Current views on the diversity and distribution of deep-water meiobenthos at the Turkish shelf (Black Sea)

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Abstract
Deep-water meiobenthos of Turkish shelf has been evaluated at the Black Sea exit of İstanbul Strait (Bosphorus) and off Sinop peninsula as a result of three scientific cruises. Taxonomic diversity of meiobenthos communities was studied at the Black Sea exit of Bosphorus on a transect with a depth range of 75-300 m. The bottom sediments were collected at the area during two cruises, on board RV "Arar" (of Turkey) and "Maria S. Merian" (of Germany) in November 2009 and April 2010, respectively. Data on meiobenthos inhabiting both normoxic and extreme conditions was collected in the studied area and meiobenthos composition included 26 high level taxa. In addition, 2-3 morphotypes of benthic fauna were recorded as incertae sedis, which require further study. The number of higher taxa decreased from 22 to 14-8 when switching from oxygenic conditions (50-125 m) to the anoxic hydrogen sulphide environment (226-300 m). The constant components of meiobenthos included protists (Ciliophora, Gromiidea and soft-shelled Foraminifera), and metazoans were constantly represented by Nematoda and Harpacticoida. In 2011, a quantitative study on meiobenthic composition of the oxic/anoxic interface at the western part off Sinop Peninsula (Southern Black Sea) has also been investigated. The material was collected by ROVs during the expedition (Black Sea Leg) of the exploration vessel (E/V) Nautilus. Results showed that the taxa composition of meiobenthos ranged from 4 to 10 major groups. Free-living marine nematodes were numerically the dominant taxon at each station. Total abundances decreased in parallel to increasing water depth, hence decreasing oxygen levels.

Key words: meiobenthos, oxic/anoxic interface, Bosphorus, Sinop, Turkey.

Introduction
The Black Sea is a deep marginal meromictic sea. It has an oxygenated surface water layer overlying an anoxic deep-water layer. It is a unique marine water body where the dissolved oxygen disappears at a depth of about 200 m while hydrogen sulphide is present at all greater depths (Zaitsev 2008). The shallow sill depth at the Bosphorus, together with the positive water balance, produce a strong pycnocline/chemocline at -100 to -150 m in the Black Sea, separating the aerated brackish waters (17-18 ‰) from anaerobic, H₂S-rich more saline waters (22.5 ‰; 8.9°C) (Özsoy & Ünlüata 1997). The chemocline depth is at ca. 100 m and the suboxic zone is at 85-120 m near the head of the Bosphorus canyon. The suboxic zone is important for...
biogeochemical and redox reactions (e.g., Murray et al. 1989, 1993; Codispoti et al. 1991; Bașturk et al. 1994).

The southern part of the Black Sea near the Bosphorus is very different from the north-western area of the sea in terms of deep-water benthic habitats. Here, the environmental conditions are modified by the influence of salty and normoxic waters that come from the Sea of Marmara with the lower jet stream. Increased salinity leads to the enrichment of the biota due to the permanent introduction of planktonic stages of benthic organisms from the Sea of Marmara. The introduction of oxygenated water at the seabed may increase the variability in the hypoxic-anoxic transition zone, and, in general, may shift the limit of oxygenated water to greater depths. Finally, the periodic pulsating current activity of the lower Bosphorus plays an important role (Özsoy et al. 2001). This area is interesting for biological studies since here, less saline surface waters of the Black Sea and the saline Mediterranean waters interact, creating a special ecological system in the Black Sea where the deep waters are permanently anoxic and contaminated with hydrogen sulphide. The hypoxic layer, where the oxygen deficiency increases with depth, is situated above the hydrogen sulphide zone. Only several organisms, which are characteristic for the oxygenated layer of the sea, have been considered to be available at this zone (Zaitsev et al. 2007). Therefore, most of the investigations on the Black Sea benthic ecosystem were focused on coastal communities.

