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**REVIEW**

# Biological Diversity of the Turkish Black Sea Coast

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**Abstract**

In this review a comprehensive biodiversity characteristic of the Black Sea is given. A brief historical survey of the investigations on the biodiversity of the Black Sea coast is followed by the data about the present status of the Turkish Black Sea marine biodiversity. Additional data about the density, biomass and distribution of the widespread Black Sea inhabitants are also given. The impact of the invasive species on the Black Sea ecosystem and some ecological problems to the Black Sea biodiversity are discussed.

*Keywords*: Black Sea, Biological diversity, Ecology, Turkey.

**Karadeniz Kıyılarının Biyolojik Çeşitliliği**

**Özet**

Bu derlemede Karadeniz'in kapsamlı biyolojik çeşitlilik karakteristiği verilmiştir. Karadeniz kıyılarının biyolojik çeşitliliği üzerine yapılan çalışmaların kısa geçmişini Türkiye'nin Karadeniz kıyıları biyolojik çeşitliliği verilerinin mevcut durumu izlemiştir. Bunlara ilaveten Karadeniz organizmalarının yoğunluk, biyokütle ve dağılımı datası da verilmiştir. Karadeniz ekosistemine istilacı türlerin etkisi ve Karadeniz biyolojik çeşitliliğinin ekolojik problemleri tartışılmıştır.

*Anahtar Kelimeler*: Karadeniz, Biyolojik Çeşitlilik, Ekoloji, Türkiye.

## Introduction

Comparatively with other seas, the biodiversity of the Black Sea is somehow different. Most of the Black Sea species are immigrants from Mediterranean, who reach the Pontic basin 7.000-10.000 years ago, after the reopening of the Bosphorus strait (Öztürk and Öztürk, 1996). The Black Sea biota according to the origins of the species, it is divided into five groups: 1. Pontian relics: The most ancient inhabitants are found in waters with low salinity. 2. Boreal-Atlantic relics: Marine species originating from cold seas and living in deep layers of the sea. 3. Mediterranean species: These constitute the highest ratio in the Black Sea fauna, comprising up to 80 % of the total fauna. Most prefer warm, saline waters, and are found in the upper layers of the sea. 4. Freshwater species: Introduced by river discharges and usually found in the sea water during the maximum river run-off. 5. Alien species: Established populations of alien species introduced by various routes.

Due to anoxia in large parts of deeper waters, deep pelagic and benthic organisms are largely absent. The structure of marine ecosystems differs from the neighbouring Mediterranean Sea by a lower species variety (ratio of the Mediterranean to Black Sea for species richness is three) and the dominant groups are different. However the total biomass and productivity of the Black Sea is much higher.

The Istanbul Strait (Bosphorus) established a connection with the Mediterranean and Atlantic Ocean. The Mediterranean immigrants are most populous elements in the Black Sea biota, comprising in some taxa up to 80% of the total number of species. The intrusion of saline waters and of Mediterranean immigrants into the Black Sea put pressure on the Pontian relics and many of them retreated to the brackish-water areas, some harbours and deltas (Zaitsev and Öztürk, 2001).

Low species diversity (i.e. low competition) combined with high habitat diversity (i.e. availability of potential niches) in the Black Sea provides favourable conditions for the introduction of alien species. Some of this species become invasive, altering the stability and functioning of the ecosystem and threatening the indigenous species (CIESM, 2010).

This review draws upon confirmed data about the biodiversity of the Turkish Black Sea coast. The data have been collected by Turkish and foreign scientific experts who have investigated the taxonomy, zoogeography, population dynamics and threats inherent to this region.

## Results

### The Biological Diversity of the Turkish Black Sea Phytoplankton

Phytoplankton is the principle group that plays a dynamic and active role in marine food web, in carriage of primer productivity to higher trophic levels and in global circulation of nutrients and elements. By itself, it comprises 1% of organic carbon and 45% of annual primary production on earth. The proteins, carbohydrates, lipids, vitamins and mineral salts they involve directly or indirectly serve as food source for all the marine organisms. Moreover, the oxygen produced by phytoplankton as a result of photosynthesis is a vital component of "life support" system on earth (Falkowski and Raven, 1997).

