POLYCHAETE RESEARCH IN THE BLACK SEA

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Abstract

The purpose of this paper is to put over the "state of the art" with regard to the knowledge of polychaetes in the Black Sea basin. Apart from a brief historical account of the study of this group in the Black Sea, the paper provides data on bionomic and depth distribution of polychaetes. In the Black Sea the polychaetes are one of the most important groups of marine organisms in terms of species richness as well as the abundance and biomass. Polychaetes are present on all types of substrate (rocky, sandy or muddy) and from the littoral fringe down to 210 m depth. Polychaetes play an extremely important role in the marine food web and especially in the feeding of demersal fishes. In the recent times it was also stressed the importance of polychaetes in the monitoring of the marine environment quality. The analysis of the polychaete assemblages can be employed with good results to assess the extent and significance of biological effects of pollution.

Résumé: La recherche sur les Annélides Polychètes de la mer Noire.

Le but de ce travail est de réaliser une synthèse sur l'état actuel des connaissances traitant les Annélides Polychètes du bassin de la mer Noire. Après un bref historique des recherches de ce groupe en mer Noire, viendra une présentation des données sur la distribution bionomique et bathymétrique des Annélides Polychètes. Dans la mer noire les Annélides Polychètes représentent l'un des groupes les plus importantes en ce qui concerne la richesse spécifique aussi que l'abondance et la biomasse. Les Annélides Polychètes sont présentes sur toutes les types des fonds (rocheux, sableux, limoneux), partant du bord de la mer jusqu'a la profondeur de 210 m. Les Annélides Polychètes jouent un rôle très important dans le réseau trophique de la mer et spécialement dans la nourriture des poissons demersaux. Dans le dernier temps il a été mis en évidence l'importance des Annélides Polychètes dans l'évaluation de la qualité de l'environnement marin. L'analyse des groupements des Annélides Polychètes peut être utilise avec des bonnes résultats dans l'évaluation de l'amplitude et de la signifiance biologique de les effets de la pollution.

Rezumat: Studiul polichetelor în Marea Neagră.

Scopul lucrării este de a realiza o sinteză asupra stadiului actual al cunoaşterii polichetelor din bazinul Mării Negre. În afara schițării unui istoric al cercetărilor asupra acestui grup în Marea Neagră, sunt prezentate date asupra răspândirii polichetelor în diferite biocenoze şi la diferite adâncimi. În Marea Neagră, polichetele reprezintă unul dintre grupurile cele mai importante atât în ceea ce priveşte diversitatea specifică, cât şi în ceea ce priveşte densitatea numerică şi biomasa. Polichetele sunt prezente pe toate tipurile de substrat (pietros, nisipos, mâlos), începând cu zona de spargere a valurilor şi până la o adâncime de 210 m. Polichetele joacă un rol deosebit de important în rețeaua trofică şi în special în hrănirea peştilor bentonici. În ultima vreme, s-a arătat importanța deosebită a polichetelor în monitorizarea calității mediului marin. Analiza asociațiilor de polichete poate fi utilizată cu rezultate bune în evaluarea amplitudinii şi semnificației biologice a efectelor poluării.

Introduction

The polychaetes are one of the most important groups of marine organisms in the benthic ecosystems. Due to their extremely wide ecological adaptations these worms are present on various types of substrate (rocky, sandy or muddy), in waters with varying salinities (from fresh water of the rivers flowing into the Black Sea to the hyper saline littoral lakes), and at all depths compatible with life in the Black Sea (from ground water of sandy beaches down to the zone contaminated with hydrogen sulphide). It is worth mentioning that in the Black Sea, polychaetes are the second most diverse group of invertebrates after the crustaceans, contributing significantly to both abundance and biomass. The facts mentioned above emphasise the importance of polychaetes in the energy flow of the Black Sea benthos.

The polychaete fauna of the Black Sea is one of the best known groups of benthic organisms, especially in some marine areas such as coasts of Crimea (Sevastopol and Karadag regions), coasts of Bulgaria and Romania, and in the north-western part of the Black Sea.

The first records concerning polychaetes from the Black Sea date back to the middle of the 19th century (Eichwald, 1830, 1841; Rathke, 1837; Marcusen, 1867). A very important contribution to the polychaete research in the Black Sea was made by Bobretzky (1868, 1870, 1872, 1881), who was concentrated on the systematic study of the polychaetes of the Gulf of Sevastopol. During the same period, Czerniavsky (1880,

1881, 1882), extended the areas of research to Yalta and Sukhumi. Other researchers who contributed to the knowledge of the polychaete fauna from Sevastopol include Pereyaslawzewa (1891), Annenkova (1924, 1925, 1929), Jakubova (1930), Kisseleva (1964a, 1964b, 1965, 1992), and Makkaveeva (1984). A series of valuable data about the ecology and distribution of Pontian polychaetes were provided by Zernov (1913).

The results of the faunistic research on polychaetes from Eastern Crimea (Karadag region) were summarised by Vinogradov (1949).

