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MEIOFAUNA OF THE UKRAINIAN SHELF OF THE BLACK SEA

Main Research Results 1973–2024

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Until 1973, information on meiobenthos as a distinct category of benthic organisms on the northwestern shelf of the Black Sea was missing. For the first time for the Ukrainian shelf of the Black Sea, lists of species of the main groups of meiobenthos (Foraminifera, Nematoda, Harpacticoida, Ostracoda, Kinorhyncha, Halacaridae, Polychaeta) are given. The features of the formation of total abundance and biomass of the permanent and temporary components of the meiobenthos on various types of bottom substrate, the influence of temperature and oxygen conditions are described, the long-term dynamics of these indicators is described. For the first time for the Black Sea, the monograph presents the results of studies of the features of biodiversity and the formation of quantitative indicators of the meiofauna in the contour biotopes of the contact zones of the Black Sea. Examples of the use of meiobenthos indicators in monitoring the quality of the marine environment of various water areas are given.

The book can be useful for hydrobiologists, ecologists, teachers and students of biological faculties of higher education institutions.

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Ukrainian Black Sea Shelf.
Main Research Results of the study of the meiofauna of the Ukrainian shelf of the Black and Asov Seas (1973–2024).

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FOREWORD

The study of the meiofauna of the Ukrainian shelf of the Black Sea was started in the Odesa branch of the Institute the Institute of Marine Biology of the National Academy of Sciences of Ukraine in 1973. In February of this year, Acad. Yu.P. Zaitsev invited Ph.D. Vorobyova L.V. to work in the Department of Hydrobiology. Vorobyova L.V. at that time worked at the Odesa National University name I.I. Mechnikov and defended her candidate's dissertation on zooplankton of the northwestern part of the Black Sea. At that time, in the Institute had a well-staffed group of professional zooplanktonologists. The same picture was typical for the macrozoobenthos group. During this period having information about the intensive study of marine meiofauna by scientists from various countries in the 1960–1970s. The author of this monograph decided to join scientists from Bulgaria, Romania and Ukraine (Sevastopol) in studying the meiofauna of the Black Sea. Meiofauna as a unique community of marine organisms has not been studied in our Institute before. As in other Seas, our studies were initially conducted in the coastal zone (pseudolittoral and supralittoral) of sandy beaches.

Already in February–March 1973, Ph.D. Vorobyova L.V took the first samples from the pseudolittoral zone of the sandy beach "Chernomorka" (Odesa Bay). The luck was that the natural beach sediments had a coarse-grained structure. Even in winter, many different invertebrates up to 2 mm in size lived in the sand. Previously, the researcher believed that representatives of zooplankton are minimal in size compared to other marine invertebrates. After looking at the first samples, it became clear to her that it was now necessary to study marine representatives whose body sizes would range from several tens of microns to two mm. Over seven years of research, more than 2,300 quantitative samples were collected and processed regularly and monthly (Vorobyova, Zaitsev, Kulakova, 1992). The peculiarity of our research consisted in long-term (8 years) regular monthly (spring, summer, autumn and winter) collection of quantitative samples on three sandy beaches with different granulometric composition of beach sediments. Samples were

collected strictly in the same morning hours on the pseudolittoral (two microhorizons) and supralittoral (5–7 microhorizons depending on the distance from the water's edge). Such research on the Black Sea has not been previously reported.

It was a great success to come to work in our department student 4th year I.I. Kulakova (Department invertebrate animals ONU). She continues to operate successfully to this day. For the first two years, she studied soil mites in beach sediments. Successful research made it possible at further substantiate the biotope of sandy beaches as a mixing zone of three different faunas: marine, freshwater and soil, which is typical for the ecotones of marine bodies of water. Throughout the study of interstitial meiofauna, monthly sampling was carried out by L.V. Vorobyova. and Kulakova I.I. The faunal composition of the interstitial meiofauna of sandy beaches required species identification by more than one specialist. In terms of the number of species, nematodes predominated, which I.I. Kulakova has been successfully studying for all fifty years. The faunal list of species of Harpacticoida, Halacaridae, Kinorhyncha and Gastrotricha given by L.V. Vorobyova. Ostracoda of the sandy beaches of the Odesa Bay were identified by Dr. A.L. Kovalenko. Data on other meiofauna taxa are presented within the framework of their quantitative characteristics.

During the same period (1973–1980), we conducted to study species diversity, the spatial distribution of seasonal population dynamics, and the dependence of the population density of sea mites on various types of substrates in the coastal zone of the Odesa region. The collection of material in the upper sublittoral zone was carried out by student ONU Yaroshenko N. for two years. Primary processing of samples and production of permanent preparations of Halacaridae was also carried out by her. Species identification – L.V. Vorobyova. The results of the first study of Halacaridae for the northwestern part of the Black Sea are given in Chapter 2.

Long-term observations of the ecological characteristics of the meiofauna of sandy beaches are the first research stage of studying the meiofauna of the northwestern shelf of the Black Sea. In the future, it was

necessary to move on to research on the northwestern shelf. Its water area, as is known, differs significantly in its hydrological and hydrochemical characteristics from other areas of the Black Sea. The role of meiofauna in the nutrition of larvae and juvenile fish has already been formulated in the world literature. Moreover, in the most productive zone of the Black Sea, it was necessary to obtain data not only on the general ecological characteristics of meiobenthic, but also on its role in the formation of the food supply for fish in the benthic and benthic complexes. By this time there was already information about the meiobenthic of the Crimean and Caucasian waters (Kiseleva; Kiseleva, Slavina).

Since 1982, sampling began on board the R/V «Miklucho Maclay» in complex expeditions. Sampling was carried out in the waters of the northwestern shelf in the period 1982 to 1998. All years (spring, summer and autumn) were sampled using a standard station grid. The grid was designed to provide representative samples for elucidating the influence of the Danube, Dniester, and Dnieper rivers flows on the formation of qualitative and quantitative characteristics of the meiobenthos. Spatial distribution patterns and seasonal dynamics were studied, key taxa in total abundance and biomass were identified, and other aspects were explored. Considerable attention was paid to the meiobenthos of bays (Odesa, Yegorlytsky, Karkinitsky, and Zhebryanskaya Bay) and estuaries (Grigoryevsky, Sukhoi, and Tiligulsky). Sampling schemes for each specific region are provided below in the relevant chapters of the monograph. The second multi-year stage of a comprehensive study of the formation of qualitative and quantitative characteristics of meiobenthos on the Ukrainian shelf of the Black Sea has begun. Since then and throughout all the decades up to the present time, the study of the meiofauna of the Ukrainian shelf of the Black Sea has been ongoing. All collections of quantitative material took place exclusively in complex expeditions. Data on hydrology, hydrochemistry, macrozoobenthos, and the development of phytoplankton in the surface layers of the sea allowed us to successfully study the ecology of the meiobenthos.

Much attention (1990–2018) at the Institute of Marine Biology was paid to the study of the meiobenthic community of organisms of the Black Sea estuaries (Grigoryevsky, Sukhoi, Tiligulsky and others). Other hydrological and hydrochemical characteristics of the ecosystems of these reservoirs made it possible to obtain interesting and important comparative data with the ecosystem of the NWBS, which also had applied meaning.

The greatest contribution to the study of the ecological characteristics of the meiobenthos at the level of large taxa was made L. V. Vorobyova: Halacaridae, Gastrotricha, Kinorhyncha, Foraminifera. Expeditionary collections of material allowed L.V. Vorobyova in collaboration with Dr. Sc., Prof. V.V. Yanko obtain data on the species composition of Foraminifera both in the NWBS and in the Bosporus water area, as well as the Sea of Azov.

The species composition of meiobenthic in this sea zone was made by I.I. Kulakova, who is a professional in the study of Nematoda. This taxon has great species diversity (second only to the Black Sea harpacticoids). Subsequently, she defended her Ph.D. thesis "Peculiarities of distribution of free-living nematodes in the north-western part of the Black Sea."

In 1992–2009, Garlitska L.A. with good professional training, studied the taxonomic composition and ecology of harpacticoids in the NWBS and Black Sea estuaries. She had a wide knowledge of the scientific literature on the ecology of the harpacticoids of the Black Sea and other Seas. All this gave her the opportunity to defend her Ph.D. thesis "Ecology of Harpacticoida (Crustacea, Copepoda) of the northwestern part of the Black Sea" in 2010.

From 2009 to the present time, the successful study of harpacticoids has been carried out by V.V. Portyanko. If L.A. Garlitska. new first information about the Harpacticoida of the NWBS was given, then Portyanko V.V. for the first time described the ecological characteristics of representatives of this taxon of all contour biotopes of the contact zones of the northwestern Shelf. In 2021, he defended his thesis "Harpacticoid copepods of the contact zones of the northwestern part of the Black Sea."

It is necessary to note the successful study (1995 – 2001) of the taxonomic composition and ecological characteristics of Halacaridae by M.V.

Helmboldt. In 2003 she defended her thesis “Sea mites (Halacaridae: Acari) of the northwestern part of the Black Sea: species diversity and ecology”. She significantly expanded the list of species of sea mites from the NWBS and supplemented the information on their environmental characteristics.

Ttraditionally at the Institute of Marine Biology, considerable attention was paid to the study of Polychaeta as a component of the community of macrozoobenthos organisms. The ecological characteristics of polychaetes, which by their size belong to the category of meiobenthos, were analyzed at the level of a large taxon (Polychaeta) of the NWBS in our Institute. PhD Bondarenko A.S. became interested in the study of meiobenthic polychaetes – professional specialist in macrozoobenthos polychaetes. The data she obtained are the first for the northwestern part of the Black Sea. They are presented in separate chapters of her Ph.D. Thesis “Ecology of polychetes of the pivnic-internal part of the Black Sea”, 2012 and in scientific publications. She is currently continuing to conduct these studies.

Information about Ostracoda of the NWBS was already available in the middle of the last century (Shornikov, 1985–1967). In subsequent years, the study of ostracods of the Ukrainian shelf was not carried out. Significant eutrophication with changes in many hydrochemical parameters created completely different conditions for the formation of the faunal composition and quantitative indicators of ostracods. E.E. Uzun actively began studying ostracods, showing initiative and a scientific approach to her research. She successfully completed her postgraduate studies at the IMB and has achieved some success so far.

In October 1989, the First All-Union Conference on the Study of Meiofauna was held in Odesa at our Institute. It was attended by specialists from various Institutes of the USSR Academy of Sciences and universities. Scientists from Odesa, Sevastopol, Moscow, Leningrad, Kyiv, and Vladivostok presented papers at the conference. This conference became possible thanks to the efforts of the branch staff L.V. Vorobyova and I.I. Kulakova.

The report by Yu. P. Zaitsev and L. V. Vorobyova noted the importance of studying marine meiobenthos of Black Sea and outlined the main tasks of its research. A number of reports examined the problems of studying new and little-studied groups of meiobenthic organisms: Kinorhyncha, Priapulida, Loricifera, Nematoda, interstitial annelids. Particular attention was paid to the consideration of the structure and organization of individual Taxocene of meiofauna. The interaction of animals with their environment – one of the most important problems in the study of meiobenthos – was reflected in a number of presentations. The conference participants noted that a group of specialists from our Institute holds the lead in studying the ecology of meiobenthos in the USSR.

The main reports of this conference were published in the republican interdepartmental collection of scientific works “Ecology of the Sea” in 1991 (issue 39).

L.V. Vorobyova defended the first doctoral dissertation in Ukraine on the ecology of marine meiobenthos, 5 candidate's theses on individual important groups of small benthic organisms were successfully defended. Currently, employees of the Institute of Marine Biology of the NAS of Ukraine continue to work on studying the taxonomic composition of individual meiobenthos groups and their ecology. Such work is carried out as part of various comprehensive national programs and many international projects.

Long-term studies and a large database of both the characteristics of individual taxa and the general meiobenthos made it possible to describe the relationship of meiofauna to the ecological characteristics of the NWBS. The dependences of the formation of the meiobenthic community on salinity, temperature and oxygen conditions, the type of substrate (natural and artificial), long-term dynamics were established, and the zones with the largest food supply for juvenile fish were determined. The trends in the development of meiobenthos on the Ukrainian shelf of the Black Sea were described at varying degrees of eutrophication of sea waters.

Scientific data on the faunistics and ecology of meiobenthos of the NWBS and Black Sea estuaries are reflected in 14 collective and one personal mogographs, as well as in numerous scientific domestic and foreign journals. Information about which is given in various chapters of the monograph

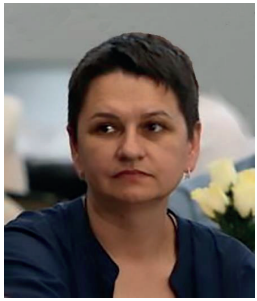
Scientific group of the Institute of Marine Biology for the study of meiobenthos of the Ukrainian shelf of the Black and Azov Seas



Ph.D. Kulakova I.I.



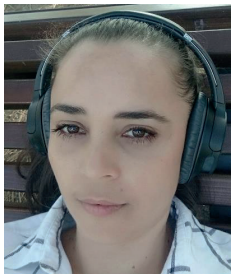
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Ph.D. Garlitska L.A



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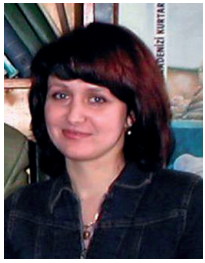
Ph.D. Bondarenko A.S.



Ph.D. Portyanko V. V



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Researcher

Data on the meiobenthos of the Ukrainian shelf of the Black Sea as a component of the monographs of the Institute of Marine Biology



The purpose of publishing the monograph is to show the factual material obtained over 5 decades and the results of its analysis. Most of the scientific results obtained on the faunistic composition and ecology of the meiobenthos of the studied water areas of the Black Sea, discussions and discussions have been published by us in various Ukrainian and foreign journals that are cited in this monograph.

Acknowledgements

Many thanks to the administration of our Institute for creating the conditions and necessary assistance for expeditionary collection of materials and further laboratory work, which allowed us to obtain new important scientific results, the main ones of which are reflected in this monograph. Our scientific group thanks the administration of the Institute of the Southern Seas (Sevastopol) and Academician V.N. Egorov for the opportunity to collect meiobenthos samples during four expeditions on the research vessel "Professor Vodyanitsky".

I express my sincere gratitude to all of my colleagues who, over the years, have given their knowledge, professionalism, strength, time and love to the studied object of research – meiofauna. Special thanks to I.I. Kulakova, who for all fifty years and to this day has been conducting joint successful research of meiobenthos in general and is the only major specialist in Ukraine on free-living marine nematodes.

Multiple joint sampling of meiobenthos and macrozoobenthos (data by I.A. Sinegub) made it possible to describe the characteristics of the meiofauna in various biocenoses of the NWBS.

I express my gratitude to Mihas R.V. for valuable and great help in the technical design of the monograph and in working with the computer.

The author of the monograph apologizes for the grammatical mistakes in the English language. I hope this will not prevent you from understanding and appreciating the main successful results of studying the meiofauna of the Ukrainian shelf of the Black Sea by a small group of scientists from our Institute over five decades. Unfortunately, the format of the monograph allowed us to describe only our most important successes. We all hope that this book will be interesting and useful for readers.

Sincerely, the author of the monograph.

CHAPTER 1.

The Black Sea is one of the few marine bodies for which fairly comprehensive data on the species diversity of most of the permanent components of the meiobenthos exist. Studies of the spatial distribution of quantitative indicators of the meiobenthos in the Black Sea began in the mid-1960s by Romanian, Bulgarian, and Soviet researchers, almost simultaneously. Scientists in these countries devoted considerable attention to faunistic studies of the main groups: Nematoda, Foraminifera, Harpacticoida, and Ostracoda, which made it possible to obtain almost complete lists of their species composition by the late 1980s. It should be noted that some meiobenthic groups remain poorly studied to this day. Only fragmentary information is available on their species composition. These include Nemertini, Gastrotricha, Turbellaria, and Tardigrada, the study of which will significantly expand the overall list of the Black Sea meiofauna.

The initiator of the study of meiofauna in Ukraine was Dr. of Biological Sciences M. I. Kiseleva (Institute of Biology of the Southern Seas, Sevastopol). She published the first information on the meiofauna of the Crimean and Caucasian shelf of the Black Sea (1965). As stated in the preface, the study of the meiofauna of the meiofauna of the northwestern shelf of the Black Sea began in 1973. By this time, the results of the study of the meiofauna of the Black Sea by Romanian and Bulgarian scientists had already been published in scientific journals. Their data concerned mainly the systematics of meiofauna. Ecological studies began later. The history of studying the meiofauna of the Black Sea is described in detail in the publications of in monographs (Vorobyova, 1999) and numerous articles in Ukrainian and foreign journals.

Our long-term research has allowed us not only to describe the biodiversity of the main meiofauna taxa, the features of the formation of its quantitative indicators, as well as the patterns of their spatial distribution depending on the main environmental factors. All of this determines the significance of this important marine community of organisms for the

ecosystem of the northwestern part of the Black Sea (Vorobyova, 1999, 2019 and others).

The role of meiofauna in the formation of biodiversity of the invertebrate fauna of the Black Sea

The important role of meiofauna in marine ecosystems lies primarily in the fact that it makes a significant contribution to the biological diversity of the marine organisms. If we consider the contribution of meiobenthos to the species richness of invertebrate animals (without parasites) of the Black Sea, it is clear that it is very impressive. According to our definitions, representatives of the meiobenthos make up more than 37% of the total list of invertebrate species (zooplankton and zoobenthos) of the Black Sea. Currently, this percentage is more than 40%. It should be taken into account, that many groups of NWBS meiobenthos (Turbellaria, Gastrotricha, Oligochaeta, Tardigrada, etc.) have not yet been sufficiently studied. It should be taken into account, that many groups of NWBS meiobenthos (Turbellaria, Gastrotricha, Oligochaeta, Tardigrada, etc.) have not yet been sufficiently studied. Further studies of their systematics can significantly expand the general list of meiobenthos species of the Black Sea. Further study of the faunistic composition of these large taxa will significantly increase the role of meiofauna not only in the formation of the biodiversity of invertebrates of the Ukrainian shelf, but for the entire Black Sea. Despite this, the list of meiobenthos species in the current period is more than twice the number of invertebrate species of macrozoobenthos of the NWBS. According to our data, the list of known species for the NWBS is currently as follows: Foraminifera, Nematoda, Harpacticoida, Ostracoda, Halacaridae, Gastrotricha, Kinorhyncha, Polychaeta.

The value of the total number of meiofauna

The significance of meiobenthos in the life of water bodies is determined by the fact that, despite their small size, representatives of the meiofauna have a very high number of organisms. The high density of settlements is one of its important features. Meiofauna reproduce so quickly and so abundantly that

predators cannot significantly reduce its population (Coull, 1999). The high density of settlements (some times we recorded more than 5 million ind.·m^{-2}) is one of the important features of the NWBS meiobenthos. It allows the meiofauna to play a very significant role in the biotopes, trophic, and energetic relationships of aquatic organisms. In addition, representatives of meiofauna have high fertility, a generally short life cycle, a rapid growth rate, and a high metabolic rate. All of this plays an important role in the balance of organic matter in bottom sediments, as well as in the transformation of energy, since a significant share of the total energy flow passes through them (Sheremetevsky, 1987; Galtsova, 1991).

At the end of the nineties of the last century, on the northwestern shelf of the Black Sea in the summer on silts, the density of meiobenthos varied from 58,500 to 3,942,250 ind.·m^{-2} (average – 844200 ± 229.7 ind.·m^{-2}). With the development of prolonged hypoxia, the density of meiobenthos sometimes reached 4–5 million ind.·m^{-2} due to the massive development of Foraminifera (the core of the complex consists of *Ammonia ammoniformis, A. compacta* and a group of Lagenids, mainly *Fissurina fragilis, F. porrecta*), the share of which in the total number could increase to 77.7–91.9 % (Vorobyova, 1999; Vorobyova, Yanko, 1990; Vorobyova, Kulakova, Bondarenko, Portyanko, 2019). The intensive development of certain Foraminifera species under hypoxic conditions in the NWBS typically determines the peak abundance of the total meiobenthos. Foraminifera as representatives of first-order consumers foraminifera facilitate the transformation of organic matter of various origins in the bottom water layers. Under favorable marine environmental conditions, the mass development of harpacticoids, ostracods, juvenile polychaetes, and mollusks contributes to the formation of a good food source for larval and juvenile fish in the NWBS, including commercial fish.

The role of meiofauna in the formation of food supply for ichthyofauna.

It is necessary to emphasize the importance of meiofauna as a food source for the larvae and juveniles of all, without exception, fish of the benthic and benthic complexes, as well as for many representatives of macrobenthos.

It is the species composition, abundance, and biomass of meiobenthos at the right time of year and in the right place in the reservoir that determine the survival and further development of each new generation of fish. This is especially important for replenishing their commercial herd. Juvenile fish use all representatives of the meiobenthos as food to a greater or lesser extent. The most preferred taxa include harpacticoids; in fish living in thicket communities, they can make up 90 % of the food.

It is the species composition, abundance, and biomass of meiobenthos at the right time of year and in the right place in the reservoir that determine the future fate of each new generation of fish, which is especially important for replenishing their commercial stock. Young fish use all representatives of the meiobenthos as food to a greater or lesser extent, but the most consumed ones include harpacticoids

Harpacticoids are clearly preferred by yearlings of the *Ocellated wrasse* (Eye-eyed wrasse). In its food bolus, 12 plant and 60 animal organisms were found (Duka, Gordina, 1971). In specimens of 4–5-year-old *Proboscis wrasse* (*S*nout wrasse), harpacticoids can constitute from 12 to 25 % of the total number of organisms. In juvenile blennies and sultanas – 90 % (Duka, 1978, 1988). Harpacticoids are actively consumed by gobies in the early stages of development. In the intestines of *Zosterisessor ophicephalus* and *Mesogobius batrachoetphalus*, in addition to harpacticoids, there are polychaetes, amphipods, pantopods, tanaids, but harpacticoids make up the majority of the food bolus – up to 80 %. In the early stages of development in *Neogobius fluviatilis*, harpacticoids can make up to 31 % of the food, in other gobies – up to 46 % (Duka, 1988). Harpacticoids predominate in the food composition of juvenile Black-headed blenny (56.2 % and 45.5 %, respectively). Meiobenthos as a food object is widely used not only by fry and juvenile fish, but also by many benthic invertebrate animals. According to M.I. Kiseleva (1975), the animal food of *Actinothoe clavata* (coelenterates, sea anemone), along with polychaetes, includes mites (*Halacarellus basteri*), ostracods, and juvenile mitillids. The sea anemone *Edvardsia claparedii* actively feeds on harpacticoids; sometimes there were 4–5 swallowed crustaceans in its food

bolus. In addition, ostracods (mainly *Callystocythere flavidefusa*) and juvenile bivalves are also frequently encountered. From 2 to 6 specimens were found in the intestines of *Nereis succinea* (hydrobia, foraminifera, nematodes, harpacticoid nauplii. The food bolus of *Hediste diversicolor* often contains remains of crustaceans, shells of juvenile bivalves, and foraminifera. Of the meiobenthos representatives, only foraminifera (67 %) and ostracods (20 %) were recorded in the intestines of *Arenicola grubii.*

Experimental studies have shown that the grass shrimp *Palaemonetes pugio* feeds on nematodes, polychaetes and oligochaetes. The total density of meiofauna, nematodes, oligochaetes and polychaetes was significantly lower than in control tanks (Coull, 1999).

Acting as a valuable food item for fish and many representatives of macrozoobenthos, meiobenthos simultaneously plays the role of a predator in relation to smaller hydrobionts. There are especially many predatory species among nematodes and turbellarians (McIntyre, 1971). Even the remains of harpacticoid nauplii were found in their food bolus. In the process of life activity, representatives of meiobenthos can consume a significant amount of bacterial and ciliate products (Gerlach, 1978).

Meiofauna as an indicator of the quality of the marine environment of the NWBS.

It has been proven that the ecological characteristics of meiofauna are a good indicator of the state of the environment. Its density, diversity, structure and functioning may indicate changes in the of various marine ecosystems. Although meiofauna is currently not yet included in the biological control section of the Water Framework Directive (WFD, Directive 2000/60/EC), meiobenthos indicators should be taken into account to provide valuable information regarding the ecological health of marine ecosystems.

Among marine benthic invertebrate animals, meiobenthos can play the greatest indicator role. This applies both for meiobenthos in general and for its individual representatives, not only at the species level, but also at the level of large taxonomic ranks. Currently, ecologists are increasingly using Foraminifera as a test object when monitoring the quality of marine waters.

This is especially important for water areas that are subject to anthropogenic influence. Benthic foraminifera (*Amphistegina lobifera, Pseudotriloculina subgranulata, Cibicides advenum*) can be used as a test object for contamination of the aquatic environment with heavy metals (Yanko, Anmand, Kaminski, 1998).

Of the relatively extensive list of Foraminifera species in the NWBS, only six are frequently recorded: Ammonia tepida, Ammonia compacta, Porosononian martcobi, Haynesina anglica, Nonion matagordanus and Canalifera parkerae. A sharp increase in the abundance of most of these species – indicates the accumulation of large amounts of organic matter and the development of hypoxic conditions near the bottom. Ammonia tepida, Haynesina anglica, and Aubignuna perlucida may serve as indicators of freshening.

It is indicated that nematodes can serve as test objects that respond to technogenic pollution, which is expressed for the organism by the restructuring of the chemoreceptor organ of nematodes – the amphid (Sergeeva, 2003). Research in recent years has shown that ostracods are perhaps the most remarkable group of indicator organisms that can be used to monitor the state and dynamics of aquatic ecosystems (Shornikov, 1996, 2014; Schornikov, 2000; Yasuhara, 2003, 2007, etc.).

Mollusk population density may also be an indicator of marine environmental quality. In areas of increased eutrophication, characterized by the periodic formation of extensive hypoxic zones, the potential for successful larval development from the velikonchi stage to a size category that allows them to transition into macrozoobenthos is sharply reduced. Even with favorable temperature conditions and substrate quality, the larvae that settle to the bottom die end masse due to oxygen deficiency. Juvenile mollusks are very sensitive to oxygen levels near the bottom. Our long-term research has established that dissolved oxygen levels in the marine environment below 4 mg/L can cause mortality among juvenile mollusks. Therefore, the presence of

isolated specimens in samples, or their complete absence from their usual habitats, indicates a critical ecological state of the marine environment.

In the meiobenthos, the densities of settlements of its mass groups are closely interrelated, and when conditions worsen, the ratio of their numbers can change very quickly (Raffaelli, 1981; Warwick, 1981). Many studies have indicated that as anthropogenic impact on marine ecosystems increases, the ratio of nematode and harpacticoid population densities (the "copepod-nematode ratio" index) varies significantly. The greater the negative impact on the ecosystem, the more the proportion of nematodes increases, the harpacticoid decreases, and the ratio index increases (Fig. 4.1.).

Analysis of long-term data obtained during research in the NWBS allowed us to confirm this conclusion. We have repeatedly used the definition of this index, which is reflected in many publications. References to these works are provided in subsequent chapters.

Compensatory role of meiofauna

In terms of population density, NWBS meiobenthos usually significantly predominates over macrozoobenthos. There is a strong negative relationship between them (Galtsova et al., 1997). A similar negative relationship between the quantitative characteristics of meiobenthos and macrobenthos was pointed out in the works of many authors and the term biocenotic compensation was proposed (Golikov, Averencev, 1977).

For the northwestern part of the Black Sea, this feature of the meiobenthos is especially important, since its water area is subject to powerful anthropogenic influence with the formation of extensive fields of hypoxia and anoxia. With a sharp reduction in macrobenthos under starvation conditions, meiobenthos takes on the role of a partial destructor of organic matter. The ratio of the number of representatives of macrozoobenthos and meiobenthos changes. For example, when the total number of macrozoobenthos decreases to 1,000–5,000 ind.·m^{-2} the population density of meiobenthos can increase 4–7 times.

In the Odesa marine region (2009), at a depth of up to 10 m, the number of macrozoobenthos averaged 2,313.5 ind.·m^{-2}, meiobenthos – on average

31,233.3 ind.·m^{-2}. The number of the latter was 13.5 times higher than that of macrobenthos, and at a depth of more than 20 m, when the density of settlements of representatives of macrozoobenthos decreased to an average of 72.85 ind.·m^{-2} the density of meiobenthos was still high and its abundance was 466 times higher than representatives of macrozoobenthos (Vorobyova, 1999).

Thus, our long-term research has once again highlighted the role of meiofauna in the Northwest Black Sea as part of the entire Black Sea ecosystem. Key indicators:

1.According to our definitions, representatives of the meiobenthos make up more than 37% of the total list of invertebrate species (zooplankton and zoobenthos) of the Black Sea. Currently, this percentage is more than 40%. It should be taken into account, that many groups of NWBS meiobenthos (Turbellaria, Gastrotricha, Oligochaeta, Tardigrada, etc.) have not yet been sufficiently studied. Стр. 17.

2. The high density of settlements is one of its important features. It allows the meiofauna to play a very significant role in the biotopes, trophic, and energetic relationships of aquatic organisms.

3. It is necessary to emphasize the importance of meiofauna as a food source for the larvae and juveniles of all, without exception, fish of the benthic and benthic complexes, as well as for many representatives of macrobenthos.

4. Among marine benthic invertebrate animals, meiobenthos can play the greatest indicator role. This applies both for meiobenthos in general and for its individual representatives, not only at the species level, but also at the level of large taxonomic ranks.

CHAPTER 2.
TAXONOMIC COMPOSITION OF THE MAIN GROUPS OF MEIOBENTHOS OF THE UKRAINIAN SHELF OF THE BLACK SEA

In scientific literature, the term ″meiobenthos″ is much younger than the concepts ″benthos″ and ″plankton″. The first was proposed by K. Peterson in 1911, the second by V. Hensen in 1887. The need to distinguish meiobenthos from benthic organisms was caused by objective reasons. The first of them is the belonging of a large group of benthic taxa to this size group.

The meiofauna of the Black Sea, as an object of study, is of particular interest. Firstly, this is due to the fact that the fauna of the sea has different origins, reflecting the geological past of the reservoir. The benthic forms (including meiobenthos) include Pontic (Caspian) relics (Sovinsky, 1904), species of boreal-Atlantic origin, and Mediterranean immigrants. The latter make up the majority of the bottom fauna. And, finally, exotic species accidentally brought by ships from other areas of the World Ocean. Secondly, due to a number of natural and anthropogenic reasons (high isolation from the World Ocean, vast catchment area, slow vertical mixing of water masses, industrialization of the coastal zone, eutrophication, etc.), profound biotypic changes have occurred in the Black Sea, affecting their inhabitants. In recent years, this aspect has attracted the attention of not only local specialists, but also international organizations.

The history of the study of the faunistic composition of the Black Sea meiofauna is quite fully reflected in the monograph by Dr.Prof. L. V. Vorobyova (1999) and gives an idea of the degree of study of its various groups at the first stage (1870-1960). It should be emphasized that if in the 60-70s the main attention was paid to the meiofauna of sandy biotopes of shallow waters, then from the mid-70s to the present day, scientists from many countries have been conducting multifaceted studies on the meiobenthos of loose substrates from the upper sublittoral to the bottom substrates of the depths of various Seas

of our planet. Analyzing the publications of the period 1961-1980, it can be stated that along with the study of the faunistic composition, the seasonal dynamics of the qualitative and quantitative characteristics of both the most representative groups in terms of settlement density and biomass, and the entire meiobenthos as a whole, were studied. This period can be characterized as the second stage of the study of the meiobenthos of the Black Sea, it can be called "faunistic-chorological". If at the first stage the Romanian and Bulgarian waters were most actively studied, then at the second stage the meiofauna research was carried out on almost the entire western shelf of the Black Sea by scientists from three Black Sea countries: the USSR, Romania, and Bulgaria.

This chapter will not describe the history of the study of the meiofauna of the Black Sea. This data is given in our monographs and numerous scientific articles. The purpose of this chapter and the entire monograph is to reflect the results of scientists of our Institute over the past fifty years.

For Bulgarian, Romanian, and Crimean waters, before the start of our research, there was already quite a lot of information about the species diversity of meiobenthos and its quantitative characteristics. Particularly noteworthy is the monograph by M. Bacescu and co-authors (Bacescu M., Gomoiu M.T., Dumitrescu, 1968), in which, along with macrozoobenthos, the qualitative and quantitative characteristics of the meiobenthos of the Romanian shelf of the Black Sea are examined in detail. Lists of species of Foraminifera (59 species), Nematoda (148 species), Gastrotricha (23 species), Kinorhyncha (10 species), Harpacticoida (161 species), Ostracoda (77 species), sea mites (25 species), etc. are provided. In the last century, data from studies of the species composition of on individual large taxa of meiofauna were summarized. in the monograph “Biology of the northwestern part of the Black Sea,” published in 1967: lists of species of Foraminifera (34 species), Nematoda (21 species), Kinorhyncha (9 species), Ostracoda (37 species), Harpacticoida (20 species).

Over fifty years of studying the meiofauna of the NWBS, significant results have been achieved at the Institute of Marine Biology. Our experts have

presented lists of species of eight major taxa, about which information will be provided in the second chapter.

2.1 Interstitial meiofauna supralittoral and pseudolittoral (mediolittoral) sandy beaches of the Black Sea.

Along with the pelagic and benthic zones, contour, or marginal, biotopes form a special category of habitats in the marine environment. For a long time, contact zones located at the sea-atmosphere, sea-coast, and sea-river boundaries did not attract the attention of researchers, considering them of little interest (Zaitsev, 2006). A very important contour biotope of the shore-sea contact zone is the psammocontour. Within the psammocontour of the sea, there are contour biotopes that differ in ecological conditions: above-water (supralitoral), near-water (pseudolittoral), and underwater (upper sublittoral) horizons (Zaitsev, 2002). There is only fragmentary information about certain types of invertebrate animals referred for the Black Sea splash zone. As for the supralittoral, it can bravely be considered as a “white spot” in hydrobiological studies of the Ukrainian shelf. Unfortunately, in our country, in contrast to the others, the researches of the external contour of the sandy sea were not well developed. This can be explained, on the one hand, by the complexity of research; on the other – by underestimation of the research results both in theory and in practice.

The coastal part of the Black Sea at a depth of 5 m is currently the least studied area. Splash zone, and especially supralittoral, previously considered as little-inhabited, has not been studied at all for a long time. Only a few decades ago, when scientists from various countries have shown that the interstitial meiofauna of these sea areas is very rich in species and quantitatively, interest in studying the sandy beaches of the Black Sea has increased dramatically.

As is known, any synecological study consists of several stages, the first of which involves studying the species composition of organisms. Due to the fact that only a few groups of interstitial meiofauna of the sandy beaches of the

Black Sea have fairly complete lists of species, our research will be relevant and necessary for quite a long time**.**

Data on the history of the study of marine meiofauna (primarily interstitial) are described by us in the monograph (Vorobyova, Zaitsev, Kulakova, 1992, Vorobyova, 1999 and others). Therefore, in this monograph we do not provide references to publications of authors who studied various large taxa of the Black Sea meiofauna. The monograph will reflect only the achievements of our scientists over many decades.

Unfortunately, contour biotope "coast-sea", which plays a very important role in the life of the upper sublittoral, remains today the least studied. This fully applies to the sandy beaches of the Black Sea, which occupy thousands of kilometers of coastline and forming a large, if not the major, part of the contour biotopes of the sea, located on the outside of the water line.

Interstitial communities of sandy beaches are influenced by both sea and land, actively responding to them, this is expressed in changes of the composition and quantity indices of this interesting and original habitat's representatives.

The presence in the Odesa region of sandy beaches with different granulometric composition of sediments (from small- to coarse-grained) allowed to use them as a model to describe the basic regularities of structure formation and the spatial distribution of meiofauna in interstitial of different parts of the Black Sea coast (Vorobyova, Zaitsev, Kulakova, 1992).

A varied composition and rich, according to number, marine meiofauna, characterize the interstitial of the Black Sea sandy beaches (pseudo- and supralittoral): Turbellaria, Nematoda, Gastrotricha, Cyclopoida, Harpacticoida, Ostracoda, Polychaeta, Archiannelida, Oligochaeta, Acarina, Mollusca. Representatives of the most groups are identified to species. Turbellaria, Nematoda and Harpacticoida are found in the sands of all types, but each group is represented by the greater number of species in the coarse-grained sand. Some organisms − Halacaridae, Polychaeta − are confined only to the coarse-grained sand. Others, giving a clear preference for one of three

types of sediments, may occur in the sands of a similar structure, but with a lower density. Thus, medium-grained sands are settled by invertebrates, that are typical for either the first (coarse-grained), or for the third (small-grained) type, but their density is usually low.

One of the determining factors in the formation of the interstitial meiofauna species composition of beaches is the granulometric composition of its sandy sediment. Abundant meiofauna develops there, where interstitia are large enough, the sand is washing and well aerating. The most diverse is meiofauna of coarse-grained sands; it is presented with nine taxa of invertebrates: Turbellaria, Nematoda, Harpacticoida, Ostracoda, Arhiannelida, Polychaeta, Oligochaeta, Halacaridae, and juvenile Mollusca). Turbellaria, Nematoda, Gastrotricha, Harpacticoida and Oligochaeta are characterized for small-grained sands.

TURBELLARIA. Turbellaria is one of the least studied groups of the Black Sea meiofauna, despite the fact, that the first papers (Pereyaslavzeva, 1891) refer to the end of the past century. For the Odesa coast at different times the following species were indicated: *Endocelis ovata* Schm., *Monocelis agilis* Schm. and *Macrostomum hystrix* Oerst., *Aphanastoma deversicolor* and *Promestoma bilineatum*, Chislenko, *M. lineata*, *M. longiceps*, *Phaenocora salinarum subsalsa*, *Procerodes lobata* and *Monocelis lineate* (Beklemishev, 1882; Buchinsky, 1885; Uljanin, 1879).

Quantitative indicators of pseudo- and supralittoral's turbellarians were carried out only (Marinov, 1975) for the Bulgarian coast. The author shows three species: *Archotoplana flexilis* Ax, *Cyclogynopora biarmata* Steinbock, *Pseudomonocelis ophiocephala* O. Schm. It is also noted, that the maximum density of worms in pseudolittoral under 1 m^2 was 89,800 sp.

Our research has shown that in the quantitative relation Turbellaria almost in all cases dominate along with Nematoda and Oligochaeta, forming the densest clusters in March-April and October. Turbellaria are found in the sandy beaches' interstitial everywhere and year-round.

NEMATODA. According to Kulakova I.I. Nematoda in the sandy beaches are represented by 41 species, belonging to four orders, 17 of which

are typical also for the open waters of the Black Sea north-western part (Vorobyova, Zaitsev, Kulakova, 1992; Vorobyova, 1999; Vorobyova, Kulakova, 2009). According to I.I. Kulakova, 17 of the discovered nematode species are characteristic of the open waters of the northwestern part of the Black Sea, the rest were recorded only on sandy beaches.

(*Anticoma pontica* Fil*., Phanoderma albidum* Bastian*, Enoplus euzinus* Fil*., E littoralis* Fil*, E. maeoticus F i L, Enoplus sp., Enoploides ciiratus* Fil*., E. brevis* Fil*, Enoplolaimus sp., Paioncholaimus zernovi Fil, Viscosia minor Ffl., V. elongate FiL, Oncholaimus brevicaudatus Fil., 0. dujardini de Man, compilocercoides FiL., Oncholaimus sp., Anoplostoma vivipaium (*Bastian*), Dilaimus sp., Sabatieiia clavicauda FilL, Paracanthonchus caecus Bastian, Paracanthonchus sp., Cobbionema aciocer,ca Ffl., Chromadora quadritricha FiL, Chromadota sp.,*

Chiomadorina obtusa Fil., Ch. gracilis Fil., Monhystera filiformis Bastian, M. conica Fil*, M. longicapitata* Fil, *M. parva* de Man*, M. rotundicapitata F i L, Monhystera sp. 1, Monhystera sp.2, Monhystera sp.3, Theristus latissimus* Fil*, Th. setosus (*Biitschl*), Th. littoralis* Fil*, Theristus sp., Terehellingia antonovi* Fil*., Dermatolaimus steineri* Fil*., Bathyaimus assimilis* de Man*.)* (Kulakova, 1992).

Enoplus maeoticus Kulakova I.I. indicates for the first time for the northwestern part of the Black Sea.

The most prevailing species of interstitial are *Enoplus euxinus* Fil., *E. littoralis* Fil., *E. maeoticus* Fil., *E. brevis* Fil., *Monhystera filiformis* Bastian, *M. conica* Fil. and *Cobbionema arcocerca* Fil.

The nematodes' proportion in the total number of meiofauna in the sands of different structures is the lowest in the pseudolittoral (average 4−17 %).

GASTROTRICHA. Representatives of the interstitial meiofauna supralittoral and pseudolittoral (mediolittoral) of the Black Sea. Gastrotricha class (Gastrotricha) are widespread in the beach sediment loads. The main habitat in the Black Sea north-western part is sand of the small-grained structure. They were detected by us in the small quantities also in the medium-grained sands, but not in the coarse-grained. According to the long-term

researches two species of Gastrotricha – X*enotrichula beauchampi, Ltvi.1950* and *Turbanella cornuta, Remane, 1925* – are the permanent component of meiofauna, the third species of Gastrotricha − *T. cornuta* – wasn't noted after 1975 year. Gastrotricha is a common specie for splash zone and it is rarely found on the spray zone, while the representatives of the family Turbanellidae are typical for both pseudolittoral and for the spray zone.

Gastrotricha are present on pseudolittoral from March to October, the rest of the year they are rare component of meiofauna.

HARPACTICOIDA. For the first time interstitial copepods were described by Wilson (Wilson, 1932) in his monograph, he showed that harpacticoids are adapted to habitation in the interstitial water. Nichols (Nichols, 1935), that was first, who introduced the term "interstitial", described harpacticoids of this unique habitat from the various parts of the world; he showed morphological adaptation of copepods to this peculiar habitat.

According to Vorobyova L.V. at the studied coastal sites harpacticoids were represented by nine species, eight from which – *Stenocaris pontica* Chapp et Serban; 1953, *Harpacticus littoralis* Sars, 1910; *Nitocra spinipes*, *N. affinis;* Gurney, 1927; *N. pusilla,* Sars, 1911; *Ectinosoma melaniceps,* Boeck, 1964; *Arenopontia subterranea, Ameira parvula,* Claus, 1866; – are confined to coarse-grained sand. In interstitial of medium-grained sands such species as *Arenopontia subterranea*, *A. parvula N. pusilla*, *E. melaniceps, N. pusilla*. *E. melaniceps* are commonly found. Only one species − *Paraleptastscus spinicauda trisetosa,* Serban et Eitel-Lang, 1957 – is typical for the small-grained drifts. We found, that the proportion of harpacticoids in the total number of meiofauna during the year widely varies, and increases from small – to coarse-grained sands. Harpacticoida is a dominant group on a population density in the coarse-grained sands.

OSTRACODA. The overwhelming majority of the marine ostracods refers to the benthic animals, living on the surface of bottom sediments. Lives of many species are associated with macrophytes. The most significant contribution to the study of the Black Sea ostracods were made by T. Marinov (Marinov, 1975) and Dr. Shornikov (Shornikov, 1967). We have established

that the spatial distribution of crustaceans is closely related to the mechanical structure of sand deposits. The main habitat is coarse-grained sands, the densest accumulations are formed in the pseudolittoral. Only single specimens are found in the splash in medium-grained sands. In fine-grained sand, they have never been found. Some species have adapted to living in the sandy sediment interstitial. On the Odesa sandy beaches on pseudo- and supralittoral they are represented by seven species: *Loxoconcha pontica*, Klie; *L. nana* Marinov, *L. elliptica,* Brady, *Microcythere longiantennata* Marinov, *Parvocythere hartmanni* Marinov, *Hemicythere bulgarica* Klie, *Leptocythere multipunctate,* Seguenza, 1883 *(Data of Dr.* А.L.Коваленко). They occur from March to October. The spatial distribution of crustaceans is closely related to the mechanical structure of sandy drifts. The main habitat is coarse-grained sand; the densest clusters are formed on pseudolittoral (layer of 4-10 cm, in the supralittoral they mostly concentrated at a depth of 30-50 cm). Medium-grained sand is a habitat for single specimens only in the splash zone. In the small-grained sand they were not found. Their share of the total number of interstitial meiofauna is insignificant and does not exceed 6 %, they are characterized by low population density (4-122 ind.·100 cm^{-3}).