A total of 401 species were reported in the studies performed in the Turkish Black Sea coast between 1989 and 2005. 81 species belonging to Bacillariophyceae, 2 belonging to Chlorophyceae, 3 belonging to Chrysophyceae, 40 belonging to Coscinodiscophyceae, 1 belonging to Cryptophyceae, 7 belonging to Cyanophyceae, 8 belonging to Dictyochophyceae, 173 belonging to Dinophyceae, 6 belonging to Euglanophyceae, 67 belonging to Mediophyceae, 3 belonging to Prasinophyceae, 9 belonging to Prymnesiophyceae and 1 belonging to Trebouxiophyceae were identified (Table 1).

The most dominant phytoplankton classes in the Black Sea are shown in Figure 1. Dinophyceae and Bacillariophyceae are the most dominant families in terms of the number of species (respectively, 173 and 89 species), followed by Mediophyceae (16%, 67 species) and Coscinodiscophyceae (10%, 40 species). Two families (Cryptophyceae and Trebouxiophyceae) are represented by only one species (Figure 1).

One of the most important changes in the Black Sea recorded within 10 years is the fast development of dinoflagellates and other micro-nanoplankton species rather than diatoms. The increase in the ratio of dinoflagellates might be related to the change in nutrient balance and the temperature regime of the seawater (BSC, 2008).

References indicated that peaks in the primary productivity of the Black Sea were known to occur twice a year, with a major bloom generally composed of diatoms in early spring, followed by a secondary bloom mainly comprising coccolithophorids in

**Table 1.** Phytoplankton species distributed along the Turkish Coast of Black Sea

| References | Period | Area | CLASS | | | | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | BAC | CHL | CHR | COS | CRY | CYA | DIC | DIN | EUG | MED | PRA | PRY | TRE | |
| I | 1989-1990 | SW-BS | 27 | - | - | 16 | - | 1 | 1 | 37 | 1 | 15 | - | - | - | 98 |
| II | 1993-1994 | SW-BS | 26 | - | - | 11 | - | 2 | 2 | 35 | 5 | 18 | - | 1 | 1 | 101 |
| III | 1995-1996 | S-BS | 39 | - | - | 20 | - | 1 | 5 | 83 | 1 | 28 | - | 2 | - | 179 |
| IV | 1999 | S-BS | 14 | - | 1 | 8 | 1 | 2 | 5 | 65 | 1 | 19 | 3 | 8 | - | 127 |
| V | 2000 | S-BS | 16 | 2 | - | 8 | - | 1 | 3 | 37 | 2 | 10 | - | 2 | - | 81 |
| VI | 2002-2003 | S-BS | 11 | - | 2 | 14 | 1 | 2 | 4 | 71 | 3 | 19 | - | 2 | - | 127 |
| VII | 2002-2003 | S-BS | 31 | - | - | 16 | - | 2 | 3 | 47 | 2 | 39 | 2 | 1 | - | 145 |
| VIII | 2004 | S-BS | 14 | - | - | 10 | 1 | 2 | 3 | 59 | 2 | 16 | - | 2 | - | 109 |

BAC: Baccillariophyceae, CHL: Chlorophyceae, CHR: Chrysophyceae, COS: Coscinodiscophyceae, CRY: Cryptophyceae, CYA: Cyanophyceae, DIC: Dictyochophyceae, DIN: Dinophyceae, EUG: Euglenophyceae, MED: Mediophyceae, PRA: Prasinophyceae, PRY: Prymnesiophyceae, TRE: Trebouxiophyceae.

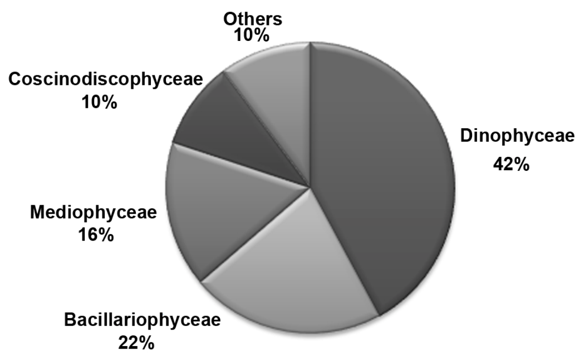


**Figure 1.** Relative percentage of the classis according to the number of phytoplankton species.

autumn. Extensive blooms of coccolithophorids and dinoflagellates occurred mainly in coastal areas of the Black Sea. Additional summer blooms with a predominance of dinoflagellates and coccolithophorids have been increasingly observed in the region in recent years (Turkoglu, 1998; Şahin, 2005; Bat *et al*., 2005; BSC, 2008).

