1980s, industrial fishing fleets systematically removed the Black Sea's apex predators and large pelagic fish—such as bluefish, mackerel,

NEXT Black Sea Basin

bonito, and large populations of dolphins. By eliminating these top predators, the natural "brakes" on the ecosystem were removed.

This loss of top-down control allowed the populations of small, plankton-eating fish (like anchovy and sprat) to temporarily explode. Fisheries subsequently pivoted to target these smaller species—a practice known as "fishing down the marine food web." However, intense and unregulated harvesting quickly led to the severe overexploitation of these small pelagic stocks as well, leaving a massive gap in the middle of the food web.

While top predators were being removed, the ecosystem was simultaneously being bombarded from the bottom up. The agricultural Green Revolution and rapid industrialization across the Danube River basin resulted in massive nutrient loading (primarily nitrogen and phosphorus) into the shallow northwestern shelf of the Black Sea. This excessive nutrient input triggered chronic, basin-wide phytoplankton blooms. With fewer small pelagic fish left to eat the zooplankton (which in turn eat the phytoplankton), the system became overloaded with unconsumed organic matter. When this massive volume of algae died and sank, its decomposition stripped oxygen from the bottom waters, creating expansive hypoxic "dead zones" that decimated native benthic communities (Daskalov, 2002).

By the late 1980s, the Romanian Black Sea was ecologically highly unstable: it possessed immense basal energy (plankton) but lacked the fish to consume it. This created a vacant ecological niche, paving the way for one of the most devastating marine invasions in history. Introduced via the ballast water of commercial ships from the Americas, the warty comb jelly (*Mnemiopsis leidyi*) found a predator-free paradise with unlimited food.

Mnemiopsis is a voracious predator that feeds directly on zooplankton, fish eggs, and fish larvae. Because it directly competed with the remaining anchovy and sprat for food—while simultaneously eating their young—the comb jelly triggered a total collapse of the region's pelagic fisheries. By 1989, the biomass of *Mnemiopsis* in the Black Sea reached an estimated one billion tons. The ecosystem's energy, which historically flowed upward into valuable fish and dolphins, was completely diverted into an ecological dead-end of gelatinous biomass—a phenomenon termed the "jellyfication" of the Black Sea (Oguz, 2017). The ecosystem remained trapped in this degraded state until the late 1990s, when a second accidental introduction occurred. Another ctenophore species, *Beroe ovata*, arrived via ballast water. Fortunately, *Beroe ovata* is a highly specialized predator that feeds almost exclusively on *Mnemiopsis*.

By actively hunting down and controlling the *Mnemiopsis* population, *Beroe ovata* acted as a biological control agent, allowing zooplankton populations to rebound and fish stocks to partially recover. Concurrently, the collapse of the Soviet Union and changes in agricultural practices led to a temporary reduction in nutrient runoff, easing eutrophication pressures. While the Black Sea ecosystem has partially recovered from the darkest days of the 1990s, these historical shifts underscore how easily the energy flow within a semi-enclosed sea can be catastrophically diverted. Today, the ecosystem exists in a fragile, alternate stable state. Maintaining this balance requires strict, multi-national adherence to fishing quotas to rebuild

NEXT Black Sea Basin

predator populations, alongside continuous, stringent pollution mitigation along the entire Danube basin.

5. MARINE PROTECTED AREAS (MPAS)

5.1. Türkiye

Türkiye has designated several Marine Protected Areas (MPAs) and Special Environmental Protection Areas (SEPAs) along its Mediterranean and Aegean coasts, aimed at conserving biodiversity, protecting endangered species, and supporting sustainable local economies. As of recent reports, Türkiye has over 125 MPAs in the Mediterranean, though only a fraction are fully closed to fishing and human activity (Anon.2026).

Number, size, and coverage rate: These areas are established in order to protect marine species and ecosystems. Marine Protected Areas (MPAs) can be open to sustainable resource use, closed to certain activities (such as drag net fishing, trawling, diving, etc.) or completely closed to all activity. These areas are representative of healthy marine ecosystems. Under efficient management, MPA's can support local economies and preserve local natural and cultural heritage for future generations.

One of the aims of the 2020 World Biodiversity Agreement, that Türkiye is also a signatory of, is for “countries with coastlines to designate 10% of significant habitats within their marine areas to be Marine Protected Areas, and at least 2% of these areas to be managed and preserved as areas closed to all fishing activity.” This goal is yet to be attained, however, as of 2020 there are 125 Marine Protected Areas in the Mediterranean. The total area of these sectors increased to 4.56% in 2012, 6.81% in 2016, and 8.3% in 2020. Mediterranean countries are engaged in efforts to increase the number of MPAs, though only 1.273% of MPAs in the Mediterranean have efficient protective mechanisms. Unfortunately, there is no MPAs in the Black Sea coasts of Türkiye. Current efforts are focused on establishing its **first Marine Protected Areas (MPAs)**, as it has historically lacked the formal protection zones found in the other seas.

Marine Protected Areas (MPAs) in the Black Sea are still limited and fragmented, but new initiatives—especially along the Turkish coast—are being proposed to safeguard biodiversity, fisheries, and coastal ecosystems. Bulgaria and Romania have already designated several MPAs, while Türkiye, Georgia, and Ukraine are exploring expansions (Öztürk et al, 2013; Öztürk et al, 2017).

Proposed MPAs are (Öztürk et al 2017):

1. Igneada (Kırklareli) → Coastal and delta ecosystems with high biodiversity. It is seen as the first cross-border MPA candidate, along with Strandzha on the border with Bulgaria.
2. Şile - Kefken line (Istanbul - Kocaeli) → Recommended for coastal fishing and the protection of species such as red coral.
3. Doğanyurt (Kastamonu) → It is important in terms of coastal ecosystems and fish breeding areas.

NEXT Black Sea Basin

4. Samsun deltas (Yeşilırmak, Kızılırmak, Bafra) → Critical habitats due to bird migration routes and sea-coastal interaction.

5. Whiting Reef (off Trabzon) → A special reef area in terms of marine biodiversity.

“Marine Protected Area” is not a legally-binding protective status in Türkiye; instead, all protected areas with shorelines or sea boundaries are included in this category and protected by national conservation statutes and international agreements of which Türkiye is a signed (Anonym,2026).

All of the existing MPAs are located on the Mediterranean and Aegean Sea Coasts. Therefore they are established due to the needs of the region.

Key Facts about Marine Protected Areas in Türkiye

- **Types of Protection**
 - **Open to sustainable use:** Some MPAs allow regulated fishing, tourism, and diving.
 - **Restricted zones:** Certain activities like trawling, drag net fishing, or anchoring are prohibited.
 - **No-take zones:** A small percentage are completely closed to fishing and extraction.
- **Legal Framework**
 - Managed under **Special Environmental Protection Areas (SEPAs)**, overseen by the Ministry of Environment, Urbanisation, and Climate Change.
 - SEPAs cover both terrestrial and marine ecosystems, including wetlands, lagoons, and coastal habitats.
- **International Commitments**
 - Türkiye is a signatory to the **2020 World Biodiversity Agreement**, which requires **10% of marine habitats** to be designated as MPAs, with **2% fully closed to fishing**. This target has not yet been fully met.

Importance of MPAs in Türkiye

- **Biodiversity Conservation:** Protects endangered species like the Mediterranean monk seal and loggerhead turtles.
- **Fisheries Recovery:** No-take zones in Gökova Bay have shown measurable increases in fish populations.
- **Tourism & Local Economy:** Eco-tourism and diving activities provide sustainable income for coastal communities.
- **Cultural Heritage:** Many MPAs overlap with ancient ruins and underwater archaeological sites, adding cultural value.

Challenges & Risks

- **Enforcement Issues:** Illegal fishing and anchoring remain problems in some areas.
- **Limited Coverage:** Current MPAs cover less than the international target of 10% of Türkiye’s marine habitats.

NEXT Black Sea Basin

Climate Change: Raising sea temperatures and pollution threaten ecosystems despite protection measures.

In Türkiye, the management of Marine Protected Areas (MPAs) and artificial reefs is governed by a combination of historical laws and modern, specialized programs. Unlike some countries where "MPA" is a single legal status, Türkiye uses a "layered" approach involving multiple ministries.

1. The Legal Foundation: Fisheries Law No. 1380

This is the primary legislative framework for all aquatic resources.

- **Authority:** It grants the Ministry of Agriculture and Forestry (MoAF) the power to regulate fishing activities, including the creation of no-fishing zones.
- **Commercial Notifications:** Every four years, the Ministry publishes updated notifications (e.g., *Notification 1/1 Regulating Commercial Fishing*) that define the GPS coordinates where trawling, purse seining, or all fishing is prohibited. These effectively serve as the boundaries for most functional MPAs.

2. Artificial Reef Legislation & Programs

Artificial reef projects in Türkiye are no longer "random" sinkings; they are strictly controlled.

- **National Artificial Reef Program (NARP):** Launched officially around 2008-2009, this program standardized the deployment of reefs.
- **The 2001 Regulation:** The first specific legal regulation on artificial reefs was enacted in 2001. It moved the focus from simple dumping to "fisheries management tools."
- **Approval Process:** To sink a structure (whether concrete modules or the occasional ship/plane), a project must receive clearance from:
 - The Ministry of Agriculture and Forestry (General Directorate of Fisheries and Aquaculture).
 - The Ministry of Environment, Urbanization and Climate Change (to ensure no marine pollution (MEUCC, 2026)).
 - The Turkish Naval Forces (to ensure no interference with navigation/sonar).

Artificial Reefs and Biodiversity

Artificial reefs enhance habitat heterogeneity within Marine Protected Areas (MPAs), boosting biodiversity and strengthening ecosystem resilience. These structures maximize biological productivity while providing physical support for enforcement by deterring illegal trawling. In the Black Sea, several studies and pilot projects have been implemented to utilize artificial reefs for ecological restoration and fisheries management. Artificial reefs in the Black Sea serve a distinct purpose compared to those in the Aegean or Mediterranean. While Türkiye's southern coasts often scuttle large assets like planes and ships to boost diving tourism, Black Sea projects are primarily focused on ecological restoration, biodiversity, and protecting fishing grounds from illegal trawling (EC, 2026).

NEXT Black Sea Basin

5.2. Bulgaria

Marine Protected Areas (MPAs) are a key instrument for the conservation of marine biodiversity, sustainable management of natural resources, and maintenance of ecosystem services. Within the European Union, the main legal framework for the establishment and management of such areas is linked to the implementation of the Habitats Directive (92/43/EEC), the Birds Directive (2009/147/EC), and the Marine Strategy Framework Directive (2008/56/EC).

In Bulgaria, protected sites designated under these directives are part of the Natura 2000 ecological network and are managed in accordance with the Biodiversity Act. Several Natura 2000 sites include areas within the Bulgarian Black Sea waters. These zones encompass both coastal habitats and parts of the continental shelf, covering approximately 30-35% of the coastal marine waters. The main protected habitat types within these areas include underwater sandy and muddy bottoms, mussel beds, seagrass meadows, coastal lagoons, and wetlands. These zones provide protection for a number of species under the aforementioned directives, including all three species of Black Sea cetaceans.

Information on the marine protected areas included in the Natura 2000 network is presented in Table 17.

Table 17. Protected areas within the Natura 2000 network containing marine waters (the indicated areas are approximate and include coastal territories).

Code	Name	Area (km ²)	Protection	Main habitats and species
BG0000573	Complex Kaliakra	~483	Habitat Directive	Reefs, sandbanks, dolphins (<i>Tursiops truncatus</i> , <i>Phocoena phocoena</i>)
BG0000116	Kamchia	~129	Habitat Directive	Coastal sandbanks, dolphin habitats, estuaries
BG0001004	Emine - Irakli	~74	Habitat Directive	Sand habitats, reefs, coastal ecosystems
BG0001001	Ropotamo	~39	Habitat Directive	Coastal lagoons, fish „nurseries“, wetlands
BG0001007	Strandzha	~1161	Habitat Directive; Birds Directive	dolphins, migration corridors for fish
BG0000130	Coastal Dobrudzha	~187	Habitat Directive	Sandbanks, reefs, dolphins
BG0000109	Shkorpilovtsi Beach	~94	Habitat Directive	Coastal sandbanks, seagrass fields
BG0000153	Galata	~52	Habitat Directive	Reefs, dolphins
BG0000622	Aheloy - Ravda - Nesebar	~43	Habitat Directive	Sandbanks, lagoons, „nurseries“

BG0000612	Karaagach	~26	Habitat Directive	Estuaries, coastal ecosystems
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5.2.1. Monitoring Methods within MPAs

Monitoring of marine protected areas in Bulgaria is carried out through a combination of biological, physicochemical, and spatial methods. The main institutions responsible for these activities include EEA, MoEW, EAFA, BSBD, as well as various scientific institutes and universities. The monitoring approaches include biological monitoring, habitat monitoring, physicochemical monitoring, and monitoring of pollution and water quality. These activities are implemented within the framework of the National Environmental Monitoring System and the National Biodiversity Monitoring System, in accordance with the requirements of the Marine Strategy Framework Directive.

5.2.2. Governance Structures, Monitoring, and Enforcement Mechanisms

Most of the governmental structures and their functions are described in detail in Chapter 3. In general, the management of marine protected areas in Bulgaria is carried out through institutional coordination among several state bodies, including MoEW, MAF and their subordinate structures such as the EAFA and the Basin Directorates. The main management mechanisms include the development of management plans for protected areas, the establishment of control and regulation measures for fishing activities, oversight of construction and infrastructure projects, and biodiversity monitoring. Compliance with protection regimes is enforced by the Regional Inspectorates of Environment and Water (RIEW), through permitting systems and inter-institutional cooperation.