Polychaete fauna from the pre-bosphoric region of the Black Sea was studied by Jakubova (1948), La Greca (1949), Marinov (1959a), Dumitrescu (1960, 1962), Rullier (1963), and Gillet and Ünsal (2000). The only data on the polychaetes from the extended Anatolian coast of the Black Sea were recently published by Çinar and Gönlügür-Demirci (2005).

On the Bulgarian coast the faunistic studies were carried out by Valkanov (1936, 1954), Caspers (1951), and especially by Marinov (1957a, 1957b, 1959a, 1959b, 1960, 1963, 1964, 1966a, 1966b, 1967, 1968, 1971, 1977).

Polychaetes from the Romanian coast were studied by Dumitrescu (1957, 1962, 1963, 1973), Manoleli (1967, 1969, 1973, 1980), Gomoiu (1982), Ţigănuş (1986, 1988, 1992), Surugiu and Manoleli (1998-1999), Surugiu (2000a, 2000b, 2003, 2005b, 2005c, 2006a, 2008b), Paraschiv *et al*. (2001) and Surugiu and Novac (2007).

In the north-western part of the Black Sea the research on the specific composition of polychaetes was carried out by Losovskaya (1956, 1958, 1963, 1976, 1977, 1988), Vinogradov (1960), Dragoli (1962), Vinogradov and Losovskaya (1963), Losovskaya and Nesterova (1964), Vinogradov *et al*. (1967), Moroz (1985), and Kisseleva (1998).

Apart from faunistic studies, numerous authors contributed to the knowledge of various aspects of the morphology and anatomy (Bobretzky, 1873; Uljanin, 1877; Zalensky, 1882-1887; Pereyaslawzewa, 1896), reproductive biology and nutrition (Vinogradov, 1949; Kisseleva, 1957, 1959, 1970, 1972, 1975, 1981; Losovskaya, 1969, 1973, 1977; Kisseleva and Vityuk, 1970, 1970a; Dragoli, 1961, 1963), and ecophysiology of polychaetes from the Black Sea (Jakubova and Malm, 1930; Pora and Roşca, 1952; Kisseleva, 1960; Turpaeva, 1961; Losovskaya, 1961, 1962, 1978; Manoleli and Telmbici, 1970, 1973; Ivleva, 1972).

The planktonic larvae of polychaetes from the Black Sea were studied by Kisseleva (1953, 1957, 1959, 1968), Kisseleva (1965, 1967), Elian (1969), Murina (1986, 1987, 1989, 1997), Murina and Lukyanova (1990), and Murina and Subbotin (1996). Some aspects of the zoogeography of polychaetes from the Black Sea were clarified by Sowinsky (1904), Vinogradov (1947, 1949, 1970), Marinov (1968), and Surugiu (2008a). In recent years the role of polychaetes of the Black Sea as indicators of natural or anthropogenic disturbances has been emphasized (Losovskaya, 1978, 1983; Surugiu, 2005a, 2009, Surugiu & Feunteun, 2008).

Habitats

In the Black Sea the polychaetes inhabit various habitats, from littoral rocks, algal belts and sands to the muddy bottoms. Some species can be encountered on various types of sediments (euryoecious), while others are strictly confined to specific types of sediment (stenoecious). The bionomic distribution of polychaetes in the biocoenoses of the Black Sea is well know due to the studies of Zernov (1913), Arnoldi (1949), Mokyevsky (1949), Kisseleva and Slavina (1963, 1964, 1965, 1966), Băcescu *et al*. (1971), Marinov (1977), and Kisseleva (1981, 2004).

In the **supralittoral ground waters of the sandy beaches** the most characteristic species are *Stygocapitella subterranea* and *Hesionides arenaria*. The former is restricted to the ground water, while the latter, though more abundant in this biotope, occurs also in sublittoral interstitial waters. Sometimes these typical species can be accompanied by *Microphthalmus fragilis*, *Microphthalmus similis*, *Pisione remota*, *Neopetitia amphophthalma*, *Saccocirrus papillocercus*, *Protodrilus flavocapitatus*, *Nerilla antennata* and *Trilobodrilus heideri*, which are not characteristic for this habitat, but have migrated from subjacent levels (Marinov, 1963, 1971).

In the **rocky pseudolittoral zone** the only polychaete that can tolerate waves and exposure to air is *Janua pagenstecheri* (Vinogradov, 1949), it occurs under stones, where can reach an abundance of few thousands individuals per m^2 (Marinov, 1964). Sometimes vagile polychaetes like *Eteone picta*, *Salvatoria clavata*, *Platynereis dumerilii*, *Perinereis cultrifera*, *Scolelepis squamata* can be found in the pseudolittoral rocks crevices or in interstices of mussel *Mytilaster lineatus* colonies (Arnoldi, 1949; Manoleli, 1967; Surugiu, 2008b). *Namanereis littoralis* is abundant under isolated stones overlying medium and coarse grained sand and limited to the upper pseudolittoral zone and can reach 120,100 ind.m^{-2} abundance, which corresponds to a biomass of 437.6 g.m^{-2} (Surugiu, 2000a).

In fine, quartzose-micoceous pseudolittoral sands of the north-western part of the Black Sea there are no typical elements. The species that occur here**,** such as *Scolelepis squamata*, *Spio decoratus*, *Alitta succinea* and *Capitella minima*, originate from sublittoral sandy bottoms (Manoleli, 1967; Băcescu *et al*., 1967a, 1968; Surugiu, 2008b).