ACARINA. As mentioned above, researches of the sandy beaches have particular interest because this habitat is region of the marine, freshwater and soil fauna mixing. The simultaneous study of the marine fauna and soil mites' faunistic composition on the sandy beaches' pseudolittoral and supralittoral have allowed to get another one confirmation that the examined area of the sea coast is a transition zone (ecotone) between the two neighboring communities, where they are interpenetrating. The literature provides information on the study of the coastal waters' mites, particularly in the coastal sandy beaches (Konners-Ionescu, 1968, 1970, 1973; Petrova, 1972, 1973, 1976, 1978; Vorobyova, 1977, 1992). During the exploration of the Bulgarian groundwaters' fauna (Petrova, 1972) species of marine mites, hitherto unknown to the Black Sea, have been discovered and described as well as a new species *Rphreaticus phreaticus* sp.n. and subspecies *Actacarus illustrans bacescui* (Konnerth-Ionescu, 1970).

On the studied coast area (Vorobyova, Kulakova, 1992) we found the following types of marine and soil mites: marine: *Actacarus pygmaeus* Schulz, 1936; *Halacarus prozerus* Viets, 1927; *H. capuzinus* Zohman, 1893; *H. floridearum* Zohman, 1889; soil: *Rhodacarus olgae* Scherbak, 1974; *Rhodacaropsis inexpectatu*s Willman, 1935; *Mediorhodacarus tetranodulus* gn. sp. Scherbak, 1976; *Tyrophagus putrescentiae* Schrank, 1884; *Halolaelaps nodosus* Willrftan, 1952; *H. saproincisus* Hyatt, 1956; *Hydrogamasus* sp. Troess., 1890; *Typhlodromus soliger* Rib., 1916; *Brevipalpus obovatus* Dannadicu, 1952; *Hypoaspis aculifer* Canestrini, 1883; *H. hesediausi* Oudemmans, 1900; T*etranychus carpini* Oudemans, 1902 (Vorobyova, Zaitsev, Kulakova, 1992).

Marine mites are found from May to October in the coarse-grained sands, in the medium-grained sands they are rare. Unlike most of the groups, more dense clusters are confined to supralittoral. Soil mites on supralittoral are usually found in the layers of 0-10, 10-20, 20-30, and in a less degree – in the layer of 30-40cm; marine mites commonly inhabit the horizons of 20-30, 30-40 and 40-50 cm (before the level of groundwaters). The closest contact of the marine and soil fauna's representatives occurs on supralittoral zone, located in 3 meters from the water's edge. On pseudolittoral some soil mites are found in the near-surface layer of 10-0 cm, marine species occupy interstitial spaces of the splash zone in layers 0-4, 4-10 and 10-20 cm.

Study of interstitial meiofauna of sandy beaches is very important at this time. Changes that occur in marine ecosystems to climatic and anthropogenic factors, particularly evident in the contour biotopes. Sandy beaches, which are located on the border of the sea and the coast, influenced both by land and sea, and from the atmosphere. The greatest human impact on species diversity and quantity of experiences interstitial meiofauna of sandy beaches in the metropolitan areas (port facilities, sanitary sewage, waterworks, etc.), and in areas where the influence of flow of river water.

2. 2. Foraminifera north-western shelf of the Black Sea.

Foraminifera belong to the few groups of meiobenthos for which sufficiently complete information has been accumulated on their species composition in various areas of the Black Sea. In 1987, the first monographic description of the morphology, taxonomy, habitat conditions, and species diversity of contemporary Foraminifera of the Black Sea was given (Yanko, Troitskaya, 1987).

At the IMB of the NAS of Ukraine, the study of the faunal composition of the taxocene Foraminifera began in 1982. For several decades, we have taken samples at 50 stations in the northwestern part of the Black Sea during expeditions on the R/V «Miklouho-Maclay». In the 90s, the species composition and quantitative distribution of foraminifera in the northwestern part of the Black Sea, the Kerch and Bosphorus regions, as well as the Sea of Azov were described. This became possible thanks to cooperation with Dr. Prof. Yanko V.V. (Mechnikov ONU) in 1986-1990. Lists of species of modern foraminifera of the Ukrainian shelf of the Black Sea and its Bosphorus waters, as well as the Sea of Azov, were compiled (Yanko V.V., Vorobyova, 1986; 1990; 1991).

In 1983–1985 14 species of Foraminifera were discovered in the NWBS. There are 5 species similar to the Danube-Dniester interfluve and the Dnieper-Bug region (Table 2.1). The most common and widespread species is *Ammonia tepida*, found almost everywhere on both muddy and sandy soil at depths from 7.5 to 41 m. In the Dnieper-Bug region, Foraminifera are represented by a large number of species.

The studied area consists mainly of Foraminifera with calcareous shells; only one species, Discammina imperspica, is agglutinated. There are no true marine species in the Northwest Black Sea. The species Ammonia tepida, Haynesina anglica, and Aubignuna perlucida can serve as an indicator of desalination. The vast majority of the presented species predominate at depths of up to 20 m. The hydrological and hydrochemical regimes in the Bosphorus region provide the formation of significantly greater faunal diversity of the taxocene Foraminifera (Table 2.2.)

Table 2.1.

Species composition of the Foraminifera in two areas of the northwestern part of the Black Sea (Vorobyova, Yanko, 1986)

Species	Region	
	Pridneprovsko-Bugsky	Danube-Dniester
Ammonia tepida Cushman	+	+
A. neobeccarii neobeccarii Stschedrina	–	+
Ammonia sp.	+	+
Haynesina anglica (Murray)	+	–
H. martcobi (Bogdanowicz)	+	+
Cribroelphidium pocyanum (Orbigny)	+	+
Elphidium ponticum (Dolgopolskaya et Pauli)	–	+
Quinqueloculina seminula Linne	+	–
Discammina imperspica Yanko	+	–
Nonion depressulus Walker et Jacob	+	–
Nonion sp.	+	–
Aubignyna perlucida Heron-Allen et Earland	+	–
Canalifera parkeri (Yanko)	+	+
Porosononion subgranosus Egger	–	+

Table 2.2

Species composition of Foraminifera in the Bosphorus region of the Black Sea (Yanko, Vorobyova, 1991).

Species	C	B
Ammonia tepida (Cushman),	6	100
A. compacta	28	100
A. ammoniformis	32,3	100
Porosononion martcobi ponticus (Kornfeld)	7	100
Cribroelphidium powyanum (d'Orbigny),	2	100
Aubignyna perlucida(Heron-Allen et Earland)	0,1	50
Canalifera parkerae, Yanko, Troitskaya, 1987	2	100
Quinqueloculina vulgaris d'Orbigny, 1826	1	100
Eggerella scabra (Williamson, 1858)	2	100
Elphidium ponticum Dolgopolskaya et Pauli,	0,12	100
Nonion matagordanus (Kornfeld)	4	100
Discammina imperspica Yanko, 1974	0,1	100
Ammobaculites ponticus Mikhalevich, 1968	0,1	100
Cribroelphidium translucens Natland, 1938	0,1	50
C. percursum (*C.Agardh*) Areschoug 1850	0,1	60

Table 2.2 continued

Species	C	B
Quinqueloculina concobrina	0,1	40
Q. curvula	0,1	100
Q. inflata	0,1	50
Q. laevigata	0,1	40
Q. oblonga	0,1	60
Cornuspira planorbis Schultze, 1854	0,1	40
Cibicides lobatulus (Walker & Jacob, 1798)	0,3	50
Parafissurina ex gr. Lateralis	2	100
P.dzementinica	2	100
Canalifera nigarensis	0,1	6
Esosyrinx jatzkoi	0,3	60
Entolingulina deplanata	0,1	50
Fissurina lucida	0,1	60
F. solida	0,5	100
Lagena vulgaris	0,2	100
Laryngosigma williamsoni	0,1	60
Orthomorphina colamorpha	0,1	100
Parafissurina aventricosa	0,2	100
Heronallenia chasteri	0,1	60
Pateoris dilatatus	0,2	100
Fissurina fragilis	4	100
F. porrecta	3	100
Planorbulina mediterranensis	0,1	60
Canalifera ex gr. vericulata	0,1	60
Fissurina fabaria	0,12	60
Orthomorphina drammenensis	0,1	80
Sigmella distorta	0,1	100
Meliolinella subrotunda	0,02	100
Bolivina doniezi	0,01	20
B. variabilis	0,01	40
Brizalina ex gr. danvillensis	0,01	40
B. striatula	0,01	50
Glandulina sp.	0,01	30
Lagena quadrilatera quadrilatera	0,01	40
L. semistriata	0,01	60
Pyrgo elongata	0,01	100
P. fisheri	0,01	80
Discorbis bertheloti	0,1	15
Canalifera earlandi	0,1	50
Orthomorphina filiformis	0,1	100
Discorbis sp.	0,02	40
Acervulina ex gr. adchaerens	0,01	30
Bolivina ex gr. dilatata	0,01	30
B. pseudoplicata	0,01	20

Table 2.2 continued

Species	C	B
Brizalina spathulata	0,01	40
Ammoscalaria sp.	0,01	40
Bulimina aculeata	0,01	40
B. elongata	0,01	40
Esosyrinx praelongus	0,01	10
Esosyrinx. sp.	0,01	10
E. undulosus	0,01	30
Gavelinopsis sp.	0,01	30
Guttulina lactea	0,01	40
Lagena striata	0,01	20
Lagena sp.	0,01	60
Miliolinella selene	0,01	40
Miliolinella sp.	0,01	10
Oolina squamosa	0,01	60
Quinqueloculina lamarkiana	0,01	40
Sigmella sp.	0,01	40
S. tenuis	0,01	60
Siphonaperta sp.	0,01	20
Textularia sp.	0,01	30
Trifarina angulosa	0,01	20

Note: C—percentage of Foraminifera, B—occurrence of Foraminifera

The most widespread are representatives of the orders Lagenida (25 species) and Rotaliida (18 species). The core of the complex consists of *Ammonia ammoniformis, A. compacta* and mainly *Fissurina fragilis* and *F. prorrecta*. The accessory (frequently encountered but small in number) group is extremely diverse.

The faunal composition of Foraminifera of the Azov Sea is formed from relict forms of the Ponto-Caspian Sea, Black Sea immigrants and endemics (Yanko and Vorobyova, 1990): *Miliammina furca* (Brady), *Mayerella brotzkajae* (Mayer), *Ammonia novoeuxinica* Stschedrina et Mayer, *A. parasovica* Stschedrina et Mayer, *A. tepida* (Cushman), *Cornuspira minuscula* (Mayer), *Elphidium caspicum azovi-cum* Jnko, ssp.n., *Haynesina anglica* Murray, *Porosononion subgranosus mediterraneum* Jnko, ssp.n., *Quinqueloculina seminulum* (Linne), *Trichochyalus aguajoi* (Bermudes), *Quinqueloculina oblonga* (Montagu), *Discammina imperspica* Jnko, *Rotaliammina ochracea* (Williamson), *Aubignyna perlucida* (Heron-Allen et

Earland), *Canalifera parkerae* Jnko, *Cribroelphidium powyanum* (d'Orbigny), *Elphidium ponticum* Dolgopolskaya et Pauli, *Nonion metagordanus* (Kornfeld), *Porosononion martcobi ponticum* Yanko, ssp.n.

Most Foraminifera are represented by shallow and cold-water species.

2. 3. Nematoda of the Ukrainian shelf of the Black Sea

Free-living Nematoda are one of the animal groups that are currently experiencing biological progress. Their small size and simple organization have led to the fact that they have practically mastered the entire biosphere and live in all known biotopes. Nematodes make a significant contribution to the formation of biological diversity of marine ecosystems. Among the representatives of the meiofauna, Nematoda, according to world literature, are its most important component both in species composition and in quantitative characteristics.

At the IMB of the NAS of Ukraine, the study of the species composition of representatives of the Nematoda taxocene has been carried out for all 50 years by Ph.D. of Biology of Science, Kulakova Irina Ivanovna. As a student of Odesa National University (Department of Invertebrate Zoology), Irina Ivanovna studied soil mites of the interstitial sandy beaches of the Odesa Gulf at our Institute (course and diploma theses). After successfully graduating from the University, she was hired to work in the Hydrobiology Department of the Institute (1976). With great enthusiasm, Kulakova I.I. began studying free-living marine nematodes of the pseudolittoral and supralittoral of the interstitial sandy beaches of the Black Sea. With her experience and the advisory assistance received from leading specialists of the Institute of Zoology of the National Academy of Sciences of the USSR, Irina Ivanovna became a leading specialist in our Country in the study of free-living Nematoda in just a few years.

In 2002, I.I. Kulakova successfully defended her Ph.D. thesis on the topic of "Features of the distribution of free-living nematodes in the northwestern part of the Black Sea". For the last 20 years of this century,

I.I. Kulakova has been the only specialist in Ukraine studying the taxonomic composition and ecology of marine free-living nematodes.

For the first time, the author described quantitative and qualitative characteristics of free-living nematodes for the NWBS [Kulakova, 2000, 2001). I.I. Kulakova was the first to discover living nematodes in the anoxic zone of the Black Sea (Zaitsev Yu.P., Antsupova L.V., Vorobyova L.V., Kulakova, 1987). Research was conducted to study the structure and quantitative indicators of free-living nematodes of the estuaries of the northern Black Sea region (Sukhoi, Grigorevsky), which have a significant technogenic load (Kulakova, 1994, 1998, 2000). An analysis was given of the state of free-living nematodes in the meiobenthos of the Odesa Gulf, Zhebriyanskaya Bay, which is under the direct influence of the Danube River runoff (Kulakova,1998, 2001).

As a result of many years of research into the species composition of free-living nematodes in various areas of the Ukrainian shelf of the Black Sea, Irina Ivanovna discovered 90 species belonging to 6 orders, 21 families and 55 genera (Table 3.1). The faunal list of nematodes includes only those representatives that have been identified to species level.

Among the studied areas, the most diverse of Nematoda species composition is in the Dnieper-Bug region, for which 70 species are indicated. 46 species were found on the Danube coast, 35 species in the Grigoryevsky estuary, and 41 species in the interstitial sandy coasts. The nematode fauna is poorer in the Danube-Dniester interfluve (32 species), in the Zhebriyanskaya Bay (28 species), Sukhoi Liman (14 species). For most of the studied areas, the nematode species composition is given for the first time.

This chapter presents her main achievements in the study of nematodes of the Ukrainian shelf. Important information is reflected in numerous publications presented in the list of scientific publications of Irina Ivanovna.

Kulakova I.I. for the first time for the Black Sea water area published a list of Nematoda species inhabiting the interstitial coastal zone of the sea (Vorobyova, Zaitsev, Kulakova, 1992). Nematodes as a component of the

interstitial meiofauna of the Ukrainian parts of the Black Sea had not been studied before our research

Table 3.1.

Taxonomic composition of nematodes in various areas of the north-western part of the Black Sea

Phylum NEMATODA
Class Chromadorea
Order **Adenophorea**
Family Leptolaimidae
1. *Leptolaimus steineri* (Filipjev 1922)
2. *Camacolaimus dolichocercus* Filipjev 1918
Family Axonolaimidae
3. *Araeolaimus ponticus* Filipjev 1922
4. *A. zosterae* (Filipjev 1918)
5. *Diplopeltis onustus* Wieser 1956
6. *Axonolaimus ponticus* Filipjev 1918
7. *A. setosus* Filipjev 1918
8. *Odontophora angustilaimus* (Filipjev 1918)
9. *Paradontophora quadristicha* (Stekhoven 1950)
Order **Desmoscolecida**
Family Desmoscolecidae
10. *Desmoscolex minutus* Claparede 1863
11. *Quadricoma loricata* Filipjev 1922
12. *Q. media* (Reinhard 1881)
13. *Q. pontica* Filipjev 1922
Order **Monhysterida**
Family Linhomoidae
14. *Metalinhomoeus zosterae* Filipjev 1918
15. *Prosphaerolaimus eurypharinx* Filipjev 1918
16. *Terschellingia longicaudata* De Man 1907
17. *T. pontica* Filipjev 1918
18. *Eleutherolaimus longus* Filipjev 1922
19. *Paralinhomoeus filiformis* (Filipjev 1922)
Family Monhysteridae
20. *Cylindrotheristus longicaudatus* (Filipjev 1922)
21. *C. maeoticus* (Filipjev 1922)

Table 3.1 continued

22. *C. oxycercus* (De Man 1888)
23. *Mesotheristus setosus* Bütschli 1874
24. *Monhystera attennuata* Filipjev 1922
25. *M. collaris* Filipjev 1922
26. *M. conica* Filipjev 1922
27. *M. filiformis* Bastian 1865
28. *M. longicapitata* Filipjev 1922
29. *M. parva* (Bastian 1865)
30. *M. rotundicapitata* Filipjev 1922
31. *Paramonohystera elliptica* Filipjev 1918
32. *Theristus euxinus* (Filipjev 1918)
33. *T. latissimus* Filipjev 1922
34. *T. littoralis* Filipjev 1922
35. *T. sabulicola* (Filipjev 1918)
Family Sphaerolaimidae Filipjev 1918
36. *Sphaerolaimus dispar* Filipjev 1918
37. *S. gracilis* De Man 1876
38. *S. macrocirculus* Filipjev 1918
39. *S. ostreae* Filipjev 1918
Order **Desmodorida**
Family Desmodoridae
40. *Microlaimus kaurii* Wieser 1954
41. *Metachromadora macroutera* Filipjev 1918
41. *Metachromadora macroutera* Filipjev 1918
42. *Spirinia sabulicola* Filipjev 1918
43. *Desmodora pontica* Filipjev 1922
Family Ceramonematidae
44. *Ceramonema attenuatum* Cobb 1920
Order **Chromadorida**
45. *Paracomesoma dubium* (Filipjev, 1918) Schuurmans Stekhoven, 1950
46. *Sabatieria abyssalis* (Filipjev 1918)
47. *S. pulchra* (G. Schnaider 1906)
48. *S. quadripapillata* Filipjev 1922
Family Chromadoridae
49. *Chromadora nudicapitata* Bastian 1865
50. *Chromadorella mytilicola* Filipjev 1918
51. *Chromadorina obtusa* Filipjev 1918

Table 3.1 continued

52. *Prochromadorella mediterranea* (Micoletzky 1922)
53. *Chromadorita gracilis* Filipjev 1922
54. *C. leucarti* (De Man 1876)
55. *Dichromadora cephalata* (Steiner 1916)
56. *Neochromadora poecilosomoides* Filipjev 1918
57. *N. sabulicola* (Filipjev 1918)
58. *Spilophorella euxina* Filipjev 1918
59. *S. paradoxa* (De Man 1888)
Family Cyatholaimidae
60. *Paracanthonchus caecus* (Bastian 1865)
61. *Cyatholaimus gracilis* (Eberth 1863)
Family Choniolaimidae
62. *Cobbionema acrocerca* Filipjev 1922
Order **Enoplida**
Family Tripyloididae
63. *Bathylaimus australis* Cobb 1894
64. *B. cobbi* Filipjev 1918
65. *Trypiloides marinus* (Bütschli 1874)
Family Oxystomidae
66. *Oxystomina elongata* (Bütschli 1874)
Family Halalaiminae
67. *Halalaimus ponticus* Filipjev 1922
68. *H. wodjanizkii* Sergeeva 1972
Family Anticomidae
69. *Anticoma acuminata* (Eberth 1865)
Family Phanodermatidae
70. *Phanoderma albidum* Bastian 1865
Family Enoplidae
71. *Oxyonchus. dubius* (Filipjev 1918)
72. *Mesacanthion conicum* (Filipjev 1918)
73. *M. heterospiculum* Sergeeva 1974
74. *Enoploides amphioxi* Filipjev 1918
75. *E. drevis* Filipjev 1918
76. *E. cirrhatus* Filipjev 1918
Family Enoplinae
77. *Enoplus littoralis* Filipjev 1918
78. *E. maeoticus* Filipjev 1918

Table 3.1 continued

79. *E. quadridentatus* Berlin 1853
Family Rhabdodemaniidae
80. *Rhabdodemania pontica* Platonova 1962
Family Anoplostomatidae f. n.
81. *Anoplostoma viviparum* (Bastian 1865)
Family Oncholaimidae
82. *Viscosia glabra* (Bastian 1865)
83. *V. elongata* Filipjev 1922
84. *V. minor* Filipjev 1918
85. *Metoncholaimus demani* (Zur Strassen 1894)
86. *Oncholaimus brevicaudatus* Filipjev 1918
87. *O. campylocercoides* De Coninck 1965
88. *O. dujardinii* De Man 1876
89. *Pontonema zernovi (*Filipjev 1918)
90. *Calyptonema sabulicola* Filipjev 1918

Long-term systematic studies of the structure and quantitative indicators of nematodes in the interstitial meiofauna have made it possible to obtain a fairly complete picture of their species diversity and changes in these parameters for beach sediments with different granulometric compositions. For the first time, the author indicates the species composition of free-living nematodes, one of the dominant groups of interstitial meiofauna, in pseudo- and supralittoral with different granulometric compositions (Vorobyova, 1977; Vorobyova, Kulakova, 1976, 1987 and others).

According to I.I. Kulakova, 41 species of nematodes belonging to 4 orders were found in the interstitial of sandy beaches (Table 2.4). Of these, 17 are characteristic of the open waters of the northwestern part of the Black Sea, the rest were recorded only on sandy beaches. The most diversely represented orders are Enoplida (19 species), Monhysterida (13 species), Chromadorida (8 species). One species was found from the order Araeolaimida.

When comparing the species composition of nematodes on different types of sand, it was noted that the beaches with coarse-grained sand were the richest in the number of species. They contained 29 species belonging to the order Enoplida (15 species), Monhysterida (8 species), Chromadorida (5

species) and Araeolaimida (1 species). Medium-grained sands contained 25 species. The ratio of the number of species belonging to one or another order was as follows: order Enoplida (12 species), Monhysterida (6 species), Chromadorida (6 species) and Araeolaimida (1 species). On beaches with fine-grained sand, 15 species were noted, of which only 7 species were from the order Enoplida, 5 species from Monhysterida, 2 species from Chromadorida and 1 species from Araeolaimida (Table. 3.2).

Table 3.2.

Species composition of free-living nematodes in the interstitial sandy beaches of the Odesa Gulf

Species	Sand		
	Large-grained	Medium-grained	Fine-grained
Order Araeolaimida			
Leptolaimus steineri (Fil.1922)	+	–	–
Order Monhysterida			
Tershellingia longicaudata De Man 1907	–	+	–
Monhystera longicapitata Fil. 1922	+	–	+
M. parva (Bastian 1865)	+	–	–
M. rotundicapitata Fil. 1922	+	–	+
M. conica Fil. 1922	+	+	+
M. filiformis Bastian 1865	+	+	+
Monhystera sp.1	+	–	–
Monhystera sp.2	–	+	–
Monhystera sp.3	–	–	+
Theristus latissimus Fil. 1922	–	+	–
Th. littoralis Fil. 1922	+	–	–
Theristus sp.	–	+	–
Mesotheristus setosus (Butschli 1874)	+	–	–
Order Chromadorida			
Sabatieria pulchra (G. Schneider 1906)	–	+	–
Chromadorita gracilis (Fil. 1922)	+	–	–
Chromadorina obtusa Fil. 1918	–	+	–
Chromadora nudicapitata Bastian 1865	+	+	+
Chromadora sp.	–	+	+
Paracanthonchus caecus (Bastian 1865)	+	+	–
Paracanthonchus sp.	+	–	–
Cobbionema acrocerca Fil. 1922	+	+	+

Table 3.2 continued

Species	Sand		
	Large-grained	Medium-grained	Fine-grained
Order Enoplida			
Anticoma acuminata (Eberth 1863)	–	+	–
Pontonema zernovi (Fil. 1916)	+	–	–
Phanoderma albidum Basrian 1865	–	+	–
Anoplostoma viviparum (Bastian 1865)	–	+	–
Enoploides brevis Fil. 1918	+	+	+
E. cirrhatus Fil. 1918	+	–	–
Enoplus quadridentatus Berlin 1853	+	+	+
E. maeoticus Fil. 1916	+	+	+
E. littoralis Fil. 1918	+	+	+
Enoplus sp.	+	–	+
Enoplolaimus sp.	–	+	–
Oncholaimus dujardinii De Man 1876	+	+	+
O. brevicaudatus Fil. 1918	+	–	–
O. campylocercoides Con. et Stekhoven 1933	+	+	+
Oncholaimus sp.	+	–	–
Viscosia elongata Fil. 1922	+	–	–
V. minor Fil. 1918	+	+	–
Bathylaimus australis Cobb. 1894	+	+	+
Dilaimus sp.	+	–	–

In the sand interstitial, the species diversity of Nematoda increases with distance from the Sea. In the pseudolittoral, 19 nematode species were recorded. The Enoplida order is represented by the greatest species diversity (12 species), while from the Monhysterida and Chromadorida orders there are only 4 and 3 species, respectively. In the supralittoral, at a distance of one meter from the splash, there are 22 species and at a distance of 3 meters, 26 species. The number of species from the Chromadorida order increases to seven. The Monhysterida order is represented by 4 species. At a distance of 3 m from the splash, along with a large number of species from the Enoplida order (11 species), an increase in the number of species (11) from the Monhysterida order is noted. The Chromadorida order is not numerous in terms of the number of species (3 species).

Since 1982 and up to the present time I.I. Kulakova continues to study the taxonomic composition and ecology of Nematoda within the framework of

complex studies of the meiobenthos of the western shelf of the Black Sea. For many years she personally conducted the main sampling in expeditions on various research vessels of Ukraine, Romania and Bulgaria.

For the first time, the author described quantitative and qualitative characteristics of free-living nematodes for the northwestern part of the Black Sea. Data on nematodes of the deep-water zone of the Black Sea were obtained. Studies were conducted to study the structure and quantitative indicators of free-living nematodes of the estuaries of the northern Black Sea region (Sukhoi, Grigorievsky), which have a significant technogenic load [Zaitsev Yu.P., Antsupova L.V., Vorobyova L.V., Kulakova I.I., Rusnak, 1987a, Kulakova I.I., Vorobyova L.V., 1987b Kulakova, 1989). An analysis of the state of free-living nematodes in the meiobenthos of the Odesa Gulf, Zhebriyanskaya Bay, which is under the direct influence of the Danube River runoff, is given Kulakova (Kulakova, Vorobyova, 1987; Kulakova I.I.1989,).

During the identification of nematodes, 70 species were found in the Dnieper-Bug region (DBR), 32 species in the Danube-Dniester interfluve (DDI), and 56 species in the southwestern region (SWR) (Table 3.5, 3.6). Analysis of the material showed that some species correspond to a specific research area. Thus, *Araeolaimus sp., A. zosterae, Axonolaimus sp., Odontophora sp., Leptolaimus sp., L. steineri, Sphaerolaimus macrocirculus, Monhystera sp., M. attenuata, M. collaris, M. paramonovi, Theristus euxinus, Th. sabulicola, Cylindrotheristus sp., Chromadorita leuckarti, Ch. gracilis, Spillophorella paradoxa, Cyatholaimus sp., Microlaimus ponticus, Laimidorus agilis, Anoplostoma viviparum, Mononholaimus sp., Bathylaimus sp.,* встречались лишь в Приднепровско-Бугском районе.

In the Southwestern Region the following species have been noted: *Diplopeltula sp., D. onusta, Cobbionema acrocerca, Metachromadora sp., Ceramonema annulata***,** *Anticoma sp., Oxystomina elongata, Rhabdodemania pontica, Paramonhystera sp., Sabatieria sp., Paracomesoma dubius, Desmoscolex sp., D. minutus, Quadricoma sp., Q. pontica.*

The following types can be called common to all three regions: *Parodontophora quadristicha, Axonolaimus setosus, Tershellingia pontica, T.*

longicaudata, Cylindrotheristus maeoticus, Mesotheristus setosus, Sabatieria pulchra, S. quadripapillata, S. abyssalis, Chromadorella mytilicola, Neochromadora poecilosomoides, Prochromadorella aff. mediterranea, Paracanthonchus caecus, Cyatholaimus gracilis, Metachromadora macroutera, Microlaimus kaurii, Halalaimus wodjanizkii.

In the PDBR, the order Monhysterida is represented with the greatest diversity in terms of species. Of the 27 species found on the silts, the largest number (11-16 species) was noted. On the silted sand and sand with an admixture of shells, the number of species from this order is also significant (9-19 species). On the shells, their minimum number is found. In the DDM, 19 of the 27 species belonging to the order Monhysterida were noted (Table 3.3.).

Table 3.3.

Species composition of free-living nematodes of the Dnieper-Bug region (DBR), the Danube-Dniester interfluve (DDI) and the southwestern region (SWR) of the Black Sea in the spring of 1983 (Kulakova, 2001).

Species	Regions		
	DBR	DDI	SWR
Araeolaimus sp.	+	–	–
A. zocterae (Filipjev 1918)	+	–	–
Diplopeltula sp.	–	–	+
D. onusta (Wieser 1956)	–	–	+
Parodontophora quadristicha (Stekhoven 1950)	+	+	+
Axonolaimus sp.	+	–	–
A. setosus Filipjev 1918	+	+	+
A. ponticus Filipjev 1918	+	+	+
Odontophora sp.	+	–	–
O. angustilaimus (Filipjev 1918)	+	–	+
Leptolaimus sp.	+	–	–
L. steineri (Filipjev 1922)	+	–	–
Tershellingia sp.	–	+	+
T. pontica Filipjev 1918	+	+	+
T. longicaudata De Man , 1907	+	+	+
Metalinhomoeus zosterae Filipjev 1918	+	–	+
M. filiformis (De Man 1907)	+	+	–
Sphaerolaimus ostreae Filipjev 1918	+	+	–
S. gracilis De Man 1976	+	+	–
S. dispar Filipjev 1918	–	–	+
S. macrocirculus Filipjev 1918	+	–	–
Eleutherolaimus longus Filipjev 1922	+	–	+

Table 3.3 continued

Species	Regions		
	DBR	DDI	SWR
Monhystera sp.	+	–	–
M. longicapitata Filipjev 1922	+	+	–
M. conica Filipjev 1922	+	+	–
M. attenuata Filipjev 1922	+	–	–
M. filiformis Bastian 1965	+	+	–
M. collaris Filipjev 1922	+	–	–
M. rotundicapitata Filipjev 1922	+	+	–
Paramonohystera sp.	–	–	+
P. elliptica Filipjev 1918	+	+	–
Theristus euxinus (Filipjev 1918)	+	–	–
T. littoralis Filipjev 1918	+	+	–
T. sabulicola (Filipjev 1918)	+	–	–
Cylindrotheristus sp.	+	–	–
C. maeoticus (Filipyev 1922	+	+	+
C. longicaudatus	+	+	–
Mesotheristus setosus (Butschi 1974)	+	+	+
Sabatieria sp.	–	–	–
S. pulchra (G. Schneider 1906)	+	+	+
S. quadripapillata Filipjev 1922	+	+	+
S. abyssalis (Filipjev 1918)	+	+	+
Paracomesoma dubium (Filipjev 1918)	–	–	+
Chromadorita leuckarti (De Man 1876)	+	–	–
Ch. Gracilis (Filipjev 1922)	+	–	–
Chromadorina obtusa Filipjev 1918	+	–	+
Chromadorella mytilicola Filipyev 1918	+	+	+
Neochromadora poecilosomoides (Filipjev 1918)	+	+	+
Chromadora sp.	–	+	+
Ch. Nudicapitata Basian 1865	–	+	+
Prochromadorella aff. mediterranea Micoletzky 1922	+	+	+
Spilophorella paradoxa De Man 1888)	+	–	–
Paracanthonchus caecus (Bastian 1863)	+	+	+
Cyatholaimus sp.	+	–	–
C. gracilis (Eberth 1869)	+	+	+
Cobbionema acrocerca (Filipjev, 1922)	–	–	+
Metachromadora sp.	–	–	+
M. macroutera (Filipjev, 1918)	+	+	+
Spirina sabulicola (Filipjev, 1918)	+	–	+
Desmodora pontica Vitiello 1971	+	–	+
Ceramonema annulata (Filipjev, 1918)	–	–	+
Microlaimus kaurii Wieser, 1954	+	+	+
Bolbollaimus murinae (Sergeeva, 1976)	+	–	+
Laimydorus agilis (De Man, 1880)	+	–	–
Leptolaimus steineri Filipjev	+	–	–

Table 3.3 continued

Species	Regions		
	DBR	DDI	SWR
Anticoma sp.	–	–	+
Leptosomatides sp.	+	–	–
*Oxystomina elongata (*Bütschli, 1874*)*	–	–	+
Halalaimus sp.	+	–	+
H. wodjanizkii Sergeeva, 1972	+	+	+
*H. ponticus (*Filipjev, 1922)	+	–	+
Anoplostoma viviparum (Bastian, 1865)	+	–	–
Oncholaimus sp.	+	–	+
Mononcholaimus sp.	+	–	–
Viscosia minor (Filipjev,1918)	+	+	–
V. glabra (Bastian, 1865)	+	–	+
Enoplus sp.	+	–	–
E. littoralis (Filipjev, 1918)	+	–	+
Enoploides sp.	+	–	+
E. brevis (Filipjev, 1918)	+	–	+
E. amphioxi (Filipjev, 1918)	–	–	+
Mesacanthion conicum (Filipjev, 1918)	–	–	+
Bahtylaimus sp.	+	–	–
B. cobbi (Filipjev, 1922)	+	–	+
Rhabdodemania sp.	+	–	+
R. pontica (Platonova, 1965)	–	–	+
Desmoscolex sp.	–	–	+
D. minutus Claparede 1863	–	–	+
Quadricoma sp.	–	–	+
Q. pontica (Filipjev, 1922)	–	–	+

Table3.4.

Nematofauna of the Danube estuary region

Species	A (delta arms)	C (delta foreland)	B (sea region)
Paradontophora quadristicha (Stekhoven, 1950)	-	+	-
Axonolaimus setosus (Filipjev, 1918)	+	+	+
Ax. ponticus ((Filipjev, 1918)	+	+	+
Odontophora angustilaimus (Filipjev, 1918)	-	-	+
Terschellingia pontica (Filipjev, 1918)	+	+	+
T. longicaudata De Man, 1907	-	+	+
Eleutherolaimus longus (Filipjev, 1922)	-	+	+
Metalinchomoeus zosterae (Filipjev, 1918)	-	+	+

Table 3.4 continued

Species	A (delta arms)	C (delta foreland)	B (sea region)
Cylindrotheristus longicaudatus (Filipjev, 1922)	+	+	+
C. oxycercus (De Man, 1888)	-	+	+
C. maeoticus (Filipjev,1922)	-	+	+
Theristus latissimus (Filipjev, 1922)	+	+	+
Mesotheristus setosus Bütschli, 1874	+	+	+
Monhystera longicapitata (Filipjev, 1918)	-	+	-
M. rotundicapitata (Filipjev,1922)	+	+	-
M. collaris (Filipjev, 1922)	+	+	-
M. ampulocauda (Filipjev, 1922)	+	+	-
*M. conica (*Filipjev, 1922)	+	+	+
Sphaerolaimus ostreae (Filipjev, 1918)	+	+	+
Sph. gracilis De Man, 1876	+	+	-
Sabatieria abyssalis (Filipjev, 1918)	-	+	+
S. pulchra (Schneider, 1906)	+	+	+
S. quadripapillata Filipjev, 1922		+	+
Chromadora nudicapitata Bastian, 1865	-	+	+
Chromadorina gracilis (Filipjev, 1922)	+	+	-
Neochromadora poecilosomoides (Filipjev, 1918)	-	+	+
Chromadorella mytilicola Filipjev, 1918	-	+	-
Prochromadorella mediterranea (Micoletzky, 1922)	-	+	+
Paracantonchus caecus (Bastian, 1865)	+	+	+
Cobbionema acrocerca Filipjev, 1922	-	+	+
Bathylaimus cobbi (Filipjev, 1922)	+	+	+
Oxystomina elongata (Butschli, 1874)	-	+	+
Halalaimus ponticus (Filipjev, 1922)	-	+	-
H. wodjaniskii Sergeeva, 1972	-	+	+
Halalaimus sp.	-	+	+
Anticoma acuminata (Eberth, 1865)	-	+	+
Phanoderma albidum Bastian, 1865	+	-	-
Enoplus euxinus (Filipjev, 1918)	+	-	+
Enoplus sp.		+	+
Enoploides brevis (Filipjev, 1918)	-	+	+
Enoplolaimus conicus (Filipjev, 1918)	-	+	-
Viscosia glabra (Bastian, 1865)	-	+	+
V. minor (Filipjev, 1918)	-	+	+
Onholaimus compilocercoides De Coninck, 1965	+	-	+
Metonholaimus demani (Zur Strassen 1894)	-	-	+
Anoplostoma viviparum (Bastian, 1865)	+	+	-

In the delta-front region (C), the key species of the taxocene include: S. pulchra, Terschellingia pontica, and Sphaerolaimus ostreae. Their relative contributions to the intracomplex average similarity and average similarity (S) were 39.9 % and 1.2; 18.9 % and 0.93; 11.9 % and 1.0, respectively.

Among the 46 nematode species there were found in the study areas (Table3.4. 3.5.), several species can be considered as potential indicators. So, in the taxocene of the dredging sites, these are *Monhystera rotundicapitata*, *M. conica* and *Sabatieria pulchra*. In the dumping sites – *S. pulchra*, *Terschellingia longicaudata*, *Sphaerolaimus ostreae* and *Axonolaimus ponticus*. In the sites of background stations – *S. pulchra*, *T. longicaudata* and *A. ponticus* (Kulakova, 2022).

Table 3.5.

Feeding types (FT) and mean relative abundance of Nematoda species at the different areas of the Danube delta

Species	FT	Dredging	Dumping	Background stations
		Mean relative abundance, %		
Enoplus littoralis	1A	0	0,3	0,3
Enoplus euxinus	2B	0	0	0,2
Enoploides brevis	2B	0	0	0,1
Oxyonhus dubius	2B	0	0	0,3
Enoplolaimus conicus	2B	0	0	0,8
Anoplostoma viviparum	1A	5,6	0,4	0,1
Phanoderma albidum	2A	0	0	0,4
Anticoma acuminata	1A	0	0,8	0,3
Viscosia glabra	2B	0	0	2,9
Viscosia elongata	2B	0	0	0,9
Viscosia minor	2B	0,7	1,3	2,3
Onholaimus compylocercoides	2B	0	0	4,3
Oxystomina elongata	1A	0	0	1,5
Halalaimus ponticus	1A	0	0	1,7
Bathylaimus cobbi	1B	0	1,4	0,3
Chromadora nudicapitata	2A	0	0,1	1,7
Chromadorella mytilicola	2A	0	0	0,3
Euchromadora striata	2A	0	0,4	0,3
Chromadorina gracilis	2A	0	0,3	0
Chromadoritta leucarti	2A	0	0,4	0,3

Table 3.5 continued

Species	FT	Dredging	Dumping	Background stations
		Mean relative abundance, %		
Neochromadora poecilosomoides	2A	0	4,9	3,2
Paracantonchus caecus	2A	7,4	2,2	0,8
Cobbionema acrocerca	2A	0	0	2,6
Microlaimus kaurii	1A	0	4,4	3,5
Monhystera collaris	1B	3,7	0,4	1,7
Monhystera conica	1B	16,3	0,4	0,7
Monhystera longicapitata	1B	0,6	0	0
Monhystera ampulocauda	1B	0,4	0	0
Monhystera rotundicapitata	1B	1,0	0	0,4
Monhystera sp. 1	1B	0,6	0	0
Monhystera sp. 2	1B	0,4	0	0
Cylindrotheristus longicaudatus	1B	0,4	0	0
Cylindrotheristus maeoticus	1B	0,0	0,3	0,2
Mesotheristus setosus	1B	0,1	0	0
Theristus latissimus	1B	0,5	0	0,2
Theristus sp.	1B	0	0,9	0
Sphaerolaimus gracilis	2B	0	2,5	1,0
Sphaerolaimus ostreae	2B	0,1	3,3	4,5
Metalinchomoeus zosterae	2A	0	0,8	0,3
Terschellingia pontica	1A	0	16,4	14,6
Axonolaimus ponticus	1B	0	7,3	7,5
Axonolaimus setosus	1B	0,4	6,8	0
Paradontophora quadristicha	1B	0	0,0	0,8
Sabatieria abyssalis	1B	0	1,1	0
Sabatieria pulchra	1B	61,0	42,1	38,7
Sabatieria sp.	1B	0,6	0,9	0

Table 3.6.

Species diversity of nematodes and quantitative indicators in different parts in the estuarine waters of the Danube

Species	Number, ind.·m^{-2}	Biomass, mg·m^{-2}
Axonolaimus ponticus	38	0,05
Terschellingia pontica	12764	6,13
Metalinchomoeus zosterae	44	0,04
Sphaerolaimus gracilis	1432	0,36
Sphaerolaimus ostreae	2931	2,29

Table 3.6 continued

Species	Number, ind.·m^{-2}	Biomass, mg·m^{-2}
Monhystera longicapitata	210	0,03
M.collaris	710	0,04
M. ampulocauda	918	0,24
M. rotundicapitata	3333	0,83
M. conica	214	0,06
Monhystera sp.	139	0,02
Theristus maeoticus	139	0,04
Th. setosus	421	0,13
Cylindrotheristus longicaudatus	631	0,11
Sabatieria pulchra	14811	7,70
S. abissalis	7914	7,12
Chromadora poecilosomoides	250	0,05
Ch. mitilycola	543	0,08
Chromadora sp.	833	0,05
Prochromadorella mediterranea	44	0,01
Cyatolaimus sp.	44	0,01
Paracantonchus caecus	788	0,05
Cobbionema acrocerca	3256	0,49
Halalaimus ponticus	1716	0,43
Oxystomina elongata	543	0,28
Anoplostoma viviparum	1744	0,44
Enoplus littoralis	3750	4,50
Enoplus sp.	176	0,03
Enoplolaimus conicus	167	0,50
Enoplolaimus sp.	139	0,03
Bathylaimus cobbi	1207	0,22
Viscosia minor	2888	0,72
V. glabra	1044	0,84
Average	**65778**	**1,03**

The presence of species from these orders is typical for areas where river and sea waters mix, whereas in open sea areas the nematode fauna is represented by species from the other 6 orders. Among the diversity of species in the biotope of sand with an admixture of shell rock, the following species dominated in terms of settlement density and occurrence: *A. acumminata, E. brevis, V. minor, P. caecus, Ax. setosus, C. longicaudatus. Dominant species: S. pulchra, Sph. ostreae*. In the branches of the Danube Delta, the dominant species are: *M. rotundicipitata, M. setosus, C. longicaudatus.*

At the coast, among the diversity of species in terms of density and occurrence, the following dominate at most stations: *S. pulchra, Sph. ostreae, V. minor.* Such distribution of nematodes is typical for eutrophic waters. In Zhebryanskaya Bay, characterized mainly by silt stations, the leading role in the number of species is played by the orders Monhysterida (50 %) and Chromadorida (23 %). The average density of nematodes in the bay compared to the silt biotype on the coast is lower and amounted to 83,118 ind.·m^{-2} (average biomass is 201.8 mg·m^{-2}). Only one species dominated both in terms of occurrence and settlement density: *S. pulchra* (occurrence is 70 %, average density is 31,174 ind.·m^{-2}).