The facts that they are sensitive indicator organisms which can rapidly react to the physical and chemical changes of the ecosystem, and the shift in the time of algal blooms which were recorded to occur for certain species and in certain time lines during previous years to time-independent overproduction of many phytoplankton species in recent years necessitates monitoring of phytoplankton in short term. It is strongly recommended that the monitoring studies should be conducted biweekly or at least once a month in the Black Sea.

## The Biological Diversity of the Turkish Black Sea Zooplankton

Zooplankton community structure plays a significant role between autotrophic and higher trophic levels in food chain. The Black Sea zooplankton community structure is more productive. However, it has lower species diversity as compared to the Mediterranean Sea (BSC, 2008). In the Black Sea, it was in the middle of the 19$^{th}$ century (1871) that zooplankton studies first began for faunistic purposes (Kovalev *et al*., 1999).

First studies about zooplankton started in 1952-1953 (Demir, 1954) on Turkish coast of the Black Sea. Demir (1954) classified the nine copepod species along the south-east part of the Black Sea coast in Turkey. Afterwards, studies increased in the southern of the Black Sea (Einarsson and Gürtürk, 1959; Güner, 1954; Yıldız, 1997; Beşiktepe and Unsal, 2000; Erkan, *et al*., 2000; Mutlu, 2002; Büyükhatipoğlu *et al*., 2002; Bircan *et al.,* 2005; Bat *et al*., 2005; Ustun *et al*., 2007; Yıldız, 2010). Most of these researches were made about copepod species. Copepod *Anomalocera patersonii* was found only in the period of 1952-1953 on the coast of Trabzon. This species was last notified in the period of 1982-1983 by Belyaeva and Zagorodnyaya (1988). Cyclopoid copepod *Oithona nana* was identified by Demir (1954), Einarsson and Gürtürk (1959) and Yıldız (1997). Güner (1994) and Beşiktepe and Unsal (2000) examined copepod species along coastlines of Turkey. Güner (1994) identified five dominant copepod species in 1991-1992, *Calanus ponticus* (=*C. euxinus*), *Acartia clausi*, *Pseudocalanus elongatus*, *Centropages kröyeri* (=*C. ponticus*) and *Paracalanus parvus*. Beşiktepe and Unsal (2000) listed the same five dominant copepod species except for *C. ponticus*, which was replaced by *Oithona similis*. Mutlu (2002) recorded the same species as Beşiktepe and Unsal (2000) did. Eight copepods species were identified in the Sinop region (*C. euxinus*, *A. clausi*, *P. elongatus*, *O. similis, P. parvus, C. ponticus*, *A. tonsa* and *Pontella mediterrenea)*. *P. mediterrenea* was only recorded in 1999 in Sinop coast of the Black Sea. Yıldız (2010) defined the same six copepod species except for *A. tonsa* and *P. mediterrenea* (Table 2).

Demir (1954) listed 5 cladocer species on the Trabzon coast (*Evadne spinifera, Evadne nordmanii, Penilia avirostris, Evadne tergestina=Pseudoevadne tergestina* and *Pleopis polyphemoides=P. polyphaemoides*). In the studies of Sinop region, the same four cladocerans were found, but not *E. nordmanii*. Mutlu (2002) recorded 5 cladocer species (*E. spinifera, E. nordmanni, Podon intermedius, Podon leucarti* and *P. polyphaemoides*). Yıldız (2010) determined 2 cladoceran species (*P. avirostris* and *P. tergestina*) (Table 2).

Classis Appendicularia (*Oikopleura dioica*), Classis Dinophyceae (*Noctiluca scintillans*) and Phylum Chaetognatha (*Sagitta setosa=Parasagitta setosa*) were represented in only one species. However Demir (1954) described Phylum Chaetognatha as *Sagitta bipunctata* (Table 2).

Meroplankton was studies mostly level of groups but Ünal (2002) identified level species of meroplankton for the first time in southern Black Sea. This study was recorded 17 meroplankton species for the first time along Turkish coastline in 1999 and noted totally 50 meroplanktonic species in Sinop region.