40 years ago, the most typical species in clean **coarse pseudolittoral sands** in the north-western part of the sea (Karkinitsky bay, Romanian and Bulgarian coasts) was the polychaete *Ophelia bicornis*. This polychaete was associated with the bivalve *Donacilla cornea* making up the characteristic *Donacilla cornea* - *Ophelia bicornis* community. The abundance of *Ophelia bicornis* in this community reached 4400 ind.m^{-2} and 394.0 g.m^{-2} (Mokyevsky, 1949). In sheltered areas of the western coast of Crimea these species are accompanied by *Microspio mecznikowianus* with extremely high densities and biomasses - up to 5080 ind.m^{-2} and up to 45.7 g.m^{-2} (Arnoldi, 1949). Other species occurring in the surf zone are *Scolelepis squamata*, *Microphthalmus fragilis*, *Syllides longocirratus*, *Protodrilus flavocapitatus* and *Nerilla antennata* (Băcescu *et al*., 1967a). Now the coarse sands are characterised by the predominance of populations of *Saccocirrus papillocercus*, *Hesionides arenaria* and *Pisione remota* (Surugiu, 2006a).

The **sublittoral rocky bottoms**, covered by a rich epibiosis of algae, mussels and barnacles, offer favourable conditions for the development of a rich and diversified polychaete fauna. This type of bottom, descending down to 17 m depth, is occupied by the biocoenosis of rocky mussels. The mean density of polychaetes on hard sublittoral substrate is 8752 ind.m^{-2} and the mean biomass is 27.3 g.m^{-2} (Surugiu, 2003).

The thin layer of detritus and sand settled on the surface of horizontal surfaces of rocks in shallow water is inhabited by numerous small polychaetes like *Fabricia stellaris* (up to 74,784 ind.m^{-2}), *Salvatoria clavata* (up to 14,315 ind.m^{-2}) and *Exogone naidina* (up to 9,351 ind.m^{-2}) (Băcescu *et al*., 1963). The polychaete *Polydora websteri* bores into the limestone and shells of molluscs forming characteristic U-shaped galleries. The abundance of this species can reach 132,500 ind.m^{-2} (Surugiu, 2008b). Another species that bores into rocks are *Lysidice ninetta*. *Sabellaria taurica*, *Vermiliopsis infundibulum* and *Janua pagenstecheri* which is living in calcareous tubes attached to rocks and shells of molluscs or crabs.

The interstices of the mussels' colonies are inhabited by a large number of onfaunal vagile species such as *Nereis zonata*, *Harmothoe impar*, *Nereiphylla rubiginosa*, *Nereiphylla nana*, *Alitta succinea*, *Syllis prolifera*, *Eumida sanguinea*, *Pterocirrus limbata*, *Nereiphylla paretti*, *Harmothoe imbricata*, *Pholoe inornata*, *Polyophthalmus pictus*, *Syllis gracilis* and *Eulalia clavigera* (Marinov, 1959; Băcescu *et al*., 1963; Dumitrescu, 1962, 1973; Manoleli, 1967, 1969). The small syllids, *Nereis zonata*, *Perinereis cultrifera* and *Platynereis dumerilii*, find shelter in the crevices of rocks. Many polychaetes (*Syllis gracilis*, *Haplosyllis spongicola*, *Nereis zonata*, and *Polydora* sp.) also live as commensals in the sponges and ascidians (Manoleli, 1967; Marinov, 1977).

At greater depth, where the proportion of small particles on hard bottom increases, infaunal polychaetes such as *Eteone picta*, *Prionospio multibranchiata*, *Capitella minima* and *Heteromastus filiformis* appear.

Algae provide a suitable shelter and food for many polychaetes (52 species). Though this microhabitat is generally inhabited by the same species as hard substrates, the substrate covered by luxuriant vegetation presents a series of distinctive features. Thus, in terms of biomass the dominant polychaete species associated with the thalli of *Cystoseira barbata* are *Platynereis dumerilii* and *Nereis zonata*. The highest densities in the *Cystoseira* belt are achieved by *Salvatoria clavata* (up to 20,550 ind.m^{-2}), *Platynereis dumerilii* (up to 17,000 ind.m^{-2}), *Exogone naidina* (up to 15,875 ind.m^{-2}) and *Pionosyllis pulligera* (up to 10,625 ind.m^{-2}) (Çinar & Gönlügür-Demirci, 2005). Other, less common but characteristic, inhabitants of algal thalli are *Syllis gracilis*, *Syllis hyalina*, *Syllis prolifera*, *Pholoe inornata*, *Perinereis cultrifera*, *Harmothoe impar*, *Nereiphylla rubiginosa*, *Eumida sanguinea* and *Polyophthalmus pictus* (Manoleli, 1967; Makkaveeva, 1984). *Sabellaria taurica*, *Janua pagenstecheri* and *Pileolaria militaris* attach their tubes to the thalli of *Cystoseira*. On *Phyllophora* the dominant species are *Harmothoe impar* and *Pileolaria militaris* (Makkaveeva, 1984).