The highest rates of species diversity were noted on the seashore in the biotope of sand mixed with shells (0.48 – 1.04). In the silt biotope they were 0.98. The dominant species were *S. pulchra, Sph. ostreae*. In the branches of the Danube Delta, the species from the order Monhysterida (*M. rotundicapitata, C. longicaudatus, M. setosus)* dominate in terms of occurrence and settlement density. The density of nematodes varied from 24,000 to 148,000 ind.·m^{-2}

The diversity index is not high and varies from 0.20 to 0.49. In the most impacted zones of the Zhebrianskaya Bay (Ust-Dunaisk port), as well as on the seashore in the area of the soil dump, the minimum density of nematodes is observed in all seasons of the year. In these areas, species of the order Monhysterida (*M. setosus, C. longicaudatus, M. rotundicipitata, S. pulchra*) predominate. The density of nematodes in Zhebryanskaya Bay reaches its maximum values mainly in the northwestern part of the bay, remote from the chemical unloading site. Here, species diversity is higher.

Our Institute has been conducting a comprehensive study of marine biota in the Odesa Marine Region (OMR) of the Black Sea since 1994-2017. The study of the formation of ecological characteristics of meiobenthos and, in particular, nematodes, is an integral part of it.

Kulakova I. I. identified 50 nematode species belonging to 5 orders in the study area (Table 3.7.). The assessment of nematode species richness (DMg) in the OMR showed that the highest values of this index (from 2.1 to 3.5)

were recorded at individual stations, indicating a large number of nematode species, each represented by a small number of individuals. At most stations, the values of the nematode species richness index are not high (from 0.3 to 1.5). The number of species varies on different substrates

Table 3.7.

Free-living Nematoda in the OMR (Kulakova, 2017).

Species	Silt	Silted shell	Sand+ shell
Areolaimida			
Araeolaimus ponticus (Filipjev, 1922)	+	+	
Axonolaimus setosus (Filipjev, 1918)	+		
*A. ponticus (*Filipjev, 1918)	+		+
Camacolaimus dolichocercus Filipjev, 1922		+	
Monhysterida			
Terschellingia pontica (Filipjev, 1918)	+	+	+
Metalinhomoeus zosterae (Filipjev, 1918)	+		
*Paralinhomoeus filiform*is (Filipjev, 1918)	+		+
Eleutherolaimus longus (Filipjev, 1922)	+	+	+
Sphaerolaimus gracilis de Man, 1876	+	+	+
Sph. ostreae (Filipjev, 1918)	+	+	+
Monhystera collaris (Filipjev, 1922)	+	+	+
M. longicapitata (Filipjev, 1918)	+		+
M. filiformis Bastian, 1865	+		+
M. conica (Filipjev, 1922)	+		+
Monhystera sp.	+	+	
Paramonhystera sp.	+		
*Theristus latissimus (*Filipjev, 1922)	+	+	
Theristus sp.		+	
Cylindrotheristus longicaudatus (Filipjev, 1922)	+	+	+
Cylindrotheristus sp			+
Microlaimus kaurii Wieser, 1954		+	+
Microlaimus sp.			
Chromadorida			
Sabatieria abyssalis (Filipjev, 1918)		+	
S. pulchra (Schneider, 1906)	+	+	+
Neochromadora poecilosomoides (Filipjev, 1918)	+	+	+
Neochomadora sabulicola (Filipjev, 1918)	+	+	
Chromadorella mytilicola (Filipjev, 1918)	+		
Chromadorella pontica	+		
Dichromadora cephalata (Steiner, 1916),	+		+
Chromadora nudicapitata Bastian, 1865	+		+
Chromadorina gracilis (Filipjev, 1922)		+	

Table 3.7 continued

Species	Silt	*Silted shell*	Sand+ shell
Ch. obtusa (Filipjev, 1918)			+
Spillophorella paradoxa (de Man, 1888)		+	
Paracantonchus caecus (Bastian, 1865)	+	+	+
Desmoscolecida			
Quadricoma loricata (Filipjev, 1922)	+		
Q. media (Reihard, 1881)	+	+	
Quadricoma sp.	+	+	
Enoplida			
Halalaimus sp. 1	+		
Halalaimus sp. 2	+		
Anoplostoma viviparum (Bastian, 1865)	+	+	+
Calyptronema sabulicola (Filipjev, 1918)		+	
Enoploides hirsutus Filipjev, 1918	+	+	
E. brevis Filipjev, 1918	+	+	+
Enoplus littoralus Filipjev, 1918		+	
Enoplus sp.		+	
Oxionhus dubius (Filipjev, 1918)	+		
Mesacanthion conicum (Filipjev, 1918)		+	
Tripiloides marinus de Man, 1886			+
Oncholaimus sp.	+		
Viscosia minor (Filipjev, 1918)		+	+

Grigorievsky Estuary. Before the research of I.I. Kulakova, there was no information about the nematodes of this reservoir. Long-term systematic sampling and their analysis allowed the author to publish (Ecosystem of Grigorievsky (Small Adzhalyk) estuary – 2008) lists of nematode species of the Grigorievsky Estuary. Her data on the formation of quantitative characteristics of nematodes will be considered in Chapter 3.

In order to have an idea of the nematode community of the Grigorevsky estuary as a whole, the trophic relationships between their different species were analyzed (Fig.3.8.). Thus, on silty soils, the main role in the taxocene is played by non-selective detritivores (1B), which make up 43.0%, and selective detritivores (1A), which account for 25 %. Predators (2B) and scrapers (2A) accounted for 17-14 %, respectively. In the biotope of silted shells, nematodes from group 1B dominate, making up 39.5 %, and predators – 27 %. In the coastal strip of the estuary in coarse sand with an admixture of shells,

representatives of the group of non-selective detritivores (50 %) and predators (22 %) prevailed, the share of selective detritivores was only 11 %.

Table 3.8.

Species composition of free-living nematodes and their occurrence (in %) in the Grigorevsky Estuary and adjacent marine waters

Species	Estuary			Marine waters
	silt	silted shells	sand with shells	Silted sand
Araeolaimus zostearae (Filipjev,1918*)*	3,5	0	0	0
*Axonolaimus ponticus (*Filipjev, 1918)	68,0	33,0	0	24,9
A. setosus Filipjev 1918	14,2	8,5	0	0
Leptolaimus steineri (Filipjev, 1922)	3,5	0	0	0
*Tershellingia pontica (*Filipjev, 1918)	73,9	66,0	20,0	56,3
T. longicaudata De Man 1907	46,0	33,0	10,0	0
Metalinchomoeus zosterae (Filipjev, 1918)	18,0	0	0	0
Paralinchomoeus filiformis (Filipjev,1918)	7,0	8,0	0	0
Eleutherolaimus longus Filipjev, 1922	42,7	8,0	0	33,3
Sphaerolaimus gracilis De Man 1976	14,2	8,0	10,0	66,0
*S. ostreae (*Filipjev, 1918)	11,8	24,7	0	0
Monhystera sp.	3,5	0	0	8,3
M. filiformis Bastian 1865	4,0	8,0	10,0	16,0
*M. conica (*Filipjev, 1918)	7,5	33,0	30,0	0
Theristus sp.	0	0	5,0	8,3
Th sabulicola (Filipjev, 1922)	8,2	0	10,0	0
Cylindrotheristus longicaudatus (Filipjev 1922)	8,2	16,2	20,0	8,3
C. maeoticus (Filipjev, 1922)	4,0	49,0	35,0	8,3
Sabatieria pulchra G. Schneider 1906	96,2	66,0	25,0	83,3
Chromadora sp.	15,0	8,2	0	16,6
Ch. nudicapitata Bastian 1865	7,0	8,2	40,0	8,3
Neochromadora poecilosomoides Fil., 1918	7,0	41,0	30,0	0
Spillophorella euxina Filipjev 1918	3,5	0	0	0
Chromadorella sp.	0	0	15,0	8,3
Paracanthonchus caecus Bastian, 1865	64,0	24,7	25,0	41,6
Anticoma acuminata (Eberth 1865)	8,2	0	0	0
Oxystomina elongata (Butschli 1874)	10,6	33,0	0	0
Halalaimus ponticus Filipjev 1922	0	8,2	0	0
Anoplostoma viviparum Bastian 1865	32,5	33,0	10,0	16,6
Catalaimus sabulicola (Filipjev, 1918)	0	8,2	0	0

Table 3.8 continued

Species	Estuary			Marine waters
	silt	silted shells	sand with shells	Silted sand
*Enoploides brevis (*Filipjev, 1918)	0	8,2	15,0	0
Trypiloides marinus Butschli 1874	4,0	8,2	0	0
*Oncholaimus brevicaudatus (*Filipjev, 1918)	0	16,5	0	0
Viscosia glabra (Bastian 1865)	7,0	24,7	0	0
*V. minor (*Filipjev, 1918)	15,0	8,2	0	8,3

In the marine area, in the biotope of coarse sand mixed with shells, non-selective detritivores also predominated, making up 44 %, and predators (25 %). Only 12 % of all nematodes were selective detritivores. The low percentage of this group is most likely explained by the insufficient amount of detritus in the soil.

Fauna of Nematoda of Sukhoi Liman is represented by 14 species from 4 orders (Table 3.9.). For the first time, the species composition of nematodes is indicated for Sukhoi Liman. The main share in abundance (81%) and biomass (86 %) on the silts were the following species: *S. pulchra* and *T. pontica*. On the silted shell, the following species dominated: *P. caecus* and *N. sabulicola*. In the marine area adjacent to the estuary, three species dominated in abundance: *E. littoralis, P. caecus* and *S. pulchra.* A high percentage of occurrence in the estuary is characteristic of only a few species. The dominant species are *S. pulchra* and *T. pontica* (85.7 % each), the subdominant species *is C. maeoticus* (57.2 %). The remaining species found in the estuary had occurrence rates ranging from 14.3 % to 42.8 %.

The species diversity of the Nematoda varied widely at different stations. The upper reaches of the estuary and the zone adjacent to the sea part were the richest in species composition. In the indicated areas, the number of species in the Nematoda were large, but each was represented by a small number of individuals. In this case, the diversity indices estimated by Shannon were the highest, and the Simpson indices were minimal). At stations located in the

middle of the estuary, the dominance of only one or two species among a small diversity was noted.

Table3.9.

Species composition of free-living nematodes in the Sukhoi Liman and adjacent marine area (Kulakova, 2006)

Species	Sukhoi Liman	Adjacent marine area
Axonolaimus setosus	+	–
Terschellingia pontica	+	+
Eleutherolaimus longus	+	+
Sphaerolaimus ostreae	+	+
Monhystera sp.	–	+
Cylindrotheristus maeoticus	–	+
C. oxycercus	–	+
C. longicaudatus	–	+
Sabatieria pulchra	+	+
Neochromadora poecilosomoides	–	+
N. sabulicola	+	+
Paracanthonhus saecus	+	+
Anticoma acuminata	+	–
Catalaimus sabulicola	+	–
Enoplus littoralis	+	–
Oncholaimus compilocercoides	–	+
Viscosia minor	–	+
V. glabra	+	–

Yagorlytskyi Gulf. Nematoda during the research period were represented by 36 species (data from I.I. Kulakova):: *Leptolaimus steineri* (Felipjev 1922), *Enoplus littoralis* Felipjev 1918, *Enoploides brevis* Felipjev 1918, *Viscosia minor* Felipjev 1918, *V. cobi* Felipjev 1918, *Oncholaimus compilocercoides* Con. et Stekhoven 1933, O. sp., *Eurystomina assimilis* (de Man. 1876), *Catalaimus sabulicola* (Felipjev 1918), *Halanonchus bul-latus* Gerlach 1964, *Monhystera collaris* Felipjev 1922, *M. longicapitata* Felipjev 1922, M. ampulocauda. Paramonov 1916, M. conica Felipjev 1922, M. rotundicopitata Felipjev 1922, Cylindrotheristus maeoticus (Fe-lipjev 1922), *C. longicaudatus* (Felipjev 1922), *Theristus littoralis* Felipjev 1922, Th. sp.,

Terschellingia longicaudata De Man 1907, *T. pontica* Felipjev 1918, *Sabatieria abissalis (*Felipjev 1918), *S. pulchra* (G. Schneider 1906), *Paracantonchus caecus* (Bastian 1865), P. sp., *Desmodora pontica* Felipjev 1922, *Chromodora* nudicapitata Bastian 1865, *Metachromodora macroutera* Felipjev 1918, *Prochromadorella mediterranea* (Micoletzky 1922), *Axonolaimus setosus* Felipjev 1918, *A. ponticus* Felipjev 1918, *Bathylaimus cobbi* Felipjev 1922, *Desmoscolex minutus* Claparede 1863.

Nematoda fauna is most diverse in shallow waters and the eastern part of the bay (12 species each). On silted ground – 5 species and 1 species are noted on eelgrass.

The study of nematodes in the **Sea of Azov** was started by I.N. Filipiev (1922). He noted 15 species of free-living nematodes. According to I.I. Kulakova (Vorobyova, Kulakova, 1989, 1990), the diversity of nematodes in the Sea of Azov is determined by 23 species belonging to 5 orders: *Rhabdodemania pontica* Platonova, *Oxystomina elongata* (Butschli), Oxystomina sp., *Enoploides brevis* Fil., *Viscosia minor* Fil., *Halalaimus wodjaniskii* Sergeeva, Halalaimus sp., *Anoplostoma viviparum* (Bastian), *Dichromadora cephalata* Fil., *Neochromadora poecilosomoides* Fil., *Prochromodorella mediterranea* Micoletzki, *Sabatieria quadripapillata* Fil., *Monchystera conica* Fil., *Paramonchystera proteus* Wieser, *Cylindrotheristus maeoticus* Fil., *Theristus littoralis* Fil., *Terschellingia longicaudata* de Man, *Eleutherolaimus longus* Fil., *Sphaerolaimus gracilis* de Man, *S. ostreae* Fil., Microlaimus sp., *Parodontophora quadristicha* Timm, Diplopeltis sp.

Of the 23 species listed, the most common are: *Sabatieria quadripapillata, Monhystera conica, Terschellingia longicaudata, Oxystomina elongata, Viscosia minor*. The greatest species diversity of nematodes is noted in the central part of the sea.

2.4. Harpacticoida of the Ukrainian shelf

Harpacticoida, as an important component of the meiobenthic community, are one of the leading groups in most marine meiobenthic

communities. Harpacticoids are second only to nematodes in population density in NWBS. Bottom copepods are an important link in the trophic chain, representing one of the main consumers of the primary production of microphytobenthos. Along with nematodes, they are represented in the meiobenthos by a large number of species.

Copepods of the order Harpacticoida are one of the leading groups of contour biotopes of the Black Sea benthal. They make a significant contribution to the species diversity of meiobenthos (the number of species of these crustaceans is one of the highest in the meiobenthic community). The highest role of Harpacticoida in the total abundance of the community is in the psammocontour of sandy beaches and the upper sublittoral, as well as in the periphyton of the northwestern part of the Black Sea. The greatest importance in the formation of the total biomass of meiobenthos, and most importantly, its quality as a food object for fish. Harpacticoids live in the Northwest Black Sea on the sandy-shell substrate, silts and in the periphyton of artificial substrates.

The harpacticoid fauna of the NWBS was studied little and fragmentarily until the end of the last century. A systematic study of the Harpacticoida of the Ukrainian shelf was started at the IMB in the early 1980s. As has been said before, these were studies of the interstitial meiofauna of sandy beaches, which was studied for many years by L.V. Vorobyova and Kulakova I.I. (Vorobyova et al., 1992).

According to Vorobyova L.V. at sandy coastal areas with coarse and medium-grained sand, 8 species of harpacticoids were found: *Ectinosoma melaniceps* Boeck 1964; *Arenopontia subterranean* Kunz 1937; *Harpacticus littoralis* Sars. 1910; *Ameira parvula* Claus, 1866*, Nitocra pusila* Sars, 1911; *N. affinis* Gurney, 1927; *N. spinipes* Boeck,1864; *Stenocaris pontica* Chapp et Serban, 1953. Only one species, *Paraleptostacus spinicauda trisetosa* Serban et Eltel-Lang, 1957, was found in areas with fine-grained sand.

Ph D Garlitska L. A. began her research work on the study of Harpacticoida while she was studying at Odesa University I.I. Mechnikov. Already in 1991, she was enrolled as an engineer at our Institute. She

successfully defended her coursework and diploma works. Over the years of work at the Institute, she has shown herself to be a successful specialist

From 1991 to 2012 Garlitska L.A. conducted an in-depth and successful study of the taxonomic composition and ecological characteristics of copepods. Her professionalism and creative approach to research has allowed her to make a significant contribution to our knowledge of this important component of the meiobenthic community. Her first publications date back to 2000 (Garlitska, 2000; Garlitska, 2000).

Having successfully completed an internship in 2000-2001 at the University of South Carolina under the guidance of Dr., Professor Bruce C. Coull (South Carolina Unversity, Columbia, USA) and successfully continuing their research into the taxonomic composition and ecology of harpacticoids. L.A. Garlitska defended her PhD thesis in 2010. In her dissertation work (Garlitskaa 2010) significantly xpanded the list of NWBS harpacticoid species.

During the research of Garlitska L.A. 82 species of Harpacticoida belonging to 24 families were found. Her the list of Harpacticoida of the Ukrainian part of the Northwestern shelf of the Black Sea has been expanded and supplemented from 52 species (Vinogradov, 1967.) to 116 species. Ten species are listed for the first time for the Black Sea, one species is new to science. For the first time, a comparative analysis of Harpacticoida communities in different areas of the NWBS was carried out, and the specificity of Harpacticoida communities at different depths and substrates, as well as their seasonal dynamics, was revealed (Garlitskaya, 2001, 2004, 2006, 2008, 2009). During sixteen years of research on the Northwestern shelf, she discovered ten species new to the Black Sea fauna: *Harpacticus flexulosus* Ceccherelli, 1988, *Proameira dubia* (Sars G.O., 1920), *P. signata* Por, 1964, *Psyllocamptus eridani* Ceccherelli, 1988, *Bulbamphiascus aff.minutus*, *Robertgurneya similis bulbamphiascoides* Noodt, 1955, *Tisbe battagliai* Volkmann-Rocco, 1972, *T. bulbisetosa* Volkmann-Rocco, 1972, *T. marmorata* Volkmann-Rocco, 1973 and *Canuella sp*. Huys et al., 1996., and one new to science, Paronychocamptus sp..The Danube and Dniester regions have the lowest species diversity.

During her research much attention Garlitska L.A. devoted herself to studying the species composition and regularities of the spatial and temporal distribution of representatives of the taxocene Harpacticoida in the Grigorievsky Liman (Garlitska, 2000; Garlitska, 2004). Previously, the species composition of harpacticoids in this Liman was not studied. For the estuary of L.A. Galitska, 38 species of harpacticoids belonging to 17 families are indicated. In 2001–2005, the author indicated 27 species for the coastal part of the estuary (depth up to 3 m), 18 species in the western upper reaches, 4 species in the eastern upper reaches, and 24 species of harpacticoids in the deep-water part of the estuary. The author concludes that the species structure of the shallow water and the deep-water zone of the estuary differ significantly. The Harpacticoida of the western and eastern coasts differ in the set of species.

Transdniester region. According to Garlitska L.A. in the waters of the estuary, 18 species from the Harpacticoida families were found: Ameiridae (1), Canthocamptidae (1), Cletodidae (1), Dactylopusiidae (2), Ectinosomatidae (2), Harpacticidae (1), Laophontidae (1), Miraciidae (2), Paramesochridae (1), Tachidiidae (1), Tegastidae (1) and Tisbidae (3). A high degree of occurrence was noted for six species – *A. parvula, P. longirostris, E. melaniceps, M. pygmaea, T. battagliai* and *Dactylopusia tisboides (*Table 4.1, 4.2).

With a population of 0.8 thousand specimens, the burrowing E. melaniceps makes up an average of 23.9%. The non-specific interstitial species *A. parvula* and *P. longirostris* contribute 21.4 and 17.8%, respectively, to this taxocene. Also, the epibenthic E. garienis (16.7 %), which was found only in this complex, and the phytal D. *tisboides* (10.4 %) play a relatively significant role here. It should be noted that this taxocene turned out to be the most impoverished: only 9 harpacticoid species were recorded here.

The silt-digging *P. bealuina* and the interstitial *X. herdmani* gravitate towards sandy, slightly silted substrates, while species of the genus Tisbe and *P. brevicornis*, which develop in the presence of an algal substrate, were more widely represented in the 1998 samples. Thus, based on the set of mass species found in both years of research, it can be concluded that this is one stable complex with local variations.

Table 4.1.

List of Harpacticoida species (Crustacea, Copepoda) and their occurrence (F, %) in the Transdnistrian region of the Black Sea.

species	Life form	F
Ameira parvula	not int	92,9
Dactylopusia tisboides	phyt	64,3
Delavalia elisabethae	epiben	7,1
Ectinosoma melaniceps	siltdw	85,7
Enhydrosoma garienis	epiben	21,4
Harpacticus flexulosus	epiben	14,3
Laophonte elongata	epiben	50,0
Mesochra pygmaea	not int	71,4
Microarthridion littorale	epiben	21,4
Paradactylopodia brevicornis	phyt	21,4
Paramphiascopsis longirostris	not int	92,9
Pseudobradya beduina	siltdw	21,4
Scottopsyllus herdmani	int	50,0
Tegastes longimanus	phyt	28,6
Tisbe battagliai	phyt	71,4
Tisbe histriana	phyt	35,7
Tisbe marmorata	phyt	21,4

Table 4.2.

Species of Harpacticoida found in the Transdnistrian region in different years of research

Species	Years of research	
	1998	2003
Ameira parvula	+	+
Amphiascus propinqvus		+
Dactylopusia tisboides	+	+
Delavalia elisabethae	+	
Diarthrodes nobilis		+
Ectinosoma melaniceps	+	+
Enhydrosoma garienis	+	+
Halectinosoma curticorne		+
Harpacticus flexulosus	+	
Laophonte elongata	+	+
Mesochra pygmaea	+	+
Microarthridion littorale	+	
Paradactylopodia brevicornis	+	

Table 4.2 continued

Species	Years of research	
	1998	2003
Paramphiascopsis longirostris	+	+
Pseudobradya beduina	+	
Scottopsyllus herdmani	+	
Tegastes longimanus	+	+
Tisbe battagliai	+	
Tisbe furcata		+
Tisbe histriana	+	
Tisbe marmorata	+	
Total number of species:	17	12

The Grigorevsky Estuary is one of those water bodies for which information on harpacticoids was extremely scarce until the early 1990s. There are only data from publications by N.I. Stakhorskaya, in the late 1960s. As a result of her research in the estuary's waters, among true zooplankton organisms, she discovered 16 species of harpacticoid copepedes.

A targeted study of harpacticoid copepods, their species diversity and some ecological characteristics was started by L.A. Garlitska in the early 1990s (Table 4.3)

Long-term studies of the meiobenthos of the Grigorievsky Estuary (Garlitska, 2000, 2004, 2005) made it possible to expand the list of Harpacticoida to 44 species. During the observation period, the order Harpacticoida was represented by 38 species (Table4.3.), belonging to 17 families: Ameiridae, Canthocamptidae, Canuellidae, Cletodidae, Dactylopusiidae, Darcythompsoniidae, Ectinosomatidae, Harpacticidae, Huntemanniidae, Laophontidae, Leptastacidae, Miraciidae, Peltidiidae, Tachidiidae, Tegastidae, Thalestridae and Tisbidae.

Table 4.3.

Harpacticoida of the Grigorievsky Estuary

Species	Literary data (before 1993)	Current data (2000-2005)	
		0,3 m	4-17 m
Alteutha typica	-	*	—

Table 4.3 continued

Species	Literary data (before 1993)	Current data (2000-2005)	
		0,3 m	4-17 m
Ameira parvula	+	18,9*	70,7*
Amphiascopsis cinctus	+	—	—
Asellopsis sarmatica	-	2,7	4,9
Canuella perplexa	+	-	-
Canuella sp.	-	91,9*	68,3
Dactylopusia tisboides	-	*	7,3*
Delavalia elisabethae	-	21,6*	28,0*
Delavalia palustris	-	18,9*	6,1*
Diarthrodes nobilis	-	*	-
Ectinosoma melaniceps	+	62,2*	62,2*
Enhydrosoma garienis	-	78,4*	76,8*
Halectinosoma curticorne	-	2,7	1,2
Harpacticus flexulosus	-	48,6*	15,9
Harpacticus flexus	+	5,4	*
Harpacticus littoralis	+	13,5	1,2
Harpacticus longiantennata	+	-	-
Harpacticus obscurus	-	*	1,2
Laophonte setosa	+	24,3*	23,2*
Leptocaris brevicornis	-	2,7	-
Mesochra aestuarii	+	2,7	1,2
Mesochra heldti	-	2,7	-
Mesochra lilljeborgii	+	-	-
Mesochra pontica	-	70,3*	6,1
Mesochra pygmaea	+	2,7*	-
Microarthridion fallax	-	35,1*	-
Microarthridion littorale	+	18,9*	92,7*
Nannomesochra arupinensis	-	2,7*	-
Nannopus palustris	-	18,9*	29,3*
Nitocra lacustris	+	-	-
Nitocra spinipes	+	-	-
Nitocra typica	-	29,7*	11,0
Paradactylopodia brevicornis	-	2,7*	2,4
Paraleptastacus spinicauda	-	-	2,4
Paramphiascopsis longirostris	-	-	2,4
Parathalestris dovi	-	16,2	-
Paronychocamptus sp.	-	16,2	-
Schizopera compacta	-	29,7*	64,6*
Tegastes longimanus	-	-	3,7
Tisbe battagliai	-	*	19,5
Tisbe bulbisetosa	-	*	-
Tisbe furcata	+	*	*

Table 4.3 continued

Species	Literary data (before 1993)	Current data (2000-2005)	
		0,3 m	4-17 m
Tisbe histriana	-	13,5*	-
Tisbe marmorata	-	*	-
Tisbe tenella	+	-	-
Averadge	16	35	26

Note: * – the species were present in qualitative samples in 1993.

In 2001–2005, 27 species of harpacticoids belonging to 14 families (i.e. the families listed above except for Leptastacidae and Tegastidae) were recorded in the coastal part of the estuary at a depth of up to 0.3 m. At 29.7 – 48.6 % of stations, 4 species were noted: *H. flexulosus, M. fallax, N. typica* и *S. compacta.* Less common (in 13.5-24.3% of cases) were: *A. parvula, H. littoralis, L. setosa, M. littorale, N. palustris, P. dovi, Paronychocamptus* sp., *D. elisabethae, D. palustris, T. histriana.* Nine species – *A. sarmatica, H. curticorne, H. flexus, L. brevicornis, M. aestuarii, M. heldti, M. pygmaea, N. arupinensis* и *P. brevicornis* – they were encountered only 1–2 times during the entire period of research of the coastal part of the estuary.

In the deep-water part of the Grigorevsky Estuary in 2000-2005, 24 species of harpacticoid copepods were found (see Table 4.3.), which belong to 14 families. The most widely represented family is Miraciidae – 4 species; Harpacticidae – 3 species; Ameiridae, Canthocamptidae, Ectinosomatidae, Dactylopusiidae and Laophontidae – 2 species, the remaining families – Canuellidae, Cletodidae, Huntemanniidae, Leptastacidae, Tachidiidae, Tegastidae and Tisbidae – 1 species. A high degree of occurrence at a depth of 4-17 m was noted for 5 species of harpacticoids: *M. littorale* (in 92.7 % of samples), *E. garienis* (76.8 %), *A. parvula* (70.7%), *Canuella sp.* (68.3 %) and *E. melaniceps* (62.2 %). *N. palustris, D. elisabethae, L. setosa, Tisbe battagliai, H. flexulosus* and *N. typica* are found much less frequently in the samples: their occurrence is within 10–30 %.

Despite the high values of the total number of recorded and expected species, in terms of the low level of both a- and b-diversity, as the author points

out, it is closer to the mouth areas of the Dniester and Danube, noticeably inferior to the Karkinitsky Bay and the open part of the NWBS. The expected number of species can be comparable with that of the Karkinitsky Bay and the open part of the NWBS only in part, since the samples of these areas are smaller (12–16 samples); in fact, it is almost half that in the richest districts (Garlitska, 2004, 2005, 2006, 2008).

As a result of the analysis of long-term material Garlitska L.A. concluded that in the five studied areas (the Danube, Transdnistrian, Grigorievsky liman, Karkinitsky Bay and the open part of the northwestern shelf of the Black Sea), the species are unevenly distributed noted only 11 of them among the most common ones: *Ameira parvula* Boeck, 1872, *Enhydrosoma garienis* Gurney, 1930, *Mesochra pygmaea* (Claus, 1863), Microarthridion littorale (Poppe, 1881*), Paramphiascopsis longirostris* (Claus, 1863), *Dactylopusia tisboides* (Claus, 1863), *Ectinosoma melaniceps* Boeck, 1865, *Laophonte elongata* Boeck, 1873, *Nannopus palustris* Brady, 1880, *Tegastes longimanus* (Claus, 1863), *Tisbe histriana* Marcus & Por, 1961.

The richest fauna were in two areas: the open part of the NWBS and the Karkinitsky Bay. At the same time, the relative richness of the fauna in the open, deepest part of the NWBS is due to high spatial heterogeneity (β-diversity), and in Karkinitsky Bay – to a high number of species per sample (α-diversity). Garlitskaya shows that the Danube and Dniester regions have the lowest species diversity.

The extremely low β-diversity in the Transdnistrian region is most likely due to the low diversity of substrates and a smaller depth range compared to the Danube region. The Danube region and Karkinitsky Bay, with the same value of β-diversity, differ significantly in other indicators. Thus, the average number of species recorded in shallow water samples of the Karkinitsky Bay is more than 5 times higher than that for the Danube region, and the number of species is 2.6 times. (Garlitska, 2006; 2008, 2009. Garlitska, 2006).

In relation to individual species of harpacticoids to environmental factors, L.A. Garlitska identified seven main groups:

– relatively deep-water (35–40 m) silted sands with shells:

Haloschizopera mathoi, Normanella serrata; – clean silts at a depth of 10–25 m: *Pseudobradya beduina, Paraleptastacus spinicauda, Microarthridion littorale, Nitocra hibernica*;

– silted sands with shells at a depth of 10–25 m: *Laophonte elongata, Tisbe marmorata, Scottopsyllus herdmani;*

– shallow (0.3–5 m) sands: *Nitocra typica, Mesochra pontica, Paronycho-camptus sp.;*

– shallow (0.3–5 m) silty sands: *Tisbe histriana, Asellopsis sarmatica, Harpacticus littoralis, Canuella sp., Microarthridion fallax, Parathalestris dovi*;

– shallow (0.3–5 m) areas of macrophytes: *Tisbe battagliai, Harpacticus flexus, Harpacticus obscurus*; – eurybiont forms: *Ameira parvula, Paramphiascopsis longirostris, Tegastes longimanus, Dactylopusia tisboides, Mesochra aestuarii, Schizopera compacta, Delavalia elisabethae, Paradactylopodia brevicornis, Mesochra pygmaea, Enhydrosoma garienis, Laophonte setosa, Delavalia palustris, Na nnopus palustris, Ectinosoma melaniceps, Harpacticus flexulosus* (Garlitska, 2010).

For the first time Garlitska L.A. made a comparative analysis of Harpacticoid communities in different areas of the NWBS, identified the specificity of Harpacticoid communities at different depths and substrates, as well as their seasonal dynamics

She was the first to substantiate the position about the nature and origin of the Black Sea of Harpacticoida. In her dissertation work, Lesya Anatolyevna widely covered this scientifically important issue (Galitskaya, 2010). The author concluded that most Ponto-Caspian harpacticoids are widespread species. To date, only 52 regional endemics are known (17.9 % of the total fauna), which is two times lower than in the Mediterranean Sea and three times lower than in the Atlantic. Eight species (*Nitocra hibernica, N. lacustris, Cletocamptus confluens, C. retrogressus, Limnocletodes behningi, Nannopus palustris, Halectinosoma abrau, Onychocamptus mohammed*) were found in the Black Sea, all of them are euryhaline cosmopolitans. Apparently, these species represent the relict fauna of the Sarmatian Sea (Garlitskaya, 2010).

Since 2010, Portyanko V.V. has been studying the SWBS Harpacticoida in the NWBS. In 2010, after graduating from ONU. I.I. Mechnikov, he entered the graduate school of the InMB NASU, which he successfully completed. A serious and thoughtful approach to his research, constant work with the scientific literature, diligence and the ability to use subtle methods to identify harpacticoid copepods allowed him to achieve good results in a relatively short period. For the first time for the Black Sea, he studied the features of the structure of the Harpacticoida taxocene in the contact zones of the northwestern part of the Black Sea.

Harpacticoids under favorable conditions form significant accumulations on various types of substrates. The author has shown that not only the density of crustacean colonies, but also their size depends on the type of substrate (Vorobyova, Portyanko, 2014). The maximum sizes of harpacticoids are characteristic of the sandy shell rock, and the minimum ones, for interstitial species living in the thickness of sandy sediments (Fig.4.1).

Most species of harpacticoids are very sensitive to changes in marine environmental conditions. In areas experiencing a large anthropogenic load, the species diversity and quantitative indicators of harpacticoids are extremely low. Taking this into account, harpacticoids can be used as an indicator of a decrease in oxygen dissolved in water in the bottom water layers. (Coull, 1985).

According to PortyankoV. V. fauna of Harpacticoida of contour biotopes in the NWBS during the period research included 75 species belonging to 46 genera from 23 families. Among the registered species, 11 were new for the Ukrainian part of the NWBS. Thanks to the researches of Portyanko V.V. the list of species of harpacticoid copepods expanded from 116 to 127 species. For the first time, a new species (*Phyllopodopsyllus pauli* (Crisafi, 1960)) was found for the Ukrainian part of the northwestern shelf of the Black Sea.

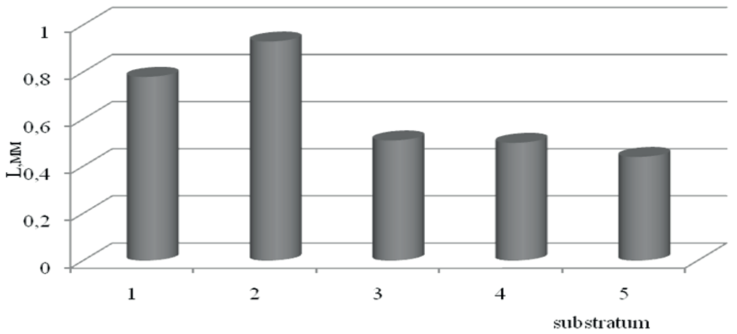


Figure 4.1. Average sizes of harpacticoids depending on the type of substrate. 1 – fouling, 2 – sand/shell, 3 – silt/sand, 4 – silt, 5 – interstitial (Vorobyova, Portyanko, 2014).

For the pseudo- and supralittoral of sandy beaches on different horizons of V.V. Portyanko, 8 species (Table.4. 4.) of harpacticoid copepods from the following families were found: Ameiridae (3), Arenopontiidae (1), Cylindropsyllidae (1), Ectinosomatidae (1), Harpacticidae (1), Leptastacidae (1). The discovered species belong to four life forms, of which the nonspecific interstitial (3 species) and specific interstitial (3 species) are the most species-rich. Horizontal distribution has a clearly defined species specificity, directly related to habitat conditions.

The water's edge is the most dynamic zone for the study area. At a depth of up to 10 cm, the largest number of species (5 species) of harpacticoids were found, belonging to epibenthic, silt-burrowing and nonspecific interstitial forms. Indeed, interstitial species live in a more static environment in the sand at depths of 20 cm and at a certain distance from the water's edge (Portyanko, 2021)

The fauna of harpacticoid copepods in contour biotopes in the NWBS during the period of study included 75 species belonging to 46 genera from 23 families. Among the registered species, 11 were new for the Ukrainian part of the NWBS, and the list of harpacticoid copepod species has expanded from 116 to 127 species. *Phyllopodopsyllus pauli* (Crisafi, 1960) was found for the

first time in the Ukrainian part of the northwestern shelf of the Black Sea (Portyanko, 2021).

Table 4.4.

List of Harpacticoida species (Crustacea, Copepoda) and the number of individuals in the sample (ind.·100 cm^{-2}) at a distance from the shore line (m) and at different depths (cm)

Species	Splash distance (m) and depth (cm))								
	0	0	1	1	2	2	3	3	3
	(0-4)	(4-10)	(20-30)	(30-40)	(30-40)	(40-50)	(30-40)	(40-50)	(50-60)
Epibenthic									
Harpacticus littoralis	63	—	—	—	—	—	—	—	—
Silting									
Ectinosoma melaniceps	94	93	—	—	—	—	—	—	—
Nonspecific interstitial									
Ameira parvula parvula	99	—	—	—	—	—	—	—	—
Nitokra pontica	82	68	—	—	—	—	—	—	—
Nitokra typica typica	60	37	—	—	—	—	—	—	—
Specific interstitial									
Arenopontia subterranea	—	—	103	93	54	61	48	73	91
Paraleptastacus ponticus	—	—	48	45	31	29	39	28	68
Vermicaris pontica	—	—	44	59	11	15	24	10	44

For the first time, the author identified harpacticoids of periphytal coastal fortifications in the Odesa Gulf (Portyanko, 2016).

For the first time Valentin Valentinovich studied in detail the faunal composition and quantitative characteristics of Harpacticoida in the upper sublittoral of the Odesa Bay (Portyanko, 2013, 2017). The author found that a total of 32 species of harpacticoids belonging to 21 genera and 13 families were identified in the studied water area (Table 4.5.). The family was dominant in the number of species Laophontidae (6 species): *Heterolaophonte minuta, Heterolaophonte stroemii stroemii, Laophonte thoracica, Laophonte elongata elongata, Heterolaophonte uncinata*. Both the family Dactylopusiidae and the family Miraciidae consist of the four species. The families Ameiridae, Normanellidae, Harpacticidae and Tisbidae contain three species each. The

remaining six families (Canuellidae, Cletodidae, Ectinosomatidae, Peltidiidae, Tetragonicipitidae, Thalestridae) were represented by only one species. Of the total number of species, 8 (*Ameira parvula p., Canuella perplexa,* Dactylopusia Tisboides, *Ectinosoma melaniceps, Enchydrosoma sordidum, Heterolaophonte stroemii s., Heterolaophonte uncinata, Tisbe marmorata*) were found in all biotopes. Based on the number of detected species, the substrates are arranged in the following sequence: shells (21 species), sand deposits (20 species), fouling and macrophytes (15 species). (Portyanko V.V. 2013, 2017)

Table 4.5.

Species composition of Harpacticoida (Crustacea, Copepoda) of the upper sublittoral biotopes of the Odesa Sea Region (Portyanko, 2017).

Alteutha typica (Czerniavski, 1868)
Ameira parvula parvula (Claus, 1866)
Amonardia similis (Claus, 1866)
Amphiascus longirostris ((Claus, 1863) Huys 2010)
Bulbamphiascus imus (Brady, 1872)
Canuella perplexa (Scott T. et A.,1893)
Dactylopusia tisboides (Claus, 1863)
Delavalia elisabethae (Por, 1959)
Diarthrodes nobilis (Baird, 1845)
Ectinosoma melaniceps (Boeck, 1845)
Enchydrosoma sordidum (Monard, 1926)
Harpacticus flexus (Brady et Robertson D.,1873)
Harpacticus littoralis (Sars G. O., 1910)
Harpacticus obscurus (Scott T., 1895)
Heterolaophonte minuta (Boeck, 1873)
Heterolaophonte stroemii stroemii (Baird, 1837)
Heterolaophonte uncinata (Czerniavski, 1868)
Laophonte elongata elongata (Boeck, 1873)
Laophonte thoracica (Boeck, 1865)
Nitokra hibernica hibernica (Brady, 1880)
Nitokra lacustris lacustris (Shmankevich, 1875)
Normanella minuta (Boeck, 1873)
Normanella mucronata (Sars G. O., 1909)
Normanella serrata (Por, 1959)
Paradactylopodia brevicornis (Claus, 1866)
Paradactylopodia latipes (Boeck, 1865)
Phyllopodopsyllus pauli (Crisafi, 1960)
Pontophonte leuke (Por, 1959)
Thalestris longimana (Claus, 1863)

Table 4.5. continued

Tisbe bulbisetosa (Volkmann-Rocco, 1972)
Tisbe furcata (Baird, 1837)
Tisbe marmorata (Volkmann-Rocco, 1973)

Portyanko V.V. indicates that of the 32 species of harpacticides found, only 8 are common to all three biotopes. Also, each of the biotopes has species characteristic only for it.

For the first time in 2013–2015, a study of the species composition and quantitative characteristics of Harpacticoida were carried out on the Island Zmeiny (Portyanko, 2017). As the author points out (Portyanko 2014, 2015) the species composition of harpacticides of algae fouling includes 20 species from the following families: Ameiridae (1), Miraciidae (4), Dactylopusiidae (2), Ectinosomatidae (3), Harpacticidae (2), Laophontidae (5), Tisbidae (1), Parastenheliidae (1). The greatest diversity at the species level was noted for the families Laophontidae (2 genera and 5 species), Miraciidae (4 genera and 4 species), Ectinosomatidae (3 genera and 3 species), and the remaining families are represented by 1-2 species (Portyanko, 2019).

The species composition of harpacticoid copepods was comprised by 19 species, including one Ameiridae, four Miraciidae, two Dactylopusiidae, three Ectinosomatidae, two Harpacticidae, five Laophontidae, one Tisbidae and one Parastenheliidae (table 2.14). Ten species from the list are epibenthic inhabitants (*D. elisabethae, H. compsonyx, H. obscurus, H. curvata curvata, H. Curvata microthros, H. stroemii stroemii, H. uncinata, P. spinosa spinosa, P. leuke, R. monardi*), three are phytal species (*D. tisboides, P. brevicornis, T. bulbisetosa*), three are unspecifi ed interstitial species (*A. parvula parvula, A. cinctus, A. cinctus*), and three species are silt-dwelling (*E. melaniceps, H. herdmani, P. minor*). Four copepod species, namely *E. melaniceps*, *H. obscurus*, *T. bulbisetosa*, and *P. brevicornis*, occurred in more than 50 % types of algal aggregations and had high frequency. The maximal number of copepod species occurred in *C. vagabunda* (10 species), less in *U. intestinalis* (9 sp.), *C. elegans* (8 sp.), *C. offi cinalis* (4 sp.), *L. paniculata* (4 sp.), and the minimal number in *P. denudata* (3 sp.).

The average copepod abundance on phytal substrates was maximal comparing to all other groups of meiobenthos, except of *L. paniculate.* The maximal number of copepods occurred in *C. vagabunda* beds (8 8750 ind.·m^{-2}), and on all other types of algal aggregations this parameter was twice lesser. Th e maximal percentage of harpacticoid copepods in total meiobenthos was maximal in *U. intestinalis* and minimal in *L. paniculata* (Portyanko, 2017).

MUDDY BOTTOM (PELOCONTOUR). The pelocontour occupies the largest area in the Black Sea. In the IMB, the ecological characteristics of harpacticoids in this contact zone were studied both in the open water area of the NWBS (Vorobyova, 1999) and in the Odesa Sea region at a depth of up to 34 m (Portyanko, 2017). Twenty-one species of harpacticoids belonging to 16 genera and 13 families were found on the silt (Table 4.6.). (Portyanko, 2017).

A feature of the fauna of Harpacticoida silt deposits is that its species diversity directly depends on the type of silt. The author found that 21 species were found on gray silt, and only 6 species were found on black silt. These species are common to these two soil types. Two families of harpacticoids, Miraciidae (4) and Tisbidae (3), are relatively rich in species. The remaining families are represented by one or two species of copepods.

Table 4.6.