For more than a century, the world of science has considered the anoxic zone of the Black Sea to be azoic, or lifeless. But modern data (Lichtschlag et al. 2015; Korovchinsky & Sergeeva 2008, Sergeeva 2000, 2003, 2004; Sergeeva & Gulin 2007; Sergeeva et al. 2014) indicate that the deep-water bottom sediments of the Black Sea, which possess permanent hydrogen sulphide pollution, are the natural habitats for some species of eukaryotic organisms (Protozoa and Metazoa). In connection with this, it has since been particularly emphasized that the term “azoic” or “lifeless” is not valid when applied to the anoxic zone of the Black Sea. Changes in the composition of benthic communities can be observed where the hypoxic waters impinge on the seafloor and create a gradient of increasing hypoxia. Approaching the boundary of the hydrogen sulphide zone, the species composition of macrofauna becomes poorer; large forms occur only occasionally and finally they disappear. Metazoan meioobenthos gradually begin to dominate, and together with the protozoans, create a distinctive benthic community (Sergeeva et al. 2017).

Rosli et al. (2017) reviewed the studies on the spatial distribution of deep-sea meioobentos (>200 m water depth) conducted across all oceans since the review of Soltwedel (2000) and up to 2016. They listed two studies from the Black Sea (Sergeeva & Gulin, 2007; Sergeeva et al. 2014) In this review, we tried to give a summary on the bathymetrical distribution of deep-sea meioobenthos including benthic protozoans and metazoans and their richness at the deep waters of the Turkish shelf of the Black Sea based on previous studies.

**Historical Data**

Meioobenthos studies date back to the second half of the 20th century at the Turkish shelf of the Black Sea. The study of meioobenthos in the composition of three benthic communities at the shelf of Turkey (Bosphorus) along a depth range of 70-115 m was carried out for the first time in 1958 and 1960 at the R/V "Academik Kovalevsky" (IBSS NASU, Sevastopol). In general, the meioobenthos included the following taxa: Foraminifera (19 species), Nematoda, Kinorhyncha, Polychaeta, Ostracoda (14 species), Harpacticoida (2 species), Acari. Free-living nematodes were as usual the most numerous taxa (Kiseleva, 1969). Follow-up studies of the taxonomic composition of meioobenthos in the Bosphorus area revealed 51 species of nematodes belonging to 37 genera (Sergeeva 1974). 20 species of meioobenthos and 15 species of macrobenthos that were not only new to the Black Sea, but also new for science were identified and described from six stations at the western part of the Bosphorus area (Bacescu & Marginneau 1959; Bacescu 1960). Several ostracod species specific only to the Black Sea exit of Bosphorus were described in the late 50s and early 60s (Caraion 1959; Marinov 1962; Shornikov 1966). In the 60s, research was focused on benthic foraminifera in the Bosphorus area (depth 80-100m) and three main foraminifera complexes were defined based on the dominant species. The first complex, dominated by the species *Streblus beccarii* (Linnaeus, 1958) was represented by six species, specimens of *Ammobaculites* Cushman, 1910 were abundant in the second set (represented by 10 species) specimens of *Ammoba culites* were abundant and the third complex consisted of a mixed group of 32 species (Didkowsky 1969). Subsequently, studies have resulted in discovery of benthic foraminiferans belonging to 6 orders, 39 genera and 79 species, of which 27 were new species unique to the Bosphorus region of the Black Sea (Yanko & Vorobyova 1991).

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Material and Methods

Detailed studies of deep-water meiobenthos have been conducted at the Black Sea exit of Bosphorus within the framework of the EU 7th FP project HYPOX (In situ monitoring of oxygen depletion in hypoxic ecosystems of coastal and open seas, and land-locked water bodies, EC Grant 226213). Additionally, oxic/anoxic interface off Sinop shores (southern Black Sea) has been investigated in terms of meiobenthic organisms as part of an international, collaborative study. Thus, the present paper summarizes the results of the analysis of meiobenthos samples obtained at the Black Sea exit of Bosphorus (75-300 m) during the cruises RV "Arar" (of Turkey) in November 2009, RV "Maria S. Merian" (of Germany) in April 2010 and also the results of the samples collected at the oxic/anoxic interface off Sinop (90-203 m) during the Black Sea Leg of the exploration vessel E/V Nautilus in August 2011. Material and methods, and maps of the sampling stations have been previously presented elsewhere (Sergeeva et al, 2017; Ürkmez et al. 2015).