5.2.3. Contribution to Biodiversity and Ecosystem Services

Marine protected areas play an important role in conserving biodiversity and maintaining ecosystem functions. In the Bulgarian Black Sea waters, they provide protection for key habitats that serve as natural fish “nurseries,” habitats for various benthic organisms, including mussel beds, as well as migration corridors for marine mammals and fish.

Marine protected areas are also essential for sustaining key ecosystem services, such as supporting fish stocks, filtering and improving water quality, carbon sequestration in coastal ecosystems, and protecting coastlines through sediment stabilization.

5.3. Romania

Romania’s Black Sea coastline hosts several Marine Protected Areas (MPAs) designated primarily under the EU Natura 2000 framework, which includes Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). These MPAs aim to conserve important marine habitats, rare benthic communities, and highly mobile species. Currently, the total coverage of MPAs within Romanian marine waters reaches approximately 11% of the national marine area. This coverage

NEXT Black Sea Basin

closely aligns with the EU Biodiversity Strategy targets, which aim to safeguard at least 10% of European marine territories by 2030 (European Environment Agency, 2023).

The size of these protected zones varies from smaller coastal patches of about 10 square kilometers to massive offshore protected regions exceeding thousands of square kilometers. This variation reflects a targeted approach to conservation, prioritizing ecologically sensitive habitats such as shallow coastal waters, submerged sandbanks, and biogenic rocky reefs.

5.3.1. Vama Veche - 2 Mai Marine Reserve (ROSCI0273 / ROSPA0076)

Located near the southern border with Bulgaria, this is one of Romania's oldest and most biologically diverse coastal MPAs. Covering approximately 50 square kilometers, it is renowned for its submerged limestone reefs. These rocky substrates support rich, canopy-forming brown algae (*Gongolaria/Cystoseira* spp.) and extensive mussel beds (*Mytilus galloprovincialis*). By acting as a three-dimensional underwater forest, this reserve protects crucial spawning and nursery grounds for benthic fish such as turbot, gobies, and blennies, as well as providing refuge for rare species like the long-snouted seahorse (*Hippocampus guttulatus*) (Figur 51) (Zaharia et al., 2012).

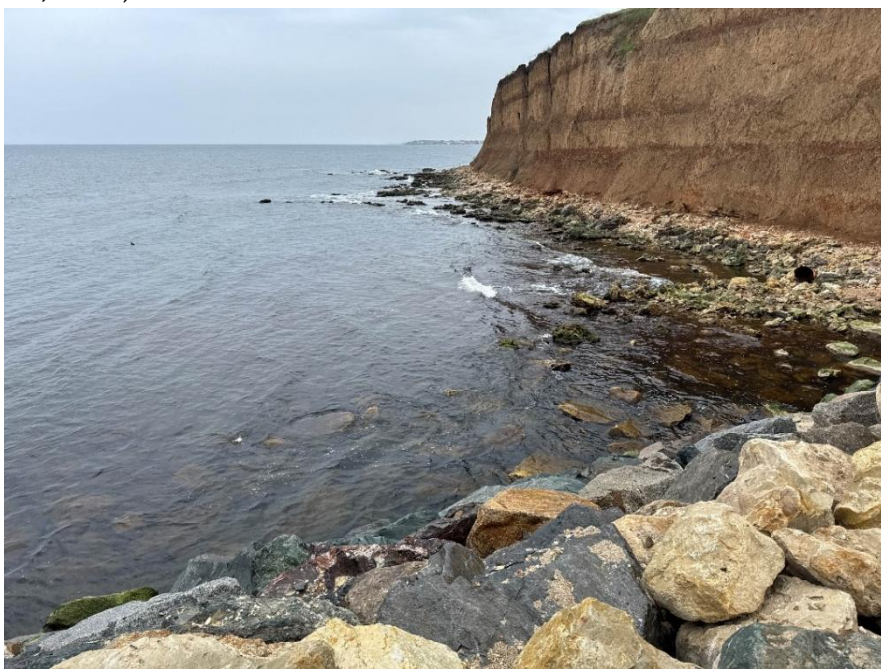


Figure 51. Coastal habitats 2 Mai - Vama Veche

5.3.2. Danube Delta Marine Zone (ROSCI0066 / ROSPA0031)

By far the largest protected marine sector in Romania, the *Zona Marină a Deltei Dunării* covers a vast expanse of offshore and coastal waters influenced by the Danube River plume. This MPA is characterized by shallow, soft-bottom sandy and muddy habitats. It serves as a vital transitional zone for anadromous species—most notably the critically endangered Black Sea sturgeons (such as the Beluga sturgeon, *Huso huso*), which must pass through these waters to reach their riverine spawning grounds. Furthermore, the nutrient-rich waters here support

NEXT Black Sea Basin

massive schools of small pelagic fish (anchovy and sprat), making it a primary feeding ground for all three species of Black Sea cetaceans (Maximov et al., 2021).

5.3.3. Cape Tuzla (Capul Tuzla - ROSCI0094 / ROSPA0041)

Situated south of Constanța, Cape Tuzla protects a unique combination of coastal cliffs and submerged rocky platforms. The marine area is critical for the conservation of biogenic reefs formed by native bivalves, which naturally filter the coastal waters. Additionally, the SPA designation protects the area as a vital wintering and resting ground for numerous species of migratory pelagic birds, including the Mediterranean gull and various cormorant species, linking the marine and terrestrial food webs.

5.3.4. Submerged Beach of Eforie (Plaja Submersă Eforie Nord - Eforie Sud - ROSCI0197)

This MPA was specifically designated to protect the shallow, constantly shifting sandbanks along the central Romanian coast. These soft-bottom habitats are essential for specialized benthic communities, particularly the wedge clam (*Donax trunculus*) and the striped venus clam (*Chamelea gallina*). These sandbanks also serve as highly productive nursery areas for juvenile flatfish.

5.3.5. Mangalia Submarine Sulfurous Springs (Izvoarele sulfuroase submarine de la Mangalia - ROSCI0095)

This MPA represents one of the most unique and scientifically significant marine habitats in the entire Black Sea basin. Located in shallow waters (typically 2 to 10 meters deep) near the port of Mangalia, the seabed here is punctuated by mesothermal sulfurous springs. Groundwater, heavily enriched with hydrogen sulfide (H_2S) and methane, erupts from underwater limestone caves and fractures into the oxygenated seawater.

Instead of relying on sunlight for photosynthesis, the primary producers in this localized ecosystem are chemoautotrophic bacteria. These bacteria oxidize the toxic hydrogen sulfide to produce organic matter, forming thick, white, filamentous microbial mats over the rocks. This process creates a shallow-water analogue to deep-sea hydrothermal vents. The mats support a highly specialized benthic community of endemic nematodes, amphipods, and unique microbial consortia that cannot survive in standard marine conditions. Protecting this site from physical disturbance by dredging or anchoring is paramount for preserving this rare chemosynthetic ecosystem (Teacă et al., 2006).

5.3.6. Razim-Sinoe Marine Transition Zone (ROSCI0065 / ROSPA0027)

While the Razim-Sinoe complex is famous as Romania's largest coastal lagoon system, its protected boundaries extend into the adjacent marine waters (such as the Periteașca - Gura Portiței - Chituc sectors). This marine transition zone is ecologically critical because it serves as the physical interface between the brackish lagoons and the open Black Sea.

The shallow coastal waters here are characterized by massive, shifting sandbanks. This MPA is a vital migratory corridor for euryhaline fish species (those that can adapt to varying salinities), including the critically endangered sturgeons and the Pontic shad (*Alosa immaculata*), which

NEXT Black Sea Basin

must navigate these coastal waters to enter the lagoons and rivers for spawning. The area also acts as an expansive nursery for grey mullet and flounder, while providing undisturbed resting grounds for massive flocks of migratory pelagic birds traversing the Via Pontica migration route (Gomoiu & Tudor, 2013).

5.3.7. The "Black Sea" Offshore Area (Marea Neagră - ROSPA0076)

Unlike the localized coastal MPAs, the "Marea Neagră" Special Protection Area is a massive offshore zone covering thousands of square kilometers of Romania's Exclusive Economic Zone (EEZ). Designated primarily under the EU Birds Directive, this pelagic MPA was established to protect the critical wintering and foraging grounds of strictly marine bird species that rarely come ashore. The primary conservation focus here is the Yelkouan shearwater (*Puffinus yelkouan*), a vulnerable seabird that gathers in massive "rafts" in the open sea to feed on schools of anchovy and sprat. The area also protects wintering populations of the Black-throated loon (*Gavia arctica*) and various grebe species. By regulating maritime traffic, limiting offshore wind farm placement, and restricting certain types of industrial fishing within this zone, this MPA also indirectly secures the offshore migration corridors used by the Black Sea's apex predators, the cetaceans (Fântână et al., 2020).

Monitoring in Romanian MPAs combines traditional ecological fieldwork with modern technological tools to track ecosystem health and human impacts effectively. Regular biological surveys conducted by institutes like NIMRD and GeoEcoMar focus on key groups such as benthic invertebrates, fish populations, and marine mammals. Complementing these physical surveys, remote sensing technologies and Geographic Information Systems (GIS) enable the high-resolution mapping of habitat changes, sediment transport, and water quality parameters (such as nutrient concentrations and turbidity from the Danube). As detailed in previous chapters, continuous acoustic monitoring (using F-POD devices) is also heavily employed within these MPAs to detect cetacean populations year-round and assess the impact of anthropogenic noise pollution from nearby shipping lanes (Paiu et al., 2023).

MPAs along Romania's Black Sea coast play a crucial role in conserving marine biodiversity. By protecting habitats critical for reproduction and growth, they support commercially important fish species such as anchovy (*Engraulis encrasicolus*), sprat (*Sprattus sprattus*), and benthic species including zander (*Sander lucioperca*) in transitional waters. By serving as undisturbed spawning and nursery grounds, MPAs help maintain the sustainable fish populations that underpin local fisheries.

Beyond biodiversity, these MPAs deliver essential ecosystem services. They provide coastal erosion protection, water filtration via intact mussel beds, carbon storage through seagrass meadows (*Zostera* spp.), and opportunities for sustainable eco-tourism. By restricting activities such as destructive bottom-trawling and habitat destruction, MPAs enhance overall ecosystem productivity and resilience against climate change. The governance of MPAs in Romania involves multiple stakeholders. At the national level, administration is coordinated by the National Agency for Natural Protected Areas (ANANP), under the Ministry of Environment, Waters and

NEXT Black Sea Basin

Forests, working in tandem with regional environmental protection agencies, scientific institutions, and civil society organizations (like Mare Nostrum and WWF Romania).

Management plans for these Natura 2000 sites set clear conservation objectives and zoning schemes to balance strict protection with sustainable use. Enforcement is carried out through regular inspections by the National Environmental Guard and the Border Police, who cooperate to combat illegal fishing (IUU) and pollution incidents. Community involvement is continuously promoted through awareness campaigns, stakeholder consultations with local fishermen, and educational programs aimed at fostering local stewardship of marine resources. Ultimately, adaptive management—driven by continuous monitoring and evaluation—enables the adjustment of conservation strategies based on real-time scientific findings and shifting socio-economic conditions (Anton et al., 2019).

6. LEGAL AND INSTITUTIONAL FRAMEWORK

6.1. Türkiye

6.1. 1. International and Regional Agreements

The Black Sea's environmental governance is anchored in international agreements, most importantly the *Bucharest Convention (1992)* and its protocols, which legally bind all six coastal states to protect the marine environment. These agreements are complemented by EU directives for Romania and Bulgaria, and regional action plans that aim to harmonize monitoring, enforcement, and biodiversity protection.

Core International Agreements are:

1. Bucharest Convention (1992)

- **Full name:** *Convention on the Protection of the Black Sea Against Pollution*.
- **Parties:** Bulgaria, Georgia, Romania, Russia, Türkiye, Ukraine.
- **Scope:** Prevent, reduce, and control pollution from land-based sources, shipping, dumping, and emergencies.
- **Institutional Body:** The **Black Sea Commission (BSC)** implements the Convention and coordinates monitoring.

2. Protocols to the Bucharest Convention

- **Land-Based Sources Protocol (2009 update):** Targets industrial, agricultural, and municipal discharges.
- **Dumping Protocol:** Regulates disposal of waste at sea.
- **Emergency Protocol:** Ensures cooperation in oil spill and hazardous incident response.
- **Biodiversity & Landscape Protocol (2002):** Focuses on conservation of habitats and species.

NEXT Black Sea Basin

3. Black Sea Strategic Action Plan (1996, revised 2009)

- Defines policy measures and national commitments for rehabilitation and protection.
- Emphasizes **ecosystem-based management**, sustainable fisheries, and biodiversity conservation.
- Updated in Sofia (2009) to align with EU directives and global targets.

4. EU Directives (Romania & Bulgaria)

- **Marine Strategy Framework Directive (MSFD)**: Requires Good Environmental Status (GES) by 2020.
- **Water Framework Directive (WFD)**: Focuses on riverine inputs and coastal waters.
- **Habitats & Birds Directives**: Establish Natura 2000 sites, many overlapping with MPAs.

5. Other Relevant International Instruments

- **UNCLOS (1982)**: Governs maritime jurisdiction and environmental responsibilities.
- **CBD (Convention on Biological Diversity)**: Guides biodiversity targets, including 30% ocean protection by 2030.
- **Regional Cooperation**: Linked with HELCOM (2021) (Baltic Sea) and OSPAR (North-East Atlantic) for shared methodologies.