The **sublittoral sands** are distributed in the Black Sea area down to 18-30 m depth. A total of 76 polychaete species were identified on the Bulgarian Black Sea coast in the sublittoral sands (Marinov, 1977). Different polychaete communities can be identified within the sublittoral sands depending on the size of the sand grains.

The north-western part of the Black Sea fine sublittoral sands are characterized by the biocoenosis with *Lentidium mediterraneum*. This community extends down to 20-22 m depth. On the Romanian coast, 27 species were reported from these sands (Băcescu *et al*., 1967). The average density of polychaetes recorded here is 1184 ind.m^{-2} and the average biomass is 2.3 g.m^{-2} (Surugiu, 2008b). On this type of sediment the most common polychaete species is *Spio decoratus* (frequency 73%). This typical psammobiotic species reaches an abundance of 86,300 ind.m^{-2} and a biomass of 60.0 g.m^{-2} (Băcescu *et al*., 1971). The accompanying species, typical for this biotope, are *Nephtys cirrosa*, *Micronephthys stammeri*, *Glycera alba*, *Capitella minima*, *Clymenura clypeata*, *Eteone picta*, *Pygospio elegans*, *Scolelepis squamata*, *Magelona minuta*, *Magelona mirabilis*, *Glycera tridacyla*, *Hediste diversicolor*, *Microspio meczniko-wianus* and *Aonides paucibranchiata* (Dumitrescu, 1963; Marinov, 1977). At greater depth, in the sandy muds, psammophilic species are accompanied by illiophilic species such as *Aricidea claudiae*, *Nephtys hombergii*, *Pectinaria koreni*, *Heteromastus filiformis* and *Prionospio multibranchiata*. Recently the populations of *Polydora cornuta* (up to 18,129 ind.m^{-2}), *Alitta succinea* (up to 8120 ind.m^{-2}) and *Capitella capitata* (up to 4859 ind.m^{-2}) have increased considerably in these sands due to the harmful effects of eutrophication (Ţigănuş, 1986, 1988, 1992).

The coarse sands community with *Amphioxus* is present from 6 to 28 m depth, where coarse clean sand is mixed with gravel and shell debris. Here 36 species of polychaetes, with an average density of 1318 ind.m^{-2} and average biomass of 5.9 g.m^{-2}, were found (Marinov, 1977). The most characteristic species for this community are *Protodorvillea kefersteini* (frequency 81%), *Ophelia limacina*, *Polygordius neapolitanus ponticus*, *Nephtys cirrosa*, *Aonides paucibranchiata*, *Glycera tridactyla* and *Polycirrus jubatus*. Other common species include *Protodrilus purpureus*, *Spio decoratus*, *Prionospio multibranchiata*, *Capitella minima*, *Hesionura coineaui*, *Streptosyllis varians* and *Paradoneis armata*. Typical, but rarely encountered, are *Microphthalmus fragilis*, *Magelona minuta* and *Goniadella bobretzkyi*. The most abundant species are *Protodorvillea kefersteini* (556 ind.m^{-2}), *Polygordius neapolitanus ponticus* (197 ind.m^{-2}) and *Aonides paucibranchiata* (114 ind.m^{-2}), but the biomass is dominated by *Ophelia limacina*, *Spio decoratus*, *Polycirrus jubatus* and also *Polygordius neapolitanus*.

33 species were identified in *Zostera* meadows which 30 years ago formed isolated patches of several metres squared on muddy-sandy substrates at 0.5 to 5 m depth (Makkaveeva, 1984). Now the surfaces occupied by *Zostera* are much reduced. The most common polychaete species associated with leaves of the eelgrass is *Janua pagenstecheri*. *Perinereis cultrifera* and *Platynereis dumerilii* also attach their mucous tubes to the blades of eelgrass. The interstices formed by the rhizomes of *Zostera* frequently harbour species such as *Hediste diversicolor*, *Nereiphylla rubiginosa*, *Eteone picta*, *Pectinaria koreni*, *Eumida sanguinea*, *Polyophthalmus pictus*, *Alitta succinea*, *Salvatoria clavata*, *Exogone naidina*, *Nephtys hombergii*, *Glycera tridactyla* and *Amphiglena mediterranea* (Dumitrescu, 1957, 1973; Manoleli, 1967; Makkaveeva, 1984).

On the western coasts of Crimea muddy sands mixed with shell debris at 10-40 m depth are represented by the *Micronephthys stammeri* community. The abundance of the dominant *Micronephthys stammeri* reaches 2000 ind.m^{-2} and 1.0 g.m^{-2} (Kisseleva & Slavina, 1964). In addition to these common species, infaunal species such as *Glycera tridacyla*, *Pygospio elegans*, *Aricidea claudiae*, *Notomastus profundus*, *Clymenura clypeata* and *Terebellides stroemii* are also present. Here species such *Harmothoe impar*, *Pholoe inornata*, *Nereiphylla rubiginosa*, *Exogone naidina*, *Nereis zonata*, *Platynereis dumerilii* and *Eunice vittata* are confined to hard substrates, represented by the shells of dead or alive molluscs.