Studies on meroplankton were made mostly in the level of groups (such as classis, family) and identified by Ünal (2002) as species for the first time. Ünal (2002) found totally 50 meroplankton species, 17 of which were first recorded in Sinop region in 1999. Number of Meroplankton species: Amphipoda: 2; Bivalvia: 4; Byrozoa: 1; Cirripedia: 2; Decapoda: 10; Gastropoda: 6; Isopoda; 2; Oligochaeta: 1; Phoronidae: 1; Polychaeta: 19.

Mediterraneanization is the most important process which enriches the community structure of the Black Sea. Kovalev *et al*. (1998) and Selifonova *et al*. (2008) listed copepod the Mediterranean originated copepod species in the Bosphorus region.

In consideration of the studies made in certain seasonal periods or during year, the distribution of zooplankton diversity along the Black Sea coast of Turkey seems stable. The reason why the diversity remains stable might be that most of these researches have been made on the east coast of the Black Sea, far away from the Bosphorus region.

## The Biological Diversity of the Turkish Black Sea Jellyfish

Gelatinous macrozooplankton important affects pelagic food webs by exerting a top-down control on their ecosystems (Shiganova *et al*., 2004). Five species of gelatinous macrozooplankton were present in the Black Sea: two scyphozoan medusa (*Rhizostoma pulmo* and *Aurelia aurita*) and three

**Table 2.** Zooplankton species distributed along the Turkish Coast of Black Sea.

| References | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Period | 1952-1953 | 1955-1956 | 1991-1992 | 1995-1996 | 1994-1996 | 1996-1997 | 1995 | 1999 | 2000 | 2002-2004 | 1999-2002; 2005-2006 |
| Location | Trabzon | Turkish coast of BS | Turkish coast of BS | Sinop | SW-BS | SE-BS | SW-BS | Sinop | Sinop | Sinop | Trabzon; Düzce-Trabzon |
| Taxonomic groups | | | | | | | | | | | |
| Appendicularia | 1 | | | | | * | 1 | 1 | 1 | 1 | 1 |
| Cladocera | 5 | 3 | | | | * | 5 | 4 | 2 | 4 | 2 |
| Chaetognatha | 1 | 1 | | | 1 | * | 1 | 1 | 1 | 1 | 1 |
| Copepoda | 9 | 6 | 5 | 5 | 5 | 4 | 5 | 8 | 7 | 7 | 6 |
| Dinophyceae | 1 | | | | | 1 | | 1 | 1 | 1 | 1 |
| Foraminifera | | | | | | | | * | * | | |
| Ostrocoda | | | | | | * | | | * | | |
| Nematoda | | | | | | | | * | * | * | |
| Rotatoria | | | | | | | | * | | | |
| Tintinnidae | * | | | | | * | | * | | | |
| Amphipoda | | | | | | | | * | * | | |
| Bivalvia larvae | | | | | | * | * | * | * | * | * |
| Byrozoa larvae | | | | | | | | * | | * | |
| Cirripedia larvae | | | | | | | * | * | * | * | * |
| Decapoda larvae | | | | | | | | * | * | * | * |
| Echinoderm larvae | | * | | | | | | | | | |
| Gastropoda larvae | | * | | | | * | | * | * | * | * |
| Isopoda | | | | | | | | * | | * | |
| Oligochaeta | | | | | | | | * | | | |
| Phoronidae larvae | | | | | | | | * | | | |
| Polychaeta larvae | | | | | | * | * | * | * | * | * |

(1:Demir, 1954; 2: Einarsson and Gürtürk, 1959; 3: Güner, 1994; 4: Yıldız, 1997; 5: Beşiktepe and Unsal, 2000; 6: Erkan *et al*., 2000; 7: Mutlu, 2002; 8: Büyükhatipoğlu *et al*., 2002; 9:Bircan *et al*., 2005; 10: Bat *et al*., 2005 and Ustun *et al*., 2007; 11: Yıldız, 2010. SW-BS: South Western Black Sea, SE-BS: South Eastern Black Sea.).
Note: * existed but unidentified species

ctenophore species (*Pleurobrachia pileus, Mnemiopsis leidyi* and *Beroe ovata*) (Kideys *et al*., 2005).