Species diversity of Harpacticoida (Crustacea, Copepoda) of gray and black silt of the Odesa Sea Region (Black Sea)

Family	Species	Gray silt	Black silt
Ameiridae	*Ameira parvula parvula* (Claus, 1866)	+	+
Canuellidae	*Canuella perplexa* (Scott T. et A.,1893)	+	-
Cletodidae	*Enchydrosoma gariene* (Gurney, 1930)	+	+
Dactylopusiidae	*Dactylopusia tisboides* (Claus, 1863)	+	-
	Paradactylopodia brevicornis (Claus, 1866)	+	-
Ectinosomatidae	*Ectinosoma melaniceps* (Boek, 1865)	+	+
Harpacticidae	*Harpacticus flexulosus* (Ceccherelli, 1988)	+	-
	Harpacticus littoralis (Sars G. O., 1910)	+	-
Laophontidae	*Laophonte elongata elongata* (Boeck, 1873)	+	-

Table 4.6. continued

Family	Species	Gray silt	Black silt
Miraciidae	*Amphiascoides subdebilis* (Willey, 1935)	+	-
	Amphiascus longirostris ((Claus, 1863) Huys 2010)	+	+
	Bulbamphiascus imus (Brady, 1872)	+	-
	Delavalia elisabethae (Por, 1959)	+	-
Nannopodidae	*Nannopus palustris* (Brady, 1880)	+	-
Normanellidae	*Normonella minuta* (Boeck, 1873)	+	+
Tachidiidae	*Microarthridion littorale* (Poppe, 1881)	+	-
	Microarthridion fallax (Perkins, 1956)	+	-
Thalestridae	*Thalestris longimana* (Claus, 1863)	+	-
Tisbidae	*Tisbe battagliai* (Volkmann-Rocco, 1972)	+	-
	Tisbe histriana (Marcus & Por, 1961)	+	-
	Tisbe marmorata (Volkmann-Rocco, 1973)	+	+

Yagorlytsky and Tendrovskiy bays. At the waters of the Yagorlytsky and Tendrovskiy bays, 34 species of harpacticoids were found (Data.V.V. Portyanko). The largest number of species was found in Yagorlytsky Bay (29 species). A richer species diversity of harpacticoid copepods was found here than in the $OdSR^s$ pelocontour. The species *A. parvula parvula, Canuella perplexa* (Scott T. et A., 1893), and *Delavalia elisabethae* (Por, 1959) were recorded in all the silts of the Yagorlytsky and Tendrovsky bays and in the $OdSR^s$ pelocontour. The basis of species complexes of harpacoid oozes are harpacticoid species with an epibenthic life form. For three species of harpacticoids at coastal stations, an occurrence of more than 85 % is noted: *Limnocletodes behningi, Nitokra hibernica hibernica, Pseudobradya beduina beduina.* At deeper stations in the study area (6-24 m), the presence of 12 species of harpacticoids copepods was noted. At the deep-water stations of the pelocontour, the species *Ameira parvula parvula, Enchydrosoma gariene, Ectinosoma melaniceps*, and *Microarthridion littorale* are most common, their occurrence exceeds 85 %. Only two species of the genus Pseudobradya were common to them: *P. beduina beduina* and *P. minor*. Epibenthic life forms predominate in the species complexes of harpacticoid copepods in the pelocontour.

Species diversity of Harpacticoida (Crustacea, Copepoda) of the pelocontour of the Odesa marine region (Black Sea) The species composition of harpacticids throughout the pelocontour includes 21 species, 17 genera and 13 families (Table 4.7).

Portyanko V.V. studied the shallow waters of the Sea of Azov, and his publication reflects the results of data on the faunistic composition and quantitative characteristics of copepods in this area (Portyanko, 2011).

The analysis of the distribution of the species composition of harpacticoids of the pelocontour of the considered reservoirs of the Sea of Azov showed that the largest number of species is characteristic of Sivash (Table 4.7.). As can be seen from the presented data, the number of species changed in 2010 and 2011. The first studies of soil contours of some reservoirs of the Sea of Azov allow us to conclude that this "shore-sea" contact zone is characterized by a diverse meiofauna, among which nematodes and harpacticoids predominate (Vorobyova, Kulakova, 1990)

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A total of 34 species of Harpacticoida were previously identified for the Danube coast at depths from 3.8 m to 45 m (Monchenko 1967, Monchenko Polishchuk 1969, Garlytska 2010). Studies of Portyanko V.V. affected the range of depths from 0.5 m to 1 m and from 6 m to 24 m (Table 4.8).

At the smallest depth range, 9 species of harpacticoid copepods from the following families were found: Ameiridae (1), Cletodidae (1), Dactylopusiidae (3), Harpacticidae (2), Laophontidae (1), Miraciidae (1).

Most of the detected species have a fairly high occurrence. Also, these species are considered to be either brackish water or withstand a wide range of fluctuating salinity.

Table 4.7.

Species composition of Harpacticoida pelocontour of Utlyuk, Molochny lymans and Sivash (Vorobyova, Kulakova,1990).

Species	Utlyuk estuary		Molochny estuary		Sivash	
	2010	2011	2010	2011	2010	2011
Ameira parvula Claus, 1866	+	+	+	+	+	+
Canuella perplexa T et A. Scott, 1893	+	+	+	+	+	+
Ectinosoma melaniceps Boek, 1865	+	-	-	-	+	+
Enchydrosoma caeni Raibaut, 1965	-	-	-	-	+	+
Enchydrosoma gariene Gurney, 1930	-	-	-	-	-	+
Heterolaophonte minuta Boek, 1872	-	-	-	-	-	+
Mesohra heldti Monard, 1935	-	-	+	-	-	-
Metis ignea Philippi, 1843	+	+	+	+	+	+
Nitocra typica Boeck, 1865	+	-	-	-	-	+

At deeper stations in the study area (6–24 m), the presence of 12 species of harpacticoid copepods was noted (Table 4.9.). They belong to the following families: Ameiridae (1), Laophontidae (1), Ectinosomatidae (3), Miraciidae (1), Normanellidae (2), Tachidiidae (1), Tisbidae (2), Cletodidae (1).

CONCLUSIONS The fauna of harpacticoid copepods of the contour biotopes of the Black Sea Coastal Region, according to the results of research in the period 2005-2017, included 76 species belonging to 46 genera from 23 families. The largest number of species was noted for the pelocontour (44), the smallest for the potamocontour (19). 6 species are common to all contour biotopes of the northwestern part of the Black Sea: *Ameira parvula parvula, Dactylopusia tisboides, Ectinosoma melaniceps, Harpacticus flexus, Harpacticus littoralis, Laophonte elongata elongata.* The largest number of

species (35 species) was determined for the lithocontour fouling of the Odesa Coastal Region

Table 4.8.

The species composition of Harpacticoida of the coastal contour of the Danube Region

Species	F, %	Life form
Dactylopusia tisboides	45	phyt
Delavalia tethysensis	65	epiben
Harpacticus flexus	35	epiben
Harpacticus littoralis	30	epiben
Limnocletodes behningi	95	epiben
Nitokra hibernica hibernica	90	not_int
Paronychocamptus sp.	45	epiben
Pseudobradya beduina beduina	85	silt_dw
Pseudobradya minor	70	silt_dw

Table 4.9.

The species composition of harpacticoids of the potamo contour of the coast at depths from 6 to 24 m in the estuary part of the Danube River (Portjanko, 2019).

Species	F,%	Life form
Ameira parvula parvula	85	not_int
Amphiascus longirostris	15	not_int
Enchydrosoma gariene	90	epiben
Ectinosoma melaniceps	95	silt_dw
Laophonte elongata elongata	55	epiben
Microarthridion littorale	85	epiben
Normanella minuta	25	epiben
Normanella serrata	20	epiben
Pseudobradya beduina beduina	75	silt_dw
Pseudobradya minor	70	silt_dw
Tisbe histriana	35	phyt
Tisbe marmorata	40	phyt

2.5. Ostracoda of the Ukrainian shelf

The first information about representatives of the subclass Ostracoda (Crustacea) of the Black Sea dates back to the second half of the last century. Interest in this group is due to their wide distribution, high population density and importance as food for juvenile benthic fish. Most species of marine ostracods are benthic animals that live on the surface of bottom sediments. The life of most species is closely related to macrophytes. Some species have adapted to living in the interstitium of sandy sediments and beaches (pseudo- and supralittoral).

In terms of the abundance of species, ostracods are on a par with harpacticoids and nematodes. On loose substrates, in contrast, they do not have the same high numbers inherent in roundworms and copepods. The densest accumulations of shell crustaceans are characteristic of macrophyte thicket biocenoses.

During our long-term research, it was established that in various areas of the Black Sea shelf, ostracods, in terms of quantitative parameters, belong to meiobenthos groups whose participation in the formation of its total number is minimal (Vorobyova, 1999).

As stated above on the Odessa coast (research 1973-1978) in the interstitial sandy sediments, we found 7 species of ostracods (identifications made by Dr. A.L. Kovalenko): *Loxoconcha pontica* Klie, *L. elliptica* Brady, *Microcythere longiantennata* Marinov *Parvocythere hartmanni* Marinov, *Herracythere bulgarica* Klie, *Leptocythere multipunctata* (Vorobyova, Zaitsev, Kulakova, 1992).

In 2013, Uzun Elena Evgenievna began her work at the IMB after graduating from Odesa State University I.I. Mechnikova. She immediately expressed a desire to study the systematics and ecology of the taxocene Ostracoda. This group of meiobenthos representatives has not been studied on the Ukrainian shelf of the Black Sea since the middle of the last century. Over this past period, the environmental situation on the northwestern shelf has changed significantly and, unfortunately, not for the better. Significant

eutrophication with changes in many hydrochemical parameters (Northwestern part) created completely different conditions for the formation of the faunal composition and quantitative indicators of Ostracoda.

E.E. Uzun actively began studying ostracods and showed initiative and a scientific approach to her research. She successfully completed her postgraduate studies at the IMB and has achieved some success so far. It is necessary to note the interesting data she presented in several publications (Uzun, 2017, 2020) about ostracods of the coastal zone of the island Zmiiniy. If quantitative indicators of ostracods in this area were previously presented, then E.E. Uzun presented the faunal composition of ostracods

According to E.E. Uzun a total of 13 Ostracoda species belonging to 4 families were identified: Loxoconchidae, Paradoxostomatidae, Bythocytheridae, Xestoleberididae (Table 2.21). All of them are belonging to subclass Podocopa. On the algal substrates were registered from 7 to 10 species. On sand-shell bottom were registered 7 species. Ostracodes species *Xestoleberis acutipenis*, *X. cornelii* and *X. decipiens* were widespread on the all the substrates types.

THE ISLAND OF ZMEINIY**.** More than 800 specimens of Ostracoda were examined by E.E. Uzun. All of them are belonging to subclass Podocopa (Uzun, 2014, 2016, 2019, 2020, 2021).

Data about meiobenthic ostracods' species on the different substrates of the Zmiiniy Island nearshore water area are presented. Meiobenthos was taken in summer seasons during 2013–2015 years at depths from 1 to 5 m. Samples were collected from three types of substrates: sandy bottom sediments, mussels (*Mytilus galloprovincialis* (Lamarck, 1819)) and alga growing attached to large rocks. Algae include six species: *Ceramium elegans* (Ducluzeau, 1806), *Cladophora vagabunda* (Hoek, 1963), *Ulva intestinalis* (Linnaeus, 1753), *Polysiphonia denudata* (Greville et Harvey, 1833), *Corallina officinalis* (Linnaeus, 1758), *Laurencia paniculata* (Kützing, 1849).

A total of ten Ostracoda species from three genera were identified: *Loxoconcha aestuarii* Marinov, 1963, *L. bulgarica* Caraion, 1961, *L. elliptica* Brady, 1868, *L. lepida* Stepanaitys, 1962, *L. pontica* Klie, 1937,

Paradoxostoma intermedium Müller, 1894, *Xestoleberis acutipenis* Caraion, 1963, *X. aurantia* (Baird, 1838), *X. cornelii* Caraion, 1963, *X. decipiens* (Müller, 1894). All of the investigated species are distributed both in phytal of deeper waters and in typically coastal algal habitats.

According to E.E. Uzun the most widespread species were *Loxoconcha pontica* and *Xestoleberis decipiens*, percentages of which respectively are 29.56 % and 22.38 % of the total ostracod specimens. More rare registered species were *Xestoleberis aurantia*, *Loxoconcha bulgarica* and *Loxoconcha aestuarii*, relative densities of which reached not over 1.09 %. Percentages of others species were 5–15 %.

There was no significant difference in species of ostracods among algal substrates (table 1). E.E. Uzun showed that nine out of the ten species were found on *Cladophora*. There were six species registered on all algal substrates. The *Xestoleberis aurantia* occurred only on Cladophora. The dominant species were *Loxoconcha pontica*, *Paradoxostoma intermedium*, *Xestoleberis cornelii* and *X. decipiens*. The species *Loxoconcha lepida*, *L. eliptica* and *Xestoleberis acutipenis* were found as subdominant. The subdominant of the first order species were *Loxoconcha bulgarica* and *L. aestuarii*. The *Xestoleberis aurantia* was a secondary member.

The density and biomass of the ostracods were higher on the algal substrates (on *Laurencia paniculata* made up 41,931 ± 12,689 ind.·m^{-2} and 400.56 ± 125.65 mg·m^{-2} respectively). In the study for the first time 13 ostracods' species belonging to 4 families were identified: Loxoconchidae, Paradoxostomatidae, Bythocytheridae, Xestoleberididae (Table 5.1.). All of them are belonging to subclass Podocopa and are common species in the north-western Black Sea. On the algal substrates were registered from 7 to 10 species. On sand-shell bottom were registered 7 species. Ostracoda species *Xestoleberis acutipenis*, *X. cornelii* and *X. decipiens* were widespread on the all-substrates types. The dominant species were *Loxoconcha pontica* Klie, 1937, *Paradoxostoma intermedium* Müller, 1894, *Xestoleberis cornelii* Caraion, 1963 and *Xestoleberis decipiens* (Müller, 1894).

The non-metric multidimensional scaling (MDS) analysis of ostracods species abundance shown that the samples of sandy-shells bottom differed significantly from algal and mussel substrates. According to the cluster analysis sand-shells bottom samples on almost 80 % differed from hard substrates.

Long-term research by E.E. Uzun allowed her to obtain new data on the species composition and ecological characteristics of representatives of the Ostracoda taxocene in the Odesa Bay of the Black Sea under modern conditions. The issues of the faunal composition of these animals were considered both in the periphyton of shore protection structures and in the benthic of open areas of this bay (Uzun, 2014, 2015, 2016, 2017, 2019, 2020, 2021, 2021a).

The most widespread species of the ostracods on the hard substrates were *Xestoleberis cornelii* Caraion, 1963, *Hemicytherura bulgarica* (Klie, 1937), *Paradoxostoma intermedium* Müller, 1894, *Cytherois cepa* Klie, 1937.

At the lithocontour, Uzun O.E. discovered of 10 species of the Ostracoda. The most widespread species is *Xestoleberis decipiens* (Müller, 1894). The greatest species diversity of ostracods (9 species) was observed on the algal substrate. Depending on the type of algae, the species of ostracods were not evenly distributed. For Ceramium, 8 species of ostracods were noted, for Polysiphonia – 7, for Enteromorpha and Cladophora – 5 species of ostracods each. Eight species of ostracods were found on mussel fouling of hard substrates. The species *Sclerochilus dubowskyi* Marinov, 1962 was recorded only on mussel fouling. Three species of barnacle crayfish were found in the shell sediments: *Loxoconcha pontica* Klie, 1937, *L. bulgarica* Caraion, 1961, and *Xestoleberis decipiens* (Müller, 1894). Only three species of barnacle crayfish were found in the bottom shell sediments.

Table 5.1.

The list of Ostracoda species on the different substrate types in Zmiiniy Island nearshore water zone (Black Sea), (Uzun, 2021).

Ostracod species	Algal substrate						mussels fouling	sand-shells bottom
	Ceramium elegans	*Cladophora vagabunda*	*Ulva intestinalis*	*Corallina officinalis*	*Laurencia paniculata*	*Polysiphonia denudata*		
Family Loxoconchidae								
Loxocauda sp.	–	–	–	+	+	–	–	–
Loxoconcha aestuarii Marinov, 1963	+	–	+	+	–	–	–	+
Loxoconcha bulgarica Caraion, 1961	+	+	–	+	–	+	+	+
Loxoconcha elliptica Brady, 1868	+	+	+	+	–	–	+	–
Loxoconcha lepida Stepanaitys, 1962	+	+	+	+	–	–	–	–
Loxoconcha pontica Klie, 1937	+	+	+	+	+	+	–	+
Family Paradoxostomatidae								
Paradoxostoma intermedium Müller, 1894	+	+	+	–	+	+	+	+
Paradoxostoma mediterraneum Müller, 1894	–	+	–	–	–	–	–	–
Family Bythocytheridae								
Sclerochilus dubowskyi Marinov, 1962	–	–	–	–	+	–	+	–
Family Xestoleberididae								
Xestoleberis acutipenis Caraion, 1963	+	+	+	+	+	+	+	+
Xestoleberis aurantia (Baird, 1838)	+	+	–	+	–	+	+	–
Xestoleberis cornelii Caraion, 1963	+	+	+	+	+	+	+	+
Xestoleberis decipiens (Müller, 1894)	+	+	+	+	+	+	+	+
Total	10	10	8	10	7	7	8	7

Ostracoda of the Odesa marine Region. Meiobenthos associated with the different types of substrates in the in the Odesa marine Region (north-western Black Sea) is well studied. Present data concerning living meiobenthic ostracods in this area are relatively few. In the result of preliminary analysis of

the samples received from the different parts of Odesa marine region 2013–2020 were registered 17 species of Ostracoda, belonging to the 7 families (Table 5.2.).

Table 5.2.

Species composition of Ostracoda (Crustacea, Ostracoda) at different depths in the Odesa marine region (north-western Black Sea) (Uzun, 2014, 2015, 2021).

Species	Depth, m	
	0.5–10	10–25
Family Cobanocytheridae		
Cobanocythere longiantennata (Marinov, 1962)	–	+
Family Cytheruridae		
Hemicytherura bulgarica (Klie, 1937)	+	–
Semicytherura euxinica (Caraion, 1967)	–	+
Family Krithidae		
Pseudopsammocythere similis (Müller, 1894)	+	+
Family Leptocytheridae		
Leptocythere reticulata Sars, 1925	+	+
Family Loxoconchidae		
Loxoconcha aestuarii Marinov, 1963	–	+
Loxoconcha bulgarica Caraion, 1960	+	+
Loxoconcha pontica Klie, 1937	+	+
Loxoconcha rhomboidea (Fischer, 1855)	+	+
Family Paradoxostomatidae		
Cytherois cepa Klie, 1937	+	–
Cytherois planus Schornikov, 1969	+	+
Paradoxostoma intermedium Mueller, 1894	+	+
Paradoxostoma navicula Schornikov, 1965	+	+
Family Xestoleberididae		
Xestoleberis acutipenis Caraion, 1963	+	+
Xestoleberis aurantia (Baird, 1838)	+	+
Xestoleberis cornelii Caraion, 1963	+	+
Xestoleberis decipiens Mueller, 1894	+	+

At the depths up to 10 m bottom landscapes in the Odesa Bay represented by sandy substrates with various hard bottom substrates types (plastic litter, concrete, natural stones and rocks). Diversity of Ostracoda was represented mainly by typical widespread species, the most abundant of which were

Paradoxostoma intermedium Müller, 1894, *Xestoleberis cornelii* Caraion, 1963 and *Xestoleberis decipiens* Müller, 1894. Comparative analysis showed that density and biomass of ostracods were lower on the plastic substrate than on other natural and artificial hard substrates.

In the waters of the Odesa marine region during 2005–2013 at depths of more than 10 m, the bottom was represented mainly by silty sediments: black and gray silts, black and gray silts with an admixture of shells, sand with shells, and sediments mix (silty sand with shells, mussels, and algae). On gray silts, the abundance of ostracods was than on black silts. The average density of ostracods on gray silts was significantly higher and made up 15,229 ind.$\cdot$m^{-2}. The lowest value of the ostracod's density (1,694 ind.$\cdot$m^{-2}) was noted on sand with shells sediments.

Research Uzun E.E. in the coastal zone of Cape Big Fontan (Odesa marine region 2013–2019) showed that in this area ostracods are represented by a small number of species. Ostracodes of 7 species were found here: *Loxoconcha pontica* Klie, 1937*, Paradoxostoma intermedium* Muller, 1894*, P. simile* Muller, 1894*; Xestoleberis acutipenis* Caraion, 1968*; X. aurantia* (Baird, 1938*); X. decipiens (*Müller, 1894); *X. corneliti* Caraion, 1968). The greatest diversity was recorded by the author in the periphyton of the rocky substrate with mussel accumulations. The species Paradoxostoma intermedium was recorded only on the shell (Uzun E. E., Portyanko V., 2020).

In the last decade of the 21st century, the IMB (Odesa) has received a lot of attention under the leadership of Ph.D. Snigireva A.A. focuses on studying the influence of plastic and other polyethylene debris on the formation of the Odesa Bay in the marine environment. Uzun E.E. (Ostracoda) together with Portyanko V.V. (Harpacticoida) conduct observations of the formation of the species composition and quantitative indicators of meiobenthos. During this period, a number of materials on this topic were published (Uzun, 2019; 2020, 2021, 2021a, 2021b). According to the author, the most common species of ostracods on the fouling of plastic debris were *Hemicytherurae bulgarica* (Klie, 1937), *Paradoxostoma variabile* (Baird, 1835) and *Xestoleberis decipiens* Müller, 1894, the occurrence of this indicator is 100 %. The most

common ostracod species found on plastic debris were *Hemicytherura bulgarica* (Klie, 1937), *Paradoxostoma variabile* (Baird, 1835) and *Xestoleberis decipiens* Mueller, 1894).

2.6. Kinorhyncha of the Ukrainian shelf

For the first time, the Kinorhyncha were described by the French naturalist Felix Dujardin. In 1863, he found an animal on the northern coast of Brittany in France and he gave the name *Echinoderes dujardinii* Claperede, 1863. Their size was less than 0.5 mm. In 1881, these small animals were separated into an independent Kinorhyncha group. After the discovery of the first of species of Kinorhyncha, several researchers began to describe the representatives of this group. In the late XIX – early XX century K. Zelinka (1896, 1928) published a number of works. In them, he organized the data of other researchers and described several new types of Kinorhyncha. An important contribution to the development of the taxonomy of this group was made by the scientist R. Higgins (1988). He described history of the study of kinorinch and many types of the Kinorhyncha.

According to the modern classification, Kinorhyncha are of the Cephalorhyncha type. Kinorinha are small invertebrates (less than 1mm in length). They belong to the permanent meiobenthos category. Members of the Kinorhyncha class are typically marine life. Currently, about 150 species are known that are found in various regions of the World Ocean (Higgins, 1988). They inhabit a wide range of depths from the littoral to the abyssal (Kristensen and Higgins, 1991), mainly on silty ground. In shallow waters and sandy beaches, Kinorhyncha are concentrated in fine sands in the near-surface sediment layer. In coarse sands, they can inhabit the interstices at a depth of more than 10 cm. The body length of a Kinorhyncha rarely exceeds 1 mm. The size of the Black Sea representatives of this group ranges from 0.1 mm (*Semnoderes ponticus* M. et E. Bacescu, 1956) to 0.6-0.8 mm (*Centroderes spinosus* Reinchard, 1987). They feed on unicellular algae and organic

sediment covering bottom objects. The lifespan of a Kinorhyncha is approximately one year.

Representatives of this large taxon are insufficiently studied for the Black Sea. To date, 11 species are known (Table 6.1.), as well as ten different forms of their larvae. There are only a few works (Kiseleva, 1965; Becescu, 1968; Sheremetevsky, 1974; Adrianov, 1991; Higgins, Adrianov, 1991; T. Marinov, 1990). *Centroderes spinosus* Reinh., *Semnoderes ponticus* M. et El. Were found in the northwestern part of the Black Sea *Pycnophyes ponticus* Reinh., *P. dentatus* Reinh., *Echinoderes agiges (syn. E. dujardini* Marinov) (Sheremetevsky, 1974)

Table 6.1.

Species diversity of the Black Sea Kinorhyncha

№	Species	coastal area		
		Bulgaria	Romania	Ukraine
1.	*Echinoderes agigens* Bacescu, 1969	+	+	–
2.	*E. dujardini Claparede*, 1864	+	+	+
3.	*E. setigera* Greeff	–	-	+
4.	*Cendroderes spinosus* Reinhard, 1881	+	+	+
5.	*Semnoderes ponticus* M. et E. Bacescu, 1965	–	+	–
6.	*S. armiger Zelinka*,1814	+		+
7.	*Pycnophyes communis* Zelinka	–	+	–
8.	*P. dentatus* (Reinhard, 1887)	–	+	+
9.	*P. ponticus* Reinhard, 1881	+	+	+
10.	*P. kielensis* Zelinka, 1928	+	–	–
11.	*P. neapolitanus* Bacescu, 1969	+	+	–

All these studies, which were carried out in the last decades of the last century, related to the shelf zones of the Crimea, the Caucasus and Romania and Bulgaria. Currently, there are no data on the Kinorhyncha of the shelf from Bay Tarkhankut to the Ukrainian estuary zone of the Danube.

The publications indicated that the Kinorhyncha are eurybiontic, euryhaline and eurythermal organisms. Specific data on their relationship to the main environmental factors were not provided in these works. We observed Kinorhyncha of the western coast of the Crimea, in the estuary area of the river

Danube, Odesa Sea Region, in Grigorievsky and Sukhoi estuaries. It was believed that in the Black Sea, the average number of Kinorhyncha can reach 10,000 ind.·m^{-2} (Marinov, 1990).

Our studies of the last decades on the Black Sea shelf made it possible to make corrections in these ideas for different regions of the Black Sea upward (Vorobyova, 1999). The occurrence of Kinorhyncha and their numbers varied significantly near the western coast of Crimea. Thus, in the shell rock biotope, the occurrence was 25 %, on silty sand – 40 % with an average abundance of 90 ind.·m^{-2}, and in silts – 66 % with an average abundance of 39,090 ind.·m^{-2}. On average, on the eastern shelf of the Black Sea, the occurrence of Kinorhyncha was 52 % with an average abundance of 5,900 ind.·m^{-2}. At depths of 1238 m (silted shell), the density of their settlements varied from 2,500 to 25,000 ind.·m^{-2}, on silty soil for depths of 44–53 m their number was 5,000–10,000 ind.·m^{-2}. At depths of 55–95 m, their number varied from 2,500 to 50,000 ind.·m^{-2} (the maximum was noted at a depth of 57 m). On a silted shell, their number was 2,500–7,500 ind.·m^{-2}, on a silty substrate – up to 10,000 ind.·m^{-2}. In the same period, in the northwestern part of the Black Sea the frequency of occurrence ranged from 11.2 % to 40 %. Among the various regions of the northwestern part of the Black Sea, the highest occurrence of Kinorhyncha is characteristic of the Grigorievsky estuary with a silty substrate (Table 6.2). Here they form relatively dense clusters in all seasons. The average indicators of the number of Kinorhyncha indicate that in the winter, spring and summer of 1992–1993 they were within the same limits. For autumn, the average indicator of their number was two times lower. Usually, the proportion of Kinorhyncha in the total number of meiobenthos is small (0.1–2.2 %).

This is typical for many other marine ecosystems of the World Ocean. For the Laptev Sea, the proportion of Kinorhyncha is 0.3 % of the total number of meiobenthos (Sheremetevsky, 1977), in the Norwegian Sea, from 0.14 to 0.3–1.7 % (Thiel, 1971; Dinet, 1977). In the estuarine coastal area of the Danube, Kinorhyncha were very rare, their population density did not exceed 2–3 thousand ind.·m^{-2}. The study of the meiobenthos of the northwestern shelf of the Black Sea (OMR) over several decades has made it possible to obtain

data on some of the ecological characteristics of Kinorhyncha. For this region, this information is provided for the first time. This group of meiobenthos reaches the greatest diversity and abundance on silts and silty sands; however, Kinorhyncha can be found in small numbers in any bottom biotopes, including well-washed coarse-grained sands (Mokievsky, 2009). In the OMR, at depths of 7-30 m, Kinorhyncha hs ere recorded only on silty soil with an average density of settlements of 2885.4 ± 509.6 ind.·m^{-2}. The highest indices of the number of Kinorhyncha were characteristic for 2,006 – 13,268.1 ± 9,022.5 ind.·m^{-2}. In samples of meiobenthos, Kinorhyncha were present in winter, spring, and summer. In the fall, they were found only once in one of the samples. Moreover, in winter, their number on silts could reach significant values. In 2005, the density of their settlements ranged from 600 to 30,000 ind.·m^{-2}. In the spring their numbers varied from 500 to 7,500 ind.·m^{-2}. In the summer period, the number of kinorhynchs were distributed very unevenly in the water area. The maximum occurrence on silts of the Odesa Sea region was noted in 2006 (in 51 % of samples).

Table 6.2.

Interannual dynamics of quantitative indicators (ind.·m^{-2}) of Kynorhyncha and their share (%) in the total abundance of meiobenthos.

Month, hours	Grigorievsky Estuary			Adjacent part of the Sea		
	interval	average	%	interval	average	%
XI 1992	1333-1770	6400	2,2	0	0	0
II 1993	0-52670	12330	2,0	0	0	0
V 1993	0-30000	11693	1,8	0-533	177	0,17
VIII 1993	9166-24170	11466,2	1,7	0	0	0
VI 1994	0-80000	21250	1,0	0-7500	3300	1,6
VIII 1994	0-7500	750	0,1	750-2500	1250	0,5
XI 1994	0-225000	4500	0,9	0	0	0
V 1995	0-17500	5000	0,5	0-7500	3500	0,6
VIII 1995	0-2500	681,8	0,1	0	0	0
X 1996	0-10000	3050	0,45	0	0	0
VI 1997	2500-170000	48000	1,1	0-2500	800	0,23
X 1996	0-10000	3630	0,4	0	0	0
IX 1997	0-7500	2500	0,4	0-800	82,5	0,17

The indices of the number were 4,000–20,000 ind.·m^{-2}. The analysis of the obtained material in the Odesa Sea region showed that their largest accumulations are confined to the depth range of 11–20 m (Fig.6.1.).

At a depth of 5–10 m, their number was 733.8 ± 182 ind.·m^{-2}, at a depth of 11–15 m, – 2,348.9 ± 2,082.5 ind.·m^{-2}, at 15–20 m, 1,897.3 ± 590,2 ind.·m^{-2} and at 21–25 m – 812.2 ± 219.4 ind.·m^{-2}.

Thus, the analysis of scientific publications, as well as our long-term observations of the species diversity of kinorhynchs and the patterns of spatial distribution of their quantitative indicators, allows us to classify representatives of Taxona as insufficiently studied groups of the Black Sea meiobenthos.

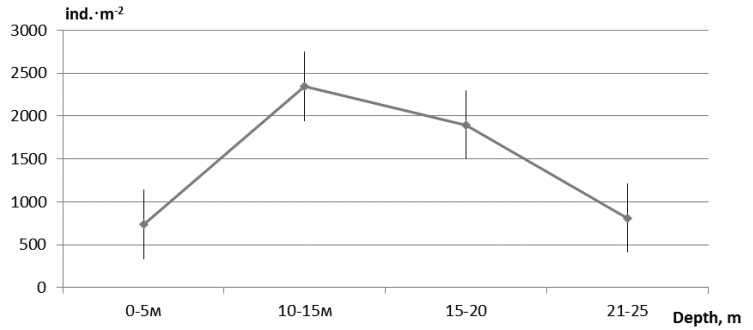


Figure 6.1. Distribution of indicators of the average abundance of Kinorhyncha on various types of soil.

2.7. Halacaridae of the Ukrainian shelf.

Representatives of the taxocene Halacaridae, which belong to the permanent component of the meiobenthos, are distributed in all marine habitats from polar to tropical latitudes and from coastal beach zones to deep-sea areas with a depth of 5000 meters (Bartsch, 1989). Sea mites often live in the cavity system (interstitium) of coarse-grained marine sediments. Some species live on algae or on relatively large marine animals such as sponges, molluscs, crustaceans, polychaetes or echinoderms. Sea mites play a role in the nutrition

of juvenile fish, especially for relatively large specimens (Sokolov, 1953). They are not very resistant to marine pollution and can therefore be used as indicators of human disturbance.

The history of the study of sea mites in the Black Sea is quite fully reflected in the monograph on the study of meiobenthos in this marine area (Vorobyova, 1999). The study of sea mites in the NWBS was first started at the Institute of Marine Biology of the National Academy of Sciences of Ukraine in the early 80s. There was no previously available information in the literature on this group of invertebrates in this region. In the list of fauna of the northwestern part of the Black Sea (Vinogradov, 1967), Halacaridae were not mentioned at all. In 1973–1980 we conducted research to study species diversity, the spatial distribution of seasonal population dynamics, and the dependence of the density of sea mite settlements on various types of substrates in the interstitium of sandy beaches in the coastal zone of the Odesa region.

For seven years Halacaridae of the pseudo-, supralittoral and subtidal zones have been studied by us as a component of the interstitial meiofauna of sandy beaches. 4 species of Halacaridae and 11 representative species of soil mites were found here. The study of the soil fauna of mites was carried out by I.I. Kulakova. This contributed to the definition of sandy beaches as a contact zone for representatives of marine, freshwater and soil fauna (Vorobyova, Kulakova, 1988; Vorobyova, Zaitsev, Kulakova, 1992).

At the same time (1973–1977), a study of the Halacaridae of the upper sublittoral of the open shelf of the NWBS and in the Karadag region was carried out. During the research period, 18 species and 5 subspecies of sea mites were discovered: 10 species from the coastal zone of the Odesa Bay, 3 species from the Black Sea estuaries, 5 species in the open waters of the NWBS and 10 from the coastal zone of Karadag.

Of the 14 species of Halacaridae found in the coastal area of the Gulf of Odesa, 6 are common with littoral species of Bulgaria and 7 species are common with sea mites of the Romanian coast. Five species are common with the species indicated by E. B. Makkaveeva (Makkaveeva, 1965, 1967) for the Caucasian and Crimean coasts of the Black Sea. For the Odesa Bay of the

second half of the twentieth century, as mentioned above, 17 species of sea mites were indicated (Vorobyova, 1999). The species described by us according to the 1953 key (Sokolov, 1953) as *Rhombognathus notops* was redescribed by E. Bartsch **(**Bartsch, 1998**)** as *Rh. tonops*.

During the period of research in different years, we analyzed the association of Halacaridae with various types of substrates. In 1974-1976, material was collected at 15 stations in the Gulf of Odesa, which made it possible to analyze the species composition on solid and algal substrates (Table7.1.)

Table7.1.

Species composition of marine mites on various substrates (Vorobyova, Yaroshenko, 1979).

Species	Mussel's fouling	fouling of the Colony hydroid	**Seaweed**			Stones	Sand
			Green algae	Red algae	Brown algae		
Agauopsis brevipalpus	+	–	+	+	–	–	–
Copidognathus ponteuxinum	–	–	–	+	–	–	–
C. ponteuxinum pestiniger	–	–	–	–	–	+	-
C. magnipalpus ponticus	–	–	–	–	–	+	–
C. magnipalpus serratisetus	+	+	+	+	+	+	+
Rh. notops	+	–	+	+	+	+	+
Rhombognahus denticulatus	+	+	+	+	+	+	+
Rh. pascens	+	–	+	+	–	–	–
Halacarellus longipes	+	–	–	–	–	+	–
H. basteri affenis	–	–	+	+	–	–	–
H. proserus	–	–	–	–	–	–	+
H. floridearum	–	–	–	–	–	–	+
H. capuzinus	–	+	–	–	–	–	+

During the period 1975 – 1976, we examined the Black Sea limans: Sukhoi, Tiligulsky, Khadzhibeysky, Kuyalnitsky and Shabolatsky, in which five species of galacariids were found: *Rhombognathus rascens*, *Rh. tonops, Coridognathus ponteuxinus rectiniger, C. magnipalpus ponticus, Aqauorsis breviralpus* (Table 7.2). In the Kuyalnitsky estuary, which is characterized by very high salinity (70-100 ‰), no ticks were found. If in the Odesa Gulf *C. magnipalpus ponticus* is a rare species, then in the estuaries, especially in Tiligulsky, it is quite common. *Aqauorsis breviralpus* is very rare and is found only in the Hadzhibey Estuary, while in the Gulf of Odesa it is a frequently encountered species.

Table 7.2.

Distribution of Halacaridae in the Black Sea Estuaries
(Vorobyova, Yaroshenko, 1982).

Species	Tiligulsky	Khadzhibeysky	Sukhoy	Shabolatsky	Kuyalniky
Phombognathus tonops	+	–	+	+	–
Ph. poscens	+	+	+	–	–
Copidognathus ponteuxius pectiniger	+	+	+	–	–
Aqauopsis. brevipalpus	–	+	–	–	–

A major contribution to the study of the species composition and ecological characteristics of the taxocene Halacaridae was made by M. V Helmboldt, who conducted her research in 1995 – 2001: in the shelf area of the NWBS, in adjacent estuaries, and the coastal zone of the Odesa coast (Helmboldt, 2001 a; 2001 b; 2001c, 2001), who successfully defended her PhD thesis in 2003 (Helmboldt, 2003).

According to Helmboldt M.V. from 1995 to 2001, 18 species (11 genera) were noted in the NWBS: In the Odesa Bay and adjacent water areas – 8 species (7 genera), in the interstitium of regional biotopes – 4 species (2 genera), in the estuaries of the northern Black Sea region – 8 species (6 genera), in Karkinitsky Bay – 5 species (4 genera), in the coastal zone of the Tarkhankut – 7 species (6 genera), o. Snake – 8 species (Helmbolt, 2001, b). The fauna of

marine mites of the Karkinitsky Bay, the coastal zone of the Tarkhankut and the Island Zmeiniy was described for the first time (Helmboldt, 2001). In the interstitium of sandy beaches, she found the following species of Halacaridae: *Actacarus ponticus, Halacarellus capuzinus, H. discretus, H. subterraneus* of the genera *Actacarus and Halacarellus* (Helmboldt, 2001).

The dominant species, as indicated by the author, was *A. ponticus*, belonging to the exclusively psammobiont genus Actacarus Schulz, 1937. The population density of Taxocene Halacaridae in the pseudo- and supralittoral zones of the coast is seasonal: the minimum values were noted in winter, the maximum in summer-autumn (Helmboldt, 2001d). This corresponds to the findings of studies in the interstitial 1973–1980. The decrease in the species composition of Halacaridae in the period 1995-2001 can be explained, in our opinion, by the fact that research in the late 80s was carried out under more favorable environmental conditions in the northwestern part than in the 90s.

In the nineties, 8 species were discovered in the coastal zone and on the traverses and breakwaters of the shore protection structures of the bay (Helmboldt, 2003). In 2013, 6 species of marine mites were found in periphytal and benthic on a sandy substrate: *Rhombognatides pascens, Rh. denticulatus, Copidognathus ponteuxinus pectiniger, C. magnipalpus ponticus, C. magnipalpus pectiniger, Aquauopsis brevipalpus*.

In 1995–2001, M.V. Helmboldt conducted studies of the taxocene Halacaridae in the biocenosis *Mytilus galloprovincialis* of the Odesa coast in the upper sublittoral at depths of 4 – 8 m. In this biocenosis, 6 species of sea mites were found belonging to 6 genera: *Rhombognathus tonops, Rhombognathides pascens, Copidognathus brachystomus, Agauopsis brevipalpus, Lohmannella falcata, Thalassarachna affinis*. It should be noted that only here a representative of the genus Lohmannella Trouessart, *L. falcata*, was encountered (Helmboldt, 2003).

New data on the Halacaridae of the coastal zone near Zmeiny Island were also obtained by M.V. Helmboldt (Helmboldt, 2001). The author established that in the summer of 1997 and 1999 and in January 2002, it was shown that 8 species of Halacaridae belonging to 7 genera lived on macrophytes in the

coastal waters of Zmeiny Island: *Agaue*, *Arhodeoporus*, *Rhombognathus*, *Rhombognathides*, *Thalassarachna*, *Copidognathus* и *Agauopsis*. In the summer of 1997 and 1999, the taxocene was presented: *Rhombognathides pascens*, *Rhombognathus magnirostris*, *Copidognathus brachystomus*, *Agauopsis brevipalpus* и *Thalassarachna affinis.*

The average number of Halacaridae in June 1997 was 2,364.3 thousand ind.·kg^{-1}, in August 1999–2973.1 thousand ind.·kg^{-1}. The most populated macrophytes were *Ceramium rubrum, C. diaphanum* (Lightf) Roth., 1806 and Bryopsis plumosa (Huds.) Ag., 1822 on the northern side of the island at a depth of 0.5 m. The author indicated that sea mites made up from 70 to 92 % of the meiobenthos of fouling macrophytes.

A study of the estuary Halacaridae in the period 1996–2001 (Helmboldt, 2001) showed that the following species were noted in the estuary in spring and summer: *Rhombognathus tonops, Rhombognathides pascens, Copidognathus brachystomus and Agauopsis brevipalpus*. The dominant species, as in the Tiligul Estuary and in the coastal zone of the Odesa coast, was a representative of the subfamily Rhombognathinae Viets (*R. tonops*): occurrence rate 100 %, density index 108.9, dominance index 0.28 (Table 7.3). Comparison of the species composition of the taxocene of ticks of the Grigorievsky and Tiligulsky Estuaries and the coastal zone of the Odesa coast (Helmboldt, 2001b) showed that the acarofauna of the Grigorievsky estuary is more similar to that of the Odesa coast (4 common species, Ks – 89%) than to the Tiligulsky Estuary (3 common species, Ks – 75 %), which was also shown earlier (Vorobyova, Yaroshenko, 1982).

In 1991, we conducted a survey in the area of coastal protection structures in order to determine the formation of the meiofauna population when the sea water temperature changed from 12 ºC to 29 ºC during May-November. Analysis of the obtained material showed that in the spring-autumn period the population of representatives of the Halacaridae taxocene is formed unevenly (Table 7.3). As can be seen from the presented table, the average indicators for the entire vertical traverse of the proportion of Halacaridae from the total number of meiobenthos changes from spring to autumn depending on

the temperature regime. Thus, in May it was 15.15 %, in June (05.06 and 25.06) – 11.5-8.13 %, in July – 1.99 %, in September – 0.67 %, in November – 6.9%.

During the period of research in different years, we analyzed the confinement of Halacaridae to different types of substrates. Thus, in 1974-1976, material was collected at 15 stations in the Odesa Gulf, which allowed us to analyze the species composition on solid and algal substrates (Table7.3.). Research in 2012 and 2014 at one of the sites in the Odesa Gulf provided an opportunity to analyze the settlement of Halacaridae and the formation of their population density on various types of substrates. The proportion of sea mites from the total number of meiobenthos was low and was: on a sandy substrate – 0.4%, on a shell rock and rocky substrate – 1.9 % each, on mixed soil – 0.1 %.

Table 7.3.

Species composition of Halacaridae on various substrates (Vorobyova, Yaroshenko, 1979)

Species	Mussel fouling	Colonies of hydroids	**Algae**			Stones	Sand
			green	red	brown		
A.brevipalpus	+	–	+	+	–	–	–
C. ponteuxinum	–	–	–	+	–	–	–
C. ponteuxinum pestiniger	–	–	–	–	–	+	-
C. magnipalpus ponticus	–	–	–	–	–	+	–
C. magnipalpus serratisetus	+	+	+	+	+	+	+
Rh. notops	+	–	+	+	+	+	+
Rh. denticulatus	+	+	+	+	+	+	+
Rh. pascens	+	–	+	+	–	–	–
Halacarellus longipes	+	–	–	–	–	+	–
H. basteri affenis	–	–	+	+	–	–	–
H. proserus	–	–	–	–	–	–	+
H. floridearum	–	–	–	–	–	–	+
H. capuzinus	–	+	–	–	–	–	+

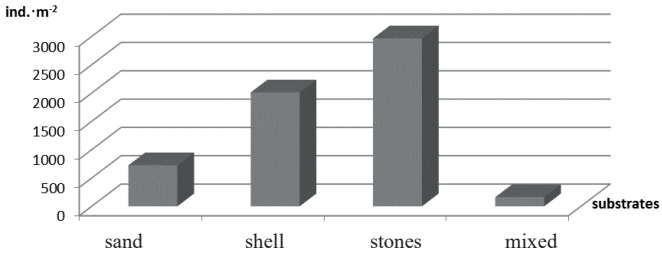


Figure 7.1. Distribution of settlement density (ind.·m^{-2}) of marine mites on different substrates in the Odesa Gulf (Vorobyova, 2022).

Collection of material in the Grigorevsky Estuary at standard stations in all seasons of the year (1993–1994) allowed us to show the formation of the density of settlements of marine mites in different periods (Table 7.4.).