In open areas the sublittoral muddy sediments usually occupies depths greater than 20 m. Several polychaete communities have been distinguished on muddy sediments depending on depth.

Enclaves of silt with *Nephtys hombergii* occur in limited areas between 12 and 22 m depth at the mouths of the Danube River. The loose pelitic mud with a high organic content is favourable for populations of polychaetes, especially for *Nephtys hombergii*. This dominant species is accompanied by *Alitta succinea*, *Harmothoe impar*, *Nereiphylla rubiginosa*, *Heteromastus filiformis* and *Melinna palmata*. The maximum density of polychaetes on this sediments is 3800 ind.m^{-2} and the maximum biomass is 104.4 g.m^{-2} (Băcescu *et al*., 1971).

The *Aricidea claudiae* community was described on the western and southern coasts of Crimea on muddy and muddy-sandy substrates situated at 22-55 m depth. The abundance of *Aricidea claudiae* can reach a maximum of 22,000 ind.m^{-2} and a maximum biomass of 7.0 g.m^{-2} (Kisseleva & Slavina, 1964). Apart from the most abundant species

in this community, the following polychaetes were identified: *Sphaerosyllis bulbosa*, *Nephtys cirrosa*, *Capitella capitata*, *Terebellides stroemii*, *Nereiphylla rubiginosa*, *Eteone picta*, *Harmothoe imbricata*, *Harmothoe impar*, *Pholoe inornata*, *Glycera tridactyla*, *Nephtys hombergii* and *Magelona minuta* (Kisseleva & Slavina, 1963, 1964).

The biocoenosis of the coastal silt with *Melinna palmata* was described from the north-western part of the Black Sea (between Odessa and Tendra), from Bulgarian (Varna Bay) and Caucasian coasts at depths of 12-40 m on loose mud (Losovskaya, 1956, 1977; Marinov, 1964). This community is relatively poor in terms of species-richness, with only 18 species identified (Marinov, 1977). The populations of *Melinna palmata* are dominant with an average abundance of 2,331 ind.m^{-2} and an average biomass of 73.2 g.m^{-2}. The maximum density of this species can exceed 17,700 ind.m^{-2} with a maximum biomass of 570.0 g.m^{-2} (Gomoiu, 1982). The most characteristic species for this community are the illiophilic polychaetes *Melinna palmata*, *Nephtys hombergii*, *Aricidea claudiae*, *Micronephthys stammeri*, *Pectinaria koreni*, *Glycera alba*, *Capitella capitata* and *Heteromastus filiformis*. However, psammophilic species such as *Scolelepis squamata*, *Spio decoratus*, *Prionospio multibranchiata*, *Priomospio steenstrupi*, *Pygospio elegans* and *Protodorvillea kefersteini* can also be found here. The average density of polychaetes on these bottoms at Bulgarian coast is 465 ind.m^{-2} and average biomass is 4.9 g.m^{-2} (Marinov, 1977).

The biocoenosis of the silt with *Mytilus galloprovincialis* is one of the well delimited and most characteristic associations of the Black Sea. It occupies a belt around the sea between 25-45 and 48-70 m depth, but is present in its most typical form between 50-65 m depth. Here 40 species were identified. The average density of polychaetes in the mytilous silt is 377 ind.m^{-2} and the average biomass is 15.0 g.m^{-2} (Marinov, 1977). Onfauna is represented by vagile species like *Phyllodoce maculata*, *Nereiphylla rubiginosa*, *Nereiphylla paretti*, *Harmothoe impar*, *Harmothoe imbricata* and *Nereis zonata*. The infaunal polychaetes are dominated by *Aricidea claudiae*, *Nephtys hombergii*, *Hediste diversicolor*, *Capitella minima*, *Terebellides stroemii*, *Melinna palmata*, *Micronephthys stammeri*, *Heteromastus filiformis*, *Prionospio multibranchiata*, *Sphaerosyllis bulbosa*, *Notomastus profundus*, *Pectinaria koreni, Protodrilus flavocapitatus* (Băcescu *et al*., 1971; Losovskaya, 1977). The most abundant is *Aricidea claudiae* which can attain densities of 3796 ind.m^{-2}. The sessile polychaetes are represented by *Pomatoceros triqueter* and *Janua pagenstecheri* which attach their tubes to the shells of mussels.

38 species were identified in the Zerov's *Phyllophora* field, located in the north-western part of the Black Sea at 20-60 m depth (Manoleli, 1973; Makkaveeva, 1984). The mean abundance of polychaetes in *Phyllophora* thickets is 170 ind.m^{-2} and the mean biomass is 2.0 g.m^{-2} (Vinogradov *et al*., 1967). The more or less constant onfaunal species are *Harmothoe impar* (2130 ind.m^{-2}), *Harmothoe imbricata*, *Harmothoe extenuata*, *Pholoe inornata*, *Nereiphylla rubiginosa*, *Nereiphylla nana*, *Eulalia clavigera*, *Nereis zonata*, *Hediste diversicolor*, *Perinereis cultrifera* and *Eunice vitatta*. The most commonly encountered infaunal polychaetes are *Nephtys hombergii* (up to 1260 ind.m^{-2}), *Protodrilus flavocapitatus* (up to 1130 ind.m^{-2}), *Terebellides stroemii* (up to 140 ind.m^{-2}), *Pectinaria koreni* (up to 30 ind.m^{-2}), *Prionospio multibranchiata* and *Euclymene collaris*. The epiphytic fauna is represented by *Pomatoceros triqueter*, *Janua pagenstecheri* and *Pileolaria militaris*, which attach their tubes to the thalli of *Phyllophora*. The last species can reach an abundance of 50,000 ind.m^{-2} (Losovskaya, 1977). It is worth mentioning that the individuals of *Harmothoe impar* which normally have brownish-green colour, in the *Phyllophora* field are brownish-red, homochromic with the thalli of this alga (Vinogradov *et al.*, 1967).