These agreements are very important as to provide binding obligations for pollution control and biodiversity protection. **Institutional coordination** (the Black Sea Commission ensures collective monitoring and reporting), **harmonization** (Aligns EU and non-EU states, reducing fragmentation in monitoring and enforcement), **youth and citizen science potential** (Agreements encourage public participation, opening space for initiatives like *DeltaWatch* or *Black Sea Guardians*).

6. The **United Nations Convention on the Law of the Sea (UNCLOS, 1982)** is often called the “constitution of the oceans.” It sets out the legal framework for all maritime activities, including navigation, resource use, and environmental protection. Key provisions are:

- **Maritime Zones Defined:**

Territorial Sea: Up to 12 nautical miles from the baseline, full sovereignty of the coastal state.

Exclusive Economic Zone (EEZ): Up to 200 nautical miles, where states have rights to explore, exploit, conserve, and manage natural resources.

Continental Shelf: Rights to seabed resources beyond the EEZ, under certain geological conditions.

High Seas: Beyond national jurisdiction, open to all states but governed by international law.

- **Marine Environmental Protection:** States must protect and preserve the marine environment, prevent pollution, and cooperate regionally and globally.
- **Marine Scientific Research:** Encourages research but requires consent of coastal states within their EEZs.

NEXT Black Sea Basin

- **Dispute Settlement:** Provides mechanisms like the International Tribunal for the Law of the Sea (ITLOS).

UNCLOS and MPAs/Biodiversity

- **Basis for MPAs:** Coastal states use UNCLOS provisions to designate MPAs within their EEZs and territorial seas.
- **Biodiversity Beyond National Jurisdiction (BBNJ):** UNCLOS laid the foundation for the 2023 BBNJ Agreement (entered into force in 2026), which specifically addresses conservation in the high seas.
- **Regional Cooperation:** In semi-enclosed seas like the **Black Sea**, UNCLOS requires bordering states (Türkiye, Bulgaria, Romania, etc.) to cooperate in managing biodiversity and pollution.

Türkiye's Position

- Türkiye is a party to UNCLOS but has **reservations** about certain provisions, especially regarding the Aegean Sea and continental shelf disputes with Greece.
- In the **Black Sea**, Türkiye applies UNCLOS principles to regulate fisheries, pollution control, and proposed MPAs (e.g., İğneada, whiting Reef).

National laws (SEPA, fisheries regulations) are aligned with UNCLOS obligations for environmental protection.

Türkiye is a member of several key international organizations and conventions dedicated to preserving biodiversity. A summary of these is provided in Table 18.

Table 18. International Organizations and Conventions on Biodiversity to which Türkiye is member

Organization	Foundation Year	Membership year	Contribution to Biodiversity
GFCM	1952	1954	MPAs (Marine Protected Areas), Vulnerable species protection By-catch reduction, Habitat conservation, IUU fishing prevention, BlackSea Working Group
CITES	1973	1996	CITES protects endangered species by banning commercial trade for those in Appendix I and strictly monitoring trade for Appendix II species, like sharks. This permit-based system prevents extinction and ensures sustainable marine populations.
IUCN	1948	1993	IUCN protects biodiversity by assessing extinction risks through the Red List , providing a global scientific standard for conservation. It guides international policies to ensure natural resource use is ecologically sustainable and prevents worldwide species loss
IWC	1946	2025	The IWC protects cetacean biodiversity by mitigating by-catch , ship strikes , and entanglement through scientific research. It monitors anthropogenic threats like noise pollution and climate change to ensure the survival of whale and dolphin populations

NEXT Black Sea Basin

ACCOBAMS	1996	2017	ACCOBAMS protects marine biodiversity by mitigating threats to cetaceans in the Mediterranean and Black Seas. It enforces strict bans on deliberate hunting, establishes Specially Protected Areas, and develops scientific programs to reduce by-catch and manage strandings.
ICCAT	1969	2003	ICCAT protects marine biodiversity by regulating tuna and tuna-like species through a strict quota system . By managing harvest levels in the Atlantic and adjacent seas, it prevents overfishing and ensures the sustainability of migratory fish stocks.
IMO	1958	1999	The IMO preserves marine biodiversity by enforcing the Ballast Water Management Convention (BWMC) to mitigate the translocation of invasive aquatic species (IAS) . By mandating rigorous treatment standards, it prevents the ecological disruption caused by non-native organisms and pathogens transported in ship ballast tanks.
BC	1994	1994	The Bucharest Convention preserves Black Sea biodiversity by mitigating land-based pollution , oil spills, and dumping through a unified legal framework. Its dedicated Biodiversity Protocol prevents habitat degradation and ensures the protection of unique regional landscapes and species.
CBD	1992	1997	The Convention on Biological Diversity (CBD) is a global framework for species conservation, sustainable use, and genetic benefit-sharing. By integrating the Aichi Targets, it establishes a scientific roadmap to address the root causes of biodiversity loss and protect critical ecosystems.
RAMSAR	1971	1994	The Ramsar Convention safeguards biodiversity by designating "Wetlands of International Importance" to ensure ecological stability. Under this framework, the Kızılırmak Delta serves as a vital biological corridor and critical habitat for migratory birds and endemic species.

6.1.2. National Regulations

The basic legal framework for biodiversity protection in Türkiye is composed of several key instruments, including the **Draft Law on the Conservation of Biological Diversity**, the **Directive of the National Coordination Board of Biological Diversity**, and the **regulations enacted under the Biosafety Law**. Together, these instruments establish the legislative foundation for safeguarding species, habitats, and genetic resources. The **Ministry of Agriculture and Forestry** serves as the principal authority responsible for policy formulation and oversight, while the **General Directorate of Nature Conservation and National Parks (DKMP)**, operating under its

NEXT Black Sea Basin

jurisdiction, is tasked with implementing conservation measures and managing protected areas at the national level.

7.1.1.1. Law on the Conservation of Biological Diversity (Draft)

The **Draft Law on the Conservation of Biological Diversity** is designed to ensure the protection and sustainable management of species, habitats, and genetic resources within Turkey's national territory. Its overarching objectives include the conservation of biological diversity, the sustainable use of natural components, and the equitable sharing of benefits derived from genetic resources. The law is grounded in internationally recognized principles such as the **precautionary approach**, **public participation in environmental decision-making**, and the **prevention of biopiracy**. Although it has not yet entered into force, the draft has been prepared to achieve **harmonization with the European Union acquis** and to fulfill Turkey's **international obligations** under global biodiversity conventions (Draft Law, <https://www.mevzuat.gov.tr> on June 30, 2026).

7.1.1.2. National Biological Diversity Coordination Board Directive (Presidential Circular No. 2019/15):

This **Directive** constitutes a pivotal component of Turkey's institutional framework for biodiversity governance. It establishes the **National Coordination Board** as the central body responsible for ensuring the coherence and effectiveness of biodiversity-related policies across sectors. The Board's duties encompass monitoring global biodiversity agendas, mainstreaming biodiversity considerations into national economic and development planning, combating **biopiracy and bio-smuggling**, and conducting comprehensive **ecosystem inventory and monitoring studies** to support evidence-based decision-making. Functioning as the **Secretariat**, the **Ministry of Agriculture and Forestry** plays a crucial role in facilitating inter-ministerial coordination, managing administrative processes, and ensuring the implementation of national biodiversity strategies in alignment with international commitments such as the **Convention on Biological Diversity (CBD)** and the **Cartagena Protocol on Biosafety**. The Directive thus serves as a governance instrument that bridges scientific research, policy formulation, and socio-economic planning—promoting an integrated approach to biodiversity conservation and sustainable development within Turkey's national and regional contexts, including the **Black Sea basin**. Complementing these structures, the Biosafety Board oversees activities related to genetically modified organisms (GMOs) and biotechnology. It is mandated to conduct risk assessments, socio-economic analyses, and ethical evaluations through specialized committees, thereby safeguarding human, animal, and plant health and ensuring environmental protection.

7.1.1.3. The Biosafety Law:

The **Biosafety Law** specifically governs activities related to **genetically modified organisms (GMOs)** and their products, with the objective of ensuring the protection of **human, animal, and plant health**, alongside the preservation of the environment. Within this framework, **risk assessment**, **socio-economic analysis**, and **ethical evaluations** are conducted by the **Biosafety Board** and its specialized committees, ensuring that decisions are informed by scientific evidence and ethical considerations (Table-11) (Biosafety Law, 2010).

Table 19. Summary Table for major regulations, objectives and competent institutions

Regulation / Institution	Enforcement	Main Objective	Competent Institution
Conservation of Biological Diversity Law (Draft)	Not yet	Species, habitat, protection of genetic resources	Ministry of Agriculture and Forestry
National Biological Diversity Coordination Board	2019	Coordination, monitoring, anti-bio-smuggling	DKMP / Ministry of Agriculture and Forestry
Biosafety Law (5977)	2010	Safety of GMO activities	Biosafety Board
Convention on Biological Diversity (CBD) (1996)	1997	International obligations	Ministry of Agriculture and Forestry

6.1.3. Other Key Legal Frameworks Supporting Biodiversity Protection

6.1.3.1. Regulation on Invasive Alien Species

The, which entered into force in **February 2026**, represents a major advancement in Turkey's environmental governance. It aims to **prevent and manage the introduction and spread of invasive alien species** across **marine, terrestrial, and inland water ecosystems**, addressing one of the most pressing threats to native biodiversity. The regulation emphasizes **science-based decision-making** and strengthens **inter-institutional coordination**, ensuring that management actions are guided by ecological risk assessments and aligned with international best practices (EU, 2014).

6.1.3.2. Protected Areas:

The framework for **Protected Areas** constitutes another cornerstone of Turkey's biodiversity policy. The country has established an extensive **network of protected areas**, including **national parks, nature reserves, and special conservation zones**, managed under the authority of the **Ministry of Environment, Urbanization, and Climate Change**. Responsibilities are shared among multiple institutions to ensure effective conservation, monitoring, and sustainable use of natural resources. This system reflects Turkey's commitment to maintaining ecological integrity while balancing conservation objectives with socio-economic development (CSB, 2026; Anonymous, 2026).

6.1.3.3. Green Taxonomy Regulation:

In addition, the emerging **Green Taxonomy Regulation** introduces a forward-looking approach to environmental governance by defining **sustainable economic activities** and promoting **biodiversity-friendly investment criteria**. The draft regulation requires **reporting on**

NEXT Black Sea Basin

sustainable activities and establishes standards for **environmentally responsible investments**, thereby integrating biodiversity considerations into financial and corporate decision-making. This initiative aligns with the European Union's Green Deal and Sustainable Finance frameworks, positioning Turkey to harmonize its environmental and economic policies with international sustainability standards (Narterlaw, 2024). These regulations reflect Turkey's ongoing efforts to balance development with the conservation of its rich biodiversity, though challenges remain in enforcement and policy implementation (UNDP, 2026).

6.1.3.4. Fisheries Law and Fisheries Management:

Fisheries management and sustainable biodiversity are intrinsically linked through the shared objective of maintaining ecological balance while supporting socio-economic resilience. In marine ecosystems such as the **Black Sea**, effective fisheries governance serves not only to regulate exploitation but also to preserve the structural and functional integrity of biodiversity (FAO, 2024; Black Sea Commission, 2025).

6.1.3.5. Ecological Interdependence:

Sustainable biodiversity underpins the productivity and stability of fisheries. Diverse species assemblages contribute to **ecosystem resilience**, enabling recovery from environmental disturbances and anthropogenic pressures. Overfishing, habitat degradation, and selective harvesting disrupt trophic interactions, leading to **biodiversity loss and ecosystem simplification**. Consequently, fisheries management strategies that incorporate **ecosystem-based approaches**, including habitat protection, bycatch reduction, and stock diversity maintenance—are essential for sustaining both ecological and economic outputs (GFCM, 2024).

6.1.3.6. Policy Integration and Adaptive Management:

Modern fisheries governance increasingly adopts **adaptive management frameworks**, integrating biodiversity indicators into decision-making processes. This approach recognizes the dynamic nature of marine ecosystems and the need for continuous monitoring and feedback mechanisms. In Türkiye, the **Ministry of Agriculture and Forestry** has begun aligning fisheries regulations with biodiversity conservation objectives, emphasizing **Marine Protected Areas (MPAs)** and **spatial planning tools** that safeguard critical habitats and spawning grounds (Ministry of Agriculture and Forestry, 2025).

6.1.3.7. Socio-Economic Dimensions:

Sustainable biodiversity contributes to long-term economic stability by ensuring the persistence of fish stocks and associated ecosystem services. Conversely, biodiversity decline can lead to economic vulnerability, particularly in coastal communities dependent on small-scale fisheries. Integrating biodiversity conservation into fisheries management thus represents a dual investment—protecting ecological capital while securing livelihoods. The ecosystem services framework, which values biodiversity as natural infrastructure, provides a compelling rationale for policy coherence between conservation and fisheries sectors (UNDP Türkiye, 2025).

6.1.3.8. Regional Cooperation and Transboundary Governance:

Given the shared nature of marine resources, regional cooperation is vital for harmonizing biodiversity and fisheries policies. The General Fisheries Commission for the Mediterranean (GFCM) and the Black Sea Commission facilitate joint monitoring, data exchange, and coordinated management actions. Such transboundary governance mechanisms enhance the effectiveness of biodiversity conservation by addressing migratory species and cumulative impacts across national jurisdictions (GFCM, 2024; BSC, 2025). Ultimately, the relationship between fisheries management and sustainable biodiversity is mutually reinforcing. Biodiversity conservation ensures the ecological foundation upon which fisheries depend, while well-managed fisheries contribute to maintaining ecosystem balance. The integration of ecological, economic, and institutional dimensions within policy frameworks represents the cornerstone of sustainable marine governance in the Black Sea region and beyond.