Table 7.4.

Average density (N, ind.·m^{-2}) and biomass (B, mg·m^{-2}) of Halacaridae and total meiobenthos (Grigorevsky Estuary, 1993-1994) (Vorobyova, 2008)

Meiobenthos	Depth 0–1,5 m		Depth 2–15 м	
	N	B	N	B
May				
Halacaridae	6 267	56,4	3 460	31,1
Eumeiobenthos	57 889	226,8	661 586	1 694,1
Meiobenthos (total)	68 656	492,2	664 679	1 836,3
August				
Eumeiobenthos	325 676	2 166,0	650 882	2 483,4
Meiobenthos (total	383 979	3 124,0	657 298	2 780,7
November				
Halacaridae	1 200	10,8	1 073	10,0
Eumeiobenthos	64 440	82,4	290 152	265,0
Meiobenthos (total)	83 040	1 045,0	295 146	471,0
February				
Halacaridae	19 866	178,8	0	0
Eumeiobenthos	75 466	376,2	627 10	506,2
Meiobenthos (total)	89 226	693,5	628 43	556,4

The peculiarity of the NWBS is that in its different parts, and especially in the Black Sea estuaries, the salinity of the water varies considerably. In this regard, we conducted studies in laboratory conditions, in which Halacaridae were kept at a salinity of up to 67 ‰. Analysis of the obtained data showed that the sea mites can withstand a very wide range of salinity. At a salinity of 4.5 ‰ to 35 ‰, their survival periods were quite significant. At a salinity of sea water of 40–60 ‰, Halacaridae were active and their survival periods differed little from the control (17 ‰). At 63-63 ‰, the sea mites lived up to 3 weeks. At 65 ‰, their survival was several days, while the mites were slightly mobile. At 67 ‰, they died after a few hours (Vorobyova, Yaroshenko, 1982).

Our long-term studies (1994–1999 and 2005–2015) in the waters of the Odesa Gulf (depth 5–28 m) showed that in this area sea mites were found at a depth of 16 m. At a depth of 5–10 m, the occurrence mites at 175 completed stations were
22.3 %. The settlement density varied from 250 to 30,000 ind.·m^{-2}, the average value was 410.8 ± 182.1 ind.·m^{-2}. At a depth of 11–15 m, the occurrence of sea mites halacariids at 96 completed stations was 11.5 %. The settlement density varied from 250 to 6,500 ind.·m $^{-2}$, the average value was 1005.5 ± 707.4 ind.·m $^{-2}$. The graphs presented (Fig. 7.2, 7.3) show that their maximum was noted in 1998, and at the beginning of the current year – in 2006.

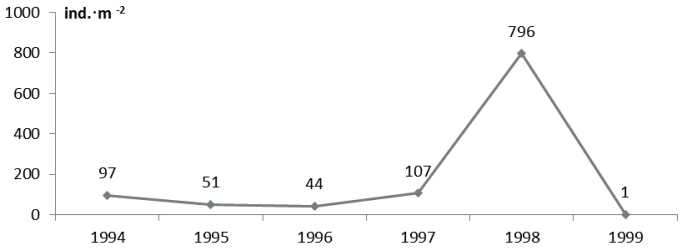


Figure 7.2. Interannual dynamics of the number of Halacaridae in the Odesa Gulf in 1994-1999.

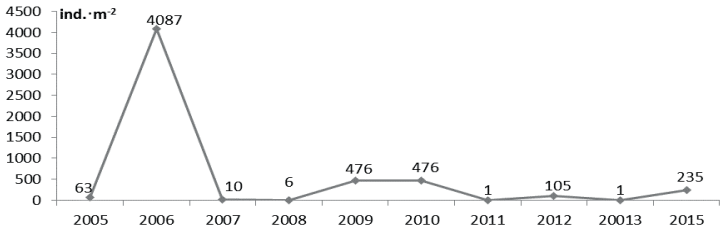


Figure 7.3. Interannual dynamics of the number of Halacaridae in the Odesa Gulf in. 2005-2015.

The maximum values in both cases were timed to the summer season on silted shells.

Thus, the half-century study of the Halacaridae taxocene for the Ukrainian shelf of the Black Sea at the IMB of the National Academy of Sciences of Ukraine allows us to classify this group of meiobenthos as the most studied along with such as Foraminifera, Nematoda and Harpacticoida.

2.8. Polychaeta of the Ukrainian shelf.

The temporary component of meiobenthos or pseudomeiobenthos in the coastal zone of the Black Sea plays a significant role in the formation of the total abundance (up to 20 – 40 %) and biomass (up to 70 %) of the entire meiobenthos (Vorobyova L.V., Bondarenko A.S., 2007). Juvenile individuals of polychaetes spend a rather short period in the meiobenthos. But at this period, they actively participate in the life of this community of organisms. Most often, researchers did not study the species composition of juvenile individuals Polychaeta of eumeiobenthos, but considered them all as a taxonomic unit of pseudomeiobenthos. In total, about 250 eumeiobenthic species are known for the World Ocean polychaetes belonging to 25 families (Giere, 2009). The first information about the species composition of the eumeiobenthic polychaetes of the NWBS shelf is given in the second half of the last century (Kiselyova, 1965, 2004).

There is very little information on the ecology and role of meiobenthic polychaetes in the formation of benthic community of organisms. The study of Polychaeta in the composition of the meiobenthos of the NWBS, their quantitative characteristics, occurrence, share in the total abundance and biomass of the meiobenthos, as well as chorological characteristics were started by us in 1982. In the first decade of the 21st century, a number of works were carried out at the IMB to study the species composition of pseudo- and eumeiobenthic polychaetes. We have presented quantitative indicators, analyzed their distribution depending on the main abiotic factors, and considered the relationship between adults of some species and their juveniles (Vorobyova, Bondarenko, Izaak, 2008, Vorobyova, Bondarenko, 2009, Bondarenko 2009, 2010). Unfortunately, there are very few data on the meiobenthic polychaetes of the Black Sea. Polychaetes are an essential component of the meiobenthos NWBS, whose contribution to its total biomass is often comparable to that of the eumeiobenthos. (Vorobyova, A.S. Bondarenko, 2007).

Almost all representatives of pseudomeiobenthos are food objects for juvenile fish and many representatives of macrozoobenthos. Research in the mid-90s XX century showed that the highest number of mollusks and polychaetes in the meiobenthos, as well as their share in total quantitative indicators on the Caucasian shelf (29.7 %), three times less – on the Crimean, and on the northwestern at the end of the last century it averaged 1.4 – 2.1% (Vorobyova, 1999). The study of the species composition of polychaetes, which by their size belong to its permanent and temporary components, became possible thanks to the experience and knowledge in the study of macrozoobenthos polychaetes Ph.D. Alena Spiridonovna Bondarenko. She has been very successfully studying polychaetes, which belong to macrozoobenthos, for many years. Her knowledge made it possible to study polychaetes, which belong to the temporary and permanent components of the meiobenthos. She not only presents lists of eumeiobenthic polychaetes in various water areas of the indicated section of the shelf, but also describes the species diversity of juvenile polychaetes that belong to pseudomeiobenthos. It

is known that polychaetes larvae migrate from the pelagial to the benthic, usually at the nektochaete stage. They are close in outline to an adult animal. Unlike trochophores and metatrochophores, nektochaetes have negative phototaxis and this causes them to sink into the bottom layers of water and look for a substrate favorable for settling (Thorson, G.1950.). In the absence of a substrate favorable for settling, nektochaetes can stay in the water column for a long time (up to several months).

On the western shelf of the Black Sea, Alena Spiridonovna registered 6 species of eumeiobenthic polychaetes (Table 8.1.).

Approximately twenty species of polychaetes are currently known for the Black Sea, forming a permanent component of the meiobenthos. Most of them inhabit a narrow coastal zone at depths of less than 10 meters. Meiobenthic polychaetes are represented primarily by juvenile macrozoobenthos species.

Table 8.1.

Species composition of meiobenthos polychaetes on the western shelf of the Black Sea (Bondarenko, 2009).

Species	Bulgaria	Romania	Ukraine
Phyllodoce mucosa Oerstéd, 1843	+	+	+
Eulalia viridis (Linné, 1767)	+	+	
Eumida sanguinea (Orstéd, 1843)	+	+	+
Phyllodocidae	+		
Nephtys hombergii Savigny, 1818	+	+	+
Nephtys sp.	+		
Harmothoe imbricata (Linnaeus, 1767)		+	+
H. reticulata (Claparède, 1879)	+	+	
Harmotoe sp.	+	+	+
Vigtorniella zaikai (Kisseleva, 1992) ▲	+		+
Neanthes succinea (Frey et Leuch)	+	+	+
Nereis sp.	+	+	
Platynereis dumerilii			+
Syllides longocirrata ▲	+	+	+
Exogone gemmifera ▲	+	+	+
Sphaerosyllis bulbosa Southern ▲	+	+	+
Microphthalmus sczelkowii ▲	+		
Pseudomalacoceros tridentata	+		
Aonides paucibranchiata Southern	+	+	+

Table 8.1. continued

Species	Bulgaria	Romania	Ukraine
Spio filicornis (O.F. Muller)	+	+	+
Pygospio elegans	+		
Polydora limicola Annenkova	+	+	+
Polydora antennata Claparede	+	+	
Prionospio cirrifera Wiren	+	+	+
Aricidea claudiae Laubier	+		
Notomastus profundus Eisig	+		
Heteromastus filiformis (Claparede)	+	+	+
Capitella capitata	+	+	+
Leiochone clypeata Saint-Joseph	+		
Terebellides stroemi Sars	+	+	
Melinna palmata Grube	+	+	+
Lagis neapolitana (Claparede)	+		+
Oriopsis armandi (Claparede) ▲	+	+	+
Pomatoceros triqueter (L.)			+

▲ –eumeiobenthic species

A. S. Bondarenko for the first time conducted a faunistic analysis of eumeiobenthic polychaetes and their main ecological characteristics for the Ukrainian shelf (Bondarenko, 2015). These studies were also innovative for various areas of the Black Sea. She showed that the polychaetes complex of eumeiobenthos was presented into the NWBS by 14 species: *Vigtorniella zaikai* Kisselev1992, *Syllides longocirratus* (Öersted, 1845), *Salvatoria clavata* (Clap., 1863), *Exogone (Exogone) naidina* Öersted, 1845, *Sphaerosyllis bulbosa*. Soutern, 1914, *S hystrix* Claparède, 1863, *Microphthalmus similis* Bobretzky, 1870, *M. fragilis* Bobretzky, 1870, *Hesionides arenaria* Friedrich, 1937, *Nerilla antennata* O. Schmidt, 1848, *Protodrilus flavocatitatus* (Uljanin, 1877), *Fabricia sabella* (Ehrenberg, 1837), *Oriopsis armandi* (Clap., 1864) and *Janua pagenstecheri* (Quatr., 1865). The species *H. arenaria* was found in quality samples collected on the supralittoral, where it was represented by single individuals, *V. zaikai* and *O. armandi* – in open deep-water part of the northwestern shelf.

Among the studied water areas, the eumeiobenthic Polychaeta fauna is the richest characteristic of the Karkinitsky Bay, where 10 species were discovered (*S. longocirratus, S. clavata, E. naidina, S. bulbosa, S. hystrix, M. fragilis, M. similis, P. flavocatitatus, F. sabella and J. pagenstecheri),* of which

S. longocirratus, S. clavata, E. naidina, S. bulbosa, S. hystrix were found in more than 50.0% of the collected samples. The following species were exclusively present in this area *S. hystrix, M. similis* and *M. fragilis*. Five species have been registered in Zernov's Philophorous field: *S. longocirratus, E. naidina, S. bulbosa, P. flavocapitatus, J. pagenstecheri*. The largest of them *S. longocirratus* (100 %) and *P. flavocapitatus* (75.0 %) were characterized by sterility.

The distribution of eumeiobenthic polychaetes on different types of substrates was analyzed: a silt, a silt/shell, a shell with sand and sand. The minimum number of species and their number are characteristic of silts. *S. clavata* and *S. longocirratus* were very rarely observed here in small quantities. High numbers of these invertebrates are characteristic of shelly and sandy silts, their maximum density in the NWBS is noted at shell with sand where they were represented by 10 species. *H. arenaria* was noted only on the supralittoral. *N. antennata* – on the supralittoral and in narrow coastal zone. Single individuals of *M. fragilis* and *M. similis* were noted by us at a depth of 8–10 m. *S. clavata* was found up to a depth of 17 m, but was most often present in samples collected at a depth of up to 10 m. *S. hystrix* was noted at a depth of 4-14 m. *P. flavocapitatus* was found up to a depth of 25 m, and its highest quantitative indicators were recorded at a depth of 0.3 m. *F. sabella* was recorded in the depth range of 0.3-10 m, and *J. pagenstecheri* was most often observed in the same range.

Interesting results were obtained by Bondarenko O. S. when analyzing the distribution of meiobenthic polychaetes in the NWBS shelf depending on depth. The main number of polychaetes species were found at a depth of 15-65 meters (Fig.8.1). At a depth of more than 100 m, only six species were found. Three of them belong to eumeiobenthic (*V. zaikai, S. longocirrata, E. gemmifera*) and three are juvenile specimens of *Prionospio cirrifera, Heteromastus filiformis* and *Capitella capitata*.

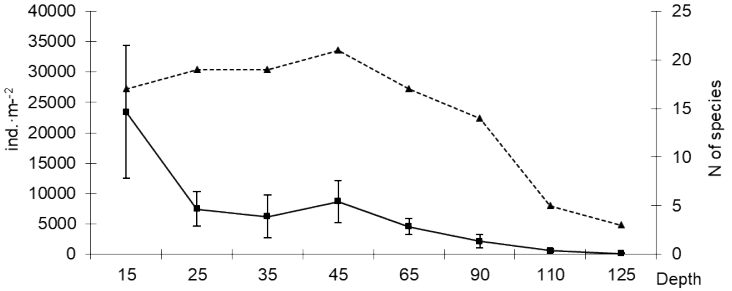


Figure 8.1. The abundance of polychaetes (ind.·m^{-2}) and the number of species at different depths.

At the pseudomeiobenthos of the northwestern part of the Black Sea (except for bays), juveniles of 28 polychaete species from 12 families were recorded during the study period: Phyllodocidae (5 species), Nephtyidae (1), Glyceridae (1), Polynoidae. (2), Sigalionidae (1), Nereidae (5), Spionidae (7), Capitellidae (2), Terebellidae (1), Ampharetidae (1), Pectinaridae (1) and Serpulidae (Vorobyova. Bondarenko, Izaak, 2008; Bondarenko, 2015).

Polychaetes of artificial substrates (Odesa Gulf). In total, 13 species of polychaetes were recorded in the waters of the beaches "Dolphin" and "Starik" in the meiobenthos of the periphytal of coastal protection structures and the biotope of sand (Vorobyova, Kulakova, Bondarenko, Portyanko, 2019). *Protodrilus flavocapitatus* (Uljanin, 1877) and *Fabricia sabella* (Ehrenberg, 1836) belong to eumeiobenthic, the rest, like all juvenile representatives of macrozoobenthos, belong to pseudomeiobenthic.

The most common were *S. clavata, P. cornuta*, juveniles of Nereidae, *F. sabella, A. succinea*, and *P. dumerilii*. 9 species were noted in the sand biotope. Here, *S. clavata*, juveniles of Nereidae, *P. flavocapitatus*, *Scolelepis (Parascolelepis) tridentata* (Southern, 1914), *Spio filicornis* (Müller, 1776), *P. cornuta, Capitella capitata capitata* Fabricius, 1780, and *F. sabella* (Table 8.2.).

Table 8.2.

Occurrence (P, %) of meiobenthos polychaetes in the periphytal of shore protection structures and sand biotope in the water areas of the beaches “Dolphin” and “Starik”.

Species	Periphytal coast protection structures	Sand biotope
Harmothoe reticulata (Claparède, 1870)	33	-
Salvatoria clavata (Claparède, 1863)	100	100
Nereis zonata Malmgren, 1867	11	-
Alitta succinea (Leuckart, 1847)	61	17
Hediste diversicolor (O. F. Müller, 1776)	6	17
Platynereis dumerilii (Audouin et M.-Edwards, 1834)	56	-
Perinereis cultrifera (Grube, 1840)	6	-
Nereidae	100	100
Protodrilus flavocapitatus (Uljanin, 1877)	-	67
Scolelepis (Parascolelepis) tridentate (Southern, 1914)	-	100
Spio filicornis (Müller, 1776)	28	100
Polydora cornuta Bosc, 1802	100	100
Capitella capitata capitata Fabricius, 1780	22	100
Fabricia sabella (Ehrenberg, 1836)	72	50

The number of individual species in the studied biotopes differed significantly. In the periphytal of bank protection structures, *S. clavata* and *P. cornuta* dominated in terms of this indicator. The juveniles of only one species, *S. filicornis,* dominated on the sandy substrate (Fig. 8.2).

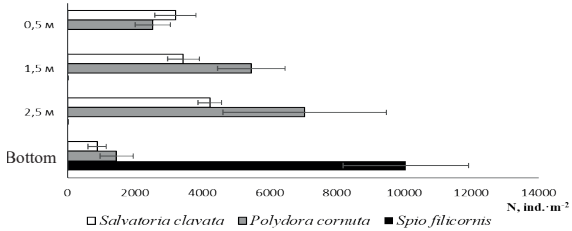


Figure 8.2. The number of dominant species of meiobenthos polychaetes on different horizons of the periphytal of coastal protection structures and in the sand biotope in the waters of the beaches "Dolphin" and "Starik"

Of the three species of eumeiobenthic polychaetes noted, *S. clavata* was characterized by 100 % occurrence in the two studied biotopes. Despite the high occurrence, the abundance of *F. sabella* in both the periphytal and benthic were low. *P. flavocapitatus* was recorded only in the sand biotope, which is the natural habitat of this species.

In the periphytal of hydrotecnical sourfaces (transect), eleven species of polychates in the meiobenthos were registered. Most often, representatives of eumeiobenthos such as: *S. clavata* and *F. sabella* and also juvenile *Polydora cornuta* Bosc, 1802, *Alitta succinea* (Leuckart, 1847), *Platynereis dumerilii* (Audouin et M.-Edwards, 1834) and Nereidae were encountered. In the sandy biotope there were 9 species of bristle worms. High numbers of eumeiobenthic *S. clavata*, *P. flavocapitatus*, *F. sabella* and juvenile, *Scolelepis (Parascolelepis) tridentata* (Southern, 1914), *Spio filicornis* (Müller, 1776), *P. cornuta*, *Capitella capitata capitata* Fabricius, 1780 and juvenile Nereidae (Table 2.31) occurred in the eumeiobenthos.

The number of separate species in the study of biotopes differed more (Table 8.3). In the periphytal of shore line protection structures, representatives of real eumeiobenthos such as *S. clavata* and juvenile *P. cornuta* prevailed. Their share in total number of meiobenthic polychaetes at different depths varied from 37 to 47 % and from 37 to 57 %, correspondently. The number of *S. clavata* at depth from 0.5 m to 2.5 m varied from 3,208 ± 607 ind.·m^{-2} to 4,233 ± 346 ind.·m^{-2}. *P. cornuta* occurred mostly at 1.5 and 2.5 m 5,467 ± 999 and 7,042 ± 2,430 ind.·m^{-2} correspondently.

Table 8.3.

Occurrence (P, %) of meiobenthic polychaetes in the periphytal and on the bottom

Species	Periphytal of hydrotecnical surfaces	Sandy biotope
Harmothoe reticulata (Claparède, 1870)	33	–
Salvatoria clavata (Claparède, 1863)	100	100
Nereis zonata Malmgren, 1867	11	–
Alitta succinea (Leuckart, 1847)	61	17

Table 8.3. continued

Species	Periphytal of hydrotecnical surfaces	Sandy biotope
Hediste diversicolor (O. F. Müller, 1776)	6	17
Platynereis dumerilii (Audouin et M.-Edwards, 1834)	56	–
Perinereis cultrifera (Grube, 1840)	6	–
Nereidae	100	100
Protodrilus flavocapitatus (Uljanin, 1877)	–	67
Scolelepis (Parascolelepis) tridentata (Southern, 1914)	–	100
Spio filicornis (Müller, 1776)	28	100
Polydora cornuta Bosc, 1802	100	100
Capitella capitata capitata Fabricius, 1780	22	100
Fabricia sabella (Ehrenberg, 1836)	72	50

Odesa Marine region. The polychaetes of the permanent component of the meiobenthos in the Odesa Sea Region are represented by only four species: *Syllides longocirratus* (Öersted, 1845), *Salvatoria clavata* (Clap., 1863), *Exogone (Exogone) naidina* Öersted, 1845, and *Protodrilus flavocapitatus* (Uljanin, 1877). The species in this water area were *E. naidina* and *P. flavocapitatus*. December 2005 at a depth of 12 m on silted sand in the Chamelea gallina (L., 1758) biocenosis E. naidina was found only on silted shell in the community of *Mytilus galloprovincialis* Lmk, 1819. *S. longocirratus* and *S. clavata* were recorded in all studied seasons. *S. longocirratus* was most often found on silty shell (53.0%) and shell with sand (45.0 %), the species were extremely rare on silt, *S. clavata* was most common in silty shell (65.0 %) and a shell with sand (70.0 %), while it clearly gravitated towards shallow depths.

Pseudomeobenthos. During the research period, juveniles of 14 macrobenthic polychaetes species from 9 families were recorded: Phyllodocidae (2 вида), Nephtyidae (1), Glyceridae (1) Polynoidae (1), Sigalionidae (1), Nereidae (1), Spionidae (4), Capitellidae (2), Ampharetidae (1).

NWBS. The work is based on the materials of expeditionary studies of 2003-2005, 2007, 2010 in the NWBS. (Bondarenko, Vorobyova, 2024). In the

pseudomeiobenthos of the northwestern part of the Black Sea (except for bay), juveniles of 28 species of polychaetes from 12 families were recorded during the study period: Phyllodocidae (5 species), Nephtyidae (1), Glyceridae (1), Polynoidae (2), Sigalionidae (1), Nereidae (5), Spionidae (7), Capitellidae (2), Terebellidae (1), Ampharetidae (1) Pectinaridae (1) and Serpulidae (1).

Using dispersion analysis, an assessment was made of the influence of the type of bottom sediments, salinity and temperature of the bottom water layer on the formation of α-diversity and the density of juveniles polychaetes in the northwestern part of the Black Sea.

The role of the substrate type for the settling of juveniles of Polychaeta to the bottom and their further development was analyzed (Fig. 8.3).

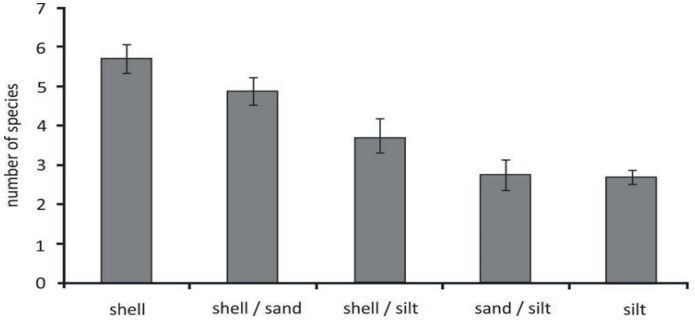


Figure 8.3. Number of pseudomeiobenthos polychaetes species in a sample on different substrates

Abundance indicators (ind.·m^{-2}) of the dominant species of pseudomeiobenthos polychaetes at various depths in the northwestern part of the Black Sea were examined. A study of the spatial distribution of juveniles of the dominant polychaetes species relative to their adult forms was carried. The larvae of *P. cornuta* actively choose the settlement sites of adults of their species to migrate to the benthic, while the abundance of juveniles of *P. cirrifera* and *C. capitata* is not associated with the settlements of their adults' forms.

DANUBE. In the pseudomeiobenthos of the Danube region juveniles of 15 polychaetes species belonging to 8 families were recorded during the study

period (Bondorenko, 2011). During this period, juvenile specimens of *A. succinea* and *P. cornuta* were most abundant at a depth of 7 to 20 m, where numerous settlements of their adult forms were noted in the macrozoobenthos. Juveniles of *P. cirrifera* most actively explored the depth of 20–24 m. The almost complete absence of representatives of the eumeiobenthos complex became a feature of the taxocene of polychaetes near the estuary. The low diversity of substrate types and, most importantly, the specificity of this contact zone and the high level of trophicity of the seashore of the river. The Danube may be the main factors hindering the development of polychaetes of the permanent component of the meiobenthos in this area.

Considering the features of the distribution of polychaetes juveniles at different depths, it should be noted that on the Danube coast in autumn, juveniles of *A. succinea* and *P. cornuta* were most abundant at a depth of 7 to 20 m, where numerous settlements of their adult forms are noted in the macrozoobenthos. Juveniles of *P. cirrifera* most actively explored the depth of 20–24 m (Bondarenko, 2011)

It is necessary to emphasize that long-term research allowed PhD. O.S. Bondarenko to present the first list of polychaetes for the North-West Black Sea region that belong to both permanent and temporary components of the meiobenthos (Table 8.4).

Table 8.4.

List of species of polychaetes pseudo- and eumeiobenthos of the North-West Black Sea (Bondarenko A.S, 2011).

Family Phyllodocidae Oersted, 1843
Genetyllis tuberculata (Bobretzky, 1868)
Phyllodoce mucosa Öersted, 1843
Eulalia viridis (Linnaeus, 1767)
Mysta picta (Quatrefagues, 1865)
Family Nephtyidae Grube, 1850
Nephtys hombergii Savigny in Lamarck, 1818
Family Glyceridae Grube, 1850
Glycera tridactyla Schmarda, 1861

Table 8.4. continued

Family Polynoidae Malmgren, 1867
Harmothoe imbricata (Linnaeus, 1767)
Harmothoe reticulata (Claparède, 1870)
Family Sigalionidae Malmgren, 1867
Pholoe inornata Johnston, 1839
Family Chrysopetalidae
Vigtorniella zaikai Kisseleva, 1992*
Family Nereidae Johnston, 1865
Namanereis pontica (Bobretzky, 1872)
Nereis zonata Malmgren, 1867
Alitta succinea (Leuckart, 1847)
Hediste diversicolor (O. F. Müller, 1776)
Perinereis cultrifera (Grube, 1840)
Platynereis dumerilii (Audouin et M.-Edwards, 1834)
Family Syllidae Grube, 1850
Syllides longocirratus (Öersted, 1845)*
Salvatoria clavata (Claparède, 1863)*
Exogone naidina Öersted, 1845*
Sphaerosyllis bulbosa Southern, 1914*
Sphaerosyllis hystrix Claparède, 1863*
Family Hesionidae, Grube, 1850
Microphthalmus fragilis Bobretzky, 1870*
Microphthalmus similis Bobretzky, 1870*
Hesionides arenaria Friedrich, 1937*
Family Dorvilleidae Chamberlin, 1919
Schistomeringos rudolphi (Delle Chiaje, 1828)
Protodorvillea kefersteini (McIntosh, 1869)
Family Nerillidae Levinsen, 1883
Nerilla antennata O. Schmidt, 1848*
Family Protodrilidae Czerniavsky, 1881
Lindrilus flavocapitatus (Uljanina, 1877)*
Family Spionidae Grube, 1850
Scolelepis (Parascolelepis) tridentata (Southern, 1914)
Aonides paucibranchiata Southern, 1914
Spio filicornis (Müller, 1776)
Pygospio elegans Claparède, 1863
Dipolydora quadrilobata (Jacobi, 1883)
Polydora cornuta Bosc, 1802

Table 8.4. continued

Prionospio cirrifera Wiren, 1883
Family Capitellidae Grube, 1862
Capitella capitata Fabricius, 1780
Heteromastus filiformis (Claparède, 1864)
Family Maldanidae Malmgren, 1867
Clymenura clypeata Saint-Joseph, 1894
Family Sabellariidae Johnston, 1865
Sabellaria taurica (Rathke, 1837)
Family Terebellidae Malmgren, 1867
Amphitritides gracilis (Grube, 1860)
Family Trichobranchidae Malmgren, 1866
Terebellides stroemi Sars, 1835
Family Ampharetidae Malmgren, 1867
Melinna palmata Grube, 1870
Family Pectinariidae Quatrefages, 1865
Lagis neapolitana (Claparède, 1869)
Family Sabellidae Malmgren, 1867
Fabricia stellaris (Müller, 1774)*
Oriopsis armandi (Claparède, 1864)*
Family Serpulidae Savigny, 1818
Spirobranchus triqueter (Linnaeus, 1767)
Janua heterostropha (Montagu, 1803)*

* – polychaetes, which belong to the permanent component of meiobenthos

In summarizing the presented data on the faunistic composition of benthic invertebrates classified as meiofauna by their body size, it should be emphasized that these are the first new data for the northwestern shelf of the Black Sea. Some species names of the meiofauna of large taxa are given according to classifications prior to 2005. The monograph "Biology of the Northwestern Part of the Black Sea" (Vinogradov, 1967) mentions only a small number of species of some large meiofauna taxa.

V. Ya. Didkovsky's list of Foraminifera species (34 species) cannot be used for comparison because it includes living foraminifera as well as redeposited shells of long-dead individuals.

Currently, more than 30 species are characteristic of the Northwest Black Sea (species identification – Professor V.V. Yanko). The obtained data

on Foraminifera in the Bosphorus Region allowed us to compare lists of these protozoans at different salinities.

Prior to the study data on the fauna of free-living nematodes in the Northwest Black Sea were virtually nonexistent. Regular, long-term research by K.B.N. I.I. Kulakova has identified more than 90 species. She has made a significant contribution to the study of the species richness of free-living marine nematodes not only for the Northwest Black Sea and some Black Sea estuaries, but also for the entire Black Sea.

Harpacticoids were also among the little-studied groups of meiobenthos. Thanks to the researches of PhD L. A. Garlitska and PhD Portyanko V.V. the list of species of harpacticoid copepods in the NWBS expanded to 127 species.

During sixteen years of research on the Northwestern shelf, PhD L. A. Garlitska discovered ten species new to the Black Sea fauna: *Harpacticus flexulosus* Ceccherelli, 1988, *Proameira dubia* (Sars G.O., 1920), *P. signata* Por, 1964, *Psyllocamptus eridani* Ceccherelli, 1988, *Bulbamphiascus aff.minutus*, *Robertgurneya similis bulbamphiascoides* Noodt, 1955, *Tisbe battagliai* Volkmann-Rocco, 1972, *T. bulbisetosa* Volkmann-Rocco, 1972, *T. marmorata* Volkmann-Rocco, 1973 and *Canuella sp*. Huys et al., 1996., and one new to science, Paronychocamptus sp..

Among the registered species of Portyanko V.V., 11 were new for the Ukrainian part of the NWBS. According to PortyankoV. V. fauna of Harpacticoida of contour biotopes during the period research included 75 species belonging to 46 genera from 23 families.

The species lists in the above-mentioned monograph (1967) do not mention to Halacaridae at all. PhD. M.V. Helmboldt made a significant contribution to the study of marine mites in the Northwest Black Sea. According to Helmboldt M.V. from 1995 to 2001, 18 species (11 genera) were noted in the NWBS: In the Odesa Bay and adjacent water areas – 8 species (7 genera), in the interstitium of regional biotopes – 4 species (2 genera), in the estuaries of the northern Black Sea region – 8 species (6 genera), in Karkinitsky Bay – 5 species (4 genera), in the coastal zone of the Tarkhankut – 7 species (6 genera), o. Snake – 8 species (Helmbolt, 2001, b). The fauna of marine mites of the Karkinitsky Bay, the coastal zone of the Tarkhankut and the Island Zmeiniy was described for the first time (Helmboldt, 2001). In the interstitium of sandy beaches, she found the following species of Halacaridae: *Actacarus*

ponticus, Halacarellus capuzinus, H. discretus, H. subterraneus of the genera *Actacarus and Halacarellus* (Helmboldt, 2001).

Very valuable and completely new data for the North-West Black Sea were obtained by A.S. Bondarenko, who, over many years, in parallel with studying macrozoobenthos polychaetes, determined in our samples the presence of juvenile polychaetes belonging to the temporary and permanent component of the meiobenthos

She showed that the polychaetes complex of eumeiobenthos was presented into the NWBS by 14 species.

Among the studied water areas, the eumeiobenthic Polychaeta fauna is the richest characteristic of the Karkinitsky Bay, where 10 species were discovered.

The polychaetes of the permanent component of the meiobenthos in the Odesa Sea Region are represented by only four species: *Syllides longocirratus* (Öersted, 1845), *Salvatoria clavata* (Clap., 1863), *Exogone (Exogone) naidina* Öersted, 1845, and *Protodrilus flavocapitatus* (Uljanin, 1877).

In total, for the studied water areas, she provides a list of more than 40 species of polychaetes, which belong to both temporary and permanent components of the meiobenthos.

CHAPTER 3.

The role of abiotic factors in the formation of the structure and dynamics of ecological indicators of the meiobenthos of the Ukrainian shelf of the Black Sea

The Black Sea is a typical inland Sea, with a bottom area of 420,325 km^2. areas with a depth of less than 200 m occupy only about 27 % of the total surface area of the Sea. The total area of the Black Sea shelf is approximately 100,000 km^2, or about 24 % of the bottom area of the Black Sea. The shelf also includes the bottom of the Sea of Azov, as well as the bays and open estuaries of the north-western coast. Modern sediments of the continental shelf of the Black Sea are very diverse, which is especially characteristic of the northwestern part of the Black Sea. There are stony, sandy, silty, silty-sandy and other types of substrates. Possessing ecological characteristics, they simultaneously serve as a nutrient medium for many representatives of the bottom fauna.

Benthic organisms living on the bottom of water bodies are adapted to the corresponding substrate, which largely determines their structure and quantitative indicators. The characteristics of the substrate depend on its physical properties (mechanical composition, moisture capacity, density, etc.), chemical composition and biological components.

Meiobenthos actively populates all types of substrates, but its qualitative and quantitative characteristics are very different. According to the degree of confinement to a certain substrate, lithophiles, psammophiles, pelophiles, etc. are distinguished. Most meiobenthic animals may not have the ability to select strictly only one type of substrate, but may give a clear preference to one of them, where they form the densest clusters. Thus, for many types of meiobenthos, macrophytes also represent a very favorable type of substrate. In addition to natural substrates, marine waters are characterized by various types of artificial (anthropogenic) substrates, which may be there due to deliberate human technogenic activity or may end up there by accident.

Most of the bottom is covered with slowly accumulating sedimentary material, the mechanical composition of which depends on the depth of occurrence. The mineral and organic particles that fall to the bottom as a result of sedimentation are a suspension, a significant part of which is the liquid phase – the ground solution. As is known, the main source of organic matter is autochthonous living matter, the predominant role in which belongs to planktonic organisms.

There are two main sources of organic matter in bottom sediments: 1) marine organisms and their products; 2) organic matter brought in by rivers. In other words, organisms living in the water column and benthos organisms create almost the entire reserve of organic matter in silts. After the death of planktonic organisms, the mass of organic detritus falls to the bottom. All these plant and animal remains, carrying various substances absorbed by them as they settle (heavy metal ions, their hydrates, etc.), perform a unique role as a transporter of various substances into bottom sediments. This is especially relevant for internal and marginal seas.

The physical and chemical properties of bottom sediments can be significantly transformed as a result of the vital activity of benthic organisms, the number and species composition of which change depending on the type of soil, hydrochemical factors and the level of pollution of the aquatic environment. The role of most representatives of the meiobenthos in the movement of sediment particles and the increase in the surface area of the most active upper layer of bottom sediments is great. This phenomenon, called ″biomixing″, is universal in nature and is observed in rivers, lakes, seas and oceans (Brekhovsky et al., 1988).

The localization of benthos biomass is basically determined by the distribution of plankton biomass in the upper layers of the pelagic. The main source of food resources for bottom animals is the population of the surface layers of the ocean. The abundance of organisms of various meiobenthos taxa in a given biotope is determined by the presence of a sufficient amount of food available to them. Predators predominate on sands and shell rock, while soil feeders and detritus feeders predominate on silts. The same species living on

different substrates can have different sizes and weights corresponding to the living conditions in a given soil. Consequently, changes in body size and corresponding changes in its shape reflect the adaptation of the organism to the conditions of the habitat. The distribution of the qualitative composition and quantitative indicators of meiobenthos varies significantly in different biotopes.

As a type of accumulative shore, sandy beaches are distinguished by a number of features that determine their biotope properties. Their physical features include the granulometric composition of sediments, which determines the degree of porosity of the sand embankment. Along the Black Sea coast, you can find beaches with different granulometry – from pebble to fine-grained with an admixture of silt particles, with a wide range of porosity indicators.

Specific environmental conditions in the interstitial zone have caused a number of morphological adaptations in organisms inhabiting this biotope. Animals with an elongated, worm-shaped body are best adapted to life in the interstitial environment. A. Remane (Remane, 1952). In the process of evolution, organisms inhabiting a certain type of soil have developed adaptations that allow them to move in narrow capillary passages between substrate particles. In addition, a positive relationship has been established between the quantitative distribution of the main groups of meiobenthos and the type of soil (Galtsova, 1991).

3.1. Influence of substrate type, depth, temperature on the formation of the meiobenthic community of organisms.

Edaphic factors are conditions that develop in bottom sediments of different mechanical (granulometric) composition and that play an important role in the life of meiobenthos. Bottom substrates of dissimilar mechanical composition have different moisture content, aeration, density, content of organic and biogenic substances, and microelements. The nature of the

granulometric composition plays a dominant role and can serve as an integrated key factor characterizing the habitat of meiobenthos (Gier, 2009)

In this regard, each type of substrate determines the formation of the species richness of organisms and has different values of the number and biomass of meiofauna. Organisms living on the surface of the substrate and inside it, together with various abiotic factors, form the habitat. Thus, the structure of the substrate depends not only on the physical-mechanical and physical-chemical composition, but also on the vital processes of living organisms. The qualitative characteristics of substrates are very variable in spatial terms.

The analysis of the confinement of meiofauna to different types of substrates was carried out by Vorobyova L.V. based on samples collected in the coastal zone of the Odesa Gulf — 1994-2017 (Vorobyova, 2022).

In the upper sublittoral of the Black Sea (10-11 m) the richest food base for fish larvae and juveniles is formed. The purpose of our research is to study the formation of quantitative characteristics of representatives of large taxa (total abundance and biomass) of the meiobenthic community in the upper sublittoral of the Odesa Bay. Earlier, studies of the end of the last century (Vorobyova, 1999) and the first decades of the 21st century were devoted to these issues (Vorobyova et al. 2017; Vorobyova et al. 2019; Vorobyova 2021; Vorobyova 2021a). The characteristics obtained by us can be used for the coastal zones of the water areas adjacent to the bay in order to determine the location and size of bottom areas with the best food supply for juvenile fish.

Studies in 1983-1998 showed that in this highly eutrophic water area, the meiobenthos in terms of its ecological characteristics differ significantly from the meiobenthos of the Romanian and Bulgarian shelves (Vorobyova, 1999; Vorobyova, Kulakova, 2009). Recent publications (Vorobyova and all 1916; Vorobyova and all, 1917; Vorobyova and all, 2021) reflect the main environmental factors (substrate type, depth, spatial distribution, etc.) that affect the formation of biodiversity, indicators of the total abundance and biomass of meiobenthos

During the research period in the Odesa Bay, from 9 to 13 groups of meiobenthos were found on various substrates: Foraminifera, Nematoda, Harpacticoida, Ostracoda, Halacaridae, Kinorhyncha, Turbellaria, Oligochaeta, larvae and juveniles of Polychaeta, Bivalvia, Gastropoda, Balanus. There were 9 large taxa on the sandy one, 12 on the shell, and 10 taxa on the stony substrate with algae cover. At the same time, Turbellaria, Kinorhyncha and Balanus larvae were noted only in one sample out of 96. Representatives of eumeiobenthos predominated in various biotopes, which accounted for 61.5 % on stony substrate, 72.7 % on shell rock, 67.6 % on sandy and on mixed one – 64.7 %. Thus, the proportion of the total abundance of these two categories of meiobenthos in the entire study area was within the same limits. The total number of meiobenthos on different substrates varied significantly. It was minimal on mixed substrate, and maximal – on rocks with algae.

The total biomass of meiobenthos on different types of substrates ranged from 1,893 $mg \cdot m^{-2}$ to 3,101 $mg \cdot m^{-2}$. The permanent (eumeiobenthos) component played the main role in the formation of the total abundance of meiobenthos, whereas the decisive role in the formation of the total biomass belonged to the pseudomeiobenthos (temporary component). So, on sandy substrate, it was 81.6 %, on a shell – 79.4 %, on stones with algal overgrowth – 74.6 %, on a mixed substrate – 78.6 %.

The analysis of the distribution of individual meiobenthic taxa on various substrates showed their significant differences. Nematoda dominated on the sandy substrate, Ostracods were absent. This is due to their ecological features and the possibility to develop mainly on the algal substrate. Juvenile Gastropoda were also absent. Most of the total abundance was formed by eumeiobenthos, accounting for 67.4 % of the total number of organisms. The total biomass (variations from 437.4 to 5,764.4 $mg \cdot m^{-2}$) averaged 2,807.5 $mg \cdot m^{-2}$, which was mainly formed by representatives of pseudomeiobenthos (81.6 %). The main role in the latter was played by polychaetes and juvenile bivalves.

On the shell rock, the total abundance of meiobenthos varied at different sites from 2,500 to 269,000 ind.·m^{-2} (average 143,300 ind.·m^{-2}), the main part of it was formed by eumeiobenthos (72.7 %). Nematoda prevailed, leaving 54.1 % of the total. The total biomass was slightly lower than on the sandy substrate – an average value made 1,893 mg·m^{-2} (the range is 125-47,675.8 mg·m^{-2}). These parameters, were formed mainly by polychaetes and bivalves as well as on the sand. Turbellarians, Kinorhyncha were met with single specimens. The remaining representatives of large taxa had a low abundance.

In the periphyton of rocky substrate, the meiobenthos consisted of 10 large taxa. Turbellaria, Kinorhyncha and Gastrotricha were absent. The total abundance varied from 59,000 ind.·m $^{-2}$ to 341,000 ind.·m^{-2} (156,107 ind.·m^{-2} on average). The proportion of eumeiobenthos in the total number of organisms was 67.4 %. The proportion of pseudomeiobenthos was quite high (32.6 %). The total biomass of meiobenthos varied widely – 739.38 mg·m^{-2} to 5,873.0 mg·m^{-2} (3,104.42 mg·m^{-2} on average). Harpacticoida dominated, Nematoda was the subdominant group. Thus, crustaceans and juvenile bivalve mollusks mainly developed on the stony substrate among algal fouling, which were also reflected in the study of the lithocontour of the northwestern part of the Black Sea (Vorobyova at al., 2019). The relatively high accumulation of nematodes is associated with silt that deposited on the settlements of Bivalvia.

On the mixed substrate, the formation of the total abundance of meiobenthos occurred mainly due to 6 groups (Nematoda, Harpacticoida, Ostracoda, Oligochaeta, Polychaeta, juveniles of Bivalvia). Indicators of the total abundance varied from 83,000 ind.·m^{-2} to 146,500 ind.·m^{-2} (120,500 ind.·m^{-2} on average). Nematoda dominated, the subdominant group – Harpacticoida. The proportion of eumeiobenthos in the total abundance of organisms was 64.7 %. The total biomass of meiobenthos ranged from 1,805.1 mg·m^{-2} to 3,708.6 mg·m^{-2} (2,458.3 mg.m^{-2} on average). The main role in its formation belonged to pseudomeiobenthos – 78.5 % of the total meiobenthos biomass. The main part of the biomass of pseudomeiobenthos was formed by polychaetes – 49.4 %.

FORAMINIFERA. At the IMB of the NAS of Ukraine, the study of the spatial distribution and formation of quantitative indicators of protozoa depending on abiotic factors was started in 1982. Features of the hydrological and hydrochemical regimes on the shelf between the estuary areas of the Danube, Dniester and Dnieper, the diversity of types of bottom sediments significantly affect the formation of species diversity of Foraminifera, and their quantitative indicators. Features of the formation of ecological characteristics of representatives of the Foraminifera taxocene in the open waters of the NWBS in the period 1982–1997 are described in detail in the monograph by L. V. Vorobyova (1999). Long-term studies in the waters of the Odesa Sea Region made it possible to provide substantiated characteristics of the formation of the structure and dynamics of quantitative parameters of the meiobenthos in the modern time period.