In 1980's, a high 'bloom' of the jellyfish *Aurelia aurita* was showed with high abundance of copepods. The population of *A. aurita* grew explosively and reached peak values (0.6 -1 kg $m^{-2}$) during the 1984-1985 when its total biomass for the total sea area was calculated to be 300-500 million tons (Shushkina and Musayeva, 1983; Lebedeva and Shuskina, 1991). After the explosive development of *M. leidyi* in 1989, the abundance of *A. aurita* dropped. In the Black Sea population of *A. aurita* was decrease 1989-1991. Average biomass of *M. leidyi*, *P. pileus* and *A. aurita* in Turkish area were determined approximately the same in 1992 and 1993 (Mutlu *et al*., 1994).

*M. leidyi* had spread throughout the Black Sea, with average biomasses of up to 1 kg.$m^{-2}$ in 1988. In the autumn of 1989, the greatest mean biomass of 4.6 kg.$m^{-2}$ and the greatest average of 7600 ind.$m^{-2}$ were measured in the open sea (Vinogradov, 1989). After 1990 biomass of *M. leidyi* decreased almost steadily until 1993 when it dropped to its lowest value. In Turkish coast of Black sea, *M. leidyi* was found in 1989-1990 the Sea of Marmara and then eastern Mediterranean Sea (Kideys and Niermann, 1994). Owing to wide temperature tolerance and need to nourishment this species was to be included in Black Sea (Shiganova, 1998).

*M. leidyi* was to be important responsible for the decrease of mesozooplankton and anchovy fishery in the Black Sea because this species great consumer for the fish eggs- larvae and zooplankton that many fish also feed. (Kideys, 2002; Finenko *et al*., 2003; Tsikhon-Lukanina *et al*., 1993). The stocks of zooplanktivorous fish (anchovy, sprat) dropped (Figure. 2) due to competition with *M. leidyi* for food and predation by *M. leidyi* on fish eggs and larvae (Tsikhon-Lukanina *et al*., 1993; Shiganova and Bulgakova, 2000).

UN FAO, DIE (Government Statistical Institute, Turkey) reports show that catches of the Black Sea anchovy *Engraulis encrasicolus ponticus* recovered to the level of late 1970's, the anchovy fishery is considerable for Turkish industry.

New invader, the ctenophore *Beroe ovata* has been introduced into the Black Sea in 1997 (Konsulav and Kamburska, 1998; Finenko *et al*., 2000; Shiganova *et al*., 2000). By 1999, the biomass of *M. leidyi* in Turkish offshore waters had decreased by the appearance of another ctenophore, *B. ovata* which exclusively feeds on *M. leidyi* and very effective in controlling its levels (Kideys *et al*., 2000; Shiganova *et al*., 2001; Bilio and Niermann, 2004) while some species of plankton have begun to increase (Finenko *et al*., 2003; Kideys *et al*., 2005).

In Sinop Bay, in Turkish coast, changing of gelatinous abundance was investigated and species showed seasonality between 2002 and 2004. Maximum average biomass and abundance of gelatinous macrozooplankton was determined in June and July 2003 and July 2004 (Birinci, 2005). In July 2003, zooplankton quantity was determined minimum in time *M. leidyi* was peak. The data presented demonstrate the pattern of *M. leidyi* population growth in summer-early autumn and its extinction after *B. ovata* appearance. *M. leidyi* abundant was peak in July 2003 in time very low zooplankton and fish eggs and larvae values were determined. In 2004, abundance of *M. leidyi* was diminishing cooperated previous two years (Bat *et al*., 2005; Birinci, 2005).

Direct and indirect effective of gelatinous macrozooplankton in the Black Sea has important. In thus, various researchers have studied to determine variation its levels and the energy flow along the food web. In Sinop University gelatinous macrozooplankton studies have sustained since 1999.