The biocoenosis of the silt with *Terebellides stroemii* is situated between 40-50 m and 60-65 m depth at the southern part of the Bulgarian littoral, at Karadag and Caucasus (Zernov, 1913). The leading species - *Terebellides stroemii* - has an average density of 1330 ind.m^{-2} in this community (Marinov, 1977). In addition to this dominant species, infaunal polychaetes are represented by *Oriopsis armandi*, *Nephtys hombergii*, *Micronephthys stammeri*, *Aonides oxycephala*, *Prionospio steenstrupi*, *Aricidea claudiae*, *Caulleriella bioculata*, *Heteromastus filiformis*, and *Notomastus profundus* (Kisseleva & Slavina, 1965, 1966). Onfaunal polychaetes such as *Nereiphylla rubiginosa* and *Harmothoe impar* live among molluscs.

The biocoenosis of the silt with *Modiolus phaseolinus* occupies depths of 50-70 m and reaches 150-180 m, with its most typical aspect situated at 58-90 m depth. Polychaete fauna of phaseoline silt is relatively poor - 26 species. The most characteristic polychaetes are *Terebellides stroemii*, *Oriopsis armandi*, *Heteromastus filiformis*, *Nephtys hombergii*, *Notomastus profundus*, *Aricidea claudiae*, *Micronephthys stammeri*, *Prionospio multibranchiata*, *Nereiphylla rubiginosa*, *Phyllodoce maculata*, *Phyllodoce mucosa*, *Harmothoe impar*, *Sphaerosyllis bulbosa*, *Exogone naidina*, *Syllides* sp., *Pholoe inornata*, *Aonides oxycephala*, *Aonides paucibranchiata*, *Protodrilus* sp., *Prionospio*

steenstrupi, *Capitella capitata*, *Galathowenia* sp., *Sternaspis scutata*, *Melinna palmata*, *Pomatoceros triqueter* and *Janua pagenstecheri* (Băcescu *et al*., 1971; Losovskaya, 1977; Marinov, 1977). The number of species and, especially, the number of individuals of infaunal polychaetes exceed that of onfaunal polychaetes. The most abundant species on silts with *Modiolus* are *Oriopsis armandi*, which has a density of up to 4000 ind.m^{-2}, *Terebellides stroemii* (up to 1190 ind.m^{-2}), *Heteromastus filiformis* (up to 1850 ind.m^{-2}) and *Melinna palmata* (up to 360 ind.m^{-2}) (Kisseleva & Slavina, 1964, 1965).

Four species of polychaetes do not occur in the Black Sea itself, but are present in the littoral lakes, river mouths and estuaries. Three of them, namely *Hypania invalida*, *Hypaniola kowalewskii* and *Manayunkia caspica*, live in completely fresh water littoral lakes and in rivers flowing into the sea (Danube, Nistru/Dinestr, and Nipru/Dniepr) (Russev & Marinov, 1964; Manoleli, 1975). *Streblospio benedicti* occurs, with a maximum abundance 2854 ind.m^{-2} (Manoleli, 1980), only in the brackish water littoral lakes of the north-western part of the Black Sea with extremely low salinities (0.2-3.2‰). The most frequent and abundant polychaetes in littoral lakes, marshes and estuaries are *Alitta succinea* and *Hediste diversicolor*, which can tolerate salinities ranging from 0.14 to 36‰ (Losovskaya, 1963; Marinov, 1977). Less common in waters with varying salinity are *Polydora cornuta*, *Nephtys hombergii*, *Spio decoratus*, *Harmothoe imbricata*, *Capitella minima*, *Aricidea claudiae*, *Pectinaria koreni*, *Eumida sanguinea* and *Ficopomatus enigmaticus* (Marinov, 1966; Losovskaya, 1977; Manoleli, 1980; Moroz, 1985).

Generally speaking, the polychaetes of the Black Sea represent more than 50% of the macrozoobenthos in terms of number of individuals and 18.6% in terms of the total biomass (Băcescu *et al*., 1971).

Vertical zonation

In the Black Sea the polychaetes inhabit the whole continental shelf, from the surf zone down to the hydrogen sulphide layer. The maximum depth at which polychaetes (*Exogone naidina* and *Nephtys hombergii*) were found in the Black Sea is 210 m (Băcescu, 1963). In the Prebosphoric region, due to the downwelling current from the Bosphorus Strait, with more saline and hence denser water, polychaetes occur at greater depths. Thus, *Nephtys inermis* was found here at 480 m depth (Gillet & Ünsal, 2000). Generally, the number of polychaetes decreases with depth, with the maximum species diversity occurring in the first 30 m (Losovskaya, 1977).