We considered all meiobenthic organisms, both protozoans and metazoans including the permanent as well as the temporary meiofauna that represents juvenile stages of macrobenthos (Bougis 1950; Higgins & Thiel 1988; Chislenko 1961; Giere 2008; Mare 1942; Sergeeva et al. 2013; 2014; Soltwedel 2000; Zaika & Sergeeva 2012).

Part of the data on the taxonomic structure, abundance and distribution of the meiobenthos at the Black Sea shelf, the upper slope area off the Black Sea exit of Bosphorus and off Sinop shores along the transition zone from oxic to anoxic conditions has been previously published (Sergeeva & Mazlumyan 2013, 2015; Sergeeva et al. 2013, 2014, 2015; Brennan et al. 2013; Ürkmez & Brennan 2013; Ürkmez et al. 2015). Nevertheless, data about meiobenthos of these areas at the interaction zones of oxygen and anoxic water masses are still scarce and require additions.

Results

Black Sea exit of Bosphorus

Oxygen concentrations in the bottom-water along the interface zone at the Bosphorus have been reported to range from normoxic (175 µmol O$_2$ L$^{-1}$ and hypoxic less than <63 µmol O$_2$ L$^{-1}$) or even anoxic/sulfidic conditions within a few kilometers’ distance (Holtappels et al. 2011; Lichtschlag et al. 2015; Sergeeva et al. 2013, 2014, 2017). In November 2009, the CTD casts showed that the stations between 150–300 m water depths might have been influenced by the Mediterranean waters during the sampling period, while stations above 122 m water depth might even permanently have oxygen in the water column (Sergeeva et al. 2013). In April 2010, the oxycline was situated at 120 m depth and was characterized by steep oxygen gradients. The onset of sulphide as marked by the 1016 kg/m density isocline was between 150 and 200 m depth. Further inshore, at water depths less than 150 m, the oxicline intersects with the seafloor causing oxygen gradients to become less steep. The bottom water of Station 285 (100 m depth) was fully oxygenated, whereas the oxygen concentrations decreased to~10 µmol/L at Station 243 (153 m). The bottom water was anoxic, but not yet sulfidic at stations 224 (200 m) and 333 (200 m), whereas it became sulfidic at all other stations deeper than 250 m depth ( Stations 203, 204, 262, 263, 332) (Sergeeva et al. 2014).

Sulphide concentrations in the sediment pore waters at different stations were varied. No sulphide was detected in the pore waters of the upper 30 cm of sediments from 100 m (Station 285) and 150 m (Station 243) water depths. At 200 m (Stations 224, 333), sulphide was occasionally present in the pore waters of the sediment however concentrations were variable and no free sulphide was found in the upper 5 cm of the sediments in the two sampled stations. Only at 250 m (Station 332), sulphide was also detected close to the sediment surface (Sergeeva et al. 2014).

The bathymetric characteristics in the distribution of the abundance and taxonomic diversity of meiobenthos at the Black Sea exit of Bosphorus are presented in figures 1 and 2. The distribution of meiobenthic communities at the studied depth range (75-300 m) was uneven. There was no clear negative effect of increasing depth and the emergence of extreme life conditions on meiobenthos characteristics. Despite the general tendency of a decrease in abundance and diversity towards maximum depths with oxygen deficiency or under the absence of oxygen and the appearance of hydrogen sulphide, several peaks of abundance and taxonomic richness were recorded at extreme areas.