6.1.3.9. Fisheries Governance and Regulatory Dynamics in the Black Sea:

Türkiye's management of Black Sea fisheries operates within a complex interplay of national legislation, ecological constraints, and socio-economic pressures. The regulatory framework combines seasonal closures, gear restrictions, and catch limits, aiming to balance resource sustainability with the livelihoods of coastal communities (MAF, 2025). However, enforcement challenges—particularly concerning illegal, unreported, and unregulated (IUU, 2025) fishing—continue to undermine the effectiveness of these measures (FAO, 2024).

The General Directorate of Fisheries and Aquaculture (BSGM), operating under the Ministry of Agriculture and Forestry, serves as the central authority responsible for the formulation, implementation, and enforcement of fisheries management regulations in Türkiye. Established under Presidential Decree No. 1 (2018), the Directorate's mandate encompasses the sustainable utilization of aquatic resources, the regulation of fishing activities, and the development of aquaculture systems (Ministry of Agriculture and Forestry, 2025). BSGM's governance framework is grounded in Fisheries Law No. 1380, which provides the legal basis for regulating marine and inland fisheries, aquaculture operations, and trade in aquatic products. The Directorate's responsibilities are further detailed in the Directive on the Duties, Authorities, and Responsibilities of Central Units (2022/2), which defines its organizational structure and operational scope (General Directorate of Fisheries and Aquaculture, 2025). BSGM develops and enforces national fisheries policies aimed at ensuring ecological sustainability and economic viability. Its regulatory functions include:

- **Licensing and Quota Management:** Issuing fishing licenses, determining total allowable catches (TACs), and regulating fishing efforts to prevent overexploitation.
- **Seasonal and Gear Restrictions:** Implementing closed seasons and gear limitations to protect spawning stocks and juvenile fish populations.
- **Aquaculture Regulation:** Overseeing site selection, licensing, and environmental compliance for aquaculture facilities.
- **Trade and Market Oversight:** Controlling the import and export of fishery products and ensuring compliance with sanitary and quality standards.

These measures align with Türkiye's commitments under international frameworks such as the General Fisheries Commission for the Mediterranean (GFCM) and the Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries (FAO, 2024a 2024b; GFCM, 2023; 2024; 2025; 2026).

6.2. Bulgaria

6.2.1 International and Regional Agreements

6.2.1.1. Convention on Biological Diversity (CBD)

Bulgaria has been a Party to the Convention on Biological Diversity (CBD) since 1996 and, as such, is committed to implementing its main objectives, namely the conservation of biological diversity and the sustainable use of biological resources. In line with these commitments, the country develops and implements national policies and strategies for nature conservation, including the National Biodiversity Strategy and Action Plan (developed by the Ministry of Environment and Water). Within the framework of the Convention's strategic plan, Bulgaria is required to take measures for the protection of ecosystems, species, and genetic diversity, as well as to integrate biodiversity conservation principles into sectoral policies such as fisheries, agriculture, and regional development. This includes the establishment and effective management of protected areas, the implementation of biodiversity monitoring, and the development of management plans for endangered species and habitats. A key instrument for fulfilling these commitments in Bulgaria is the Natura 2000 network, which covers a significant portion of the country's terrestrial and marine territory. In the Black Sea waters, these sites play a crucial role in the conservation of marine habitats, dolphin populations, fishery resources, and coastal ecosystems.

6.2.1.2. United Nations Sustainable Development Goals

Bulgaria actively participates in the implementation of the United Nations Sustainable Development Goals (SDGs). This global framework comprises 17 goals aimed at achieving balanced development across economic, social, and environmental dimensions. UN Member States are committed to integrating these goals into their national policies and development strategies. In the context of the marine environment and biodiversity conservation, the most relevant is Goal 14 - "Life Below Water", which promotes the conservation and sustainable use of oceans, seas, and marine resources. Bulgaria implements this goal through national policies for marine environmental management, including the application of European directives such as the Marine Strategy Framework Directive and the Habitats Directive.

This includes measures to reduce marine pollution, ensure sustainable management of fishery resources, protect coastal and marine ecosystems, and expand the network of marine protected areas.

6.2.1.3. EU 2030 Biodiversity Strategy

The Biodiversity Strategy for 2030 is a key policy framework of the European Union for the conservation and restoration of nature, adopted as part of the European Green Deal. The strategy aims to halt biodiversity loss and restore degraded ecosystems across Europe by 2030. As an EU Member State, Bulgaria is required to integrate the objectives of this strategy into its national policies and natural resource management plans. One of the main targets of the strategy is to protect at least 30% of the EU's land and sea areas, with at least one third of these areas placed under strict protection. For Bulgaria, this entails the expansion and effective management of the existing Natura 2000 network, which includes a number of marine sites in the Black Sea. With regard to the Black Sea ecosystem, the strategy emphasizes the conservation of marine ecosystems, the sustainable management of fishery resources, and the restoration of degraded habitats. In the Bulgarian Black Sea waters, this includes measures to protect sensitive marine habitats such as seagrass meadows, mussel beds, and coastal lagoons, as well as the conservation of protected fish species and the three Black Sea dolphin species. The strategy also requires Member States to take action to restore degraded ecosystems, reduce pollution, and limit pressures on natural resources. This involves integrating conservation objectives into sectoral policies such as fisheries, maritime transport, and coastal development.

6.2.1.4. Marine Strategy Framework Directive (MSFD)

The Marine Strategy Framework Directive (MSFD) is the main legislative instrument of the European Union for the protection of the marine environment. Its primary objective is to achieve Good Environmental Status (GES) of EU marine waters and to ensure the sustainable use of marine resources. In this context, Bulgaria is required to implement the directive in its Black Sea waters through the development and execution of a national marine strategy. This strategy includes an assessment of the state of the marine environment, the definition of environmental objectives, and the development of a programme of measures aimed at improving the condition of marine ecosystems. It is based on the ecosystem-based approach to marine resource management and requires the integration of conservation objectives into sectoral policies such as fisheries, maritime transport, and coastal development.

The assessment of the marine environment is carried out using a set of 11 ecological descriptors, which cover the main components of marine ecosystems. In the context of the Black Sea, these descriptors enable systematic monitoring of key ecological processes and pressures on the marine environment. As part of the directive's implementation, Bulgaria conducts regular monitoring of the marine environment through the National Environmental Monitoring System. This monitoring includes the measurement of physicochemical water parameters, assessment of the status of marine habitats, fish and marine mammal populations, and the evaluation of pollution levels. The collected data are used to assess the condition of marine ecosystems and to develop measures aimed at reducing anthropogenic pressures. The descriptors that are directly relevant to the status of marine mammals, fish populations, and marine habitats are as follows:

NEXT Black Sea Basin

Descriptor 1 - Biodiversity assesses the condition and distribution of marine species and habitats, including populations of dolphins and other protected species.

Descriptor 3 - Commercial fish and shellfish evaluates the status of fishery resources and determines whether populations of exploited fish species are within sustainable biological limits.

Descriptor 4 - Food webs examines interactions between different trophic levels within the marine ecosystem, allowing for the assessment of food web structure and functioning, including the role of top predators such as dolphins.

Descriptor 6 - Seafloor integrity assesses the condition of marine habitats and benthic communities by evaluating the extent of impacts on the seabed and its capacity to support ecosystem functions.

Together, these descriptors provide a comprehensive basis for assessing the status of marine ecosystems and for developing measures aimed at biodiversity conservation and the sustainable management of marine resources in the Black Sea.

6.2.1.5. Regional conventions (Barcelona Convention, Black Sea Bucharest Convention)

Regional marine conventions constitute an important legal framework for cooperation among countries in the protection of the marine environment. In the European and regional context, two of the most significant are the Barcelona Convention and the Bucharest Convention. While the Barcelona Convention applies primarily to the Mediterranean Sea, the Bucharest Convention represents the main international framework for the protection of the marine environment in the Black Sea. Bulgaria has been a Party to the Bucharest Convention since 1992 and is committed to preventing, reducing, and controlling marine pollution. The convention addresses various sources of pollution, including land-based inputs, shipping, and activities on the continental shelf. Within this framework, Black Sea countries cooperate in monitoring the marine environment, exchanging scientific information, and developing joint measures for ecosystem protection. The convention promotes the conservation of biodiversity and the sustainable use of marine resources, supported by regional programmes for monitoring marine ecosystems, as well as fish and marine mammal populations. All three dolphin species in the Black Sea are included in Annex II of the Protocol on the Conservation of Biological Diversity and Landscape of the Convention, where they are listed as endangered species.

Table 20. International Organizations and Conventions on Biodiversity to which Bulgaria is member

Organization	Foundation Year	Membership year	Contribution to Biodiversity
GFCM	1952	1969	MPAs, Vulnerable species protection By-catch reduction, Habitat conservation, IUU fishing prevention, BlackSea Working Group
CITES	1973	1991	CITES protects endangered species by banning commercial trade for those in Appendix I and strictly monitoring trade for Appendix II species,

NEXT Black Sea Basin

			like sharks. This permit-based system prevents extinction and ensures sustainable marine populations.
IUCN	1948	1993	IUCN protects biodiversity by assessing extinction risks through the Red List, providing a global scientific standard for conservation. It guides international policies to ensure natural resource use is ecologically sustainable and prevents worldwide species loss
ACCOBAMS	1996	2001	ACCOBAMS protects marine biodiversity by mitigating threats to cetaceans in the Mediterranean and Black Seas. It enforces strict bans on deliberate hunting, establishes Specially Protected Areas, and develops scientific programs to reduce by-catch and manage strandings.
ICCAT	1969	Exclusively through its European Union membership. Under the Common Fisheries Policy, the EU negotiates quotas and conservation rules on behalf of all its member state	ICCAT protects marine biodiversity by regulating tuna and tuna-like species through a strict quota system. By managing harvest levels in the Atlantic and adjacent seas, it prevents overfishing and ensures the sustainability of migratory fish stocks.
IMO	1958	1960	The IMO preserves marine biodiversity by enforcing the Ballast Water Management Convention (BWMC) to mitigate the translocation of invasive aquatic species (IAS). By mandating rigorous treatment standards, it prevents the ecological disruption caused by non-native organisms and pathogens transported in ship ballast tanks.
BC	1994	1995	The Bucharest Convention preserves Black Sea biodiversity by mitigating land-based pollution, oil spills, and dumping through a unified legal framework. Its dedicated Biodiversity Protocol prevents habitat degradation and ensures the protection of unique regional landscapes and species.

NEXT Black Sea Basin

CBD	1992	1996	The Convention on Biological Diversity (CBD) is a global framework for species conservation, sustainable use, and genetic benefit-sharing. By integrating the Aichi Targets, it establishes a scientific roadmap to address the root causes of biodiversity loss and protect critical ecosystems.
RAMSAR	1971	1994	The Ramsar Convention safeguards biodiversity by designating "Wetlands of International Importance" to ensure ecological stability.
(UNCLOS)	1982	Ratified 1996	United Nations Convention on the Law of the Sea
Convention for the Prevention of Pollution from Ships (MARPOL 73/78)	1973	1985	Preventing and minimizing pollution from ships - both accidental pollution and that from routine operations

6.2.2. National Regulation

6.2.2.1. Competent authorities and responsibilities

The management of the marine environment in the Bulgarian Black Sea waters involves coordination among various institutions responsible for the conservation of marine ecosystems, the management of fishery resources, environmental monitoring, and the regulation of human activities in the marine area. The main coordinating role is carried out by the Ministry of Environment and Water (MoEW), which is responsible for the development and implementation of the national marine strategy and for enforcing European environmental policies. Other key institutions, such as BSBD, EEA and EAFA are involved in environmental monitoring, water resource management, and the regulation of fishing activities. This institutional framework is further supported by scientific institutions and international cooperation among the countries of the Black Sea region.

As EU member Bulgaria integrates European Union directives, international conventions, and national legislation, covering environmental protection, coastal and marine spatial planning, fisheries management, and biodiversity conservation. Together, these instruments ensure coherent policy implementation, monitoring, and cross-sectoral coordination.

The main focus on the improvement of marine environment is on the EU Marine Strategy Framework Directive (MSFD - Directive 2008/56/EC), which requires member states to achieve

NEXT Black Sea Basin

or maintain a Good Environmental Status (GES) in their marine waters. Bulgaria transposed the MSFD into national law through Government Emergency Ordinance (OUG).

Bulgaria actively participates in international and regional agreements relevant to the Black Sea, notably the Convention on the Protection of the Black Sea Against Pollution (Bucharest Convention, 1992). This convention provides a regional framework for cooperation among Black Sea states on pollution control, biodiversity conservation, marine resource management, and integrated coastal zone management, coordinated through the Black Sea Commission. Bulgaria has also ratified the Protocol on the Conservation of Biodiversity and Natural Habitats of the Black Sea, which emphasizes regional conservation priorities and cooperative measures for ecosystem protection. At the national level, the Ministry of Environment and Waters (MEW) is the primary authority responsible for marine environmental protection and biodiversity conservation. It coordinates MSFD implementation, oversees environmental monitoring, and ensures compliance with ecological standards for coastal and offshore activities, including reviewing Environmental Impact Assessments (EIAs) for ports, marinas, and other coastal infrastructure. Government Emergency Ordinance no. 195/2005 on pollution prevention and control provides legal protection for water bodies, sediments, and marine ecosystems, supporting EU and Bucharest Convention obligations.