According to the vertical distribution, polychaetes can be divided into the following groups:

1. Bathophylic species, found only at depths exceeding 100 m. In the Black Sea the only species in this catergory is *Vigtorniella zaikai*, which was found only in the oxic-anoxic layer at depths between 117 and 151 m (Sergeeva & Zaika, 2000).

2. Eurybathic species, which occur at depths between 0 m and more than 100 m, down to the external limit of the shelf. These include *Exogone naidina* (0-210 m), *Nephtys hombergii* (0-210 m), *Terebellides stroemii* (2.5-178 m), *Syllides longocirratus* (0-170 m), *Melinna palmata* (0-162 m), *Phyllodoce maculata* (0-160 m), *Protodrilus flavocapitatus* (0-160 m), *Oriopsis armandi* (10-150 m), *Aonides paucibranchiata* (0-125 m), *Notomastus profundus* (10-125 m), *Nereiphylla rubiginosa* (0-110 m), *Sphaerosyllis bulbosa* (0-105 m), *Clymenura clypeata* (0-103 m), *Micronephthys stammeri* (0-100 m) and *Heteromastus filiformis* (0-100 m).

3. Species that live at depths between 0 and 90 m and which are typical inhabitants of muddy bottoms: *Nephtys cirrosa*, *Aricidea claudiae*, *Prionospio steenstrupi*, *Alitta succinea*, *Polydora cornuta*, *Capitella minima*, *Pholoe inornata*, *Harmothoe impar*, *Eteone picta* and *Pomatoceros triqueter*.

4. Species occurring down to the 30-40 m izobath and which are usually confined to sandy or rocky bottoms: *Syllis hyalina*, *Hediste diversicolor*, *Platynereis dumerilii*, *Nereis zonata*, *Perinereis cultrifera*, *Dorvillea rubrovittata*, *Prionospio multibranchiata*, *Pygospio elegans*, *Glycera tridactyla*, *Sabellaria taurica*, *Pectinaria koreni*, *Eulalia clavigera*, *Parascolelepis tridentata*, *Polyophthalmus pictus*, *Lysidice ninetta*, *Glycera alba*, *Micronephthys stammeri*, *Spio decoratus*, *Salvatoria clavata*, *Polygordius neapolitanus*, *Fabricia stellaris*, *Ophelia limacina* and *Pileolaria militaris*.

5. Species limited in their vertical distribution to the surf zone: *Syllis variegata*, *Microphthalmus fragilis*, *Namanereis littoralis*, *Hesionides arenaria*, *Stygocapitella subterranea*, *Ophelia bicornis*, *Saccocirrus papillocercus*, *Spirobranchus tetracerus* and *Nainereis laevigata*.

The vertical distribution is determined largely by the distribution of types of sediment (Vinogradov, 1949). Thus, the distribution of psammophilic and lithophilic species is limited by the distribution of sandy and rocky bottoms down to 30-40 m depth, whereas the distribution of illiophilic species such as *Melinna palmata*, *Nephtys hombergii* or *Terebellides stroemii* is determined by the distribution of muddy bottoms.

The role of polychaetes in the food chain

The polychaetes play an important role in the nutrition of fishes, both benthic and pelagic. They have a high caloric content, being almost integrally ingested and digested, except for the chitinous structures such as cuticle, setae, paragnaths or jaws. Of lesser nutritional value are polychaetes living in tubes (pectinariids, ampharetids, sabellids, serpulids and spirorbids) or species whose digestive tract is full of swallowed sand or mud (maldanids, opheliids and capitellids).

The pelagic larvae of nereidids and spionids, along with planktonic crustaceans, are consumed by the planktophagic fish such as anchovy (*Engraulis encrasicholus ponticus*) and sprat (*Sprattus sprattus phalericus*) (Vinogradov, 1948; Marinov, 1977). However, adult polychaetes make up a larger proportion of the diet of fishes, especially the mass species. These are consumed by almost all adult benthophagic fishes (Vinogradov, 1949; Marinov, 1977; Surugiu, 2006b).

Of the fish examined, the red mullet (*Mullus barbatus ponticus*) feeds on the widest range of polychaetes. For example, Vinogradov (1948) reports 15 species and Marinov (1977) 13 species. In the near-shore areas the most commonly consumed polychaetes by this fish are *Capitella giardi*, *Scolelepis squamata* and *Alitta succinea*, which made up 33.6% of the total ingested food (Kaneva-Abadjieva & Marinov, 1960). In the off-shore areas the polychaetes represent 19.7% of the stomach volume, with the most frequently encountered in the stomach being *Nephtys hombergii* and *Terebellides stroemii* (Kaneva-Abadjieva & Marinov, 1961). At the mouths of the Danube the red mullet feeds mainly on *Spio decoratus*, which represents 1.3-11.5% of the ingested food (Băcescu *et al*., 1965).