## The Biological Diversity of the Turkish Black Sea Benthos

The diversity of zoobenthos in the Turkish Black Sea is not known well. Macrozoobenthic populations of the Turkish littoral and sublittoral zones have been investigated only partially so far. For the last 45 years, the studies of zoobenthic organisms carried out mostly within the Bosphorus-Black Sea junction region. Afterwards studies were extended more recently to the rest of the southern coastal waters (Kocataş and Katağan, 1980; Ateş, 1997; Mutlu, 1992; Mutlu, 1993; Sezgin *et al*., 2001; Gönlügür, 2003; Çulha, 2004; Öztürk *et al*., 2004; Çınar, 2005; Kırkım *et al*., 2006; Sezgin and Katağan, 2007; Bilgin *et al*., 2007; Sezgin *et al*., 2007). According to the latest unpublished data, the number of zoobenthic species amounts to 421, belonging to 13 taxonomic groups (Table 3). Polychaeta is the most diverse of these, with 120 species. Molluscs constitute the second most diverse group, with 115 species. Taking into account the fact that some groups- Protozoa,

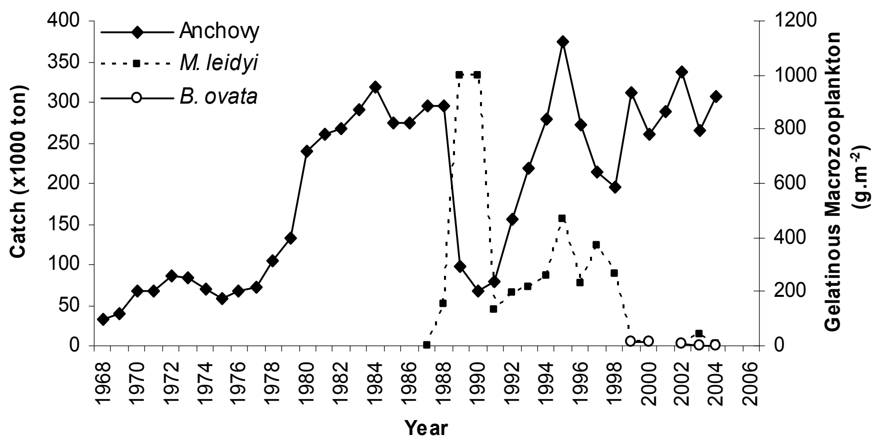


**Figure 2.** Long-term changes in anchovy catch (tons) and biomass of *M. leidyi* in the Black Sea (until 2001 from Shiganova and Bulgakova (2000); total anchovy catch from DIE (2006); value of *M. leidyi* and *B. ovata* after 2001 from Bat *et al.* (2005) and Birinci (2005)

**Table 3.** Species richness of zoobenthos over the Black Sea and along the Turkish coast (unpublished data)

| Taxon | The Black Sea | Turkish Black Sea Coastal Zone | | |
|---|---|---|---|---|
| | | 1980-1990s | 2000-2007 | For all time observations |
| Polychaeta | 308 | 112 | 120 | 120 |
| Mollusca | 177 | 103 | 115 | 115 |
| Amphipoda | 104 | 75 | 86 | 86 |
| Decapoda | 59 | 29 | 31 | 31 |
| Isopoda | 34 | 13 | 14 | 14 |
| Echinodermata | 27 | 13 | 14 | 14 |
| Cumacea | 26 | 12 | 13 | 13 |
| Porifera | 33 | 12 | 11 | 12 |
| Tanaidacea | 6 | 6 | 6 | 6 |
| Anthozoa | 6 | 4 | 3 | 4 |
| Ascidacea | 10 | 3 | 3 | 3 |
| Cirripedia | 7 | 2 | 2 | 2 |
| Sipuncula | 1 | 1 | 1 | 1 |
| Total | 798 | 385 | 419 | 421 |

Oligochaeta, Turbellaria, etc. - have not yet been well studied, it can be assumed that the number of benthos species is actually much higher than the current total.

According to the Table 3, out of 10 different groups; Polychaeta, Mollusca and Amphipoda accounted for 76% of the total abundance, followed by Decapoda, Isopoda, Echinodermata, Cumacea, Porifera, and others. 385 macrobenthos species were registered during 1980-2000, and this number increased to 419 in 2000-2007. Therefore, no evidence exists for the reduction of species richness in the Turkish Black Sea coastal zone during the last 25 years. Moreover, bottom fauna was enriched in 2000-2007 due to (1) introduction of some species that were previously recorded only in the Bosphorus region; (2) introduction of alien species; (3) Mediterranization (climate change effects); (4) more detailed studies to cover neglected geographical locations or habitats; (5) recovery of ecosystem health (Revkov, 2009).