Marine biodiversity protection is also addressed through fisheries and aquaculture legislation, administered by the National Agency for Fisheries and Aquaculture (NAFA). NAFA regulates fishing activities, establishes catch limits, controls fishing gear, and designates seasonally or spatially restricted zones to safeguard vulnerable populations, while aquaculture regulations ensure environmental safeguards, biosecurity, and impact assessments. Black Sea commercial fisheries in Bulgaria are managed within the framework of the EU Common Fisheries Policy (CFP) and the regional measures of the General Fisheries Commission for the Mediterranean (GFCM) for GSA 29 (Black Sea).

The main national institutions responsible for data collection and management are the Ministry of Agriculture and Food (MAF), which ensures policy coordination of the sector and interaction with European structures under the Operational Programme for Fisheries, and the Executive Agency for Fisheries and Aquaculture (EAFA) - a subordinate body of MAF and the national competent authority for policy implementation, administration of registers, and licensing. EAFA also acts as the primary coordinator for the collection of technical, biological, and economic fisheries data under the EU Data Collection Framework (DCF). The Directorate-General for Maritime Affairs and Fisheries (DG MARE) is a department within the European Commission responsible for the Common Fisheries Policy (CFP), the EU's maritime policy, sustainable management of fishery resources, and international fisheries agreements. In the Black Sea context, DG MARE develops regulations and technical measures, coordinates the implementation of quotas and control mechanisms for Total Allowable Catch (TAC), and provides the framework and technical infrastructure for DCF data reporting, as well as for the evaluation of work plans and annual reports.

NEXT Black Sea Basin

The Joint Research Centre (JRC) is the scientific body of the European Commission that provides scientific and technical support for policy development, data analysis and modeling, and methodological frameworks for data collection and validation. In the field of fisheries, the JRC coordinates the technical aspects of the DCF, supports scientific expert groups, and develops tools for stock assessment, economic analysis, and data quality control.

Bulgaria implemented the EU Birds Directive (2009/147/EC) and Habitats Directive (92/43/EEC), creating a network of Natura 2000 protected areas, including marine and coastal habitats. Along the Romanian Black Sea coast, Special Protection Areas (SPAs) and Sites of Community Importance (SCIs) protect species and habitats of EU conservation concern. Management plans for these sites include public consultations, biodiversity monitoring, and measures to mitigate human impacts, balancing conservation goals with sustainable fisheries and tourism.

Marine Spatial Planning (MSP), as required by Directive 2014/89/EU, integrates environmental, economic, and social objectives for the marine space. In Bulgaria, MSP aligns development priorities with ecological objectives through stakeholder consultations and cross-sectoral coordination among ministries responsible for environment, transport, fisheries, and economic development. Responsible institution is Ministry of Regional Development and Public works.

6.3. Romania

The protection and sustainable use of marine and coastal biodiversity in the Romanian Black Sea region is governed by a highly structured, three-tiered legal framework. This framework integrates international conventions, European Union directives, and specific national legislation. Together, these instruments aim to mitigate cross-border pollution, manage shared marine resources, and preserve critical habitats in a semi-enclosed basin heavily impacted by human activity.

6.3.1. International and Regional Agreements

Because the Black Sea is a shared, semi-enclosed water body, localized conservation efforts are ineffective without transboundary cooperation. Romania is fully integrated into a matrix of global and regional agreements designed to standardise marine protection.

The regional anchor: Bucharest Convention

The central regional instrument is the Convention on the Protection of the Black Sea Against Pollution (Bucharest Convention, 1992), ratified by Romania and all other coastal states. Coordinated by the Black Sea Commission (BSC) in Istanbul, the convention explicitly requires member states to control pollution and protect marine living resources. It is operationalized through four specific protocols:

NEXT Black Sea Basin

- Land-Based Sources Protocol (2002): Crucial for Romania, as it mandates the reduction of agricultural and industrial runoff from the Danube River, directly addressing the basin's eutrophication crisis.
- Dumping Protocol (2002) & Emergency Situations Protocol (2003): These regulate the disposal of dredged materials and coordinate rapid responses to oil spills.
- Biodiversity and Landscape Conservation Protocol (2002): This protocol drives regional cooperation in establishing Marine Protected Areas (MPAs) and protecting highly migratory species, such as cetaceans and sturgeons, across geopolitical borders.

UNCLOS

At the global level, Romania is bound by the United Nations Convention on the Law of the Sea (UNCLOS, 1982), often referred to as the "constitution of the oceans." UNCLOS establishes the legal boundaries of Romania's 12-nautical-mile Territorial Sea and its Exclusive Economic Zone (EEZ). The exact delimitation of Romania's continental shelf and EEZ was historically contested but definitively resolved by the International Court of Justice (ICJ) in 2009 (*Maritime Delimitation in the Black Sea, Romania v. Ukraine*), which granted Romania jurisdiction over 9,700 square kilometers of maritime space (ICJ, 2009). Crucially, while UNCLOS grants Romania sovereign rights to exploit living and non-living resources (such as offshore gas and fisheries) within its EEZ, Article 192 of the convention imposes a strict, legally binding obligation to "protect and preserve the marine environment." This mandates that any resource extraction must not exceed sustainable harvest limits, preventing the collapse of shared pelagic fish stocks.

Global Biodiversity Commitments (CBD and Bern Convention)

To fulfill its UNCLOS obligations regarding living resources, Romania aligns its national policies with the Convention on Biological Diversity (CBD, 1992). Most recently, under the CBD's Kunming-Montreal Global Biodiversity Framework (GBF), Romania is committed to the "30x30" target, driving the ongoing expansion of its coastal and offshore MPAs.

Species-specific protection is rigorously guided by the Bern Convention (1979) on the Conservation of European Wildlife and Natural Habitats. The Bern Convention mandates the strict protection of species listed in its Appendix II, which includes all Black Sea cetaceans and sturgeons. It was the Bern Convention's "Emerald Network" that served as the legal precursor to Romania's current Natura 2000 network, compelling the state to criminalize the deliberate capture, disturbance, or trade of these vulnerable marine species.

MARPOL and maritime traffic enforcement

Given the heavy maritime traffic moving through the Port of Constanța (the largest port on the Black Sea) and navigating the Sulina channel into the Danube River, shipping-related treaties are a critical line of defense against pollution. The MARPOL Convention (73/78) and its specific annexes are rigorously enforced by the Romanian Naval Authority (ANR) through routine Port State Control inspections. Under MARPOL, the Black Sea is legally designated as a "Special Area"

NEXT Black Sea Basin

due to its oceanographic vulnerability (being semi-enclosed with a slow water renewal rate). This designation means discharge limits are exceptionally stringent:

- Annex I (Oil) & Annex V (Garbage): Complete prohibition of any discharge of oil, oily mixtures, and plastic debris into the sea. Vessels must use authorized port reception facilities in Constanța, Midia, or Mangalia.
- Annex IV (Sewage) & Annex VI (Air Pollution): Strict regulations govern the release of untreated sewage and cap the sulfur content of marine fuels used by vessels operating in Romanian territorial waters to prevent atmospheric acidification of the sea (IMO, 1973).

The Espoo Convention and offshore Industrial Projects

As Romania advances its energy independence through offshore industrial initiatives, transboundary environmental law becomes paramount. The UNECE Espoo Convention (1991) governs environmental impact assessments (EIAs) in a transboundary context. It mandates that a state undertaking a major project must consult neighboring states if the project could cause cross-border environmental harm. A concrete contemporary example is the Neptun Deep offshore gas extraction project located in Romania's EEZ. Because the drilling, platform construction, and seabed pipeline installation have the potential to disturb benthic habitats, generate hazardous underwater noise affecting cetaceans, and alter water quality, the Espoo Convention requires the Romanian Ministry of Environment to formally share the project's EIA with neighboring coastal states (such as Bulgaria). This ensures that transboundary environmental risks are scientifically evaluated and mitigated before any extraction permits are finalized, preventing unilateral industrial actions from degrading the shared Black Sea ecosystem (UNECE, 1991).

Important Marine Mammal Areas (IMMAs) as a conservation blueprint

In late 2021, the IUCN Marine Mammal Protected Areas Task Force established Important Marine Mammal Areas (IMMAs) in the Black Sea, providing a critical scientific framework for advancing Romania's network of Marine Protected Areas (MPAs). While not legally binding reserves themselves, these evidence-based designations spotlight vital habitats necessary to protect the basin's three endemic and threatened cetaceans: the Black Sea harbour porpoise, bottlenose dolphin, and common dolphin. Driven by the urgent need to mitigate unsustainable levels of accidental fishing bycatch and coastal habitat degradation, the IMMA framework serves as the modern standard for evaluating marine biodiversity. By identifying the exact migratory and foraging corridors these mammals rely on, the IMMAs offer Romanian policymakers the precise spatial data required to expand current protections and meet global "30 by 30" conservation targets.

For the Romanian coast, this effort is anchored by two primary designations: the coastal Kaliakra to Danube Delta IMMA and the offshore Western Black Sea IMMA. The coastal corridor spans shallow shelf waters, acting as a crucial summer feeding ground that connects fragmented existing reserves—such as the Danube Delta and Vama Veche—across areas otherwise vulnerable to intense port traffic. Further offshore, the deep-water Western Black Sea IMMA represents a

NEXT Black Sea Basin

severely unprotected stronghold that hosts over 70% of the entire harbour porpoise population during the summer. Integrating these two IMMAs into formal marine spatial planning is now the frontier of Romania's ecological policy, shifting the conservation paradigm from protecting isolated coastal pockets to managing continuous, transnational corridors equipped with enforced bycatch mitigation protocols.

6.3.2. European Union Integration

As an EU Member State since 2007, Romania's environmental policies are fundamentally shaped by European directives, which carry legally binding targets, strict enforcement mechanisms, and mandatory reporting cycles to the European Environment Agency (EEA).

The Marine Strategy Framework Directive (MSFD - 2008/56/EC)

The MSFD serves as the core pillar of Romania's marine governance, transposed into national law via Government Emergency Ordinance (OUG) no. 71/2010 (later updated by Law 279/2018). It mandates that Romania achieve "Good Environmental Status" (GES) across 11 Qualitative Descriptors, ranging from maintaining biodiversity to controlling underwater noise.

- *Implementation example:* To meet MSFD requirements, the National Institute for Marine Research and Development (NIMRD) actively monitors specific descriptors, such as D8 (Contaminants), testing coastal sediments for heavy metals (cadmium, lead) and petroleum hydrocarbons. Furthermore, under MSFD guidelines, Romania's marine waters are legally classified into specific typologies (e.g., RO-TT03 for northern waters under the direct influence of the Danube, and RO-CT01 for central coastal waters) to ensure that the national Program of Measures is precisely tailored to the physical and chemical realities of different sectors.

The Water Framework Directive (WFD - 2000/60/EC)

This directive complements the MSFD by heavily regulating the water quality of inland, transitional, and coastal waters (extending 1 nautical mile offshore). Its primary goal is to prevent the deterioration of aquatic ecosystems and ensure they achieve "Good Ecological Status."

- *Implementation example:* Through continuous River Basin Management Plans (RBMPs), the WFD specifically targets the massive nutrient pollution plumes originating from the Danube Delta. The directive legally binds Romanian authorities to classify the "Ecological" and "Chemical" status of these coastal waters based on strict Environmental Quality Standards (EQS). If chemical concentrations (like agricultural nitrates and phosphates) exceed permissible thresholds in the coastal zone, the state is forced to implement stricter land-based agricultural runoff controls far upstream.

The Habitats (92/43/EEC) and Birds (2009/147/EC) Directives

These directives form the legal foundation for the Natura 2000 network, formally transposed into Romanian law through OUG no. 57/2007. They compel the government to designate specific, highly valuable marine zones as Sites of Community Importance (SCIs) and Special Protection Areas (SPAs).

NEXT Black Sea Basin

- *Implementation example:* Under Article 17 of the Habitats Directive, Romania must strictly report on the conservation status of critical benthic habitats, such as the *Cystoseira* (Gongolaria) algal reefs, and the population trends of apex predators like the bottlenose dolphin. This legal framework prevents any coastal development—such as port expansions or massive beach nourishment projects—from proceeding without a rigorous "Appropriate Assessment" to scientifically prove it will not degrade these protected habitats or disrupt avian migratory corridors.

The Marine Spatial Planning Directive (MSP - 2014/89/EU)

As the Black Sea becomes increasingly crowded with economic activities, this directive forces Romania to map and allocate its marine space logically. The EU directive was transposed into national legislation through Law no. 88/2017 to resolve spatial conflicts between ecology and industry.

- *Implementation example:* Supported by transboundary data initiatives like the MARSPLAN-BS projects, Romania officially adopted its first comprehensive Maritime Spatial Plan on November 10, 2023, through Government Ordinance no. 97/2023. This legally binding plan resolves critical spatial conflicts—explicitly zoning out areas for future offshore wind farms, mapping the extraction corridors for offshore gas, and designating shipping lanes—while strictly ensuring these industrial footprints do not overlap with or degrade the established Natura 2000 marine conservation zones.

The Urban Wastewater Treatment Directive (UWWTD - 91/271/EEC)

Because the Black Sea is highly susceptible to hypoxia, the UWWTD is a critical piece of legislation targeting the organic matter and nutrient pollution (nitrogen and phosphorus) that drive the sea's eutrophication.