Polychaetes form an important component of the diet of the flounder (*Pleuronectes flesus luscus*). For example, Kaneva-Abadjieva and Marinov (1960) identified 7 species of polychaetes in the stomach of flounder. This represented 49.9% of the ingested food. The most important species were *Scolelepis squamata*, *Capitella giardi* and *Arenicola marina*. Similarly, Băcescu *et al*. (1965) frequently found *Arenicola marina* and various nereidids and spionids in the stomachs of flounder from the Romanian coast.

Karapetikova (1962) found that on the Bulgarian coast, polychaetes made a smaller contribution to the diets of adult turbot (*Scophthalmus maeoticus*) than they did to that of the juveniles. The polychaetes were found in 41.4% of the analysed stomachs,

making up 12.8% of the ingested food. Similarly, Băcescu *et al*. (1967) found that on the Romanian coast the food of the adult turbot was made up mainly of *Nephtys cirrosa* and *Arenicola marina*, while juveniles fed mainly on *Spio decoratus*.

Pesev (1964) found that polychaetes represent 60.6% of the volume of the food ingested by the sole (*Solea lascaris nasuta*). The most frequently consumed polychaetes were *Scolelepis squamata* and *Pygospio elegans*. The same results were obtained by Băcescu *et al*. (1967) who found that *Spio decoratus* represents 30-50% of the stomach volume of the sole on the Romanian coast.

The goby, *Gobius niger*, fed on 10 species which made up 20.6% of the stomach contents. The polychaetes were found in 23.7% of the analysed stomachs, with the most frequent component of the food being *Arenicola marina* (Kaneva-Abadjieva & Marinov, 1963). Similarly, polychaetes represent 21.4% of the total stomach contents of gobies of the genus *Pomatoschistus*. By contrast, only 3 species of polychaetes were identified in the stomachs of another goby *Neogobius melanostomus*.

Nephtys hombergii and *Melinna palmata* play an important role in the nutrition of the adult sturgeons of the north-western part of the Black Sea (Vinogradov, 1948; Losovskaya, 1956; Dragoli, 1960).

Seven species were identified in the stomachs of *Odontogadus merlangus euxinus*, representing 4.7% of the total volume of ingested food (Kaneva-Abadjieva & Marinov, 1960).

Despite the fact that anchovy is known as planktophagic fish, it also actively feeds on adults of *Alitta succinea* (Surugiu, 2006b). This is due to the swarming of the heteronereid stages which rise up into the water column during reproduction. The same fact was reported by Stark (1959) for populations of *Alitta succinea* sampled in the Sea of Azov.

Polychaetes as bioindicators

In the last few decades polychaetes have been proved to be good indicators of the quality of the marine environment (Losovskaya, 1978, 1983; Surugiu**,** 2000a, 2005a, 2009; Surugiu & Feunteun, 2008). The analysis of the polychaete assemblages can be employed with good results to assess the extent and significance of biological effects of pollution. Many polychaetes are resistant to pollution. They include a large number of so-called opportunistic species - species capable of rapid colonisation in strongly disturbed habitats. These opportunistic species characterize the degree

of pollution of water and sediments with organic matter, because they develop in large numbers under conditions that reduce community complexity in the waters subjected to pollution and eutrophication. In the Black Sea the main opportunistic species are *Alitta succinea*, *Polydora cornuta*, *Polydora websteri* and *Capitella capitata* (Zernov, 1913; Losovskaya, 1978, 1988; Surugiu, 2005a, 2009; Surugiu & Feunteun, 2008). Another category of bioindicators is represented by so-called sensitive or nontolerant species, which respond negatively to the increased levels of organic pollution. Examples of such sensitive species in the Black Sea are *Perinereis cultrifera*, *Nereis zonata*, *Syllis gracilis*, *Syllis hyalina*, *Eulalia clavigera* and *Nereiphylla rubiginosa* (Losovskaya, 1988; Surugiu, 2005a, 2009; Surugiu & Feunteun, 2008).

Losovskaya (1977, 1978) showed that the almost complete absence of epibenthic species such as *Nereiphylla rubiginosa*, *Harmothoe impar* and *Pomatoceros triqueter* could be used as an indicator of the disturbance of the biocoenosis of mud with *Mytilus galloprovincialis* in the north-western part of the Black Sea. This reduction in the species composition of polychaetes was a consequence of the mass mortality of benthic organisms caused by hypoxia and anoxia in the 1990's. An indicator of the recovery of this community is the increase in the proportion of small-bodied deposit-feeding species such as *Spio decoratus*, *Polydora cornuta*, *Prionospio multibranchiata*, *Capitella capitata*, and *Capitella minima*. As the muddy mussel biocoenosis further recovers the relative number of epibenthic species increases, at the expense of small detritivorous polychaetes.

A large number of polychaetes contribute actively to the natural self-purification process. For instance, Gomoiu (1982) deduced the fact that the populations of *Melinna palmata* from the Romanian Black Sea shelf are able to process up to 4.8-9.6 kg of mud/m^2/day. Manoleli (1975) estimated that the facultative suspension-feeding polychaeta species *Hypania invalida* filters in an interval of 24 hours a quantity of sediment which exceeds 9-10 times the volume of the animal itself.

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