The objective data for each studied depth (by stations) have particularly been presented, since this allows us to show the uneven distribution of fauna. For example, at the same sampling site (St. 203 and St.
204, depth 252 m) the meiobenthos structure was different, which was undoubtedly due to the combined microheterogeneous properties of habitats. Unfortunately, it was impossible to assess the multifactorial differences in the habitat of deep-sea fauna using present instrumental methods.

Figure 1. Trends in the abundance ($10^3$ ind.m$^{-2}$) and richness (number of taxa) of meiobenthos along the studied depth gradient at the Black Sea exit of Bosphorus in November 2009 (in addition to Sergeeva et al. 2013, Sergeeva & Mazlumyan 2015).

Figure 2. Trends in the abundance ($10^3$ ind.m$^{-2}$) and richness (number of taxa) of meiobenthos along the studied depth gradient at the Black Sea exit of Bosphorus in April 2010.

Meiobenthic organisms were registered at this range of depths along the studied area and its composition included 26 high level taxa (type, class, order). Moreover, 2-3 morphotypes of benthic fauna were recorded as *incertae sedis*, which require further study to identify their taxonomical level (Table 1). A number of higher taxa were recorded for the first time in this water area, with most of them found under conditions of hypoxia and anoxia associated with the presence of hydrogen sulphide.
The number of higher taxa at the sampling stations decreased from 22 to 14-8 when switching from the oxygenic conditions (50-125 m) to anoxic hydrogen sulphide conditions (226-300 m). The constant components of meiobenthos were ciliophorans, gromiids and soft-shelled foraminiferans among benthic protozoans; and nematodes and harpacticoids among metazoans. These groups were dominant in the meiobenthic communities. Representatives of other groups were recorded as well in a wide range of depths, but their abundance were not so high compared to the above-mentioned taxa.

Table 1. Distribution of meiobenthos along the depth gradient at the oxic / anoxic interface of the Black Sea exit of Bosphorus (+ November 2009, • April 2010).

| Taxa of meiobenthos | Range of depth, m | 50-75 | 76-100 | 101-125 | 126-150 | 151-175 | 176-200 | 201-225 | 226-250 | 251-275 | 276-300 |
|---------------------|-----------------|-------|--------|---------|---------|---------|---------|---------|---------|---------|---------|
| Protozoa            |                 |       |        |         |         |         |         |         |         |         |         |
| Ciliophora          |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Gromiidea           |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Foraminifera :      |                 |       |        |         |         |         |         |         |         |         |         |
| Hard-shelled        |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Soft-shelled        |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Metazoa             |                 |       |        |         |         |         |         |         |         |         |         |
| Cnidaria            |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Turbellaria         |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Nemertea            |                 | •     | •      | •       | •       | •       | •       | •       | •       | •       | •       |
| Gastrotricha        |                 | •     | •      | •       | •       | •       | •       | •       | •       | •       | •       |
| Nematoda            |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Rotifera            |                 | •     | •      | •       | •       | •       | •       | •       | •       | •       | •       |
| Polychaeta          |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Oligochaeta         |                 | +     | •      | +       | +       | +       | +       | +       | +       | +       | +       |
| Kinorhyncha         |                 | +     | •      | +       | +       | +       | +       | +       | +       | +       | +       |
| Harpacticoida       |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Ostracoda           |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Amphipoda           |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Tanaidacea          |                 | •     | •      | •       | •       | •       | •       | •       | •       | •       | •       |
| Cumacea             |                 | +     | •      | •       | •       | •       | •       | •       | •       | •       | •       |
| Decapoda            |                 | •     | •      | •       | •       | •       | •       | •       | •       | •       | •       |
| Acari               |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Pantopoda           |                 | +     | •      | •       | •       | •       | •       | •       | •       | •       | •       |
| Bivalvia            |                 | +     | •      | •       | •       | •       | •       | •       | •       | •       | •       |
| Gastropoda          |                 | •     | •      | •       | •       | •       | •       | •       | •       | •       | •       |
| Ophiuroidea         |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Tardigrada          |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Ascidiae            |                 | +     | +      | +       | +       | +       | +       | +       | +       | +       | +       |
| Other (incertae-sedis) |             | +     | •      | •       | •       | •       | •       | •       | •       | •       | •       |
| Total taxa (without others) |       |       |        |         |         |         |         |         |         |         |         |
|                     |                 | 16    | 22     | 19      | 22      | 20      | 13      | 10      | 15      | 14      | 8       |