The importance of Foraminifera taxocene representatives in marine ecosystems has been noted by us throughout all the years of research (Vorobyova, 1999; Vorobyova et al. 2017; Vorobyova et al. 2019; Vorobyova, 2017; Vorobyova, 2021). The most important abiotic factors for benthic Foraminifera are, along with salinity, the type of bottom substrate, the depth of the marine area under consideration, water temperature, the amount of dissolved oxygen, and the content of organic matter. It is known that the most productive substrate for foraminifera is silt, a mixture of silt, sand, and detritus (Phleger, 1960**).**

The most important abiotic factors for benthic Foraminifera at NWBS are: salinity, type of bottom substrate, depth, temperature of the bottom layers of water, the amount of dissolved oxygen, and the content of organic matter. In this regard, we can conclude that the patterns of distribution of bottom foraminifers are controlled by a large number of environmental characteristics.

On the sandy bottom, they were noted at one of the stations – 5,000 ind.$\cdot$m^{-2}. On a shell rocky substrate, mainly where the mollusks formed dense settlements, their average density is 1,789 ind.$\cdot$m^{-2}, which is 1.5% of the total abundance of meiobenthos (Fig. 1.1.). On the shell rock, their occurrence was about 50% and the abundance at a depth of 6 to 11 m varied from 4,000

to 18,000 ind.·m^{-2} (average – 4,480 ind.·m^{-2}). At the same time, the share of foraminifers in the total abundance of meiobenthos was 4.2 %. At the same time, during summer, the proportion of foraminifers in the total number of meiobenthos organisms increased sharply. In the summer period (2005)5, in most sites in the OMR, the oxygen content in the bottom layers was 2–4 mg·l^{-1}. The abundance of Foraminifera settlements in this period ranged from 250,000 ind.·m^{-2} to 835,000 ind.·m^{-2}, their share of the total number of meiobenthos was very high, which was 82.6-94.9 %.

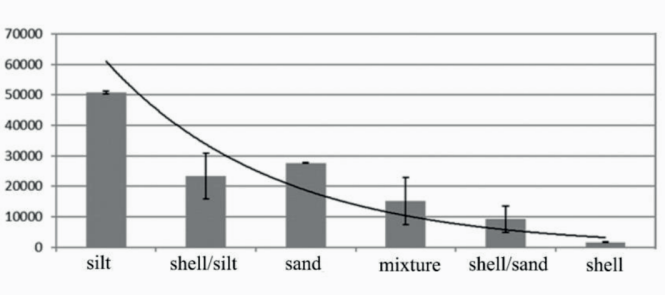


Figure 1.1. Long-term average density indices (ind.·m^{-2}) of Foraminifera settlements on various substrates

Depths. Of the benthic Foraminifera the dynamics of their distribution at different depths was well pronounced. Three Foraminifera complexes were distinguished in the northwestern shelf of the Black Sea: shallow 0-35 m, relatively deep 36–70 m, and deep 71–150 m (Yanko and Troitskaya, 1987). The distribution of these organisms shows close correlation with depth, because this factor determines many other parameters: illumination, temperature, oxygen and carbon content (Blum and Taldenkova, 2002). Thus, the depth is an integral parameter (Mokievsky, 2009), which is important for the northwestern part of the Black Sea with its diverse and dynamic conditions of abiotic factors. The shallow-water complex of Foraminifera was represented in the OMR. The analysis of the distribution density of Foraminifera populations in the OMR was carried out according to the results of ten-year observations at depths from 5 to 27 m. But even in this small range of depths,

a clear zonality was visible in the distribution of Foraminifera abundance (Figure 1.2.).

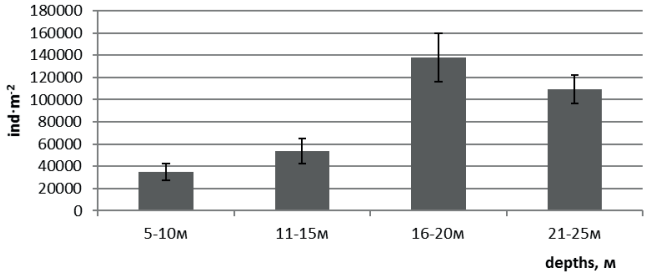


Figure 1.2. Long-term average density indices (ind.·m^{-2}) of Foraminifera settlements at various depths.

In the northwestern part of the Black Sea in general, and OMR in particular, Foraminifera play a significant role in the formation of the total number of meiobenthos (Fig. 1.3.).

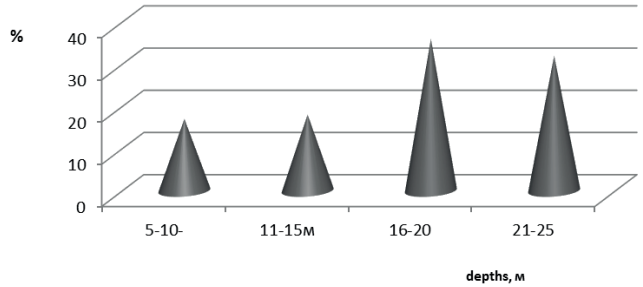


Figure 1.3. The long-term average indicator of the percentage (%) of Foraminifera in the total number of meiobenthos at various depths in the Odesa Sea Region.

Their dominance, as well as the dominance of representatives of the Foraminifera-Nematoda complex, may indicate deteriorating environmental conditions.

When studying the meiobenthos of the NWBS, we recorded living foraminifera in the substrate thickness up to 10 cm in water areas at depths of 25–90 (Vorobyova, Kulakova, 2009).

The temperature regime of the bottom layers of water is of great importance in the formation of quantitative indicators of the Foraminifera taxocene. In this regard, the formation of the density of foraminifera settlements is very dynamic throughout the year (Fig. 1.4.)

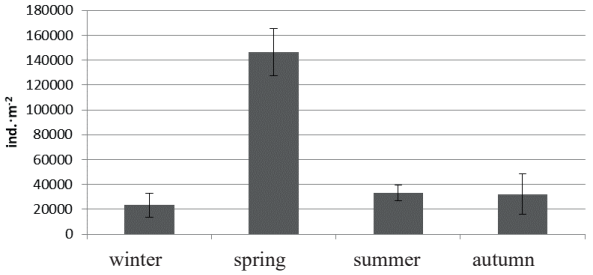


Figure 1. 4. Average long-term abundance indicators (ind.·m^{-2}) of Foraminifera in different seasons of the year.

Analysis of the obtained material indicates that the average long-term maximum densities of foraminifera are confined to the spring period, often acting as the dominant group in the total number of meiobenthos during this period (Fig. 1.5.).

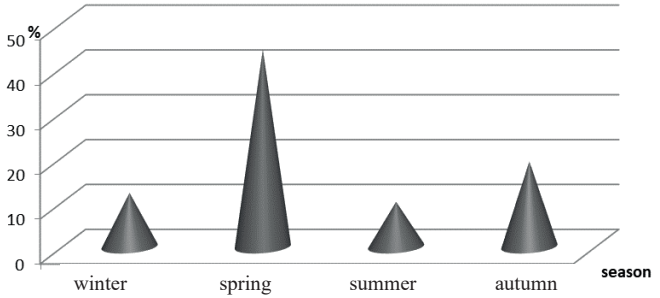


Figure 1.5. Average long-term indicators of the proportion (%) of foraminifera in the total number of meiobenthos

Such indicators of foraminifera in spring can serve as an indicator of the time of year when a large amount of organic matter accumulates at the bottom, entering the benthal after the mass development and death of unicellular algae in the surface layers of the Sea.

Their dominance, as well as the dominance of representatives of the Foraminifera-Nematoda complex, may indicate deteriorating environmental conditions.

Naturally, the number of Foraminifera increases with increasing salinity levels in the bottom layers of water (Fig. 1.6).

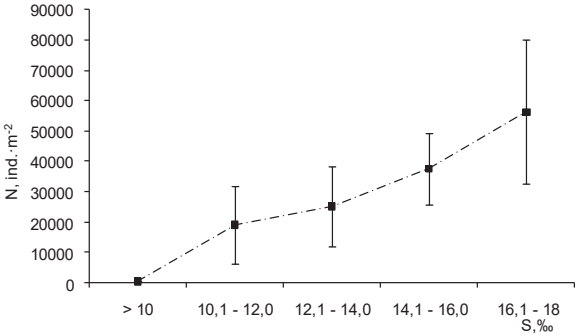


Figure 1.6. Dynamics of Foraminifera density in different salinity.

Nematoda. In the second chapter we noted that nematodes in the meiobenthos of the northwestern Black Sea are second only to harpacticoids in terms of species number, but differ from them in having the highest frequency of occurrence and abundance in all studied water area.

PhD Irina Ivanovna Kulakova was the first to study the features of the spatio-temporal distribution of free-living nematodes for the Ukrainian part of the northwestern shelf of the Black Sea, and analyzed the influence of the main abiotic and anthropogenic factors on the formation of the Nematoda taxocene (Kulakova, 1989, 1990, 1992, 2002, 2004, 2005, 2013 and others).

Analyzing the materials collected in various areas of the NWBS, its bays and estuaries, I.I. Kulakova described the main patterns of formation of the density of settlements and biomass of this taxocene depending on the types of bottom substrates (natural and artificial), temperature conditions, depth. Her results on the study of the nematode taxocene at large depths in the zones of methane seeps are especially important. She described the long-term dynamics of the nematode population at the end of the last century and in the first decades of the current century. (Kulakova, 1989, 2001, 2023). She determined the main trends in the development of nematodes in areas with different anthropogenic loads.

The studies of 1973–1978 as already mentioned, to compile a list of nematode species of the interstitial sandy beaches of the NWBS. The results of the analysis of long-term material allowed Kulakova to establish for the first time, for the Black Sea, the patterns of formation of the density of nematode settlements not only in the pseudolittoral. She obtained completely new information on the ecological characteristics of nematodes: the dependence of quantitative parameters on the granulometric composition of beach sediments; features of spatial distribution depending on the distance from the splash (water edge) and the spatial distribution in the sand thickness (from 0 to 70 cm); to establish the seasonal dynamics of the density of nematode settlements in the pseudo- and supralittoral (Kulakova, 1992). The distribution of nematodes is impacted mainly by the characteristics of the substrate and in particular, the size of the interstitial spaces that can serve as a refuge for nematodes (Gerlach, 1953, 1958).

Determination of the role of nematodes in the total number of interstitial meiofauna in the thickness of beach sediments allowed us to establish that it is minimal in the pseudolittoral. Here, on all types of sand in the upper layer (0–4 cm), they make up 4–10 % of the total number of organisms (Table 1.1), and in the lower layer (4–10 cm), the proportion of nematodes does not exceed 17 % on average, where turbellarians and harpacticoids mainly predominate.

Table 1.1.

Average annual indicators of the proportion of nematodes (in %) in the total number of interstitial meiofauna in the pseudo- and supralittoral

Horizon (cm)	Type of sand		
	Coarse grained	Medium grained	Fine grained
Pseudolitoral			
0 – 4	4,0	10,0	10,0
4 – 10	12,0	17,0	7,0
Supralittoral, l=1			
0 – 10	26,0	37,0	26,0
10 – 20	26,7	50,6	17,9
20 – 30	25,0	45,0	25,0
30 – 40	21,0	35,6	4,5
40 – 50	14,5	5,0	–
Supralittoral, l=3 м			
0 – 10	38,2	61,0	42,0
10 – 20	38,2	62,0	47,0
20 – 30	36,0	57,0	43,0
30 – 40	27,0	32,0	33,5
40 – 50	28,0	30,0	16,0
50 – 60	19,5	–	–

The average long-term values of nematode density are 61,885 ind.·m^{-2}, with average values of the total number of interstitial meiofauna being 1,226,740 ind.·m^{-2}.

The results of the analysis of data from long-term systematic studies in the Odesa marine region (according to a standard grid of stations at a depth of 6–30 m, in the period 1994–2013) I. I. Kulakova published information both in collective monographs (Kulakova, 2006, 2017) and in some scientific journals. These data are of great scientific importance since they reflect the development of the meiobenthos and, in particular, the Nematoda taxocene in new environmental conditions (Vorobyova, Bolshakov, 2023) in the waters of the NWBS in the first two decades of the twenty-first century.

Quantitative indicators of Nematoda and their percentage in the total density of meiobenthos varied significantly over the years (Table 1.2).

Table 1.2.

Average population density ($N \pm m_N$ thousand ind.$\cdot m^{-2}$) and average biomass ($B \pm m_B$ thousand mg$\cdot m^{-2}$) of nematodes in the Odessa marine Region

Year, month	N			B		
	$N \pm m_N$	Min	Max	$B \pm m_B$	Min	Max
1994, V	102,2±29,1	1,0	320,0	19,43±3,7	0,2	60,8
1994, VIII	231,4±34,7	3,2	917,5	44,0±9,8	0,6	174,3
1995, V	263,5±40,3	3,2	1185,0	62,7±13,7	0,6	348,0
1995, VIII	103,2±30,1	0,3	310,0	19,6±4,6	0,1	58,9
1996, V	152,7±27,6	3,5	632,5	29,0±6,1	0, 7	120,2
1996, IX	210,5±41,7	0,3	972,5	40,0±8,2	0,1	184, 8
1997, IX	56,5±13,4	0	172,0	10,7±2,1	0,0	32,8
1998, V	96,9±27,9	1,8	390,0	18,4±3,4	0, 4	74,1
1998, VIII	94,9±25,1	5,0	612,5	18,0±4,1	0,9	116,4
1998, IX	56,4±17,1	0	207,50	10,7±2,2	0,0	39,4
2005, IV	71,9±15,5	6,4	272,0	13,7 ±2,9	1,2	51,7
2005, VIII	41,4±6,8	3,5	145,0	7,9±1,3	0,7	27,5
2005, XII	327,1±68,8	1,6	1547,5	50,9±11,5	0,0	294,1
2006, VI	445,9±82,1	20,0	1870,0	84,7±15,6	3,8	355,3
2007, VIII	32,4±5,9	0,6	86,0	5,9±1,2	0,1	16,4
2008, VIII	120,6±30,4	6,6	580,0	22,9±5,8	1,3	110,20
2008,XI	189,1±45,8	2,0	800,0	35,9±8,7	0,4	152,0
2009, VII	173,6±31,2	3,0	577,5	32,9±5,9	0,6	109,7
2009, X	30,9±14,2	0	338,0	5,89±2,7	0,0	64,2
2010,VI	392,3±43,6	3,7	1150,0	74,3±8,4	0,7	218,5
2011, VII	163,2±26,3	17,0	558,0	30,4±5,1	3,2	106,0
2012, IX	78,8±17,1	15,0	211,0	14,9±5,1	2,8	40,1
2013, VII	270,6±40,1	102,0	588,0	54,4±7,6	19,4	111,7
average	152,1±31,1			30,7±6,1		

Note: **N** is the mean value of the population density; **B** is the mean value of biomass; m_N and m_B are the error of the mean.

The results of Kulakova I.I.'s research in open areas of the NWBS (Dnieper-Bug region, Danube-Dniester interfluve) are reflected in the published monograph (Vorobyova, 1999). The distribution characteristics of the density, biomass and species composition of nematodes are given. No work including both an analysis of the species composition and quantitative distribution of free-living nematodes in these areas, had been conducted before Kulakova I.I.'s research.

In the studied areas, Nematoda are the dominant group of meiobenthos, comprising more than 80% of all organisms. The total number of nematodes fluctuates widely (600–1,130,000 ind.·m^{-2}), creating mass accumulations of numbers on silts and silted shells. On silty soils in the first of the indicated areas, at most stations, nematodes constituted from 80 to 97 % of the total number of meiobenthos. At all depths, their density was high and varied from 60,750 to 876,880 ind.·m^{-2}, averaging 310,600 ± 74,411 ind.·m^{-2} for silts. On silted sand, characterized by depths of 12–20 m, nematodes are the dominant group of meiobenthos, comprising more than 80 % of all organisms. Their numbers varied from 3,250 to 312,250 ind.·m^{-2}, averaging 170,375 ± 39,946 ind.·m^{-2}.

In the sand and shell biotope, the nematodes abundance varied widely (from 625 to 408,500 ind.·m^{-2}), averaging 72,662 ± 55,860 ind.·m^{-2}. In the shell biotope, the nematode abundance was insignificant and varied from 0 to 1,125 ind.·m^{-2}. In the Danube-Dniester interfluve, Nematoda were distributed very unevenly. The minimum values ranged from 125 to 4,750 specimens m^{-2} at the outlet of the Dniester Estuary. On the silts in this area, the density of nematodes averaged 149,500 ± 88,750 ind.·m^{-2} and on the sand mixed with shells – 16,300 ± 4,250 ind.·m^{-2}.

According to I.I. Kulakova during the identification of Nematoda, 70 species were found in the first of the indicated areas, and 32 species in the second. A complex of mass species was identified, of which the most widespread species in all areas were*: S. pulchra, P. caecus, A. setosus*. The density indices of these species reached maximum values in one or another biotope.

In the upper sublittoral (Odesa Marine Region, depth up to 15 meters) the highest density of nematodes was on sandy substrate (Table 1.3.). The abundance of Nematoda varied from 2,300 ind.·m^{-2} to 484,000 ind.·m^{-2} (100,972 ind.·m^{-2} on average). Their maximum accumulation located near the breakwater parallel to the coast (depth 6.4 m). It was established that there is a connection between the density of nematodes settlement and the type of soil. The average number and biomass of nematodes varied widely. The poorest in

terms of quantitative indicators of nematodes is the biotope of sand with an admixture of shells. Biotopes of gray and black silts of the OMR are characterized by high indicators of density and biomass of nematodes. On the sandy substrate nematodes were the dominant group, accounting for 50.4 % of the total abundance of meiobenthos and 76.78 % of the total abundance of eumeiobenthos (Kulakova, 2017).

With increasing depth, a different picture is observed and the maximum density is confined to the silty substrate (Table 1.3.). The maximum number of nematodes on different types of substrates were observed in the summer. In general, no clear dependence of the quantitative characteristics of nematodes on seasonality was noted. Apparently, they are influenced by numerous factors, such as the type of substrates, different cycles of reproduction of animals, and the availability of food. Fluctuations in the density of Nematoda settlements in different years are also due to changes in various environmental factors.

Table 1.3.

Comparative characteristics of the average settlement density ($N \pm m_N$ thousand ind.$\cdot m^{-2}$) and average biomass ($B \pm m_B$ thousand mg$\cdot m^{-2}$) of nematodes on different types of substrates in the Odesa Marine Region.

Soil type	N			B		
	$N \pm m_N$	Min	Max	$B \pm m_B$	Min	Max
Silt	270,0±52,9	37,9	755,0	50,9±10,1	7,2	143,5
Silted Shell	129,1±40,1	23,4	312,0	24,5 ±7,6	4,5	59,3
Sand mixed with shell	80,7±25,8	12,5	159,1	15,3± 4,9	2,4	30,2

Note: N is the mean value of the population density; B is the mean value of biomass; m_N and m_B are the error of the mean.

Having analyzed the spatial distribution of nematodes for the period 1994–2013 in the OMR water area, I. I. Kulakova found that the cores of the maximum indicators of their settlement density are confined to both the Odesa Gulf and the zone located between two estuaries (Grigorevsky and Dofinovsky), where, apparently, organic matter accumulates in the silts. In

coastal zones with depths of up to 7 meters and a predominance of sandy substrate, the density of nematode settlements is the lowest (Kulakova, 2017).

The dominance of Nematoda in the meiobenthos indicates a high trophic status of the OMR. Nematoda are organisms that find favorable conditions for their development in soils enriched with organic matter. Thus, among the indicated nematodes species, the role of oxyphilic representatives of the Chromadorida order in the OMR is low, and species from the Monhysterida order, which are less demanding of environmental quality, predominate. An increase in trophic status leads to changes in the ecosystem, in which ecological niches are captured by species that are best adapted to the prevailing environmental conditions.

The study of nematode taxocene in water areas with the most critical ecological conditions was conducted by Kulakova I.I., in particular in Zhebriyanskaya Bay. Zhebriyanskaya Bay is located directly at the Danube Delta and is essentially an avant-delta region. It belongs to the hypereutrophic regions of the NWBS. Water bloom is constantly observed here, as a result of which a large amount of organic matter accumulates in the bottom layer.

The results of the analysis of the formation of the nematode taxocene in Zhebriyanskaya Bay are described by I.I. Kulakova based on samples collected in 18 expeditions in 1982–1996 (Vorobyova, Kulakova, 1998). It should be noted that a very complex ecological situation developed in the bottom layers of the bay during the period of our studies. The content of dissolved oxygen at the bottom in all years of observations fluctuated from 0.05 to 2.7 mg l^{-1} in spring, summer and early autumn.

In the spring period, only nematodes were 100 % frequent. Their share in the total number of meiobenthos increases, amounting to 21.4 to 82.0% in different years. In most cases, the density of nematodes was 35,000-141,330 ind.$\cdot m^{-2}$. The average long-term indicator for spring is 84,543 ind.$\cdot m^{-2}$.

In different summer months shows an increase in the diversity of organisms of the meiobenthos. It is represented by 9 groups, of which the most significant in terms of participation in the formation of its settlement density

were nematodes, foraminifers and harpacticoids. The proportion of nematodes in different summer months varied from 10.1 to 59.2 % of the total meiobenthos density. The average value of the nematode abundance in the summer months was 124,450 ind.·m^{-2}. Due to the fact that the hydrochemical regime of the Bay is very dynamic, environmental conditions can differ significantly for the same time period in different years. In this regard, the qualitative and quantitative characteristics of the meiobenthos vary significantly. It should be noted that in the summer months, nematodes, along with foraminifers, are the dominant group. The highest values of the total meiobenthos abundance were recorded in July of the mid-90s. Thus, in 1995, the average density of nematodes was 434,000 ind.·m^{-2}, making up 76 % of the total meiobenthos.

In autumn, 4 groups of meiobenthos were usually present in Zhebryanskaya Bay: Foraminifera, Nematoda, Harpacticoida and Ostracoda. At each station, 2–3 groups were most often present. In percentage terms, nematodes belong to the subdominant group. The second group in terms of quantitative indicators is nematodes (20.1 %), the density of which fluctuated from 42,500 to 200,000 ind.·m^{-2} (average – 120,250 ind.·m^{-2}). The average long-term indicator for the winter months is 14,209 ind.·m^{-2}.

Harpacticoida. Representing a permanent component of the meiobenthos, Harpacticoida play a very significant role in the formation of the species diversity of this community of organisms and its quantitative indicators (Fig. 1.7). They actively populate various substrates (sand, silt, shell, algae), have a wide spatial distribution (from the supralittoral to the continental slope).

For the NWBS data on the species diversity of Harpacticoida were practically absent before our studies. Before 1979, there were publications on harpacticoids of the lower reaches and estuarine coastal areas of the Danube and the Dnieper-Bug Estuary (Monchenko, 1967**),** as well as in a monograph on the interstitial sandy beaches of the Odesa coast (Vorobyova et al., 1992).

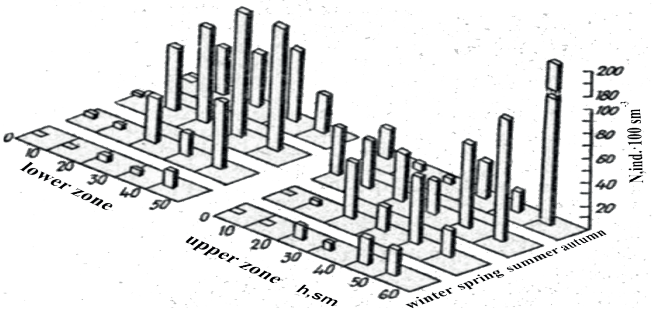


Figure 1.7. Scheme of spatial distribution of Harpacticoida density in coarse-grained sand in different seasons of the year in the supralittoral zone.

Long-term studies allowed L. V. Vorobyova to discover 9 species of harpacticoids (Chapter 2), living mainly in coarse-grained sands of the pseudo- and supralittoral. Of these nine species found in the pseudo- and supralittoral, only one is characteristic of fine-grained beach sediments (*Paraleptastacus spinicauda trisetosa*), the rest were found in coarse-grained sands.

The proportion of harpacticoids in the total number of meiofauna in this biotope fluctuates significantly throughout the year and increases from fine-grained to medium- and coarse-grained sand, which is also characteristic of the spatial distribution of their numbers. The number of crustaceans is not uniform in spatial terms. In the lower supralittoral zone (1 m from the splash), the lowest density of Harpacticoida settlements in the entire thickness of sand were noted in winter and spring. A similar picture is observed in the upper zone (3 m from the splash). Here, in autumn, harpacticoids migrate to deeper layers of sand deposits and the maximum number was recorded at a depth of 60 cm near groundwater.

Most harpacticoid species are very sensitive to the conditions of the surrounding marine environment. In areas experiencing high anthropogenic pressure, their species diversity and quantitative indicators are extremely poor.

Long-term studies in the NWBS have shown that in terms of species diversity, Harpacticoida is one of the richest groups of meiobenthos adapted to living in the benthal.

In the previous text, it was noted that PhD Garlitska L.A. made a great contribution to the study of the taxocene of the Harpacticoida in the NWBS. Her conclusions were based on material collected in different areas in 1992–2009 in the Danube and Transnistrian regions, the Grigoryevsky Estuary, Odesa Marine Region, the Karkinitsky Gulf and the open part of the northwestern shelf of the Black Sea.

According to L. A. Garlitska, the number and biomass of harpacticoids in the Danube Region vary depending on the season. In May-June, the abundance of harpacticoids is the highest, reaching a maximum of 2,800.0 thousand ind.·m^{-2} (on average 173.0 thousand ind.·m^{-2}), and their share accounts for 34.1 % of the total number of meiobenthos and 56.7 % of the total biomass. By the end of summer, the number of harpacticoids decreases by more than 2 times (on average 81.8 thousand ind.·m^{-2}), in parallel with this, their share in the meiobenthic community also decreases – to 9.0 % of the total number and to 16.8 % of the total biomass. In October-November, the lowest density indicators are recorded – from 0 to 131.3 thousand ind.-m (on average 22.0 thousand ind.·m^{-2}). At the same time, the share in the total number and biomass of meiobenthos increases (on average 19.9 and 27.0 %, respectively). According to the archival data in the mid-1980s – early 1990s in the Danube region in the summer (July), on average 62.6 thousand ind.·m^{-2} of bottom copepods were counted, which is quite comparable with modern values. In autumn (October), the numbers did not exceed 8,000 ind.·m^{-2}, and this is significantly lower than the data obtained during our observations (Garlitska, 2004, 2009).

Long-term studies of the meiobenthic community of Zhebryanskaya Bay show that during that period, unfavorable conditions for the development of crustaceans often developed, namely: a decrease in the oxygen content in the bottom layer of water during the period of development of stable temperature

stratification (Garkavaya, Yu.I. Bogatova, N.A. Berlinsky, 1998). The most "difficult" years for bottom organisms were 1990–1993.

The abundance of harpacticoids on different types of soil varies significantly. Compared to other biotopes, silt is populated more actively by bottom copepods: the average abundance is 62.4 thousand ind.·m^{-2}, which is 22.8 % of the total number of meiobenthic organisms. In biotopes of sand and silted sand with an admixture of shells, the density of harpacticoids on average is only 0.8 and 14.3 thousand ind.·m^{-2}, respectively. As the depth increases, the quantitative indicators of harpacticoids also increase. A sharp difference is observed between the depths of 3.8–5.0 m (on average 0.9 thousand ind.·m^{-2}) and 5.1–10.0 m (on average 50.0 thousand ind.·m^{-2}), and the maximum values are confined to the range of 15.1–20.0 m (on average 103.8 thousand ind.·m^{-2}). It turned out to be interesting that with such a significant difference in the actual values of the abundance at depths from 5.1 to 20.0 m, the proportion of harpacticoids in the total number of meiobenthos remains practically unchanged (27.1±2.9 %) (Vorobyova, Kulakova, Garlitska, 1998).

Garlitska studied seasonal changes in harpacticoid communities using the example of the Grigorievsky Estuary (1992–2009), the hydrochemical regime of which is generally similar to the regime of the adjacent waters of the NWBS.

In the spring months, with an increase in the number of harpacticoids throughout the water area, an increase in their share of the total number of meiobenthic organisms was observed in the shallow zone of the estuary (from 18.1 to 26.4 %). At depths of 4–17 m, it decreases almost 2 times (from 30.1 to 16.7 %).

At the beginning of summer, a wide amplitude of fluctuations in the abundance of harpacticoids is characteristic of all depths (on average, 39.7–448.4 thousand ind.·m^{-2} in shallow water and 5.9–199.0 thousand ind.·m^{-2} at depths of 4–17 m). At the end of summer, a decrease in the number of benthic copepods occurs to varying degrees, both in the coastal part and at depth. At the same time, density indicators vary significantly from year to year.

At the beginning of autumn, harpacticoids in the relatively deep-water part are in a depressed state (6.6 % of the total meiobenthos) and nematodes and foraminifers come out on top in terms of numbers, while in the coastal zone, on the contrary, September is characterized by the highest rates of harpacticoids both in the total number (41.5 %) and in the total biomass (63.7 %) of the meiobenthos (Garlitska, 2000, 2005).

Substrate type. The distribution of Harpacticoida differs significantly in areas with different types of substrates. The quantitative indicators of Harpacticoida on the silts of the part of the shelf we studied vary widely: the number fluctuates from 1.2 to 780.0 thousand ind.·m^{-2} (on average for the biotope 99.7 thousand ind.·m^{-2}). The average values of the number of bottom copepods are maximum in the summer months (171.7 thousand ind.·m^{-2}), while the indicators for the spring and autumn months are almost twice as low (80.5 and 73.2 thousand ind.·m^{-2}, respectively). The total density of Harpacticoida on silted sands varies within the range of 0.2–262.0 thousand ind.·m^{-2}, averaging 55.4 thousand ind.·m^{-2}, in 1.8 times lower than on the silt biotope. The maximum number of bottom copepods on this type of substrate is confined to the summer months.

The distribution of the total density of harpacticoids on the sands is uneven: in the Transdnistrian region, the abundance fluctuates from 0.4 to 3.9 thousand ind.·m^{-2}, averaging 2.2 thousand ind.·m^{-2}; in the Karkinitsky Gulf – 2.0–44.4 thousand ind.·m^{-2} (an average of 18.5 thousand ind.·m^{-2}); and in the coastal shallow part of the Grigoryevsky Estuary – 4.8-356.0 thousand ind.·m^{-2} (an average of 85.6 thousand ind.·m^{-2}). The maximum number of species in a sample is noted in the Karkinitsky Gulf (9-17 species), while on average for the regions under consideration, it is equal to 9±4 species.

Depth is traditionally considered one of the leading factors determining the abundance of meiobenthos. There is a clear dependence of diversity on depth: diversity increases with increasing depth. But the number of species depends nonlinearly on depth. The richest in species are depths of 8–12 m, while at the shallowest (0.3 m) and at depths greater than 20 m their number decreases. It is in this range of average depths that silted sands with shells

predominate, the fauna of which is the most diverse. Additional data on the open part of the NWBS, covering a larger range of depths (from 15 to 125 m), show that there is another maximum of species' richness at depths of 65–90 m (Garlitska, 2001, 2004, 2009). Thus, these depths act as a typical ecotone – a contact zone of deep-water and shallow-water fauna. (Garlitska, 2008).

Based on the accumulated long-term material, a distribution scheme of families on the northwestern shelf of the Black Sea has been constructed (Fig. 1.8.). From the upper sublittoral to a depth of 125 m, benthic copepods of only five families are found: Miraciidae, Cletodidae, Canthocamptidae, Laophontidae and Dactylopusiidae. If the first two families are distributed more or less evenly, then Canthocamptidae and Laophontidae have two peaks of abundance due to different species: in shallow water – *Mesochra aestuarii, M. heldti, M. pontica, Nannamesochra arupinensis, Asellopsis sarmatica and Paronychocamptus sp.,* and at depths greater than 60 m – *Mesochra pygmaea, Heteropsyllus major, Archesola typhlops pontoica, Laophonte elongata* and *L. brevifurca*.

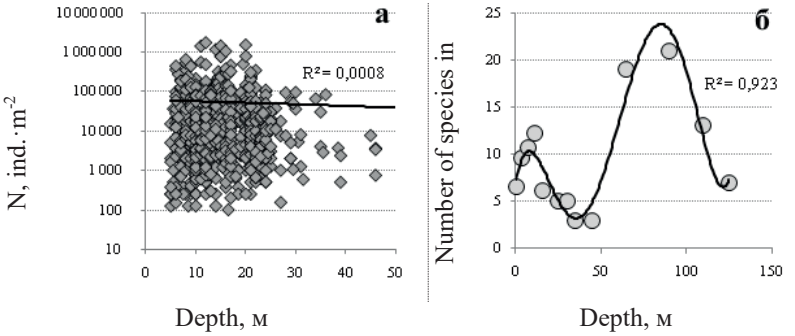


Figure 1.8. Distribution of the number (a) of harpacticoids and the number of species in a sample (б) by depth in the NWBS (Garlitska, 2010).

Copepods of the Tachidiidae Family are distributed by depth in the NWBS, firstly, unevenly, and secondly, no deeper than 65 m. Their main habitat range is from the upper sublittoral to 25 m.

In the NWBS the density of copepods settlements in the mussel biocenosis varied over the years from 3,889 ind.·m^{-2} to 25,916 ind.·m^{-2} (average values). In the Mia biocenosis, their numbers averaged 160,580 ind.·m^{-2}, in the Phaseolina biocenosis, the number of harpacticoids decreased with increasing depth from 45,000 (45 m) to 5,000 ind.·m^{-2} (90–100 m). In the *Lentidium biocenosis*, they were leaders in settlement density, making up 78 % of the total meiobenthos, a similar picture is observed in the *Nereis biocenosis*, where the proportion of harpacticoids averaged 42 % (Vorobyova, Synegub, 1986; Vorobyova, Sinegub, Kulakova, 1994; Vorobyova, Synegub, 2017; Synegub 1989).

The type of substrate determines not only the density of crustacean settlements, but also the size of the harpacticoids (Vorobyova, Portyanko, 2014). As can be seen from the graph, the maximum size of harpacticoids is typical for sandy shell rock, and the minimum is for interstitial species living in the thickness of sandy sediments (Fig. 1.9.).

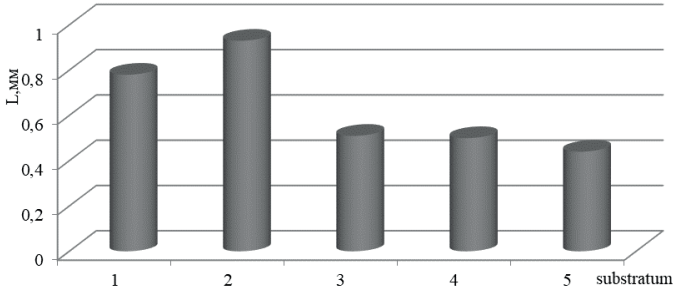


Fig. 1.9. Average sizes of harpacticoids depending on habitat in the NWBS

(1 – fouling, 2 – sand/shell, 3 – silt/sand, 4 – silt, 5 – interstitial)

Organic sediments serve not only as a substrate, but also as a food source for animals feeding in the upper layer or on the surface of the soil. The spatial

and structural conditions of a particular biotope and the physicochemical conditions that develop in them depend on the size of the soil particles (Giere, 2009). The abundance of crustaceans on silts is regulated mainly by predators (Coull, 1979), and on sands by changing physical factors such as granulometric composition, mixing and aeration of the soil (Coull, 1985; Vorobyova, Zaitsev, Kulakova, 1992).

Species living on macrophytes often have large bodies with numerous setae, strong legs, well adapted to holding on to the algal substrate, as well as for swimming. Typical interstitial species live in fine- and medium-grained sands and have a thin, worm-like body. Long-term studies in the OSR have made it possible to obtain representative data on the formation of qualitative and quantitative characteristics of this group of meiobenthic community of organisms in habitats with different types of bottom substrates: silt, silted sand, shell, sand, etc. (Fig.1.10).

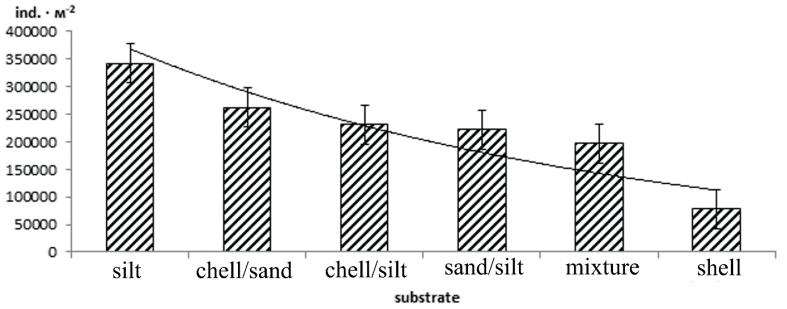


Figure1.10. Average abundance (ind.·m^{-2}) of harpacticoids on different substrates. Odesa marine region 1994–2017 (Vorobyova, 2017)

As can be seen from the presented figure, the highest density of crustacean settlements is on silted sand and shells with an admixture of sand, the minimum density is typical for shells.

As indicated above (Chapter 4), data on the formation of the faunal composition and ecological characteristics of harpacticoid copepods in the

contact zones of the NWBS and their contour biotopes were obtained as a result of many years of research by V. Portyanko (2013, 2015, 2017).

The fauna of Harpacticoida of the main bottom biotopes of the Odessa marine Region comprises 50 species (Portyanko, 1917). In the biotopes of the upper sublittoral of the OMR, 29 species belonging to 19 genera and 13 families were found (Table 1.4).

Table 1.4.

Harpacticoida of some biotopes of the upper sublittoral (Portyanko, 2013).

Families	Species	shell	sand
Ameiridae	*Ameira parvula parvula* (Claus, 1866)	+	+
	Nitokra hibernica hibernica (Brady, 1880)	+	-
	Nitokra lacustris lacustris (Shmankevich, 1875)	+	-
Canuellidae	*Canuella perplexa* (Scott T. et A.,1893)	+	+
Cletodidae	*Enchydrosoma sordidum* (Monard, 1926)	+	+
Dactylopusiidae	*Dactylopusia tisboides* (Claus, 1863)	+	+
	Diarthrodes nobilis (Baird, 1845)	+	-
	Paradactylopodia brevicornis (Claus, 1866)	+	+
	Paradactylopodia latipes (Boeck, 1865)	-	+
Ectinosomatidae	*Ectinosoma melaniceps* (Boeck, 1845)	+	+
Harpacticidae	*Harpacticus flexus* (Brady et Robertson D.,1873)	-	+
	Harpacticus obscurus (Scott T., 1895)	-	+
	Harpacticus littoralis (Sars G. O., 1910)	+	+
Laophontidae	*Heterolaophonte stroemii stroemii* (Baird, 1837)	+	+
	Heterolaophonte uncinata (Czerniavski, 1868)	+	+
	Heterolaophonte minuta (Boeck, 1873)	+	-
	Laophonte elongata elongata (Boeck, 1873)	+	+
	Laophonte thoracica (Boeck, 1865)	+	-
Miraciidae	*Amphiascus longirostris* ((Claus, 1863) Huys 2010)	-	+
	Bulbamphiascus imus (Brady, 1872)	+	-
	Delavalia elisabethae (Por, 1959)	-	+
Normanellidae	*Normanella mucronata* (Sars G. O., 1909)	+	-
	Normanella serrata (Por, 1959)	+	-
Peltidiidae	*Alteutha typica* (Czerniavski, 1868)	-	+
Tetragonicipitidae	*Phyllopodopsyllus pauli* (Crisafi, 1960)	+	+
Thalestridae	*Thalestris longimana* (Claus, 1863)	-	+
Tisbidae	*Tisbe bulbisetosa* (Volkmann-Rocco, 1972)	+	-
	Tisbe marmorata (Volkmann-Rocco, 1973)	+	+
	Tisbe furcata (Baird, 1837)	-	+

These biotopes have 12 common species, with 21 species recorded on the shell and 20 species on the sand. Of the 13 Harpacticoida families found, two families with the largest number of species can be distinguished: Dactylopusiidae (4) and Laophontidae (5).

According to V. Portyanko, on the silts, the maximum accumulation of harpacticoids (1,405,000 ind.·m^{-2}) was found in June 2005 at a depth of 10–15 m at a bottom water temperature of 8 ºC, salinity of 17 ‰ and a dissolved oxygen content of 10 mg l^{-1}. A feature of the harpacticoid fauna of silt deposits is that its species diversity directly depends on the type of silt (Table 1.5).

Table 1.5.

Species diversity of Harpacticoida (Crustacea, Copepoda) of gray and black silts of the Odessa marine Region, Black Sea (Portyanko, 2017).

Families	Species	gray silts	black silts
Ameiridae	*Ameira parvula parvula* (Claus, 1866)	+	+
Canuellidae	*Canuella perplexa* (Scott T. et A.,1893)	+	-
Cletodidae	*Enchydrosoma gariene* (Gurney, 1930)	+	+
Dactylopusiidae	*Dactylopusia tisboides* (Claus, 1863)	+	-
	Paradactylopodia brevicornis (Claus, 1866)	+	-
Ectinosomatidae	*Ectinosoma melaniceps* (Boek, 1865)	+	+
Harpacticidae	*Harpacticus flexulosus* (Ceccherelli, 1988)	+	-
	Harpacticus littoralis (Sars G. O., 1910)	+	-
Laophontidae	*Laophonte elongata elongata* (Boeck, 1873)	+	-
Miraciidae	*Amphiascoides subdebilis* (Willey, 1935)	+	-
	Amphiascus longirostris ((Claus, 1863) Huys 2010)	+	+
	Bulbamphiascus imus (Brady, 1872)	+	-
	Delavalia elisabethae (Por, 1959)	+	-
Nannopodidae	*Nannopus palustris* (Brady, 1880)	+	-
Normanellidae	*Normonella minuta* (Boeck, 1873)	+	+
Tachidiidae	*Microarthridion littorale* (Poppe, 1881)	+	-
	Microarthridion fallax (Perkins, 1956)	+	-
Thalestridae	*Thalestris longimana* (Claus, 1863)	+	-
Tisbidae	*Tisbe battagliai* (Volkmann-Rocco, 1972)	+	-
	Tisbe histriana (Marcus & Por, 1961)	+	-
	Tisbe marmorata (Volkmann-Rocco, 1973)	+	+

From this table it is clear that 21 species were found on gray silts, and only 6 species were found on black silts, which are common to these two types of substrates.

When considering the degree of participation of Harpacticoida in the formation of the total number of the permanent component of the meiobenthos, it is clear that on silty sand they predominate not only in terms of ind. density, but also by their share in the permanent component population in the eumeiobenthos. On silty ground, the proportion of harpacticoids was 11 %, on sand/silt ground – 22 %, on shell/silt – 17 %, shell – 18%, shell/sand – 20%, a mixture of substrates – 15 %. Thus, crustaceans take a minimal part in the formation of the total number of the permanent component of the meiofauna on silty ground (Vorobyova, Kulakova, Portyanko, 2017).

During the year, the density of harpacticoids is non-uniform, which can be determined by the temperature of the bottom layers of water, the content of dissolved oxygen at the bottom, and food resources for crustaceans.

Long-term observations in the OMR allowed us to obtain average values of the density of harpacticoids settlements in different seasons of the year. They are maximum in the summer (Fig.1.11.) and minimum in winter.

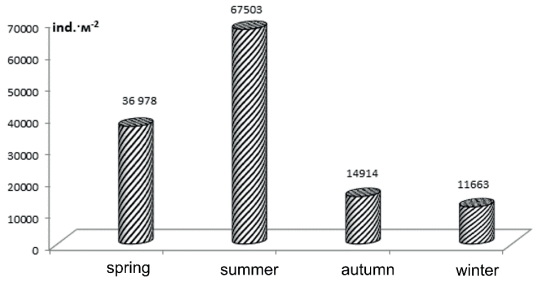


Figure 1.11. Seasonal dynamics of the number (ind.·m^{-2}) of Harpacticoida in the OMR.