- *Implementation example:* To comply with the UWWTD, Romania has undertaken massive, EU-funded infrastructural upgrades to its coastal agglomerations. Wastewater treatment plants in cities like Constanța, Eforie, and Mangalia have been upgraded to include mandatory secondary and tertiary treatments. This ensures that nutrient loads are chemically and biologically stripped from urban sewage before the effluent is discharged into the sea, directly mitigating the severity of seasonal algal blooms along the tourist coast.

The Port Reception Facilities Directive (EU 2019/883)

Designed to prevent ship-source pollution and align EU law with the global MARPOL convention, this directive ensures that ships do not dump garbage, oily residues, or sewage into the sea by requiring adequate waste reception infrastructure at all ports.

- *Implementation example:* In major hubs like the Port of Constanța and Midia, this directive mandates an "indirect fee" system. Ships must pay a flat waste-handling fee regardless of whether they actually discharge waste at the port. By removing the financial incentive to avoid disposal fees, the law drastically reduces the likelihood of

NEXT Black Sea Basin

captains illegally dumping toxic cargo residues or garbage into the vulnerable Black Sea just outside territorial waters.

The Single-Use Plastics Directive (SUP - EU 2019/904)

Addressing the severe plastic pollution crisis in the world's oceans, this directive bans specific single-use plastics and mandates circular economy practices to reduce marine litter—directly supporting the goals of MSFD Descriptor 10.

- *Implementation example:* Beyond banning items like plastic cutlery and straws from Romanian coastal resorts, the SUP Directive specifically targets the fishing industry. Romania is required to establish Extended Producer Responsibility (EPR) schemes for fishing gear containing plastics. This forces manufacturers to cover the costs of collecting and recycling abandoned or lost gillnets ("ghost nets") retrieved by port authorities, directly addressing one of the primary causes of cetacean bycatch in the Black Sea.

The Offshore Safety Directive (2013/30/EU)

Given the rapid expansion of hydrocarbon extraction in the Black Sea, this directive establishes minimum requirements to prevent major accidents during offshore oil and gas operations and limits the consequences should a spill occur. It was transposed into Romanian law via Law no. 165/2016.

- *Implementation example:* Before initiating deep-water extraction projects like *Neptun Deep* in Romania's Exclusive Economic Zone, operators are legally required to submit a comprehensive "Report on Major Hazards" to an independent national competent authority. The operator must scientifically demonstrate they possess the internal emergency response plans, as well as the immediate physical and financial resources, to cap a blowout and contain an oil spill before it can devastate the enclosed Black Sea marine environment.

6.3.3. National Legislation

To make international and EU obligations enforceable, Romania has transposed these directives into a robust body of national law. Because the Black Sea faces intense, competing pressures—from commercial fishing and tourism to offshore energy and shipping—this legal framework provides the strict regulatory boundaries necessary to protect marine ecosystems and hold polluters accountable.

Government Emergency Ordinance (OUG) no. 71/2010 & GD no. 432/2020 (Updated by GD 79/2024)

Government Emergency Ordinance (OUG) no. 71/2010, subsequently amended by Law 279/2018, is the fundamental legislative act that transposed the EU Marine Strategy Framework Directive (MSFD) into Romanian law. It legally mandates that state agencies actively monitor the marine environment across all 11 Qualitative Descriptors and apply punitive measures against polluters who degrade Good Environmental Status (GES). To operationalize this ordinance, the government adopted the official *Program of Measures* through Government

NEXT Black Sea Basin

Decision (GD) no. 432/2020, which was recently updated and expanded by GD 79/2024 to address emerging threats and align with the latest regional environmental targets.

The updated *Program of Measures* legally binds the state and private operators to implement specific conservation technologies. For instance, to combat the critical issue of cetacean bycatch (MSFD Descriptor 1), the law mandates that commercial fishermen operating in the Black Sea equip their bottom-set gillnets with acoustic deterrent devices, commonly known as "pingers." These devices emit high-frequency sounds to warn bottlenose dolphins and harbour porpoises away from the invisible mesh, directly translating a national legislative mandate into a practical, life-saving technology on the water.

Government Emergency Ordinance (OUG) no. 57/2007 on the Regime of Protected Natural Areas

This ordinance acts as the national legal backbone for all biodiversity conservation in Romania, including the marine environment. It formally establishes the strict zoning and usage rules within Romania's Natura 2000 marine sites (Sites of Community Importance and Special Protection Areas) and transposes both the EU Habitats and Birds Directives.

Concrete Example: OUG no. 57/2007 criminalizes the destruction of protected marine habitats and the unauthorized harvesting of protected species, such as sturgeons, dolphins, and rare benthic invertebrates. Crucially, it explicitly mandates that every Marine Protected Area (MPA)—from the shallow Vama Veche reserves to the deep-water transition zones—must have a state-approved Management Plan. Without this legally binding plan and a rigorous "Appropriate Assessment," any potentially destructive coastal development (such as deep-water dredging for port expansions or large-scale sand extraction for beach nourishment) cannot legally receive an environmental permit.

Law no. 176/2024 on Fisheries and the Protection of Living Aquatic Resources

Enacted in June 2024, Law no. 176/2024 represents a major, modern overhaul of Romania's fisheries legislation. This comprehensive law establishes the strict contemporary rules governing commercial, recreational, and familial fishing across all Romanian waters, including the Black Sea Exclusive Economic Zone (EEZ). It addresses historical loopholes and drastically increases penalties for environmental crimes.

The new law dictates strict regulations on the technical characteristics of fishing gear (such as minimum mesh sizes) to prevent the capture of juvenile fish, ensuring stocks have the opportunity to reproduce. Furthermore, Law 176/2024 severely penalizes illegal, unreported, and unregulated (IUU) fishing. Under Article 59, it empowers authorities to move beyond mere fines by allowing the permanent confiscation of vessels, *unelte de pescuit* (fishing gear), transport vehicles, and even firearms used in the poaching and transport of illegal Black Sea catches, such as smuggled turbot or sturgeon caviar.

Government Emergency Ordinance (OUG) no. 195/2005 on Environmental Protection:

Often considered the cornerstone of Romania's ecological legislation, OUG no. 195/2005 is an overarching, foundational law that regulates the issuance of environmental agreements and

NEXT Black Sea Basin

permits for any coastal or offshore development. It establishes the baseline rules for environmental impact assessments (EIAs) and public consultations before any industrial project can break ground.

Concrete Example: This ordinance ensures that the "polluter pays" principle is strictly and legally applied across the Romanian coastal zone. It covers a vast spectrum of ecological violations—ranging from industrial chemical spills originating from the Midia petrochemical refineries, to the unauthorized dumping of construction debris on tourist beaches, to the discharge of untreated wastewater. By granting the National Environmental Guard (GNM) the authority to levy massive fines and halt non-compliant operations, OUG 195/2005 ensures that the economic costs of environmental degradation are borne by the perpetrators, not the public or the marine ecosystem.

Government Emergency Ordinance (OUG) no. 202/2002 on Integrated Coastal Zone Management (ICZM):

Approved and amended by Law no. 280/2003, this ordinance recognized early on that the Black Sea coast cannot be managed separately from the adjacent terrestrial environment. It established the legal framework for Integrated Coastal Zone Management (ICZM), explicitly aiming to resolve conflicts between explosive urban development, tourism, and marine conservation. *Concrete Example:* OUG 202/2002 established a strict "coastal setback zone" (o fâșie de protecție) where permanent construction is heavily restricted to prevent the destruction of fragile sand dunes and coastal wetlands. Furthermore, it mandated the creation of the National Coastal Zone Committee (CNZC), an inter-ministerial body designed to ensure that municipal zoning plans (PUGs) for coastal towns like Constanța and Năvodari do not violate national marine environmental targets.

Government Emergency Ordinance (OUG) no. 19/2006 on the Utilization of the Black Sea Beach:

Approved by Law no. 274/2006, this legislation directly regulates the physical boundary between the land and the sea. Because the sandy beaches and cliffs are defined as public property of the state (administered by "Apele Române"), this law dictates exactly what human activities are permitted in this highly vulnerable ecological interface. *Concrete Example:* To protect nesting seabirds, prevent coastal erosion, and stop the physical crushing of shallow-water benthic organisms, OUG 19/2006 strictly outlaws the circulation or parking of unauthorized motorized vehicles (like ATVs and cars) directly on the beaches or in the immediate shallow waters. It also sets strict spatial limits for tourist operators, ensuring that at least 30% of leased beach areas remain free of commercial sunbeds, preserving public access and natural sand dynamics.

NEXT Black Sea Basin

Law no. 121/2024 on Offshore Wind Energy

Enacted in May 2024, this represents the newest and one of the most critical additions to Romania's marine legal framework, designed to facilitate the country's green energy transition while legally safeguarding the marine ecosystem. It dictates how the Ministry of Energy will assess, lease, and regulate perimeters in the Black Sea for massive offshore wind farms. *Concrete Example:* The law explicitly mandates that the selection of offshore wind perimeters cannot be based solely on wind potential. It legally subordinates these energy projects to the national Maritime Spatial Plan (MSP) and biodiversity laws. Before any concession is granted, developers must utilize the "best available techniques" (BAT) to prevent pollution and must prove that the underwater noise generated by driving wind turbine monopiles into the seabed will not fatally disrupt the migration routes of the endangered Black Sea harbour porpoises.

Law no. 165/2016 on the Safety of Offshore Oil Operations

Transposing the EU Offshore Safety Directive, this law establishes the strict safety and environmental standards for the rapidly expanding hydrocarbon extraction industry in Romania's Exclusive Economic Zone (EEZ). It created the Competent Authority for the Regulation of Offshore Operations in the Black Sea (ACROPO) to oversee drilling safety. *Concrete Example:* Before initiating deep-water extraction projects like *Neptun Deep*, operators (such as OMV Petrom and Romgaz) are legally required by Law 165/2016 to submit a comprehensive "Report on Major Hazards." The operator must scientifically and financially demonstrate they possess the internal emergency response plans, as well as the immediate physical equipment (like capping stacks), to instantly contain an underwater well blowout and prevent a catastrophic oil spill from decimating the enclosed Black Sea marine environment.

7. ANALYSIS AND GAPS

7.1. Türkiye

7.1.1. Biodiversity Implementation

Türkiye aligns with the *Convention on Biological Diversity (CBD)*, yet its national biodiversity law remains in draft form, limiting enforceability (CBD, 2024; 2026). The *National Biological Diversity Coordination Board* oversees integration of biodiversity into economic sectors and combats biopiracy, but inter-ministerial coordination and local participation remain weak. Inventory and monitoring studies exist but lack standardized FAIR data protocols and digital integration with EU biodiversity databases. Enforcement and adaptive management are underdeveloped—biodiversity goals often remain declarative rather than operational.

7.1.2. Biosafety Governance

Türkiye's *Biosafety Law (No. 5977)* regulates GMOs and biotechnology risks, consistent with the *Cartagena Protocol*. Limited laboratory capacity and fragmented risk assessment procedures hinder effective biosafety enforcement. Cross-border biosafety coordination in the Black Sea basin is minimal, despite shared ecological risks.

NEXT Black Sea Basin

7.1.3. Black Sea Marine Protected Areas (MPAs)

Türkiye's MPAs cover limited coastal zones (e.g., Kızılırmak and Sakarya deltas), with weak enforcement and insufficient ecological connectivity. The *EU Marine Strategy Framework Directive* and Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ based tools (UN, 2023)). Overlapping jurisdiction between ministries and lack of marine spatial planning impede coherent protection.

7.1.4. Fisheries Management

Managed under the *Fisheries Law (No. 1380)* and periodic circulars by the Ministry of Agriculture and Forestry. Overfishing, illegal catches, and weak vessel monitoring persist. Enforcement mechanisms are reactive rather than preventive. Recent efforts include digital catch reporting and seasonal bans, but adaptive management and stakeholder inclusion remain limited.

7.1.5. Main Impacts of Regulations

The implementation of recent environmental regulations in Türkiye has produced measurable ecological and socio-economic outcomes, particularly in the context of marine and coastal management. Regulatory efforts targeting land-based pollution have led to significant improvements in water quality and ecosystem resilience. Initiatives such as farmer training programs on eco-friendly agricultural practices and public awareness campaigns have reduced nutrient runoff and curbed eutrophication processes. These measures have contributed to the gradual recovery of previously hypoxic marine zones and the replenishment of fish stocks, demonstrating the effectiveness of integrated watershed management and community-based environmental education. The expansion of marine protected areas (MPAs) and the enforcement of stricter controls on coastal development have enhanced the conservation of ecologically sensitive habitats and species. These interventions have stabilized benthic ecosystems and supported the natural regeneration of commercially important fish populations, aligning with global conservation targets under the Convention on Biological Diversity (CBD) and the EU Marine Strategy Framework Directive (CBD, 2024; 2026). There are several MPA proposals to be implemented in the Black Sea soon. Despite the establishment of regulatory frameworks, the introduction and proliferation of invasive alien species—originating primarily from the Mediterranean and Indo-Pacific regions—remain a persistent challenge. Climate change-induced shifts in sea temperature and overfishing have accelerated biological invasions, leading to alterations in native biodiversity composition and disruptions in trophic dynamics. This underscores the need for adaptive management strategies, enhanced biosecurity measures, and regional cooperation within the Black Sea basin to mitigate transboundary ecological risks.