Table 1 shows the recorded group of organisms at several depth ranges in the studied oxic / anoxic layer. The generalized data received in 2009 and 2010 made it possible to trace the patterns in the distribution of different groups of meiobenthos under depletion of oxygen and increase of hydrogen sulphide at the oxic/anoxic interface.

The share of benthic protozoans and basic representatives of metazoans in meiobenthos of the Black Sea exit of Bosphorus at the sampled depths in 2009 and 2010 can be seen in figures 3 and 4.
Figure 3. Share of benthic protozoan taxa in total protozoa along the depth gradient at the oxic/anoxic interface of the Black Sea exit of Bosphorus (November 2009).

In 2009 autumn, the largest contribution to the community of protozoans was made by ciliophorans and hard-shelled and soft-shelled foraminiferans, and gromiids accounted for a significant proportion only under oxygenated conditions. The community of protozoa under anoxic conditions with hydrogen sulphide was represented only by ciliophorans and a small ratio of soft-shelled foraminiferans.

Figure 4. Share of benthic protozoan taxa in total protozoans along the depth gradient at the oxic/anoxic interface of the Black Sea exit of Bosphorus (April 2010).

Different shares of these protozoan groups were observed in 2010 spring. When all the depths are considered in general, only two groups of ciliophorans and soft-shelled foraminiferans were predominant. Protozoans were totally absent at two stations (depths 223 and 262 m).

A clear dominance of nematodes was observed at all the studied depths in the composition of the metazoan fauna, and harpacticoids were the permanent component (Figures 5 and 6).
Figure 5. Share of main meiobenthic taxa at the depth gradient along the oxic/anoxic interface at the Black Sea exit of Bosphorus (November 2009).

Figure 6. Share of main meiobenthic taxa along the depth gradient at the oxic/anoxic interface of the Black Sea exit of Bosphorus (April 2010).

The bathymetric distribution of benthic protozoans and the most important multicellular organisms in the Black Sea along a range of depths and oxygen concentrations have been previously described in several papers (Sergeeva & Mazlumyan, 2015; Sergeeva et al. 2013, 2014, 2015, 2017).
Oxic/anoxic interface at the north-western area off Sinop

The seabed across the oxic/anoxic interface (90-300 m) at the north-western area off Sinop was explored during the Black Sea expeditions of E/V Nautilus in 2011. Internal wave motion between these water layers affects sediment dynamics along the shelf at this area. Identification of sampling locations and sediment core collections were conducted with the remotely operated vehicles (ROVs) *Hercules* and *Argus*. Push cores were collected with an ROV in sediments underlying the oxic, suboxic, and anoxic waters for geological and biological analyses. The suboxic zone was found to begin at 120 m depth by using the dissolved oxygen (O$_2$) sensor on the ROV (O$_2$ < 5 μM). The anoxic core was collected at 203 m, well into the anoxic zone with a complete lack of oxygen. The anoxic core was taken from a sediment surface composed of fine mud with no visible biology, and also in an area of bedforms originating from the activity of internal waves across the chemocline (Ürkmez et al. 2015). Duman *et al.* (2006) has reported the oxic/anoxic halocline to be between 100 and 110 m, with the suboxic transitional zone extending from 100 m down to ~ 200 m, which is the depth where bedforms were seen. The suboxic conditions at 120 m depth agreed well with the ranges cited by Duman *et al.* (2006). Temperature and salinity reached minimums between 50 and 60 m depths, while oxygen becomes depleted between 100 and 120 m.