However, contrary to the steady character of species richness, abundance and biomass of some species were dramatically changed. The decline in populations of many benthic invertebrates (Crustacea, Mollusca, Polychaeta), which play a significant role in the food chain of the benthos consuming fish, has been clearly noted in the last two decades. The first visible changes in the structure of coastal benthic communities in southern coast of Black Sea were the increase in density of some Mollusca species (such as *Patella* spp., *Rapana, Chamelea*) during the last 10 years. Moreover, the replenishment of juvenile bivalve populations was found to depend on the strength of *Mnemiopsis-Beroe* interactions in the pelagic zone and therefore subject to considerable interannual variations. Better resistance of *Anadara ineaquivalvis* to environmental stresses than the native species permitted its population to become a dominant group at the 10-30 m depth range (Revkov, 2009).

Available observations appear to indicate that eutrophication and different survival ability of benthic species in hypoxic conditions played an important role in the development and formation of macrobenthic communities. It appears that the invasion of *Beroe ovata* in 1999 did not play any major role for either the recovery of benthic communities or the development of a new stable structure. On the contrary, disturbing quasi-stability of the system, the community started experiencing more pronounced fluctuations in both abundance, biomass and species structure. On the other hand, the Mediterranization process or invasion of the system by new species continued (Revkov, 2009).

The Black Sea bottom algae flora is the impoverished derivative of the Mediterranean one. The species list today comprised 80 Chlorophyta, 76 Phaeophyceae and 169 Rhodophyta (Milchakova 2002; 2003a; 2003b; 2007). A detailed account of the early algal records along the Turkish coast of the Black Sea is given by Aysel *et al*. (1996; 2000; 2004; 2005). In these studies, 25 macroalgal taxa were reported in Trabzon coastal waters and 21 macroalgal taxa at Sinop and its vicinity (central zone), 55 taxa along the coast of Trabzon and 88 taxa between Rize and Sarp in the southeastern part of the Black Sea, 210 taxa at Bartin and 205 taxa at Zonguldak (western zone) belonging to four algal classes (Cyanophyceae, Rhodophyceae, Phaeophyceae and Chlorophyceae). In total, 258 taxa were identified in the Turkish Black Sea region, from five classes: Cyanophyceae with 13 species, Rhodophyceae with 140 species, Phaeophyceae with 53 species, Chlorophyceae with 50 species and Charophyceae with 2 species. With new additions of algal taxa, this number increased later to 297 by Aysel *et al*. (2004). Karacuha and Gönülol (2007) performed a study and collected marine algae species on the coastline between Sinop and Ayancık coasts. Totally 206 algae species were determined. Eight of them belonging to blue-green algae (Cyanophyta), 109 to red algae (Rhodophyta), 42 to brown algae (Ochrophyta) and 47 to green algae (Chlorophyta). The preliminary list of algal taxa and macrophytes along the Turkish coast of the Black Sea is given by Aysel *et al*. (2005) (Table 4). However it is essential to prepare an actual checklist based on "htpp://www.algaebase.org" due to the some omitted, undetermined and synonym species.

**Table 4.** Benthic algae and macrophytes diversity from different areas in the Black Sea coast of Turkey (Aysel *et al*., 2005)

| Regions | Seaweeds | | | | Macrophytes | Σ |
|---|---|---|---|---|---|---|
| | Cyanophyta (CY) | Rhodophyta (R) | Phaeophyta (O) | Chlorophyta (C) | Magnoliophyta | |
| Kırklareli | 23 | 71 | 24 | 30 | 3 | 151 |
| Kocaeli, Sakarya, Düzce | 30 | 126 | 50 | 46 | 3 | 255 |
| Zonguldak | 20 | 100 | 42 | 43 | 3 | 208 |
| Bartın | 12 | 116 | 43 | 39 | 3 | 213 |
| Kastamonu | 22 | 133 | 56 | 48 | 3 | 262 |
| Sinop | 22 | 136 | 52 | 55 | 3 | 268 |
| Samsun | 20 | 106 | 27 | 22 | 3 | 178 |
| Ordu | 14 | 93 | 27 | 26 | 4 | 164 |
| Giresun | 18 | 109 | 33 | 30 | 3 | 193 |
| Trabzon | 1 | 23 | 8 | 23 | 3 | 58 |
| Rize, Artvin | 3 | 43 | 15 | 27 | 3 | 91 |
| Total | 30 | 142 | 57 | 58 | 4 | 297 |