7.1.6. Recent Developments

Türkiye's participation in international agreements and regional initiatives has strengthened monitoring and conservation efforts, contributing to improved water quality and biodiversity

NEXT Black Sea Basin

awareness (OMU, 2025; OMU, 2026a; 2026b). Campaigns and educational programs have raised public consciousness about marine conservation, encouraging sustainable practices and community involvement in protection efforts (OMU, 2025a; 2025b). Overall, while legal regulations have brought some improvements to the Black Sea's marine environment, persistent challenges require continued policy enforcement, international cooperation, and adaptive management strategies (Topçu, 2012). Despite regulations, illegal, unreported, and unregulated (IUU) fishing remains a significant issue. Small-scale vessels sometimes operate outside permitted zones or during closed seasons, undermining conservation efforts. Persistent IUU fishing remains a critical obstacle to sustainable management. Small-scale vessels often operate beyond permitted zones or during closed seasons, eroding regulatory credibility. Moreover, illegal bottom trawling, despite formal prohibitions, continues to damage benthic habitats and increase bycatch of non-target species, undermining ecosystem integrity. Bottom trawling, which is banned in the Central and Eastern Black Sea, still occurs illegally, damaging seabed habitats and causing high bycatch of non-target species. Monitoring gaps persist due to limited satellite coverage and inadequate vessel tracking, particularly in remote coastal areas, exposing weaknesses in technological surveillance and institutional capacity.

7.1.7. Good Practices and Transferable Models

Over the past decade, Türkiye has made notable progress in aligning its marine environmental governance with international sustainability frameworks, gradually transitioning from sectoral management to an integrated, ecosystem-based governance model. Key achievements include the expansion of Marine Protected Areas (MPAs) aligned with the EU Marine Strategy Framework Directive and the BBNJ Agreement, targeted watershed interventions that have partially mitigated nutrient runoff and eutrophication, the ratification of the UN High Seas Treaty, and the drafting of a Green Taxonomy Regulation mirroring EU sustainable finance frameworks. However, a significant dichotomy persists between policy design and on-the-ground reality: despite strong scientific foundations and successful pilot projects like BlackNETs and BIOBLACK, Türkiye still ranks lowest among Black Sea littoral states in effective marine protection coverage due to systemic gaps in enforcement, institutional coordination, and long-term funding. Bridging this implementation gap to achieve sustained, large-scale ecosystem recovery will ultimately require stronger enforcement mechanisms, expanded protected area coverage, active public engagement, and continuous adaptive management.

Türkiye has implemented several successful biodiversity projects in the Black Sea, focusing on marine conservation, invasive species management, and public awareness.

Turkey's biodiversity projects in the Black Sea region, particularly those targeting sustainable outcomes, can be analyzed by their operational status, strategic focus, and tangible impacts on ecosystem health. These initiatives range from EU-funded cross-border collaborations to national policy-driven actions.

- **REEFS Project:** The REEFS Project (Restoration of Essential Filters of the Black Sea) is a major EU ENI CBC initiative that restores oyster and mussel reef habitats to improve

NEXT Black Sea Basin

biodiversity, water quality, and ecosystem resilience. It combines ecological engineering (reef modules), non-invasive monitoring methods, and cross-border cooperation among institutions including Karadeniz Technical University. Main objective is to restore essential filter-feeding organisms (*Mytilus galloprovincialis*, *Ostrea edulis*) to regenerate reef habitats, reduce eutrophication, and enhance biodiversity. Artificial reef structures designed to mimic natural substrates, were deployed in the sea providing settlement surfaces for oysters, mussels, and benthic organisms. At monitoring phase, living organisms were count visually and specimens studies in the laboratory. Main outcomes of the Project were ecological gains (increased species richness and biomass in restored reef areas, enhanced self-purification capacity of coastal waters, establishment of nursery grounds for fish and invertebrates), preperation of fish checklists and baseline biodiversity reports, supporting designation of new Marine Protected Areas (MPAs), contribution to EU Biodiversity Strategy 2030 and Marine Strategy Framework Directive targets and Strengthening fisheries sustainability (EC, 2026).

- **BlackNETs Project:** BlackNETs - Exorcising the BLACK Sea's Silent Killers (BlackNETs). A joint initiative with Romania, Bulgaria, and Georgia, supported by the EU, this project targets ghost nets—abandoned fishing gear that harms marine ecosystems. Activities include removing up to 8 tons of ghost nets, educating children about marine ecosystems, and involving local communities in beach clean-ups and recycling. The project has raised significant awareness and contributed to cleaner seas (KTU, 2025).
- **BIOBLACK Project (Ongoing):** Raising Awareness for the Black Sea People to Recognize and Protect Black Sea Biodiversity (BIOBLACK). The biodiversity of the Black Sea faces severe threats, including overfishing, pollution, invasive species, ghost fishing, marine debris, and climate change. To combat these challenges, it is essential for bordering and coastal nations such as Turkey, Bulgaria, and Romania to take a joint action. The project aims to raise awareness among a broad group of stakeholders, ranging from students to policymakers. The training sessions will utilize 3D models, underwater footage, and digital materials to address the region's ecosystems and conservation methods. Furthermore, through the integrated BLACKPYRAMID mobile app, citizens will be able to contribute directly to data collection by uploading images they observation of marine life. Ultimately, this initiative aims to establish a regional cooperation model to protect the Black Sea through educational programs, reports, and policy recommendations (KTU, 2026).

Outcomes;

- Defining the current status of Black Sea biodiversity based on scientific resources
- Production of 3D miniatures of Black Sea species and visualization of their place in the food pyramid
- “BLACKPYRAMID” mobile application for the identification, mapping, and conservation of Black Sea biodiversity

NEXT Black Sea Basin

- An “e-booklet” featuring information on the 3D miniature marine species
 - Black Sea Biodiversity Workshop
 - Marine surveys
 - Stakeholders training
-
- **IASON+ Project (Ongoing):** Invasive Alien Species Observatory and Network Development for the Assessment of Climate Change Impacts and Contextual Ecosystem Services Evaluation in Black Sea Deltaic Protected Areas (IASON+) project has been awarded funding under InterregNEXT. The project is designed as a continuation of the previous CBC-BSB IASON project (BSB-1121). The project is lead by Danube Delta National Institute for Research and Development (Romania) with partners Danube Delta Biosphere Reserve Authority (Romania), Demeritus University of Thrace - Special Account for Research Funds (Greece), Karadeniz Technical University - Faculty of Marine Sciences (Turkey), Institute of Marine Biology of the NAS of Ukraine (Ukraine) and N(N)LE International Business and Economic Development Center (Georgia). The IASON+ Project focuses on the impact of Invasive Alien Species (IAS) on Ecosystem Services (ES) in the Black Sea Basin (BSB) region and aims to address the common challenges and impact on ES, particularly in the Danube Delta, Nestos Delta, Kızılırmak Delta, Çoruh and Kolkheti Deltas. These delta regions are particularly vulnerable to the emergence and spread of IAS due to their unique ecological characteristics, including diverse habitats and high biodiversity. IAS can disrupt the delicate balance of these ecosystems, threaten native species, and adversely affect the provision of ES such as water purification, flood regulation, coastal protection, fisheries, and tourism. The overall objective of the project is to improve the management and mitigation of IAS in delta regions to protect and restore ES. The project aims to create positive change by reducing the spread and impact of IAS, increasing the resilience of ecosystems, and ensuring sustainable ES provision in deltaic regions (KTU, 2026).

The project outputs:

- Establishment of IAS Monitoring and Warning System,
- Establishment of Integrated Management Strategies and Action Plans,
- Preparation of Capacity Building and Training programmes.

Local communities living in delta regions whose livelihoods depend on the provision of sustainable energy sources. Biodiversity conservation organisations and institutions are responsible for managing and conserving the unique ecosystems of the Delta regions. Policy makers and government officials are involved in environmental management and decision-making processes. Scientists and researchers are interested in studying the impacts of IAS and developing effective management strategies. Industries and sectors that rely on ecosystem services, such as tourism, agriculture, fisheries, and water resources management. The project adopts a transnational approach due to the nature of delta regions in different countries in the BSB, which is crucial to effectively address the challenges faced

NEXT Black Sea Basin

by IAS in these regions. The planned approach involves co-operation, exchange of information, and joint efforts between partners from different countries and delta regions. This cooperation facilitates a more comprehensive and coordinated response to the IAS challenge in the BSB deltaic regions by sharing experiences, expertise, best practices, and resources.

- **WatchReefFish (Ongoing):** Non-Invasive Fish Monitoring Network for Reef Fishes in the Black Sea Basin "WatchReefFish". Coordinated by the Karadeniz Technical University (KTU) Faculty of Marine Sciences and co-funded by the European Union. The initiative aims to monitor fish biodiversity across the Black Sea Basin using non-destructive, environmentally friendly methods. The project brings together a strategic network of research institutions from Türkiye, Greece, Romania, Bulgaria, and Georgia to bridge critical knowledge gaps regarding reef ecosystems. Moving away from traditional invasive sampling, the project utilizes innovative technologies such as Baited Remote Underwater Video (BRUV) systems, underwater visual census, and environmental DNA (eDNA) analysis to observe fish behaviors and identify species without harming the marine environment. These efforts will result in a comprehensive scientific database and AI-supported recognition tools. Through comparative studies across the basin—ranging from analyzing protected areas to comparing natural and artificial reefs—the project will provide essential data and scientific recommendations to help policymakers ensure the long-term sustainability of the Black Sea (KTU, 2026b). The activities of the project;
 - Fish Checklist Preparation and Site Selection for Pilot Actions
 - On-field Methodology Standardization Training
 - eDNA Training and Capacity Building for Fish Diversity Monitoring
 - Preparation of fish database for eDNA
 - Implementing Reef Monitoring (Pilot Studies)
 - Development and Implementation of Shiny App (IT Tool for Digital Map)
 - Integration of Fish Species Identification and Recognition to non-invasive monitoring techniques

The outputs of the project;

- Comprehensive Fish Checklist and Baseline Data Reports
- Standardized Protocols for non-invasive methods
- eDNA guideline for assessment of fish diversity in the Black Sea
- Preparation of Fish Reference Database for eDNA unique to the Black Sea
- UVC, BRUV, and eDNA datasets from each pilot study
- Shiny Application
- Artificial Intelligence Integrated Fish Recognition and Species Identification

NEXT Black Sea Basin

7.1.8. Main Regulatory and Implementation Gaps

Türkiye's Black Sea governance faces significant implementation gaps despite a developed legal framework, characterized by a complete lack of operational Marine Protected Areas (MPAs), insufficient vessel monitoring that leaves roughly 70% of the fleet untracked, inadequate coastal wastewater infrastructure, reactive invasive species management, and a reliance on transient donor funding rather than a permanent national budget. These shortcomings undermine stock regeneration, aggravate eutrophication and invasive species risks, and leave conservation progress vulnerable once project-based funding ends. To achieve lasting marine sustainability and fulfill international commitments under frameworks like the BBNJ Agreement and FAO guidelines, Türkiye must transition from reactive, isolated interventions to a cohesive, institutionalized national strategy by fully operationalizing MPAs, extending digital monitoring to artisanal fisheries, integrating land-based pollution controls with agricultural reform, enforcing strict biosecurity protocols, and securing long-term national financing (Table-13) (FAO, 2024a; 2024b; 2025).

Table 21. Summary of Critical Needs for the major gaps

Gap Area	Current Status	Required Action
Protected Areas	Proposed but not operational	Finalize MPA declarations and establish management authorities immediately.
Enforcement	Weak monitoring of small vessels	Expand VMS coverage, increase patrols, and impose stricter penalties for IUU fishing.
Pollution	Partial reduction of runoff	Upgrade wastewater infrastructure and reform agricultural subsidy policies.
Invasive Species	Reactive management	Implement strict port biosecurity and ballast water controls.
Funding	Donor-dependent	Create a national trust fund or dedicated budget for Black Sea conservation.

To strengthen the conservation and long-term sustainability of the Black Sea's unique biodiversity, a comprehensive set of targeted actions must be implemented to bridge regulatory gaps and enhance operational capacity. Key strategies include expanding and strictly enforcing Marine Protected Areas (MPAs) with fully designated no-take zones, alongside strengthening fisheries surveillance through satellite technology and community monitoring to curb illegal, unreported, and unregulated (IUU, 2025) practices—particularly among small-scale fleets. Concurrently, governance must shift toward adaptive, precautionary, and integrated assessment frameworks that combine ecological, economic, social, and climate resilience indicators, while actively supporting small-scale fisheries' livelihoods and traditional structures. Addressing environmental degradation further requires mitigating land-based pollution and eutrophication by upgrading wastewater infrastructure and scaling up initiatives like the "Zero Waste Blue" campaign. Finally, fostering public stewardship, deepening international

NEXT Black Sea Basin

cooperation within regional conventions like Barcelona and Bucharest, and embedding climate change adaptation into marine policy are essential to establishing a resilient ecosystem-based management model.

7.2. Bulgaria

7.2.1. Lessons Learned

The analysis of the status of fishery resources and marine ecosystems in the Bulgarian Black Sea waters shows that the ecosystem is highly sensitive to the combined effects of pressures such as overfishing, pollution, and habitat degradation, together with climate change. The available data clearly demonstrate that intensive fishing pressure can induce long-term structural changes in ichthyofauna and lead to the collapse of key populations and entire trophic levels, particularly at the level of top predators. The observed shifts in trophic structure highlight the need to apply an ecosystem-based approach to fisheries management.

Coordinated international and regional cooperation is of critical importance for mitigating the effects of these pressures. The Black Sea is a transboundary basin, and the effective management of its resources requires coordinated actions among all coastal states, the development of harmonized monitoring methodologies, and the exchange of scientific data. Experience to date shows that the existence of a regulatory framework alone is not sufficient to ensure the conservation of the Black Sea ecosystem without effective enforcement, reliable data, and the active involvement of the scientific community in the decision-making process.