Meiobenthos was represented by a total of 13 higher taxa and ranged between 4 and 10 taxa at each site (Table 2) (Ürkmez *et al.* 2015). Nematoda was quantitatively the most abundant meiofithic taxon at three sites followed by Harpacticoida in the oxic and suboxic samples. The third abundant group was Polychaeta in the oxic sample and Cnidaria (Hydrozoa) in the suboxic sample. Higher taxa recorded in the anoxic sample, following Nematoda, were Acari, Harpacticoida and hard shelled Foraminifera with reduced densities. Total abundance of meiobenthos significantly decreased with increasing water depth, and decreasing O$_2$ levels from the oxic site towards the anoxic site (Fig. 7). Representatives of Kinorhyncha were only found in samples from the oxic and suboxic sites. The share of higher meiofithic taxa in the area are shown in figure 8. Nematoda was numerically the most abundant meiofithic taxon at each station making its highest contribution (90%) to the sample associated with the suboxic zone (Fig. 9).

Table 2. Distribution of meiobenthos at three locations along the oxic / anoxic interface off Sinop shores (southern Black Sea).

| Taxa of meiobenthos | Anoxic 203 m | Suboxic 120,5 m | Oxic 90 m |
|---------------------|--------------|-----------------|-----------|
| **Protozoa**        |              |                 |           |
| Foraminifera :      |              |                 |           |
| Hard-shelled F.     | +            |                 | +         |
| Soft-shelled F.     |              | +               |           |
| **Metazoa**         |              |                 |           |
| Cnidaria            | +            |                 |           |
| Turbellaria         |              |                 |           |
| Nematoda            | +            | +               |           |
| Polychaeta          |              | +               |           |
| Oligochaeta         | +            |                 |           |
| Kinorhyncha         |              |                 |           |
| Harpacticoida       | +            | +               | +         |
| Ostracoda           |              |                 |           |
| Acari               | +            | +               | +         |
| Bivalvia            |              | +               |           |
| Echinodermata       |              |                 |           |
| **Other (incertae-sedis)** | + | + | + |
| **Total taxa (without others)** | 4 | 9 | 10 |
**Figure 7.** Trends in the abundance ($10^3$ ind.m$^{-2}$) and richness (taxa number) of meiobenthos along the studied depth gradient at the oxic/anoxic interface off Sinop shores (southern Black Sea) in 2011 (in agreement with Ürkmez et al. 2015).

**Figure 8.** Share of main meiobenthic taxa at the oxic, suboxic and anoxic sites off Sinop shores (southern Black Sea).

**Figure 9.** Share of nematodes in total meiobenthos obtained from samples at the A. Anoxic B. Suboxic C. Oxic sites off Sinop shores (southern Black Sea).
Nematodes were represented by 84 species belonging to 23 families. A significant part of the nematode fauna in the oxic sample was composed of members of the families Comosomatidae (22.9%), Linhomoeidae (15.2%), Desmodoridae (14.4%) and Enopliidae (12.3%). Some other families were also found in notable amounts. The number of species within particular families varied from 1 to 10 at each site. Maximum number of species were distributed within the family Linhomoeidae with *Terschellingia* cf. *distalamphida*, being the most abundant species of the family. Suboxic site revealed a relatively lower nematode density. 21 families and 30 species were recorded at the suboxic site with a distinctively high dominance of *Trefusiidae* (49.5%). *Trefusia aff. longicaudata* presented with the highest number of individuals (42.5%) in the suboxic sample which on the contrary had a contribution of just 1% at the oxic sample. Number of families was nearly similar whereas oxic zone harboured a richer nematode species diversity. Only five specimens of Nematoda were recruited from the anoxic sample although three replicates were able to be taken only from this zone. However, the specimens were juveniles and in bad condition. For more detailed information see Ürkmez *et al.* (2015).