## The Biological Diversity of the Turkish Black Sea Fish and Mammals

In the Black Sea investigations on the determination of fish fauna started in late 1940's. The Black Sea fishes have different origins. Rass (1949) divided the Black Sea fish fauna into four main groups, based on their origins and ecologies. These are: a) freshwater species; b) brackish Ponto-Caspian relicts; c) cold-water species with Boreal-Atlantic origin; and d) warm-water species with Mediterranean origin. The last two groups (c and d) include the most widely spread and commercially important species in the Black Sea.

Öztürk (1999) reviewed to the general biodiversity in the Turkish Black Sea, and stated that the presence of 140 fish species. Bilecenoglu *et al*. (2002) have published a checklist of the marine fish fauna of Turkey and report a total of 151 species are given in the Turkish Black Sea coast. However, a few data are available on the fishes of Turkish Black Sea coast (Slastenenko, 1955-1956; Akşiray, 1987; Bilecenoglu *et al*., 2002; Can and Bilecenoğlu, 2005). In the recently study a total of 94 fish species belonging to 44 families were identified in the Sinop and Samsun coast (Bat *et al*., 2005). *Acipenser persicus*, *Apletodon dentatus bacescui*, *Gobius cruentatus* and *Zebrus zebrus* were new recorded from Sinop Peninsula of the Turkish Black Sea (Bat *et al.*, 2005 and 2006). Considering to one of the last review (Keskin, 2010), a total of 161 species present in the Turkish Black Sea: 62.73% of which is Atlanto-Mediterranean species, 6.83% cosmopolitans, 28.57% endemics (18.01% Black Sea endemics, 10.56% Mediterranean endemics) and 1.86% introduced species (Indo-Pacific and Atlantic origins) such as, *Liza haematocheila, Sphraena obtusata* and *Salmo salar*. Finally Black Sea Fish Check-List was given by BSC (2010).

Populations of some fish species have been significantly reduced due to extreme fishing pressures on the Turkish part of Black Sea. Although it has 168 species of fish in the Black Sea (Zaitsev and Mamaev, 1997), there are only a few species of economic importance and the supply of fishes is limited because of intensive fishing, industrialisation and urbanisation have caused fisheries the most favoured species to decline (Kideys, 1994; Bat *et al.,* 2007). In particular, the populations of anchovy and turbot have been reduced over the last several years.

There are only few taxonomic groups of marine mammals in the Black Sea fauna that include three cetacean species–the harbour porpoise (*Phocoena phocoena*), the short-beaked common dolphin (*Delphinus delphis*) and the common bottlenose dolphin (*Tursiops truncatus*).

## Conclusion

In terms of species diversity, the Black Sea biological diversity is of average richness when compared to the world's other large expanses of water. Generally, in undisturbed natural conditions species diversity in the Black Sea fauna is approximately three times less than that in the Mediterranean. Living organisms and habitats are easily affected by human activities, e.g. trawling, eutrophication and coastal constructions. Such human activities present the most important contemporary threat to biological diversity, both in the shallow shelf and in the hydrogen sulphide-rich layers below 150 m. These facts suggest the urgent need for protective and restorative measures. To protect the biological diversity of the Turkish Black sea region: trawling should be prohibited; sea construction should not be permitted without ecological analyses prepared by marine experts; marine protected areas should be established in territories that are important sources of benthic and planktonic larvae. We know a considerable amount about Black Sea biodiversity but our knowledge has a limited value because the data are often presented in non-congressional languages; the data are not available (unpublished or in grey literature) or not comparable (different sampling/analyses protocols used) c) the data are insufficient (limited number of taxonomic groups studied) and d) we are not able to translate scientific information into indicators to support adequately political decisions /track policy effectiveness. In summary, the Turkish Black Sea coast shelves are subject to anthropogenic interference, resulting in almost complete destruction of the sea bottom communities. This results in changes in the diversity, quantity, and reproductive capacity of biological resources.

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