7.2.2. Good Practices and Transferable Models

Among the best practices, the implementation of European mechanisms for data collection and management stands out, particularly through the Data Collection Framework (DCF), which provides a standardized methodology for gathering biological, technical, and economic indicators. Regional initiatives such as BlackSea4Fish and scientific assessments by the GFCM contribute to the harmonization of monitoring activities and the improvement of data quality.

Another good practice is the integration of scientific research into management processes, through the participation of national research institutes in international programmes and regional working groups. The application of quota systems, seasonal and permanent fishing bans, and technical restrictions has also demonstrated positive effects in reducing fishing pressure on endangered and vulnerable species. The development of electronic monitoring systems, the use of remote sensing technologies, and the establishment of integrated databases can also be highlighted as effective approaches, enabling more precise assessment of fishing pressure on commercial stocks and biodiversity as a whole. Such approaches can be applied in other semi-enclosed marine basins with similar ecological characteristics, such as the Caspian Sea and the Sea of Azov.

NEXT Black Sea Basin

7.2.3. Methodological Gaps

Despite the availability of a substantial volume of data, a number of significant methodological gaps still exist. The most critical limitations are related to the incomplete reporting of catches in small-scale and recreational fisheries, which leads to an underestimation of the actual fishing pressure. There is also a lack of sufficiently reliable spatial data on fishing effort and bycatch, particularly for small vessels, which hampers the assessment of cumulative impacts on biodiversity. A major shortcoming is the limited availability of data on bycatch of protected and vulnerable species, including cetaceans and sharks.

The application of ecosystem models that integrate biological, climatic, and oceanographic data in stock assessments remains limited. There are also substantial gaps in long-term time series of biological indicators, which are essential for reliable modelling of population dynamics of key commercial species.

There is a need for broader implementation of modern approaches such as electronic reporting, automated monitoring systems, and standardized methodologies for collecting spatial data on catches.

7.3. Romania

The experience gained from assessing marine biodiversity in Romania's Black Sea waters offers several important lessons. While Romania has made notable progress in aligning its national legislation with EU directives and international conventions, practical implementation on the water still faces significant structural obstacles.

7.3.1. Progress and Implementation Barriers

Establishing Marine Protected Areas (MPAs) has been an essential milestone, successfully pushing the country to meet the European target of protecting roughly 11% of its marine territory. However, a recurring theme across these protected zones is the disconnect between legal designation and actual operational capacity.

- **Enforcement deficits:** These designated areas frequently suffer from limited enforcement, leaving vulnerable habitats exposed to illegal or unmonitored human pressures.
- **The funding bottleneck:** Legal frameworks alone are insufficient without dedicated, long-term national funding. Currently, monitoring networks operate under a high degree of financial volatility.
- **The project-based trapped cycle:** Because long-term ecological monitoring heavily relies on short-term, project-based European or regional funding, data collection is often fragmented. When a specific research project ends, continuous sampling programs often stall, breaking the multi-decadal data sequences required to confidently separate natural seasonal variations from long-term, climate-induced ecological shifts.

NEXT Black Sea Basin

7.3.2. Good practices and transferable models

Despite these financial and administrative constraints, several good practices and transferable models have emerged within the Romanian monitoring framework that can serve as blueprints for the broader Black Sea basin.

7.3.3. Integrated Marine Spatial Planning (MSP)

Romania's adoption of integrated Marine Spatial Planning stands out as a major success in stakeholder-inclusive governance. The MSP process has moved beyond purely academic exercises, actively bringing together competing sectors—including commercial fisheries, offshore oil and gas developers, maritime transport authorities, tourism operators, and environmental NGOs. By forcing these diverse entities into a single, coordinated spatial dialogue, Romania has successfully piloted an ecosystem-based approach that seeks to balance aggressive economic Blue Growth with absolute conservation priorities.

7.3.4. Sophisticated Biotic Metrics

On the scientific front, the application of advanced ecological metrics highlights a major step forward in marine data processing. The integration of multivariate ecological indices—most notably the specialized M-AMBI(n) (Multivariate Azti Marine Biotic Index)—reflects an upgraded capacity to assess the true health of benthic habitats. Rather than relying on simple species counts, these advanced indices integrate biological abundance, chemical contamination levels, and physical sediment data into a unified ecological health score. This provides environmental managers with a highly accurate, statistically sound method for identifying early signs of seafloor degradation.

7.3.5. Methodological and information gaps

Nevertheless, critical methodological gaps persist that continue to weaken the reliability of national biodiversity inventories.

The offshore void:

A primary limitation is the stark spatial imbalance in data collection. While shallow coastal zones and transitional areas near urban centers receive a high degree of scientific attention, the offshore pelagic and deep-sea benthic zones remain severely under-sampled. Conducting research cruises in deeper waters requires specialized vessels and expensive equipment, which are rarely sustainable under temporary project budgets. Consequently, national biodiversity assessments remain fundamentally incomplete, leaving large-scale offshore habitats, migration corridors, and deep-water ecosystems functionally unmapped.

Neglect of socio-economic dynamics:

Existing monitoring initiatives remain hyper-focused on purely ecological and chemical parameters, almost entirely neglecting the socio-economic drivers that fuel environmental degradation. An ecosystem cannot be managed in a vacuum; without systematically tracking indicators such as coastal tourism density, local fishing community dependence, and the

NEXT Black Sea Basin

economic drivers behind coastal urbanization, policymakers cannot design regulations that are socially enforceable or economically viable over the long term.

Missing accountability and regional misalignment:

Furthermore, there is currently no systematic, standardized framework in place to evaluate the management effectiveness of Romania's MPAs. Without performance-based assessments, conservation managers cannot determine whether a specific fishing ban or spatial restriction is yielding positive ecological outcomes, rendering adaptive management nearly impossible.

This internal issue is compounded by a lack of regional harmonization. Black Sea riparian states continue to utilize inconsistent data collection protocols, different sampling frequencies, and varying biodiversity indicators. This regional misalignment dilutes the comparative value of transboundary data, severely weakening joint responses to basin-wide threats like gelatinous species invasions, cross-border oil spills, and the accelerating impacts of climate-driven deoxygenation.

7.3.6. Strategic Path Forward

In summary, Romania has successfully established a solid structural foundation for marine biodiversity conservation through modern legal frameworks, wide stakeholder engagement, and sophisticated scientific innovation. To build upon these foundational achievements, the next phase of national marine planning must prioritize shifting from passive, project-dependent recording to active, predictably funded ecosystem management. Addressing these underlying gaps related to funding stability, deep-sea methodological standardization, performance-based MPA tracking, and cross-border protocol harmonization is essential. Only by securing these systemic improvements can Romania transition its marine networks from "paper parks" into resilient, adaptive shields capable of safeguarding the long-term ecological integrity of the Western Black Sea.

8. CONCLUSION

8.1. Türkiye

Marine biodiversity provides the ecological foundation for sustainable development, supplying vital ecosystem services that uphold economic productivity, climate resilience, and food security, particularly in semi-enclosed basins like the Black Sea. Recognizing this imperative, Türkiye is aligning its national marine governance—led by the Ministry of Agriculture and Forestry through the General Directorate of Fisheries and Aquaculture (BSGM) (2025) and the General Directorate of Nature Conservation and National Parks (DKMP, 2026)—with global commitments such as the UN Sustainable Development Goals (SDG 14) and the Kunming-Montreal Global Biodiversity Framework under the Convention on Biological Diversity (CBD). Key strategies, outlined in Türkiye's National Biodiversity Strategy and Action Plan (NBSAP, 2018-2030), emphasize expanding Marine Protected Areas (MPAs), implementing ecosystem-based management, and curtailing pollution and overexploitation. However, achieving lasting ecological resilience and effective regional governance ultimately relies on bridging existing execution and funding gaps through political will, as well as fostering strong, multi-stakeholder synergy among policy, science, and society to ensure that management decisions remain scientifically grounded, socially inclusive, and politically accountable (MAF, 2025; 2026).

8.2. Bulgaria

The threats to biodiversity in the Bulgarian Black Sea are interconnected and mutually reinforcing. Pollution and eutrophication degrade water quality and reduce habitat sustainability. Coastal development and overfishing further diminish ecological resilience. Climate change compounds these pressures by altering temperature regimes, oxygen dynamics, and species distributions. Effective mitigation requires integrated, cross border management strategies, improved monitoring, and strict enforcement of environmental regulations.

Biodiversity in the Bulgarian Black Sea is under significant and escalating threat. Addressing these challenges demands coordinated regional action, reduction of nutrient and pollutant inputs, protection of critical habitats, and adaptation to climate driven changes. Long term ecological monitoring and ecosystembased management are essential to preserve the ecological integrity and economic value of this unique marine basin.

1. Necessity of conserving marine biodiversity for sustainable development. The conservation of marine biodiversity in the Black Sea is a fundamental prerequisite for the sustainable development of coastal regions and their associated economic activities. Marine ecosystems provide essential ecosystem services, including the maintenance of fishery resources, regulation of biogeochemical cycles, protection of coastal zones, and support for the tourism sector. Their degradation may lead to direct economic losses, declines in fish populations, and deterioration in the quality of life of coastal communities.

Sustainable management of marine resources requires a balance between economic interests and ecological constraints, with priority given to the long-term preservation of ecosystem

NEXT Black Sea Basin

resilience. The implementation of an ecosystem-based approach, combined with effective control and science-based decision-making, is a key condition for achieving this balance.

2. Importance of cooperation among policy, science, and society. Effective management of the Black Sea ecosystem requires close interaction and cooperation among governmental institutions, scientific organizations, non-governmental organizations, and society. Policy decisions should be based on reliable scientific data and long-term environmental assessments, while the scientific community should actively support the development of management measures through monitoring, data analysis, and modeling.

Society and stakeholders, including the fisheries sector and non-governmental organizations, should play an important role in the implementation of sustainable practices and in raising public awareness. Special attention should be paid to the environmental education of the young generation and its active inclusion in the citizen science society and actions is very necessary for the formation of a responsible awareness for the protection of the environment.

The involvement of all stakeholders in decision-making processes will enhance transparency and effectiveness in the management of marine ecosystem conservation. Coordinated cooperation among institutions, scientific bodies, and civil society is a key factor for the conservation of marine resources and a guarantee for their sustainable use.

8.3. Romania

The Black Sea is a marine environment of paradoxes. It is highly vulnerable due to its semi-enclosed nature, slow water turnover, and massive riverine inputs, yet it has demonstrated remarkable ecological resilience in the face of catastrophic historical degradation. As this report highlights, the biodiversity of the Romanian coastal and marine zones is the fundamental engine that maintains the region's ecological balance, food web stability, and essential ecosystem services. The current status of Romania's marine biodiversity reveals a system in a delicate, alternate stable state. We see encouraging signs of recovery in the pelagic zone, where regional regulations have allowed foundation species like anchovy and sprat to stabilize after historical collapses. However, the ecosystem remains severely challenged. Endemic apex predators—the Black Sea bottlenose dolphin, common dolphin, and harbour porpoise—face mounting pressures from incidental bycatch, noise pollution, and habitat fragmentation. Simultaneously, benthic communities struggle against localized hypoxia, destructive fishing practices, and the persistent restructuring of the food web caused by opportunistic invasive species like the *Mnemiopsis leidyi* comb jelly and the *Rapana venosa* whelk.

The establishment of Marine Protected Areas (MPAs) under the Natura 2000 framework, now covering approximately 11% of Romania's marine territory, marks a critical turning point. These zones—ranging from the shallow limestone reefs of Vama Veche to the expansive transition waters of the Danube Delta—safeguard the critical nurseries that replenish regional fish stocks. Crucially, the management of these areas is modernizing. By integrating traditional ecological

NEXT Black Sea Basin

sampling with next-generation tools like autonomous acoustic tracking and satellite-based remote sensing, Romania is actively transitioning toward a highly responsive, data-driven approach to marine governance.

Romania benefits from a robust legal and institutional architecture, anchored in international commitments such as the Bucharest Convention, the Convention on Biological Diversity, UNCLOS, and the overarching framework of the EU Marine Strategy Framework Directive (MSFD). The legal tools to achieve Good Environmental Status (GES) exist. However, the true test lies in implementation. For these frameworks to succeed, Romania must bridge the gap between legislative intent and on-the-water enforcement. This requires shifting from project-based, fragmented research to predictable, long-term funding for continuous monitoring, alongside aggressive cross-border cooperation to police transboundary pollution and illegal fishing.

Ultimately, the conservation of marine biodiversity cannot be siloed as a purely environmental issue; it is the bedrock of Romania's coastal society and its emerging Blue Economy. Healthy, biodiverse ecosystems guarantee long-term food security, support sustainable coastal tourism, provide natural shoreline protection against climate-driven storms, and regulate local water quality. Long-term success depends on a tripartite cooperation model: the integration of rigorous **science**, enforceable governance, and active society engagement. Policymakers must base their spatial planning decisions on continuous, standardized data, while local fishing communities and coastal stakeholders must be brought to the table as active stewards of the marine environment, rather than merely as regulated entities. Conserving marine biodiversity in Romania's Black Sea waters is both a binding legal obligation and an urgent practical necessity. By strengthening cross-sector collaboration, expanding deep-water monitoring, and aggressively addressing both legacy pollution and emerging climate threats, Romania can transition from crisis management to genuine ecological stewardship. The lessons learned over the past decades provide a clear roadmap: with adaptive management and sustained institutional commitment, the Romanian Black Sea can be rebuilt into a resilient, thriving ecosystem capable of supporting both marine life and the human communities that depend upon it.

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