**Conclusion and Discussion**

In relation to above, there is a thin intermediate layer of up to 10—20 m with a coexistence of oxygen and hydrogen sulphide, known as the suboxic zone (a gap between oxic and anoxic layers) in the Black Sea. It has recently been discovered and shown to be a permanent feature of the Black Sea (Glazer *et al.* 2006). Duman *et al.* (2006) has reported a permanent halocline at 100-110 m depth, followed by the transitional suboxic zone down to ~200 m at the western part of Sinop. As a result of the optode readings of ROV at the suboxic zone, O$_2$ was observed to drop to zero between 100-120 m, followed by more stable conditions downward into the anoxic layer (Ürkmez *et al.* 2015). It has been considered that only some organisms characteristic for the oxygenated layer of the sea might be registered in this zone (Zaitsev 2008; Zaitsev *et al.* 2007). Accordingly, current investigations on the benthic organisms of the Black Sea have been focused on coastal communities.

Studies of deep-sea meiobenthos at the Turkish shelf revealed new and unusual results, which indicate a large diversity of meiobenthic communities. Many unknown species, moreover morphotypes, were registered in all meiobenthic groups, which require further detailed studies to determine their systematic level. Preliminary analysis of the species composition of protozoans and metazoans, particularly soft-shelled foraminifera, gromiids, ciliophorans, free-living nematodes, gastrotrichs, rotifers and representatives of other groups, showed that most of them are not known for the Black Sea and have to be precisely and carefully investigated since they have the potential to be new for science.

As a result of these investigations, a number of new records among meiobenthic taxa have been reported for the Black Sea. In addition, it was first shown that both protozoans and multicellular animals are well adapted to extreme hydrogen sulphide and anoxic conditions, which allow them to dwell into depths of 300 m (see table 1). The protozoans and fungi along the shelf and continental slope of the Black Sea with oxygen deficiency were previously recorded by Zaika & Sergeeva (2009), Sergeeva & Kopytina (2014) and Sergeeva *et al.* (2014). First findings of epibiont peritrich and suctoriant ciliates on oligochaetes and harpacticoid copepods from the deep-water hypoxic/anoxic conditions of the Black Sea have also been reported. *Cathurnia maritima* Ehrenberg, 1838 on oligochaete *Tubificoides* sp.; *Paracineta lividiana* (Merenskowsky, 1881) and *Corynophrya lyngbyi* (Ehrenberg, 1834) on harpacticoid copepod *Amphiascella subdebilis* (Willey, 1935), *Haloschizopera pontarchis* Por, 1959, *Cletodes tenuipes* Scott, 1896 and *Enhydrasoma longifurcatum* (Sars, 1909) were found recently at the Bosphorus region of the Black Sea (at depths of 200 and 248 m), under hypoxic/anoxic conditions (Sergeeva & Dovgal 2014). *Loricophrya bosporica* nov. sp. (Ciliophora, Suctorea) was described in Sergeeva & Dovgal (2016) as an epibiont of the nematode *Desmoscolex minutus* Claparède, 1863 which lives in extreme permanent hydrogen sulphide conditions at 252 m water depth. The representatives of the genera *Hyperammina* and *Reophax* (Hard-shelled Foraminifera) have been recorded for the first time in deep-water sites (Sergeeva & Mazlumyan 2013). It is noteworthy to mention that some morphospecies of the genera *Ammonia* and *Reophax* were found alive at one of the stations with presence of hydrogen sulphide. During these studies, soft-shelled foraminiferans and gromiids became known for the given region of Turkey (Sergeeva *et al.* 2013, 2015). It was also shown for the first time that ciliophorans can live in deep-sea hydrogen sulphide conditions in the deep-sea Turkish shelf of the Black Sea (Sergeeva *et al.* 2013, 2014, 2017). A representative of Hydrozoa, *Protohydra leuckarti* Greeff, 1870 has also been recorded for the first time in this region.