In different periods of the year, the degree of participation of harpacticoids in the total number of meiobenthos and its permanent component is not the same. Their share fluctuates from 3 % to 18 % of the number of the

permanent component of meiobenthos: in winter – 3 %, in spring – 10 %, in summer – 18 %, in autumn – 9 % (Portyanko, 2013, 2015).

In the Odesa marine region, the density of Harpacticoida settlements varied significantly depending on the depth (Fig.1.12).

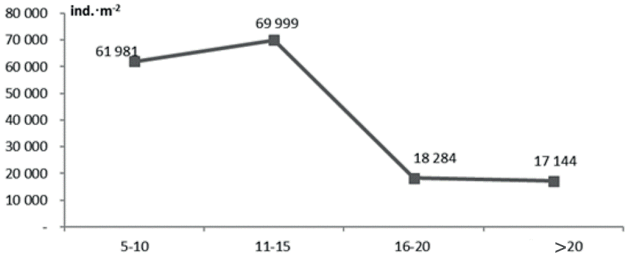


Figure 1.12. Distribution of settlement density (ind.·m^{-2}) of Harpacticoida at different depths.

However, as the author points out, the absence in most cases of a connection between the quantitative distribution of animals and depth may be due to the fact that the latter is an integral parameter, which is important for the northwestern part of the Black Sea with its heterogeneous and dynamic conditions of abiotic factors.

In shallow water (5–10 m, 175 samples), the occurrence rate was 97.8 % with an average density of 61,980±9,429 ind.·m^{-2}. The proportion of harpacticoids in the total number of eumeiobenthos was relatively high and averaged 31.5 %. The average density of harpacticoid settlements increases at a depth of 11–16 m (362,999±23,277 ind.·m^{-2}). The occurrence rate of crustaceans was 84.4 %. With increasing depth, the occurrence rate of harpacticoids decreases to 74.7 %. At the same time, their settlement density decreases sharply, more than threefold and the average long-term indicator was 18,283±2,602 ind.·m^{-2}. If at a depth of up to 15 m the role of Harpacticoida in the formation of the general indicators of the density of the entire meiobenthos in general and eumeiobenthos in particular was, as can be seen in the figure, quite high, then at a depth of 16–20 and 20–25 m their share of participation

in the general indicators of abundance is very insignificant and does not exceed 5 % on average.

The study of the formation of ecological indicators of the taxocene Harpacticoida fouling of hard substrates of the Island. Zmeiny (Portyanko, 2014) allowed the author to make a comparative analysis of the formation of these copepods on a plastic substrate (Uzun, Portyanko, 2020).

In conclusion, it should be emphasized once again that the copepod crustaceans of the Harpacticoida order are one of the leading groups of contour biotopes of the Black Sea benthal. They not only make a significant contribution to the species diversity of the meiobenthos (the number of species of these crustaceans is one of the highest in the meiobenthic community), but also play a significant role in the formation of the total abundance indicators. Its value depends on many factors (edaphic, climatic, hydrological and hydrochemical parameters, depth, etc.). Their role in the total community abundance is highest in the psammocontour of sandy beaches and the upper sublittoral, as well as in the periphyton of the northwestern part of the Black Sea. Harpacticoids have the greatest significance in the formation of the total biomass of the meiobenthos, and most importantly, its quality as a food object for fish, on the sand-shell substrate, silts and in the periphyton of artificial substrates.

Ostracoda. The most significant contribution to the study of Black Sea Ostracoda was made by Marinov (1978) and Shornikov (1965, 1966, 1967). And if the works of the latter are interesting for the ecological and zoogeographical aspects of the Black Sea shelf, then Marinov's works provide information on the ostracods of the interstitial biotope of sandy beaches. Based on the results of our studies on the spatial distribution of Ostracoda in different seasons of the year, we can conclude that beach sediments are most actively populated by crustaceans in the summer and early autumn.

During our long-term studies over 15 years (1983–1998) it was established (Vorobyova, 1999) that Ostracoda in various areas of the Black Sea Shelf, according to quantitative parameters, belong to meiobenthos groups whose participation in the formation of its total abundance is minimal. Thus,

in the northwestern part of the Black Sea, their share of the total meiobenthos abundance, during 1983-1992, varied from 0.05 to 4.2 % with a population density of 500-25,000 ind.·m^{-2}. Maximum values were usually noted on silted shells in the Pridnestrovian-Bug Region (Vorobyova, 1999).

In the Odesa Gulf and adjacent marine areas at a depth of 7 to 20 m, the density of Ostracoda in 1994–1998 varied from 0 to 5,000 ind.·m^{-2}. Their lowest occurrence (up to 24%) was noted on a silty substrate, and 64 % on silted shells. Their share in the total number of meiobenthos was 0.02–6.30 % in different areas (Vorobyova, 2017). Compared to this area, the development of ostracods in the Grigoryevsky Estuary was much more intensive (Vorobyova, 1999). In many cases, when crustaceans were not observed in the waters adjacent to the Odesa Gulf, their numbers in the estuary were quite high (from 663 ind.·m^{-2} to 5,450 ind.·m^{-2}).

Ostracoda are mobile benthic crustaceans and are included in the meiobenthos category by their size. The abundance of Ostracoda settlements, to a greater extent than for other taxa of the meiobenthos is formed depending on the type of substrate. Crustaceans are poor swimmers; they prefer places with small bottom currents and biotopes with good development of periphyton. According to many literary data Ostracoda are omnivorous animals. They prefer to feed on the remains of small organisms and play a significant role in the transformation of organic matter. Representatives of this taxon, having a relatively high calorie content (Vorobyova, Targonska, 1998), are an excellent food source for juvenile fish. At present, there is information about the faunal composition of Ostracoda in the coastal zones of the northwestern part of the Black Sea (Uzun 2016, 2021). The minimum accumulations of Ostracoda are characteristic of sandy substrate. Here the occurrence of Ostracoda in the period of our research was 27.7 %. The average abundance was 778 ind.·m^{-2}. On the shell, their occurrence was – 72.0 %. The average abundance was 4741 ind.·m^{-2}, which is 4.1 % of the total abundance of meiobenthos. As can be seen from the presented graph (Fig.1.13), the maximum concentrations of ostracods live on a stony substrate among the growth of algae and mussels.

The average number was 17,815 ind.·m^{-2}. Their share in the total number of meiobenthos was 8.4 %, and in the eumeiobenthos – one seventh.

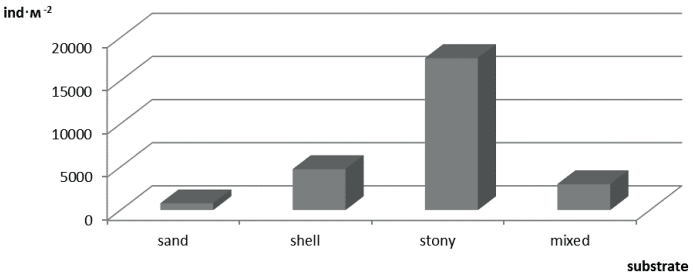


Figure 1.13. Average numbers (ind.·m^{-2}) of Ostracoda on different substrates in the upper sublittoral of the Odesa Bay (Vorobyova, 2022).

The conducted analysis of comparative readings of the abundance of Ostracoda in the NWBS and the Azov Sea showed that the Azov Sea differs significantly from the Black Sea in terms of settlement density. Here, Ostracoda play a more significant role in the formation of quantitative indicators of the meiobenthos. In some areas, the proportion of ostracods reaches 70-73%. On silty soil, their maximum number is 432,000 ind.·m^{-2}. The minimum number of Ostracoda in the Azov Sea was recorded on sand with shells (an average of 1,800 ind.·m^{-2}. The average indicators for silts and silted shells were 63,400 and 17,900 ind.·m^{-2}.

The monograph by L.V. Vorobyova (1999) reflects the features of the formation of quantitative characteristics of ostracods in the Yegorlytsky and Odesa Bays, in the Zhebriyanskaya bay and in the Sukhoi Estuary. In 2003, studies were conducted to study the meiobenthos of the western part of the Black Sea. Comparative characteristics of the formation of quantitative indicators of Ostracoda in the Bulgarian, Romanian and Ukrainian sections of the shelf are given (Vorobyova, Kulakova, 2009).

The study of meiobenthic organisms simultaneously with macrozoobenthos was first carried out off the western coast of Crimea, the

Caucasus and in the Bosphorus region (Kiseleva, 1965, 1967) and later on the pseudolittoral off the coast of Bulgaria (Marinov, 1978).

Throughout all the years of studying the meiobenthos of the Ukrainian shelf, Vorobyova L.V. analyzed the confinement of certain representatives of large meiobenthos taxa to various biocenoses. In 1998 and 1994-1996, she analyzed the distribution of Ostracoda in various biocenoses of the NWBS. In the biocenosis of the mussel (*Mytilus galloprovincialis* Lamarck), the density of shell crustacean settlements is low (75–886 ind.·m^{-2}). In the biocenosis *Heteromastus filiformis* (Claparede), ostracods were found only at one station out of 11. In the biocenoses *Mya arenaria* L. not typical for ostracods habitat.

In 1991, during a study of the formation of the density of meiobenthos settlements on artificial substrates of two basins of coastal protection structures in the Odesa Gulf, the influence of temperature on the quantitative indicators of representatives of the Ostracoda taxocene was studied. On the traverses of both basins, at a seawater temperature of 12–18 ºC, the number of shell crustaceans is low and fluctuates from 0 to 25,000 ind.·m^{-2}. At the end of June – beginning of July, with the establishment of a consistently high temperature (18–22.9 ºC), their density increases, reaching maximum values (90,000 ind.·m^{-2}) in September. On the bottom substrate (sand, shell) in May they were practically absent. With an increase in temperature and throughout the summer period, the number of ostracods varied from 1,250 to 26,500 ind.·m^{-2}. In September (16 ºC) on the sandy bottom Ostracoda were not noted, while in the basin with a freshwater outlet, the density of ostracods remained relatively high (maximum 20,000 ind.·m^{-2}). In November (12 ºC) they were absent from both basins.

In recent decades, much attention has been paid to the formation of quantitative indicators of meiobenthos, ostracods in the upper sublittoral of the NWBS, which is the most productive in this shelf area, and ostracods make their own contribution to the formation of the food supply for young fish.

For the Odesa Gulf minimal accumulations of ostracods were typical for sandy ground (upper sublittoral). Here, the occurrence of ostracods during our

studies was 27.7 % (Fig.1.14). The average density of settlements was only 778 ind.·m^{-2}.

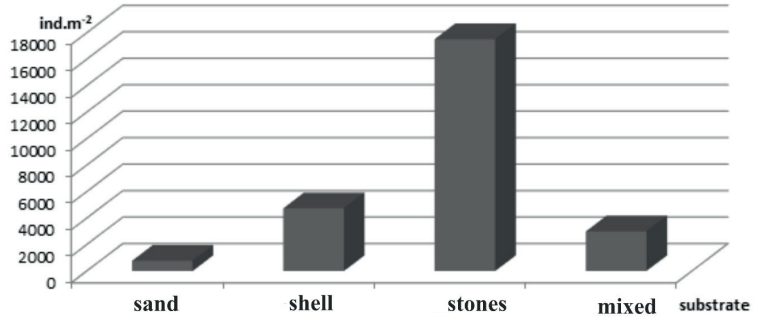


Figure 1.14. Average abundance (ind.·m^{-2}) of Ostracoda on different types of substrates.

On the shell, their occurrence was high – 72.0 %. The average abundance was 4741 ind.·m^{-2}, which was 4.1 % of the total number of meiobenthos. As can be seen from the graph (Fig.1.14.), the maximum accumulations of ostracods were on the rocky substrate among the growth of algae and mussels. Here, the average number of shell crustaceans is 17,815 ind.·m^{-2}, the share in the total number of meiobenthos is 8.4 %, and in the eumeiobenthos their population density was one seventh.

In 2013 and 2015 during studies in the upper sublittoral of the Zmeiny Island water area, an analysis of the confinement of ostracods to a particular algal substrate was carried out (Vorobyova, Kulakova, Bondarenko, Portyanko, 2019). From the presented graph it is clear that the minimum development of this substrate belongs to Polysiphonia and Enteromorpha. The maximum accumulation of ostracods is characteristic of Cladophora and Laurentia (Fig. 1.15).

In August 2015, in the fouling of Laurentia, the total number of meiobenthos (average 232,750 ind.·m^{-2}) was formed actually due to two

groups – ostracods and Bivalvia, of which the share of the former was 42.2 % of the total number (on average 111,500 ind.·m^{-2}).

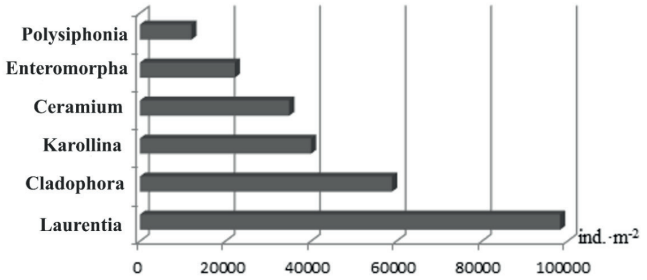


Figure 1.15. Density of settlements (ind.·m^{-2}) of ostracods in fouling of rocky substrates of Zmeiny Island.

As mentioned above, Elena Evgenievna Uzun began her work at the IMB in 2013 after graduating from Odesa State University named after I.I. Mechnikov. It is necessary to note the interesting data she provided in several publications (Uzun, 2017, 2020) on the ostracods of the coastal zone of Zmeiny Island. If quantitative indicators of the ostracods of this water area were previously presented, then E.E. Uzun provided the faunistic composition, she registered a total of 10 species of Ostracoda.

The most common species is *Xestoleberis decipiens* (Müller, 1894). E. Uzun found that the greatest species diversity of ostracods (9 species) was noted on the algal substrate. Depending on the type of algae, the species of shell crustaceans were distributed unevenly. For Ceramium, 8 species of ostracods were noted, for Polysiphonia – 7, for Enteromorpha and Cladophora – 5 species of ostracods each. Eight species of ostracods were found on mussel fouling of hard substrates. The species *Sclerochilus dubowskyi* Marinov, 1962 was recorded only on mussel fouling. Three species of Ostracoda were found in the bottom sediments of the shell: *Loxoconcha pontica* Klie, 1937, *L. bulgarica* Caraion, 1961, and *Xestoleberis decipiens* (Müller, 1894). In general, it can be noted that the abundance and biomass indicators vary

significantly depending on the nature of the substrate. The highest values were noted for the periphyton of hard substrates. Only three species of shell crayfish were found in the bottom sediments of the shell.

In the last decade, much attention has been paid by E.E. Uzun to the study of shell crustaceans of the Odesa Gulf, their species composition and spatial distribution. The issues of the faunistic composition were considered both in the periphyton of coastal protection structures and in the benthal of open areas of this bay (Uzun, 214, 2015, 2016, 2017, 2019, 2020, 2021, 2021a). Research by Uzun E.E. in the coastal zone of Cape B. Fontan (2013–2019) showed that in this area ostracods are represented by a small number of species. Ostracoda of 7 species were found here: *Loxoconcha pontica* Klie, 1937, *Paradoxostoma intermedium* Muller, 1894, *P. simile* Müller, 1894; *Xestoleberis acutipenis* Caraion, 1968; *X. aurantia* (Baird, 1938; *X. decipiens* (Müller, 1894); *X. corneliti* Caraion, 1968). The greatest diversity was recorded in the periphyton of the rocky substrate with mussels. The species *Paradoxostoma intermedium* was noted only on the shell. Data on the abundance and biomass of ostracods on the rocky substrate are given.

In the last decade of the 21st century, at the Institute of Biological Biology, much attention has been paid to studying the influence of plastic and other polyethylene waste on the formation of phytoplankton in the marine environment of the Odesa Gulf under the supervision of Ph.D. Snigireva A.A. Uzun E.E. (Ostracoda) together with Portyanko V.V. (Harpacticoida) have been observing the formation of the species composition and quantitative indicators of the meiobenthos for several years. During this period, a number of materials on this topic have been published (Uzun, 2019; 2020,2021, 2021a, 2021b).

According to Uzun E. the most common species of ostracods on plastic debris fouling were *Hemicytheruraë bulgarica* (Klie, 1937), *Paradoxostoma variabile* (Baird, 1835) and *Xestoleberis decipiens* Müller, 1894, the occurrence of this indicator is 100 %. The values are found on traverses and breakwaters, where the values fluctuate between 2000 ind.$\cdot$m^{-2} and 8000 ind.$\cdot$m^{-2}, but 2.5–14 times less than on natural hard substrate fouling,

where their density can reach more than 13,000 ind.·m^{-2} -70,000 ind.·m^{-2} (Vorobyova et all. 2016; Uzun 2015). The biomass of ostracods on plastic waste averaged 28.16–33.7 mg·m^{-2} and was almost three times less than on natural solid substrates (Uzun, 2015).

Halacaridae. Representatives of the taxocene Halacaridae (Halacaridae: Acari), which belong to the permanent component of the meiobenthos, are distributed in all marine habitats from polar to tropical latitudes and from the coastal beach zone to deep-sea places of 5000 meters (Bartsch, 1989). Marine mites often live in the system of cavities (interstitium) of coarse-grained marine sediments ("mesopsammon"). Some species live on algae or on relatively large marine animals such as sponges, mollusks, crustaceans, nemertean, polychaetes. They play an important role in the turnover of organic matter, the direct consumption of which by other larger animals is impossible or energetically unprofitable.

The history of the study of marine mites of the Black Sea is quite fully reflected in the monograph on the study of the meiobenthos. (Vorobyova, 1999). The study of marine mites in the waters of the northwestern part (Ukrainian shelf) was first started at the IMB of the NAS of Ukraine in 1973. There was no information on this group of invertebrates in this region in the literature before. As was indicated in Chapter 2, Halacaridae were not mentioned at all in the list of fauna of the northwestern part of the Black Sea (Vinogradov, 1967). In 1973–1980, we conducted research on the study of species diversity, spatial distribution, seasonal dynamics of numbers, dependence of the density of sea mite settlements on different types of substrates in the coastal zone of the Odesa Region.

For seven years, we have been studying sublittoral and pseudo- and suprattoral sea mites as a component of the meiofauna of sandy beaches. Four species of Halacaridae and 11 species of soil mites were found here. The study of the soil fauna of mites was conducted by I.I. Kulakova, which contributed to our definition of sandy beaches as a contact zone for representatives of marine, freshwater and soil fauna (Vorobyova, Kulakova, 1988; Vorobyova, Zaitsev, Kulakova, 1992)

The works of L. V. Vorobyova and I. I. Kulakova are devoted to the interstitial meiofauna of the NWBS, in particular the Odesa Gulf. They discovered four species of psammophilic Halacaridae: *Actacarus pygmaeus* Schulz, 1937, *Halacarellus procerus* Viets, 1927, *H. capuzinus* (Lohmann, 1893), *H. floridearum* (Lohmann, 1889). On coarse-grained sands, 90–98 % of the sea mites' population were *H. procerus*, while the species *A. pygmaeus* and *H. floridearum* were few in number. It was established that the supralittoral zone (to a depth of 10 cm) is the poorest. This is due to the low humidity and sharp temperature fluctuations in this zone. The largest number of sea mites in the upper layer was noted only in the presence of seaweed emissions after storms, and sea mites can survive in the sand of beaches for a long time. Representatives of Halacaridae predominate at a distance of up to 3 m from the splash zone, maximally populating the horizon of 30–50 cm. *Halacarus procerus*. *Actacarus pygmaeus*, *Halacarus floridearum* are not numerous.

At the same time (1973–1977) a study of the Halacaridae of the upper sublittoral of the open shelf of the NWBS and in the Karadag area was conducted. During the study period, 18 species and 5 subspecies of sea mites were discovered. Among them, 10 species and 4 subspecies from the coastal zone of the Odesa Gulf, 3 species and 2 subspecies from the Black Sea estuaries, 5 species in the open waters of the northwestern part of the Black Sea and 10 species and 3 subspecies from the coastal zone of the Karadag coast.

We have shown that the number of sea mites on the coast is uneven and fluctuates from 29 to 2,892 ind.$\cdot$m^{-2}. It has been established that in the area of the hydroelectric construction (Odesa Bay) the number of Halacaridae is most dependent on the degree of anthropogenic impact on the biocenoses of the upper sublittoral. In the first years after sand washes on the beaches, the number of sea mites decreases sharply. The average number of sea mites in the transformed areas of the coast fluctuated from 383 to 2,762 ind.$\cdot$m^{-2}, while in natural areas it was from 119 to 5,596 ind.$\cdot$m^{-2}, with their number being maximum on the algal substrate. If on stones not covered with algae, the maximum number of mites on 1 m^2 of area averaged 335 ind., then on stones

in the same area and during the same period, but covered with Ceramium, Cladophora and Enteromorpha 23,292 ind.·m^{-2}. The same pattern is typical for other parts of the coast.

The number of sea mites also depends on the type of algae on which they live. In summer, its minimum values are typical for green algae (from 20 to 70 ind. kg^{-1}) and maximum values are typical for Ceramium (7,123–10,000 ind.·kg^{-1}). Seasonal dynamics of the number of mites is very uneven, the poorest samples are from the winter months (up to 195 ind.$^{-2}$). In more than 80 % of samples, they were completely absent. In April, their numbers increase, in May, the maximum number of mites is 400 ind.·m^{-2}. The most massive development of mites is observed in the summer (in some areas of the coast per square meter of area – up to 13,000–104,000 ind.·kg^{-1}). In the autumn period, approximately in 30% of the samples, sea mites were absent; in the rest, their average number per 1 m^2 of substrate were 4,000 ind.

As mentioned above, 17 species of sea mites were indicated for the Odesa Gulf in the second half of the twentieth century (Vorobyova, 1999). The species described by us according to the 1953 identification guide (Sokolov, 1953) as *Rhombognathus notor*, was redescribed by E. Bartsch (Bartsch, 1998) as *Rh. tonops*. During the period of research in different years, we analyzed the association of Halacarida with different types of substrates. During the period of research in different years, we analyzed the confinement of Halacaridae to different types of substrates. Thus, in 1974-1976, material was collected in the Odesa Gulf, which allowed us to analyze the species composition on solid and algal substrates (Table 1.6.).

Data analysis showed that, as expected, the highest number of sea mites was confined to the rocky substrate overgrown with macrophytes (Fig.1.16.). The proportion of sea mites from the total number of meiobenthos was low: on the sandy substrate – 0.4 %, on the shell rock and rocky substrate – 1.9 % each, on the mixed ground – 0.1 %.

Table 1.6.

Species composition of marine mites on various substrates (Vorobyova, Yaroshenko, 1979)

species	Mussels fouling	Colonies Hydroids	Algae			Stones	Sand
			green	red	brown		
Agauopsis brevipalpus	+	–	+	+	–	–	–
Copidognathus ponteuxinum	–	–	–	+	–	–	–
C. ponteuxinum pestiniger	–	–	–	–	–	+	-
C. magnipalpus ponticus	–	–	–	–	–	+	–
C. magnipalpus serratisetus	+	+	+	+	+	+	+
Rh. tonops	+	–	+	+	+	+	+
Rhombognahus denticulatus	+	+	+	+	+	+	+
Rh. pascens	+	–	+	+	–	–	–
Halacarellus longipes	+	–	–	–	–	+	–
H. basteri affenis	–	–	+	+	–	–	–
H. proserus	–	–	–	–	–	–	+
H. floridearum	–	–	–	–	–	–	+
H. capuzinus	–	+	–	–	–	–	+

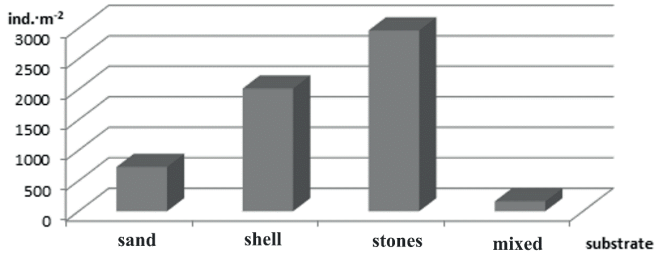


Figure1.16. Distribution of settlement density (ind.·m^{-2}) of sea mites on different substrates in the Odessa Gulf.

During the period 1975-1976 we examined the Black Sea Estuaries: Sukhoi, Tiligulsky, Khadzhibeysky, Kuyalnitsky and Shabolatsky, in which five species of sea mites were found: *Rhombognathus pascens*, *Rh. tonops*, *Coridognathus ponteuxinus pectiniger*, *C. magnipalpus ponticus*, *Aqauopsis brevipalpus* (table). In the Kuyalnitsky Estuary, which is characterized by very high salinity (up to 170 ‰), sea mites were not found. However, if in the Odesa

Gulf *C. magnipalpus ponticus* is a rare species, then in the estuaries, especially in Tiligulsky Estuary, it is quite common. *Aqauopsis brevipalpus* is very rare and is found only in the Khadzhibey Estuary, while in the Odesa Gulf it is a common species (Table 1.7).

Таблица 1.7.

Distribution of Halacaridae in the Black Sea Estuaries
(Vorobyova, Yaroshenko,1982).

Species	Tiligulsky	Khadzh-ibeysky	Suchoy	Shabo-latsky	Kuyalnitsky
Phombognathus tonops	+	–	+	+	–
Ph. poscens	+	+	+	–	–
Copidognathus ponteuxius pectiniger	+	+	+	–	–
C. magnipalpus ponticus,	+		+		
Aqauopsis brevipalpus	–	+	–	–	–

The remaining three species were found by us in Tiligulsky, Khadzhibeysky, Sukhoy, and Shabolatsky estuaries. They are also the most widespread in the coastal zone of the Odesa Gulf. The Tiligulsky Estuary is the richest in species diversity. A distinctive feature of the Tiligulsky Estuary compared to the sea coast is the presence in the plant biocenoses, in addition to red and green algae, also flowering aquatic plants (Ruppia and Zanihelia). It was on these plants that the predominant species were *Rh. tonops* and *C. magnipalpus*.

The average number of sea mites in the Estuaries for the summer months per 1 m^2 of area is higher than in the same period in the coastal areas of the sea (41,400 and 12,400 ind., respectively). The maximum number of mites per 1 m^2 of substrate (615,000 ind.) was recorded in the Tiligul Estuary. This reservoir is also characterized by the highest average number of mites in the summer (133,500 ind.$\cdot m^{-2}$ and 119,100 ind.$\cdot kg^{-1}$ of algae). The minimum number was in the Khadzhibey Estuary.

Collection of material in the Grigorevsky Estuary at standard stations in all seasons of the year (1993–1994) allowed us to show (Vorobyova, 2008) the formation of the density of settlements of sea mites in different periods of the year (Table1.8.).

Table1.8.

Average density (N, ind.·m^{-2}) and biomass (B, mg·m^{-2}) of Halacaridae and total meiobenthos (Grigorevsky Estuary, 1993–1994) (Vorobyova, 2008).

Meiobenthos	Dept, 0-1,5 м		Dept, 2-15 м	
	N	B	N	B
May				
Halacaridae	6 267	56,4	3 460	31,1
Permanent meiofauna	57 889	226,8	661 586	1 694,1
Meiobenthos (total)	68 656	492,2	664 679	1 836,3
August				
Permanent meiofauna	325 676	2 166,0	650 882	2 483,4
Meiobenthos (total)	383 979	3 124,0	657 298	2 780,7
November				
Halacaridae	1 200	10,8	1 073	10,0
Permanent meiofauna	64 440	82,4	290 152	265,0
Meiobenthos (total)	83 040	1 045,0	295 146	471,0
February				
Halacaridae	19 866	178,8	0	0
Permanent meiofauna	75 466	376,2	627 10	506,2
Meiobenthos (total)	89 226	693,5	628 43	556,4

Another peculiarity of the NWBS is that in its different parts, and especially in the Black Sea estuaries, the salinity of the waters varies considerably. In this regard, we conducted studies in laboratory conditions, in which Halacaridae were kept at a salinity of up to 67 ‰. Analysis of the obtained data showed that the mites can withstand a very wide range of salinity. At a salinity of 4.5 ‰ to 35 ‰, their survival times were quite significant. At a salinity of seawater of 40-60 ‰, the mites were active and their survival times differed little from the control (17 ‰). At 63–65 ‰, marine mites lived up to 3 weeks. At 65 ‰, their survival rate was several days, while the mites were sedentary. At 67 ‰ they died within a few hours (Vorobyova, Yaroshenko, 1979).

A major contribution to the study of the species composition and ecological characteristics of representatives of the Halacaridae taxocene was made by PhD Helmboldt M.V. (1995–2001). She conducted her research in the shelf waters of the NWBS, in the adjacent estuaries and the coastal zone of the Odessa coast (Helmboldt, 2001a; 2001b; 2001c, 2001d). M. V. Helmboldt

successfully defended her PhD dissertation in 2003 (Helmboldt, 2003). In her research from 1995 to 2001 in the NWBS, 18 species (11 genera) were noted: in the Odessa Gulf and adjacent waters – 8 species (7 genera), in the interstitial of marginal biotopes – 4 species (2 genera), in the estuaries of the northern Black Sea region – 8 species (6 genera), in the Karkinitsky Gulf – 5 species (4 genera), in the coastal zone of the Tarkhankut Peninsula – 7 species (6 genera), Zmeiny Island – 8 species (Helmboldt, 2001). The fauna of marine mites of the Karkinitsky Gulf, the coastal zone of the Tarkhankut Peninsula and Zmeiny Island is described for the first time (Helmboldt, 2001)

In the interstitial of sandy beaches of Odesa Gulf, she discovered such species Halacaridae: *Actacarus ponticus, Halacarellus capuzinus, H. discretus, H. subterraneus* of the genera Actacarus and Halacarellus (Helmboldt, 2001). The dominant species, as indicated by the author, was *A. ponticus*, belonging to the exclusively psammobiont genus Actacarus Schulz, 1937. The density of the sea mites taxocene settlement in the pseudo- and supralittoral of the coast is seasonal: minimum values were noted in the winter period, maximum – in the summer-autumn (Helmboldt, 2001d). This corresponds to the conclusions of the studies of L.V. Vorobyova in the interstitial of 1973–1980.

In the coastal zone on the traverses and breakwaters of the coastal protection structures of the bay, she found 8 species of marine mites (Helmboldt 2003, 2008). In 2013, in the periphytal zone and in the benthal zone on the sandy substrate – 6 species of marine mites: *Rhombognatides pascens, Rh. denticulatus, Copidognathus ponteuxinus pectiniger, C. magnipalpus ponticus, C. magnipalpus pectiniger, Aquauopsis brevipalpus.* It is indicated that the density of Halacaridae was distributed vertically in the periphytal zone almost uniformly (on average from 3800 to 7000 ind.$\cdot$m^{-2}).

In 1995–2001 M.V. Helmboldt conducted studies of the taxocene of marine mites in the biocenosis *Mytilus galloprovincialis* of the Odesa coast in the upper sublittoral at depths of 4–8 m. In this biocenosis she discovered 6 species of marine mites belonging to 6 genera: *Rhombognathus tonops*, *Rhombognathides pascens, Copidognathus brachystomus, Agauopsis*

brevipalpus, Lohmannella falcata, Thalassarachna affinis. It should be noted that only here was a representative of the genus Lohmannella Trouessart – *L. falcata* encountered (Helmboldt, 2003).

Species, as in the Tiligul Estuary and in the coastal zone of the Odesa coast, were a representative of the subfamily Rhombognathinae Viets (R. tonops): occurrence rate 100 %. Comparison of the species composition of the taxocene of ticks of the Grigorievsky and Tiligulsky Estuaries and the coastal zone of the Odesa coast (Helmboldt, 2001) showed that the acarofauna of the Grigorievsky Estuary is more similar to that of the Odesa coast (4 common species) than that of the Tiligulsky estuary (3 common species), which was also shown earlier (Vorobyova, Yaroshenko, 1982).

In 1991 we collected samples in the area of coastal protection structures in order to determine the formation of the meiofauna abundance when the seawater temperature changes from 12 ºC to 29 ºC (May-November) (Vorobyova, 1999). Analysis of the obtained material showed that in the spring-autumn period the abundance of representatives of the Halacaridae taxocene is formed unevenly (Table1.9.). As can be seen from the presented table, the average indicators of the proportion of foraminifera in the total number of meiobenthos for the entire vertical traverse changes from spring to autumn depending on the temperature regime. Thus, in May it was 15.15 %, in June (05.06 and 25.06) – 11.5–8.13 %, in July – 1.99%, in September – 0.67 %, in November – 6.9 %.

Our long-term studies (1994–1999 and 2005–2015) in the waters of the Odesa Gulf (depth 5–28 m) showed that in this area sea mites were found at a depth of 16 m. At a depth of 5–10 m, their occurrence at 175 completed stations was 22.3 %. The population density varied from 250 to 30,000 ind.·m^{-2}, the average was 410.8 ± 182.1 ind.·m^{-2}. At a depth of 11-15 m, the occurrence of sea mites at 96 stations was 11.5 %. The population density varied from 250 to 6,500 ind.·m^{-2}, the average was 1,005.5 ± 707.4 ind.·m^{-2}.

Thus, the half-century study of the Halacaridae taxocene for the Ukrainian shelf of the Black Sea at the IMB of the NAS of Ukraine allows us

to classify this group of meiobenthos as the most studied along with Foraminifera, Nematoda and Harpacticoida.

Table1.9.

Number of Halacaridae on the traverses of coastal protection structures at different sea water temperatures.

	Depth, м	T°C	Halacaridae	Total number of meiobenthos
07.05.1991	0.7	12.2	0	52500
07.05.1991	1.5	12.2	25000	152500
07.05.1991	2	12.2	12500	42500
average			**12500**	**82500**
05.06.1991	0.7	18.2	2500	62500
05.06.1991	0.7	18.2	27500	222500
05.06.1991	1.5	18.2	4000	16000
05.06.1991	1.5	18.2	7000	31000
05.06.1991	2	18.2	1000	17000
05.06.1991	2	18.2	1000	23000
average			**7166.6**	**62000**
25.06.1991	0.7	22.9	0	66000
25.06.1991	0.7	22.9	1000	5000
25.06.1991	1.5	22.9	16000	24000
25.06.1991	1.5	22.9	8000	88000
25.06.1991	2	22.9	4000	72000
25.06.1991	2	22.9	2000	126000
average			**5166.6**	**63500**
06.08.1991	0.7	22	0	170000
06.08.1991	0.7	22	0	275000
06.08.1991	1.5	22	2000	104000
06.08.1991	1.5	22	0	180000
06.08.1991	2	22	10000	110000
06.08.1991	2	22	10000	262500
average			**3666.6**	**183583.3**
17.09.1991	0.7	16	0	400000
17.09.1991	0.7	16	10000	820000
17.09.1991	1.5	16	5000	250000
17.09.1991	1.5	16	0	85000
17.09.1991	2	16	0	155000
17.09.1991	2	16	0	515000
average			**2500**	**370833.3**

Table 1.9 continued

	Depth, м	T, °C	Halacaridae	Total number of meiobenthos
12.11.1991	0.7	12	0	62500
12.11.1991	0.7	12	5000	105000
12.11.1991	1.5	12	5000	112500
12.11.1991	1.5	12	12500	122500
12.11.1991	2	12	12500	115000
12.11.1991	2	12	12500	167500
average			**7916.6**	**114166.6**

TEMPORARY MEIOFAUNA (PSEUDOMEOBENTHOS). In terms of density and biomass, the majority of the temporary meiofauna (pseudomeobenthos) of the NWBS consists mainly of young bivalves and polychaetes. Many researchers who study marine meiobenthos often neglect the study of pseudomeiobenthos, motivated by its smaller number compared to eumeiobenthos. Unfortunately, there are very few special studies for the Black Sea that would show the peculiarities of the formation of this temporary component of the meiobenthos. At the same time, juvenile macrofauna can constitute a significant part of meiobenthos biomass (Thorson, 1966) or its products (Yingst, 1978). In the meiobenthic community of organisms, it is customary to distinguish the permanent and temporary components of the meiofauna (Bougis, 1950) or in the terminology of L. L. Chislenko – eumeiobenthos and pseudomeiobenthos (Chislenko, 1961). In terms of population density and biomass, the majority of pseudomeiobenthos in the NWBS is represented in most cases by young bivalves and polychaetes.

V. V. Galtsova regrets that many meiobenthologists often neglect the study of pseudomeiobenthos, motivating them to have a lower abundance compared to eumeiobenthos (Galtsova, 1991). Unfortunately for the Black Sea there are few special studies that would show the features of the formation of the temporary component of meiobenthos (Vorobyova 2017, Vorobyova, Kulakova, 2009). According to our data, with a favorable hydrochemical regime, the indices biomass and production are very significant. Among

representatives of the temporary component, the densest clusters are characteristic of juvenile individuals of polychaetes and bivalve mollusks. Under the crisis conditions for marine benthos organisms (high anthropogenic load, oxygen deficiency in the bottom layers of the water, low salinity, etc.) their share in the total indices sharply decreases even during periods of favorable seasonal periods for the mass larvae settling to the bottom.

The description of the ecological characteristics of the pseudomeiobenthos of the Odesa Sea Region is based on the analysis of 327 samples 2005-2015 (Vorobyova, 2021).

The large volume of samples made it possible to establish the features of the formation of the total number of pseudomeiobenthos (temporary meiofauna) and its individual groups depending on the type of substrate on which they live. During the period of mass sedimentation, the larvae and juveniles of bivalve mollusks are characterized by mosaic patterns in the distribution of their quantitative indicators. There is a fairly pronounced selectivity of larvae of different species with respect to the substrate (Sveshnikov,1979). Of great importance are the size of the particles and the gaps between them in the bottom sediments (Wilson, 1991). In addition, its chemical properties are of great importance when choosing a suitable substrate for sedimentation of larvae (Scheltema,1965, Williams, 2003). Active subsidence of larvae and successfully completed (finishing) of metamorphosis makes it possible to replenish and restore bottom communities.

On silty substratum prevailed oligochaetes, polychaetes and mitillids. The total number of invertebrates in this category averaged 11,705.5±1337.8 ind.·m^{-2} (maximum – 118,000 ind.·m^{-2}). Polychaetes dominate, accounting for 46 % of the total number of organisms.

On the silted shell (42 samples), meiobenthos was represented by only seven large Taxons, of which three belong to pseudomeiobenthos. Its total abundance was formed mainly by polychaetes (48%) and juvenile bivalve mollusks (46%), the average of polychaetes density reached 12,439.5±3,898.5 ind.·m^{-2} (maximum 125,000 ind.·m^{-2}), mollusks – 12,145.1±6867.0 ind.·m^{-2} (maximum 286,000 ind.·m^{-2}). The average indicator density of oligochaetes

was 1,466.5±541.6 ind.·m^{-2} (maximum – 16,000 ind.·m^{-2}). The low density of oligochaetes settlements can be explained by the fact that on this substrate they are poorly provided with food.

On the shell substrate meiobenthos was very poor, during our research only six large taxons were present, of which two belonged to the temporary component, which makes up 20.3 % of the total abundances of meiobenthos. The total indices density of pseudomeiobenthos organisms was formed by Polychaeta and Bivalvia – 15,815.4±9,574.6 ind.·m^{-2}. The proportion of polychaetes reached 56.7 % of the total abundance of pseudomeiobenthos (7,646.15±8,574.2 ind.·m^{-2}).

On the sand/shell substrate pseudomeiobenthos was the most diverse, with an average for 11.7 % of the total abundance of meiobenthos. Oligochaeta, Polychaeta, mitilides and Gastropoda were found, the total density of settlements of which was 30,865.8±5,384.3 ind.·m^{-2}. Polychaetes dominated (49 %) with average 1,5031.3±2,564.8 ind.·m^{-2}, subdominant – Bivalvia (30), the density of which was 9,376.3±2,605.3 ind.·m^{-2}. The number of oligochaetes were 3.5 times higher than on silted shells and silted sand and 1.5 times higher than on silts (17 % of the total number of meiobenthos) with an average density (5,253.1±1,447.1 ind.·m^{-2}. We found gastropods only on this substrate.

Thus, an analysis of the data obtained allows us to conclude that the number of pseudomeiobenthos is characteristic of the shell/sand substrate, which was formed by almost 50 % due to polychaetes. This generally applies to all other substrates except silty sand where they accounted for 36 %.

Mitilides on almost all types of substrates have a significant density, with the exception of silts and, to a lesser extent, shell and sand.

The work of many authors (Galtsova,1991; McIntyre, Murison,1973; Thiel,1971) confirms the existence of direct or indirect relationships between the number of meiobenthos in and the depth of the sea water. It should be noted that the relationship between the concentration of meiobenthos and depth is an important integral (Mokievskij, 2009). This factor is important for the NWBS, which has heterogeneous and dynamic conditions of abiotic factors. Long term

studies in the Odesa Sea Region made it possible to establish the heterogeneity of quantitative indicators of the temporary component of meiobenthos even at such relatively shallow depths of the shelf zone (Fig. 1.17.)

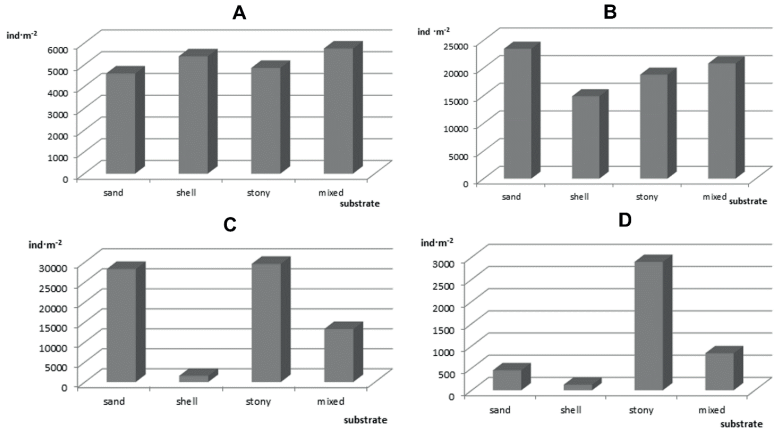


Figure 1.17. The abundance of the main taxa of pseudomeiobenthos on different types of substrates. (A – Oligochaeta, B – Polychaeta, C – Bivalvia, D – Gastropoda), (Vorobyova, 2021).

From a depth of 5-10 m, 172 samples were processed. The total number of pseudomeiobenthos at this depth was an average 12,839.0±2,710.3 ind.·m^{-2} (6.16% of the total of the meiobenthos). Polychaetes prevailed (5,417.2±852.9 ind.·m^{-2}). Their share in the total population density of pseudomeiobenthos was 42 %. Young Bivalvia were represented by 29 %. Oligochaeta occupied the third place with 21 %. The occurrence of gastropods was low (13.4 %). The formation of total biomass occurs both due to eumeiobenthos (62 %) and due to the temporary component (38%). The biomass of the temporary component is mainly formed by polychaetes and oligochaetes.

With an increase in depth (10–15 m), a silty substrate, silted shell, silted sand prevailed. Sand with shells was rarely observed. 96 samples of

meiobenthos were collected and processed. The total number of pseudomeiobenthos was 2,0826.3±5,010.4 ind.·m^{-2} – 7.0 % of the total number of meiobenthos. Juveniles of bivalve mollusks dominated (average 9,515.5±3,787.0 ind.·m^{-2}), accounting for 46 % of the total pseudomeiobenthos. Polychaetes (37 %) were the subdominant group with an average density 7,789.4±1,430.2 ind.·m^{-2}. The number of oligochaetes and their participation in the formation of the total number of representatives of the temporary component remained practically unchanged. The average number of Gastropoda was (309.3±137.8 ind.·m^{-2}), its share in the total index decreased from 6 % to 1 %.