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The results of the investigations of tardigrades in the Black exit of Bosphorus showed two new records for the Black Sea: Dipodarctus subterraneus (Renaud-Debeyser, 1959) and Tanarctus ramazzottii (Renaud-Mornant 1975). Tardigrades have been found at 4 stations along a depth range of 88-250 m (Kharkevych & Sergeeva 2013). The marine tardigrade fauna of the Black Sea is poorly known.

Harpacticoida was represented by 40 species at the Black Sea exit of Bosphorus, inhabiting depths between 80 to 300 m. Species were not uniformly distributed with water depth and Haloschizopera pontarchis Por, 1959 was present at almost all studied depths reaching its highest abundance at 150 m. A large number of Amphiassocides subdebilis (Willey, 1935) was also found at the same depths, whereas Bulbamphiascus imus (Brady, 1872) reached a high abundance at 200 m. Cletodes tenuipes (Scott T., 1897) was observed often as well (Kolesnikova et al. 2014).

Particular groups of nematodes were observed at suboxic zone off Sinop shores. Most of them were slender and possessed a filiform tail to enhance the dissolved organic matter uptake through their body surfaces. Diversity of nematodes were found to decrease as the oxygen level declined along with an increasing dominance of single species, and the relative abundances of several taxa changed markedly from oxic to suboxic/sulfidic depths. The genus Trefusia de Man, 1893 has been reported for the first time for the Black Sea (Ürkmez et al. 2015). Suboxic sample was represented mostly by Trefusia aff. longicaudata in spite of the fact that only a few individuals were recorded from the oxic sample. This may be a result of adaptation mechanisms of a preference for such a biotope. In suboxic sediments, nematodes with a longer body such as the above mentioned species, can overcome oxygen deficiency more easily, since they have a slow respiration rate and these conditions are in favor of slender nematodes (Braeckman et al. 2013). Terschellingia de Man, 1888 was the second most abundant genus in the hypoxic sample with the dominance of Terschellingia cf. distalamphida, which is probably a new species record for the Black Sea (unpublished data). Among the nematodes from the oxic sample, Leptolaimus seereevae (Ürkmez & Brennan 2013) Holovachov & Boström, 2013 was reported as a new species for science. The species was originally described under the genus Halaphanolaimus, but later five genera of the family Leptolaimidae have been combined under the genus Leptolaimus in the monograph of Holovachov & Boström (2013). Among the nematodes from this oxic/anoxic interface, many specimens still await detailed examinations for species identification. Our results demonstrated that severe oxygen depletion does not extremely affect nematode abundance at the oxic/anoxic interface off Sinop, a probable cause of their tolerance to hypoxic and suboxic conditions and also reduction of predation. Moreover, such conditions support the abundance of several taxa which have higher tolerance.

Direct microscopic observations of alive and actively moving ciliophorans and free-living nematodes (Sergeeva et al. 2014) provide evidence that sediments underlying a sulfidic water column can be a natural habitat for eukaryotes (i.e. metazoans: Nematoda, Polychaeta, Kinorhyncha, Rotifera, Harpacticoida, Tardigrada and protozoans: Gromida, Foraminifera, Ciliophora). These eukaryotic organisms seem to be indigenous inhabitants of the anoxic/sulfidic sediments.

However, the environmental factors and the specific physiological and biochemical processes of the benthic fauna to retain their metabolic activity and facilitate their survival are currently still unknown. Further comprehensive studies are needed as well on the distribution and taxonomic composition of meioiobenthos in sediments underlying the depth gradients from the sulfidic water column towards the maximum depths in the Black Sea. However, exploration of deep sea ecosystems remains limited due to high costs needed to work in these environments, particularly due to technological requirements. The presented data open new perspectives for the study of metazoan and protozoan life in Black Sea habitats under permanent conditions of oxygen deficiency and hydrogen sulphide availability. It has been clearly shown that eukaryotes (Metazoa and Protozoa) can live in the Black Sea under these extreme conditions.

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