The role of pseudomeiobenthos in the formation of the total abundance of all meiobenthos sharply decreases at depths of 16-20 m (to 2.7%). Of the 103 stations were collected and processed at this depth, 82.5% of the substrates were represented by black, gray, and meline silts. At the considered depth, the total number of pseudomeiobenthos averaged 10,128.9±1,744.8 ind.·m^{-2}. Oligochaetes dominated (average 36 % of the total number of the temporary component), with an average density 3,653.6±709.8 ind.·m^{-2}. Polychaetes and Bivalvia (33 % and 28 % respectively) were subdominant groups; the average 3,363.4±787.6 ind.·m^{-2} and 2834.6±898.7 ind.·m^{-2} respectively. The average density of gastropods has not changed.

At a depth of 21–25 m during the research period, 182 stations were collected, 92.5 % of which had silty soil. The total number of pseudomeiobenthos sharply decreased and amounted to 7,195.2±1,333.4 ind.·m^{-2} (2 % of the total number of meiobenthos). Polychaeta dominated with an average settlement density 507.4±993.6 ind.·m^{-2}; their share in the total number of pseudomeiobenthos reached 48 %.

In the spring, the occurrence of temporary meiofauna in the studied water area was 74.35 %, its total number varied from 250 to 16,000 ind.·m^{-2}, averaging 4,195.9±814.6 ind.·m^{-2}. These indicators formed three groups of meiobenthos: oligochaetes, whose average density was 2,594.2±540.0 ind.·m^{-2}; polychaetes with an average density of 1,062.3±224.9 ind.·m^{-2} and juveniles of bivalve mollusks with an average number of 2,025.8±984.3 ind.·m^{-2}. The

proportion of pseudomeiobenthos was 1.79 % of the total number of meiobenthos. Typically, this temperature regime (8-10 °C) in the Odesa Sea Region is reached in late March and early April. Thus, sedimentation of juvenile mitilides on the ground occurs in early summer.

The occurrence of oligochaetes in the period under review was 50 %, with an average 2,368.2 ind.·m^{-2}, with the density of their settlements from 300 ind.·m^{-2} up to 12,000 ind.·m^{-2}. The minimum concentration was observed on silted shells, the depth was 11-15 m. The maximum indicator was on silts, the depth was 21–25 m. The average density of oligochaetes over a long period (1994-1998, 2005) was 1,748.2± 489.3 ind.·m^{-2}.

The occurrence of polychaetes is about 55 %, the density of settlements ranged from 100 ind.·m^{-2} on a silted shell at a depth of 11–15 m. At a water temperature of 9 °C at the bottom and 14 % salinity, 10 mg·l^{-1} of dissolved oxygen at the bottom – to 15,000 ind.·m^{-2} (silt, depth 20-25 m). The total biomass of invertebrates was 284.9±47.6 mg·m^{-2}, oligochaetes (181.63±37.8 mg·m^{-2}), polychaetes dominated.

In the summer period, the total number of pseudomeiobenthos averaged 18,847.8±2,918.1 ind.·m^{2}, its share in the total number of meiobenthos was 5.69 %. In 1982, it was only 0.8 %. These indicators may indicate that the situation in the Odesa Region has now improved. 77 % of it was juvenile bivalves and polychaetes. The average density of settlements of juvenile mitilides is – 7,406.3±2,036.1 ind.·m^{-2}, Polychaetes – 7,535,9±1,151 ind.·m^{-2}, Olygochaeta – 4,030,9±543,5 ind.·m^{-2}.

In autumn, representatives of temporary meiofauna the greatest part in the formation of general indicators of the meiobenthos, they accounted for 9.14%. Comparing this indicator with its counterpart in 1982-1983 (0.04-0.9%, respectively), we can once again emphasize that the ecological state of the considered water area in the current period is significantly different for the better. The total number of the meiobenthos is 15,289.7±3,407.5 ind.·m^{-2}, its maximum rate is 129,000 ind.·m^{-2}. Polychaetes dominated with an average density 8,848.4±1,912.1 ind.·m^{-2}. The subdominant Group in pseudomeiobenthos was Oligochaeta (3,282.8±844.4 ind.·m^{-2}).

The average number of mitillids in the autumn is more than in the summer. Gastropoda are represented by average indices of 844.8±311.8 ind.·m^{-2} (Fig.1.18.).

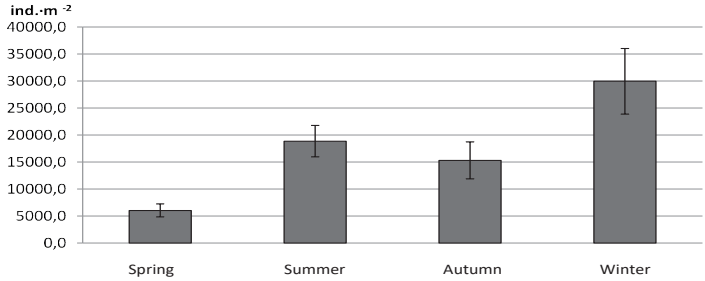


Figure 1.18. Average abundance of the temporary component of meiobenthos in different seasons of the year

In winter, the density of pseudomeiobenthos (29,955.8±6,063.6 ind.·m^{-2}) was 7.3% of the total number of meiobenthos, which was significantly higher than in other seasons. Its maximum total number was 137,500 ind.·m^{-2}. Polychaetes dominated (58 %) with an average density of 17,701.9±3,542.9 ind.·m^{-2}. In addition to polychaetes, mitillids took an active part in the formation of the total number of the temporary component; their share in the total number of meiobenthos was 39% (11673.1±3062.4 ind.·m^{-2}). The average abundance of oligochaetes and gastropods is extremely low (384.6±192.7 ind.·m^{-2}).

In addition to polychaetes, mitillids took an active part in the formation of the total number of the temporary component; their share in the total number of meiobenthos was 39 % (11,673.1±3,062.4 ind.·m^{-2}). The average abundance of Oligochaeta and Gastropoda was extremely low (384.6±192.7 ind.·m^{-2}).

As shown by long-term studies, the average indicators of the total number of meiobenthos are highest in the winter period (Vorobyova, 2017). The same applies to the density of the temporary component.

The temporary component of meiobenthos plays an important role in the formation of the productivity of water bodies, since it serves as the main food

for a number of larvae, juveniles, and adult individuals of commercial benthos fish.

Depending on the set of different abiotic factors, the dynamics of their quantitative characteristics in meiobenthos can vary significantly.

During the period of mass settling of larvae within the bottom communities, many of them, after reaching the bottom, are destroyed by adult invertebrates of the bottom (Thorson, 1954, 1964, 1966]. In these cases, the future structure of adult populations of certain species may be influence on those species that are mutually neutral in adulthood (Mokievskij, 2009).

Under favorable conditions for passing through the stages of metamorphosis for temporary meiofauna, the abundance and biomass of juvenile mollusks and polychaetes can play a significant role in the formation of density and biomass indices common to the entire meiobenthic community.

As can be seen from the data presented, the most favorable conditions for the development of representatives of pseudomeiobenthos are in the depth range up to 16 m, then with increasing depth, the number of the considered category of meiobenthos decreases. In the Odesa Marine Region, a higher abundance of the temporary component of meiobenthos is noted on the shell/sand and silted shell.

POLYCHAETA. Polychaetes in the eumeiobenthos are represented by a small number of species. In total, about 250 species of eumeiobenthic polychaetes are known for the World Ocean, belonging to 25 families (Giere, 2009). Despite the low species diversity, the density of eumeiobenthic polychaetes can reach very high values. According to literary data, about 20 species of eumeiobenthic polychaetes are known for the Black Sea, belonging to 10 families: Dinophilidae, Nerillidae, Parergodrilidae, Polygordiidae, Protodrilidae, Saccocirridae, Hesionidae, Syllidae, Pisionidae, Sabellidae (Vinogradov, 1949; Vorobyova, 1977; Marinov, 1977; Kiseleva, 2004, Mastepanova, 2004, etc.).

Juvenile individuals of polychaetes spend a rather short period in the meiobenthos. But at this period, they actively participate in the life of this community of organisms. Most often, researchers did not study the species

composition of juvenile individuals and polychaetes of eumeiobenthos, but considered them all as a taxonomic unit of pseudomeiobenthos. Recently, for the northwestern shelf, a number of works have been carried out to study the species composition of pseudo- and eumeiobenthos polychaetes, quantitative indicators are given, and their distribution is analyzed depending on the main abiotic factors (Vorobyova, Bondarenko & Izaak, 2008; Vorobyova & Bondarenko, 2009; Bondarenko 2009, 2010).

The first information about the species composition of the eumeiobenthic polychaetes of the Ukraine shelf is given in the second half of the last century (Kiselyova, 2004). The study of polychaetes, which by their size belong to the meiobenthos, in the North-West Black Sea was first conducted by PhD A.S. Bondarenko (see Chapter 2). Before her research, we operated only with general indicators for the Polychaeta taxocene.

Polychaetes are an essential component of the meiobenthos, whose contribution to its total biomass is often comparable to that of the eumeiobenthos. (Vorobyova, Bondarenko, 2007)

Almost all representatives of pseudomeiobenthos are food objects for juvenile fish and many representatives of macrozoobenthos. Despite the low species diversity, the abundance of eumeiobenthos polychaetes can reach very high values (Villora-Moreno, 1997). Research in the mid-90s. XX century showed that the highest number of mollusks and polychaetes in the meiobenthos, as well as their share in total quantitative indicators on the Caucasian shelf (29.7 %), three times less – on the Crimean, and on the northwestern at the end of the last century it averaged 1.4 – 2.1 % (Vorobyova, 1999; L.V. Vorobyova, A.S. Bondarenko, 2023).

The results of studying the ecological characteristics of representatives of the Taxocene Polychaeta over 20 years made it possible to obtain interesting data on the features of the spatial distribution, the formation of quantitative indicators of meiobenthic polychaetes on the NWBS, its bays and the Black Sea estuaries (Vorobyova, 1999). This approach allows us to obtain general ideas about the dynamics of their quantitative characteristics, but which do not carry information about the species structure.

In 2001 the study of the species composition of polychaetes, which by their size belong to its permanent and temporary components, became possible thanks to the experience and knowledge in the study of macrozoobenthos polychaetes PhD. Alena Spiridonovna Bondarenko. She not only presents lists of eumeiobenthic polychaetes in various water areas of the indicated section of the shelf, but also describes the species diversity of juvenile polychaetes that belong to pseudomeiobenthos

In the first decade of the 21st century, a number of works were carried out at the IMB to study the species composition of pseudo- and eumeiobenthos polychaetes. We have presented quantitative indicators, analyzed their distribution depending on the main abiotic factors, and considered the relationship between adults of some species and their juveniles **(**Vorobyova, Bondarenko, Izaak, 2008; Vorobyova, Bondarenko, 2009; Bondarenko 2009, 2010).

A. A. Bondarenko, a candidate of biological sciences, conducted a series of studies on the species composition of pseudo- and eumeiobenthic polychaetes for the Northwest Black Sea coast. She presented quantitative indicators, analyzed their distribution depending on the main abiotic factors, and examined the relationships between adults of some species and their juveniles. A.S. Bondarenko summarized the results of long-term research of this group of animals in the Odesa Sea Region were summarized. (Vorobyova, Bondarenko, Izaak, 2008; Vorobyova, Bondarenko, 2009; Bondarenko 2009, 2010, 2017, 2019).

The polychaetes of the permanent component of the meiobenthos in the Odesa Sea Region are represented by only four species: *Syllides longocirratus* (Öersted, 1845), *Salvatoria clavata* (Clap., 1863), *Exogone (Exogone) naidina* Öersted, 1845, and *Protodrilus flavocapitatus* (Uljanin, 1877). The rarest species in this water area were *E. naidina* and *P. flavocapitatus*. December 2005 at a depth of 12 m on silted sand in the *Chamelea gallina* (L., 1758) biocenosis *E. naidina* was found only on silted shell in the community of *Mytilus galloprovincialis* Lmk, 1819. *S. longocirratus* and *S. clavata* were recorded in all studied seasons *S. longocirratus* was most often found on silty

shell (53.0 %) and shell with sand (45.0%), the species was extremely rare on silt, *S. clavata* was most common in silty shell (65.0%) and a shell with sand (70.0%), while it clearly gravitated towards shallow depths.

During the study period juveniles of 14 macrobenthic Polychaeta species from 9 families were recorded in the meiobenthos: Phyllodocidae (2 species), Nephtyidae (1), Glyceridae (1), Polynoidae (1), Sigalionidae (1), Nereidae (1), Spionidae (4), Capitellidae (2), Ampharetidae (1). The total number of pseudomeiobenthic polychaetes fluctuated significantly between the surveys.

According to Bondarenko A.S. highest frequency of occurrence in the OSR was characterized by juveniles of the families Nereidae, Spionidae, Capitellidae and Ampharetidae, it varied depending on the season. The rate of occurrence of juvenile individuals of *Alitta succinea* (Leuck., 1847) in the spring was 23.8 %, in the summer – 61.5 %, in the autumn – 44.0 %. Despite the high frequency, juvenile polychaetes of this species were few in number in all the seasons studied. Two representatives of the Spionidae family (*Polydora cornuta, Prionospio cirrifera*) were characterized by high rates of occurrence and slightly increased from spring to the second half of the year and amounted to 33.3 %, 57.7 % and 60.0 % in the spring, summer and autumn periods. In the Odesa marine region, juvenile *P. cornuta* were found at various depths and on substrates of varying degrees of siltation. During the study period, juvenile *P. cirrifera* was most often recorded at a depth of up to 10 m and 11–15 m (87.0 and 90.9 %, respectively). With increasing depth, this indicator slightly decreased, amounting to 60.0 % at a depth of 16–20 m and 47.8 % at a depth of 21–25 m. Juvenile *P. cirrifera* was most often recorded on silted shells (94.0 %), least often on silts (51.0 %). In the spring, its quantitative characteristics were the lowest. C. capitata in the meiobenthos was most often recorded at depths of up to 10 m and 11–15 m. In the autumn, the greatest abundance of juveniles of this species was confined to depths of 16–20 and 21–25 m.

Substrate type is one of the main abiotic factors influencing the formation of qualitative characteristics of pseudomeiobenthos polychaetes. It is known that when settling from the pelagial, the larvae of many species are

able to actively choose the substrate that is optimally suited for their metamorphosis. In case of its absence, they can prolong the planktonic phase for some time. At the same time, the larvae of a number of species do not show selectivity to the substrate upon transition to the benthal. Consequently, the role of the edaphic factor in the formation of the qualitative characteristics of pseudomeiobenthos polychaetes is manifested both in the selectivity of species to its quality and in their further elimination after settling on unsuitable substrates.

When studying the interstitial meiofauna of sandy beaches, representatives of the Polychaeta taxocene (*Hesionides arenaria*, Friedrich, 1937, *Protodrilus flavocapitatus* (Uljanin, 1877), *Nerilla antennata* O. Schmidt, 1848) were found only in coarse-grained sand. They were not found in medium-grained and fine-grained sand. *Hesionides arenaria* was not previously indicated for the Ukrainian shelf of the NWBS (Vorobyova, Zaitsev, Kulakova, 1992)).

The largest number of juvenile polychaetes species in the sample in the NWBS were recorded on a shell and a shell with the sand, and the smallest number, on silty sand and silt. Accordingly, the number of species decreased with an increase in the degree of silting of the substrate (Fig. 1.19.).

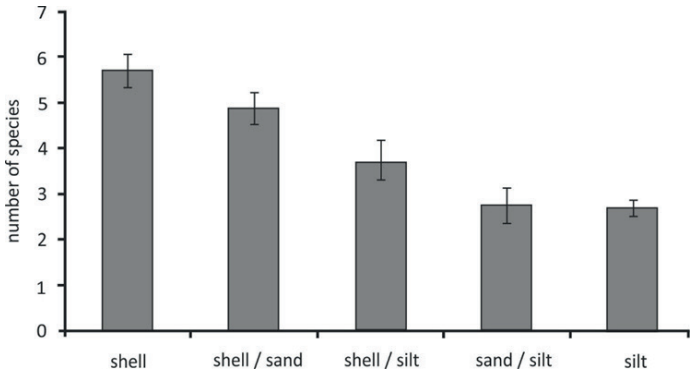


Figure 1.19. Number of pseudomeiobenthos polychaetes species in a sample on different substrates.

The work is based on the materials of expeditionary studies of 2003-2005, 2007, 2010 at the NWBS (Bondarenko, Vorobyova, 2024). In the pseudomeiobenthos (except for bays), juveniles of 28 species of polychaetes from 12 families were recorded during the study period: Phyllodocidae (5 species), Nephtyidae (1), Glyceridae (1), Polynoidae (2), Sigalionidae (1), Nereidae (5), Spionidae (7), Capitellidae (2), Terebellidae (1), Ampharetidae (1) Pectinaridae (1) and Serpulidae (1).

Using dispersion analysis, an assessment was made of the influence of the type of bottom sediments, salinity and temperature of the bottom water layer on the formation of α-diversity and the density of juveniles polychaetes in the northwestern part of the Black Sea (Bondarenko, 2024). The role of the substrate type for the settling of juveniles of Polychaeta to the bottom and their further development was analyzed. Abundance indicators (ind.·m^{-2}) of the dominant species of pseudomeiobenthos polychaetes at various depths in the northwestern part of the Black Sea were examined. A study of the spatial distribution of juveniles of the dominant polychaete species relative to their adult forms was carried. The larvae of *P. cornuta* actively choose the settlement sites of adults of their species to migrate to the benthic, while the abundance of juveniles of *P. cirrifera* and *C. capitata* is not associated with the settlements of their adults' forms

On the silted sand, juveniles of only two species, *A. succinea* and *P. cornuta*, were most often found (64.5 and 61.3 %, respectively). On silts, the highest occurrence rates were in juveniles of *P. cirrifera* (51.6%) and *Heteromastus filiformis* (Claparède, 1864) (52.7 %), as well as in *A. succinea* (48.4 %) and *P. cornuta* (43.0 %). Juveniles of these species were often found (in more than 50 % of collected samples) on all other types of substrates. On the shell with sand, juveniles of *Capitella capitata* (Fabricius, 1780) and *Spio filicornis* (Müller, 1776) were recorded with the same frequency.

Thus, with an increase in the degree of silting of the substrate, the local diversity of pseudomeiobenthos polychaetes decreased. According to Bondarenko A.S. the largest number of species in the sample was characterized by shell and shell with sand, the smallest – by silty sand and silt. On a shell

and shell with the sand, juveniles of *A. succinea*, *P. cornuta*, *P. cirrifera, H. filiformis, C. capitata* and *S. filicornis* were most often found, on silty shell – *A. succinea, P. cornuta P. cirrifera* and *H. filiformis* on silty sand – *A. succinea* and *P. cornuta*. Juveniles of species rare for the NWBS, as a rule, were noted in places typical for the habitation of adults of their species.

A large volume of samples (Odesa Sea Region) allowed us to establish the dependence of the formation of the total number of pseudomeiobenthos and its individual groups depending on the type of substrate (Bondarenko, 2017). On silty soil (154 stations were completed), the share of the total number of pseudo-meiobenthos averaged only 3.42% of the total meiobenthos (Fig. 1.20).

On the silty bottom the polychaetes community structure of the temporary component of the meiofauna were based on representatives of Spionidae, Capitellidae, and Ampharetidae (Fig. 3.19). Juveniles of 9 Polychaeta species were recorded here. The most common juveniles were *Melinna palmata* (57.4%), *Prionospio cirrifera* (50.0 %), and *Heteromastus filiformis* (42.6 %). The density of juvenile polychaetes on this substrate ranged from 0 to 46,000 ind.·m^{-2}. Juveniles of *M. palmata* dominated in density. Juvenile specimens of *P. cirrifera* and *Capitella capitata* were found in significant quantities on this substrate; 1980 they accounted for 22.2% and 15.3% of the total respectively.

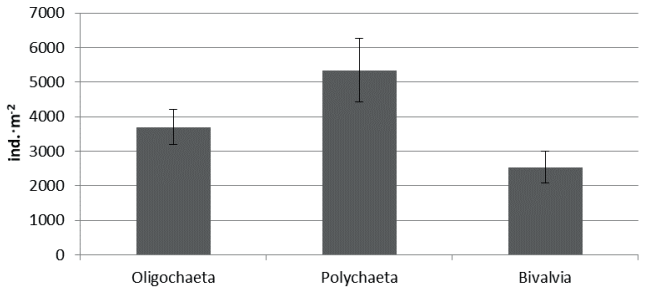


Figure 1.20. Average density of settlements of different taxa of pseudomeiobenthos on silty substrarate

On the silted sand, the density of pseudomeiobenthic polychaetes was based on juveniles of Spionidae, Capitellidae and Nereidae. Juveniles of 8 species were noted here. Their total abundance varied from 700 to 10,633 ind.·m^{-2}. The average density was 4,683 ± 1,810 ind.·m^{-2}, 53.4 % of which was accounted for by *P. cirrifera* and 19.7 % by *C. capitata.*

On the silted shell (42 stations were completed), juveniles of the Spionidae family were most abundant. In total, juveniles of 12 polychaetes species were recorded on this substrate. The juveniles of *P. cirrifera* (80.0 %), *P. cornuta* (53.3 %), *C. capitata* (53.3 %) and *H. filiformis* (40.0 %) were characterized by a high rate of occurrence on this substrate, while the juveniles of one species, *P. cirrifera*, dominated quantitatively, the abundance of which amounted to 87.1 % of the total number of pseudomeiobenthic polychaetes. Its density at individual stations ranged from 0 to 62,160 ind.·m^{-2} (Fig.1.21).

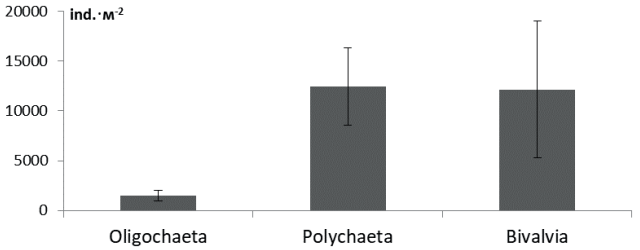


Figure 1.21. Average density of settlements of various taxa of pseudomeiobenthos on silted shell.

Juveniles of 11 Polychaeta species were present on the shell. The basis of the pseudomeiobenthic polychaetes community were made up of juveniles of Spionidae, Capitellidae, and Nereidae (Fig. 1.22.). On this substrate, 100 % of the juveniles of *Alitta succinea, Polydora cornuta, P. cirrifera,* and *C. capitata* were found. Juveniles of *H. filiformis* were recorded at 70 % of the stations. No pronounced dominance of juveniles of any species was observed on this substrate. The most abundant species were C. capitata (36.7 % of the total), *P. cirrifera* (21.2 %), *P. cornuta* (18.3 %), and *A. succinea* (11.2 %).

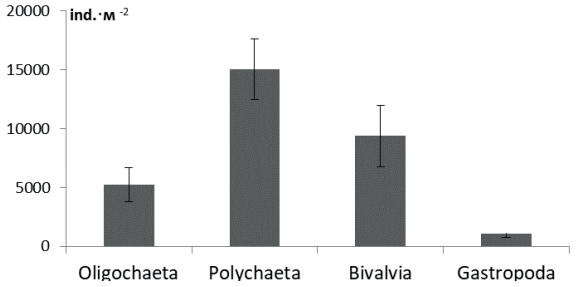


Figure 1.22. Average settlement density of various pseudo-meiobenthos taxa on shell with sand.

On the sand/shell bottom, pseudomeiobenthos was the most diverse, comprising 11.7 % of the total meiobenthos. Polychaetes dominated (49%) with a population of 15,031.3±2,564.8 ind.·m^{-2}. The most abundant species were C. capitata (36.7 % of the total), *P. cirrifera* (21.2 %), *P. cornuta* (18.3 %), and *A. succinea* (11.2 %).

On the sandy shell, as well as on the silted shell, the basis of the pseudomeiobenthic polychaetes community was formed by juvenile individuals of Spionidae. Juveniles of 9 species of polychaetes worms were found here. According to the occurrence rate, the main species included juveniles of *P. cirrifera* (88.0 %), *A. succinea* (80.0%), *P. cornuta* (76.6%), *C. capitata* (76.6 %) and *H. filiformis* (52.0 %). In terms of numbers, as on the silted shell, juvenile individuals of *P. cirrifera* dominated (81.6 %), with their maximum numbers amounting to 40,841 ind.·m^{-2}. Thus, as can be seen from the above, the greatest number juvenile of Polychaeta species was recorded on the silted shell.

Interesting results were obtained by Bondarenko O. when analyzing the distribution of meiobenthic polychaetes in the NWBS shelf depending on depth **(**Vorobyova, Bondarenko, 2009).

The main number of polychaetes species were found at a depth of 15–65 meters (Fig. 1.23).

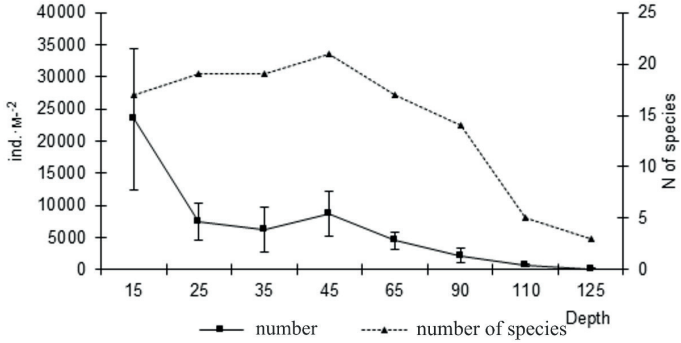


Figure 1.23. The number (ind.·m^{-2}) of meiobenthic polychaetes at different depths.

At a depth of more than 100 m, only six species were found. Three of them belong to eumeiobenthic (*V. zaikai, S. longocirrata, E. gemmifera*) and three are juvenile specimens of *Prionospio cirrifera, Heteromastus filiformis* and *Capitella capitata* (Bondarenko O., Vorobyova L., 2024)

Abundance indicators (ind.·m^{-2}) of the dominant species of pseudomeiobenthos polychaetes at various depths in the NWBS were examined. A study of the spatial distribution of juveniles of the dominant polychaetes species relative to their adult forms was carried. The larvae of *P. cornuta* actively choose the settlement sites of adults of their species to migrate to the benthic, while the abundance of juveniles of *P. cirrifera* and *C. capitata* is not associated with the settlements of their adults' forms (Vorobyova, Bondarenko, Izaak, 2008; Bondarenko, 2015; Vorobyova, Kulakova, Bondarenko, Portyanko, 2019).

In the Odesa Gulf on the concrete of the traverses the number of individual species in the studied biotopes differed significantly. In the periphytal of protection structures, *S. clavata* and *P. cornuta* dominated in terms of this indicator. The juveniles of only one species, *S. filicornis*, dominated on the sandy substrate (Fig.1.24).

Of the three species of eumeiobenthic polychaetes noted, *S. clavata* were characterized by 100 % occurrence in the two studied biotopes. Despite the

high occurrence, the abundance of *F. sabella* in both the periphytal and benthic were low. *P. flavocapitatus* was recorded only in the sand biotope, which is the natural habitat of this species.

Bondarenko A.S. analyzed the nature of changes in the quantitative parameters of pseudomeiobenthos polychaetes depending on depth (artificial substrate of hydraulic structures, Odesa Bay). The distribution of quantitative indicators of the dominant pseudomeiobenthic polychaetes species (*A. succinea, P. cornuta* and *P. cirrifera*) at different depths of the Ukrainian shelf was analyzed (Figure 3. 24). Juveniles of *A. succinea* were present at all studied depths.

Their greatest abundance at OSR was typical for depths of 5–10 and 11–15 m, which coincides with the distribution of adults of this species.

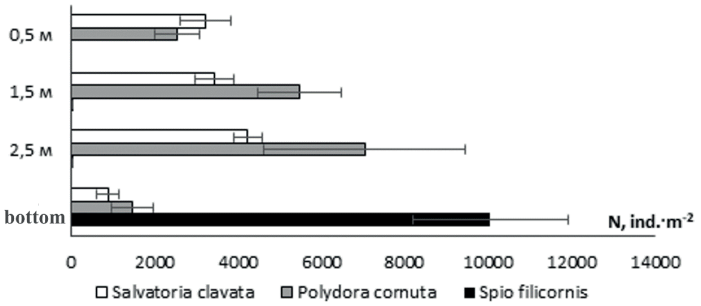


Fig. 1.24. The number of dominant species of meiobenthos polychaetes on different horizons of the periphytal of coastal protection structures and in the sand biotope in the waters of the beaches "Dolphin" and "Starik".

The maximum abundance of *A. succinea* juveniles was recorded at a depth of 11–15 m and amounted to 9,600 ind.·m^{-2}. With the growth of the values of this factor, its quantitative indicators decreased (Fig. 1.25). It is known that in the Black Sea, adults of *A. succinea*, as a rule, live in the coastal zone. During the period of intense eutrophication, they spread to a depth of 35–40 m. Probably, the ability of the larvae to settle at these depths contributed to

the rapid development of bottom areas that were freed up after the degradation of the *Melinna palmata* Grube, 1870 biocenosis.

Juveniles of *P. cornuta*, like the juveniles of the previous species, were found at all studied depths, but they were most numerous in the range of 5–20 m. There are adults at high densities (see Fig. 1.24). In this range, the maximum indicator of this characteristic was registered, which amounted to 49,017 ind.·m^{-2}.

Juveniles of *P. cirrifera* were absent in the narrow coastal zone and were recorded at depths greater than 5 m. The highest numbers of juveniles of this species were recorded at 11–15 m. This characteristic remained high with increasing depth (see Figure 1.24). In the entire range of depths, accumulations of their juveniles were noted, the density of which exceeded several tens of thousands of specimens per 1 m^2. Thus, at a depth of 5–15 m, the maximum abundance of this species was 40,841 ind.·m^{-2}; at 11–15 m, 62,160 ind.·m^{-2}; 21–30 m – 71,977 ind.·m^{-2}, at a depth of 31–40 m – 20,000 ind.·m^{-2}. It is known that *P. cirrifera* in the Black Sea is distributed to a depth of 110 m.

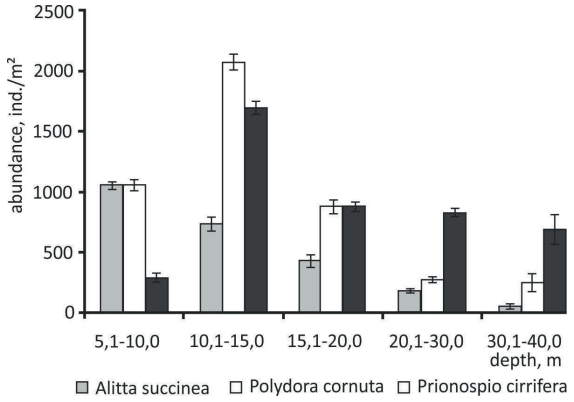


Figure1.25. Abundance (ind.·m^{-2}) of the dominant species of pseudomeiobenthos polychaetes at various depths in the northwestern part of the Black Sea

The results of the correlation analysis show a positive linear relationship between the density of *P. cornuta* juveniles and the density of its adults. They most actively colonize areas of the bottom that are inhabited by adults of their own species.

Long-term studies in the Odesa Sea Rregion have revealed heterogeneity of quantitative indicators of the temporal component of meiobenthos even at such relatively shallow depths of the shelf zone. At a depth of up to 10 m, juveniles of 14 species of polychaetes worms were recorded. The most frequently recorded were *P. cirrifera* (90.9 %), *A. succinea* (82.6 %), *P. cornuta* (81.3 %), *C. capitata* (78.1 %), *H. filiformis* (56.3 %). Juveniles of *P. cirrifera* dominated in terms of numbers, their share in the total number of polychaetes of pseudomeiobenthos reaching 58.8 %. The contribution of *P. cornuta* to this indicator was 15.4 %, *A. succinea* and *C. capitata* – 10.0 % and 9.7 %, respectively. Juveniles of other species were present in insignificant quantities.

At a depth of 10.1–15.0 m during the study period, juveniles of 11 species of Polychaeta were present. The structure of the temporary community of juvenile polychaetes differed little compared to the depth of up to 10 m. The occurrence of *P. cirrifera* and *C. capitata* did not change, *A. succinea* (65.0 %), *P. cornuta* (70.0 %) and *H. filiformis* (45.0 %) were recorded somewhat less frequently. At the same time, juveniles of *P. cirrifera* constituted more than 79.0 % of the total number. The share of *P. cornuta* decreased to 7.9 %, *A. succinea* – to 4.2 %, *C. capitata* – to 6.4 %.

With further increase in depth (15.1–20.0 m), changes in the structure of the temporary community of pseudomeiobenthos polychaetes were noted. The number of juvenile species was 8. The main species were juveniles of *M. palmata* (57.1 %), the occurrence of *P. cirrifera* decreased to 57.1 %, *H. filiformis* (47.7 %), *C. capitata* – to 42.9 %, *A. succinea* – to 28.6 %, *P. cornuta* – to 19.1 %. The total density of juvenile polychaetes worms at this depth decreased. Juveniles of *M. palmata* (42.2 %) and *P. cirrifera* (39.7 %) prevailed in numbers. The share of *C. capitata* in the total density of juvenile

polychaetes was 9.5 %. The contribution of other species to this indicator was insignificant.

At a depth of 20.1–26.0 m, juveniles of 11 polychaetes species were recorded. The most common were *M. palmata* (48.6%), *P. cirrifera* (45.9 %) and *H. filiformis* (40.5 %). The occurrence of *C. capitata* decreased to 21.6 %. At the same time, the contribution of *M. palmata* and *P. cirrifera* to the total density of juvenile polychaetes remained virtually unchanged and amounted to 41.6 % and 36.7 %, respectively, and the share was 16.4 %.

The influence of the temperature factor on the local diversity of pseudomeiobenthos polychaetes is expressed in a slight but significant increase in the number of species in the sample with an increase in the indicators of the analyzed factor. As a rule, the larvae of most species of Polychaeta develop in plankton during the spring-summer and summer-autumn periods.

In the NWBS at low temperatures (4.6–8.0 °C), juveniles of *P. cirrifera* (57.6%), *A. succinea* and *H. filiformis* (44.1% each) were most meet in samples in the benthos. The rest of the species were extremely rare. The occurrence of juvenile specimens of P. cirrifera and *H. filiformis* at different temperatures of the bottom water layer changed a little (41.3–70.9 and 41.2–62.1%, respectively). They were not directly dependent on this factor. The juveniles of *A. succinea* and *P. cornuta* were characterized by the most pronounced positive dependence of occurrence on the temperature regime. The maximum rates of their occurrence (93.1 and 96.9%) were registered at a temperature of 20.1–24 °C. Juveniles of representatives of the Phyllodocidae family, rarely found in the NWBS, were noted at a temperature of the bottom water layer of more than 8.0 °C, H. imbricata – in the range of 7.0–12.0 °C. Juvenile specimens of *Dipolydora quadrilobata* (Jacobi, 1883), which recently spread in the waters of the NWBS, were noted at a temperature of 5.0–10.0 °C.

The influence of the temperature factor on juvenile polychaetes worms is manifested in an increase in their diversity with an increase in temperature. First of all, this is due to the timing of reproduction and settling of larvae of many species from the pelagial to the benthal.

Studies conducted in some Estuaries of the NWBS suggest that the number of polychaetes does not play a significant role in the formation of the total number of meiobenthos. According to Bondarenko A. S. in the Grigorevsky estuary, the average annual numbers of polychaetes and their share in the total quantitative indicators of the meiobenthos of the open part of the Estuary were similar to those in other estuaries. In the last decade of the last century, the number of polychaetes here usually did not exceed 3,000–5,000 ind.·m^{-2} with an occurrence of up to 40 – 50%, in the summer months at a depth of 6–14 m it was on average 31 – 45.2 % for polychaetes in different years, their share in the total number of organisms did not exceed 0.6%. In autumn, the maximum density of polychaetes settlements is 5,000 ind.·m^{-2}. In shallow water (0-1 m) in different parts of the coast the average annual number of 478 ind.·m^{-2}. In the Daphin Estuary polychaetes do not play a significant role in the formation of the total number and biomass of the meiobenthos. This is especially true for zones with a depth of more than one meter (the number of polychaetes worms usually does not exceed 800 ind.·m^{-2}). It should be noted that in most cases polychaetes in the meiobenthos were present in samples taken in the upper reaches of the estuary. In the coastal zone (up to 1 m) in different seasons of the year the density of polychaetes settlements was 2,000–6,000 ind.·m^{-2}. Their share in the total number fluctuated between 0–0.29 and 1.33–2.86 %; in the total biomass – from 1.2 to 15.34 %. The density of polychaetes settlements and their share in the total number and biomass of meiobenthos in the Tiligul estuary, as in the listed water areas, depended on the biotope, depth, and period of the year. The densest accumulations of worms were noted in the shallow waters of the coastal zone, the maximum indicator reached 243,000 ind.·m^{-2} (on average for 2,005–39,000 ind.·m^{-2}). Polychaetes accounted for 11.2 % of the total number of all meiobenthos and 81 % of the total number of the temporary component. During the same period, the share of polychaetes in the total biomass of pseudomeiobenthos was 48.0 %, in pseudomeiobenthos – 90.0–91.0 %. On the silts of the central part of the estuary, the density of polychaetes settlements fluctuated from 2,000 to 5,000 ind.·m^{-2}.

According to Bondarenko A.S. in the pseudomeiobenthos of the Danube region, juveniles of 15 polychaetes species belonging to 8 families were recorded during the study period (Bondorenko, 2011). During this period, juvenile specimens of *A. succinea* and *P. cornuta* were most abundant at a depth of 7 to 20 m, where numerous settlements of their adult forms were noted in the macrozoobenthos. Juveniles of *P. cirrifera* most actively explored the depth of 20–24 m. The almost complete absence of representatives of the eumeiobenthos complex became a feature of the taxocene of polychaetes near the estuary. Low diversity of substrate types and, most importantly, the specificity of this contact zone is high trophicity under the influence of river runoff. The Danube may be the main factors hindering the development of polychaetes in this area.

Considering the features of the distribution of polychaetes juveniles at different depths, it should be noted that on the Danube coast in autumn, juveniles of *A. succinea* and *P. cornuta* were most abundant at a depth of 7 to 20 m, where numerous settlements of their adult forms are noted in the macrozoobenthos. Juveniles of *P. cirrifera* most actively explored the depth of 20–24 m (Bondarenko, 2011)

NORTHWESTERN PART. The work is based on the materials of expeditionary studies of 2003-2005, 2007, 2010 in the northwestern part of the Black Sea (NWBS). (Bondarenko, Vorobyova, 2024).

The purpose of this work is to study the role of environmental factors in the formation of the meiobenthic polychaetes community on the northwestern shelf of the Black Sea in the modern period.

The qualitative composition and distribution of the quantitative characteristics of polychaetes are closely dependent on a number of environmental factors. Juveniles Polychaeta worms differ in ecological characteristics from adults of their own species. This determines the need to study this age category separately from representatives of macrozoobenthos. Using dispersion analysis, an assessment was made from the influence of the type of bottom sediments, salinity and temperature of the bottom water layer

on the formation of α-diversity and the density of juveniles polychaetes in the northwestern part of the Black Sea.

MOLLUSKA. Juvenile molluscs are a valuable forage object for many representatives of the ichthyofauna, in terms of calories, they are not inferior to harpacticoids and ostracods (Vorobyova & Targonska, 1998). In addition, many species of gobies, small southern sticklebacks, and sea dogs use rocky substrate for laying caviar. The shallow depth attracts the young of many bottom-dwelling fish with a variety of food resources. Juvenile gobies, sultanas (*Mullus barbatus ponticus*), black sea athers (*Atherina boyeri pontica*), anchovies (*Engraulis encrasicolus*), mullets (Mugilidae) and others feed here on small polychaetes, molluscs and crustaceans. During the period of mass settling of larvae within bottom communities, many of them are destroyed by adult bottom invertebrates after reaching the bottom (Thorson, 1958, 1964).

Molluscs whose body sizes allow them to be part of the meiobenthos only for a short period of their life cycle belong to the pseudomeiobenthos (a temporary component of the meiofauna). Despite their small size, young molluscs play a significant role in marine ecosystems, contributing to the development and restoration of bottom biocenoses. Pseudomeiobenthos molluscs are an excellent forage object for young and adult forms of benthic and demersal benthic ichthyofauna. Indicators of the density of settlements and its biomass can be used in monitoring the quality of the marine environment. In terms of population density and biomass, the majority of the pseudomeiobenthos of the NWBS is represented mainly by young bivalve molluscs and polychaetes. Gastropods were encountered in our studies with a very low population density. Features of the formation of quantitative characteristics of molluscs, which are considered based on the results of processing 520 quantitative samples collected in the Odesa Sea Region in 1994-2015, are given for the first time. The influence of the main environmental factors (substrate type, depth, oxygen regime) on the formation of quantitative indicators of mollusks of the meiobenthos category was considered.

In terms of density and biomass, the majority of the pseudomeiobenthos

of the NWBS consists mainly of young bivalves and polychaetes. Many scientists who study meiofauna often neglect the study of pseudomeiobenthos, motivated by its smaller number compared to eumeiobenthos. Unfortunately, there are very few special studies for the Black Sea that would show the peculiarities of the formation of this temporary component of the meiobenthos. At the same time, juvenile macrofauna can constitute a significant part of meiobenthos biomass (Thorson, 1966) or its products (Yingst, 1978). Juvenile molluscs, belonging to the temporary category of meiobenthos, with further development and the size of individuals pass into the category of macrozoobenthos. Despite their small body size, young molluscs play an essential role in marine ecosystems. First of all, they contribute to the development and restoration of benthic biocenoses. In addition, young molluscs are an excellent forage object for young and adult forms of benthic ichthyofauna. Also, indicators of the density of settlements and its biomass can be used during monitoring in the assessment of the quality of the marine environment, especially in eutrophic water areas. In conditions of crisis for marine benthos organisms (high anthropogenic load, lack of oxygen in the bottom layers of water, low salinity, etc.), their share in the total indicators decreases sharply. Depending on the set of various abiotic factors, the dynamics of their quantitative characteristics in the meiobenthos can vary significantly. Under favorable conditions for passing the stages of metamorphosis, the number and biomass of young molluscs and polychaetes can play a significant role in the formation of density and biomass indicators common to the entire meiobenthic group. Thus, the density of pseudomeiobenthos can be an indirect indicator of the ecological situation in the benthic.

Depending on the combination of various abiotic factors, the dynamics of the quantitative characteristics of young molluscs in the meiobenthos can change significantly. During the period of mass settlement of mollusk larvae within the benthic communities, many of them, having reached the bottom substrate, are destroyed by adult invertebrates. (Thorson, 1958, 1964, 1966). In these cases, the future structure of adult populations of individual species

may have an effect on those species that are mutually neutral as adults. Under favorable conditions for passing the stages of metamorphosis for the temporary meiofauna, the number and biomass of juvenile molluscs and polychaetes can play a significant role in the formation of density and biomass indicators common to the entire meiobenthic group.

The density of young mollusk settlements on the bottom substrate depends on their larvae in the pelagic. In turn, the dynamics of the formation of the density of planktonic larvae of benthic invertebrates depend, firstly, on the timing and intensity of spawning of the parent forms, secondly, their quantitative representation in the benthic is determined by the duration of their pelagic stage; thirdly, from the loss of larvae as a result of removal from the adult population. So, on the one hand, the pelagic period contributes to a greater settlement of molluscs, on the other hand, it leads to an increase in mortality due to predation or entry into unfavorable conditions in the lower layers of water near the bottom. In the Black Sea, due to peculiar hydrological conditions, a huge number of larvae of zoobenthic forms die, which are carried to a considerable distance from the shore with depths of more than 150–200 m.

Our observations at the beginning of the present century showed that the sedimentation of larvae of macrozoobenthic forms, and especially molluscs, from the pelagic to the benthic takes place in the NWBS with great losses due to unfavorable conditions for the existence and passage of larvae at various stages of development (deficiency or complete absence of oxygen, a large amount of suspension, etc.). There is a fairly pronounced selectivity of larvae of different species in relation to the substrate. The size of the particles and the spaces between them in the bottom sediments, the structure, the contour of the substrate, as well as its illumination are of great importance when choosing a suitable substrate for larval settlement, it has its chemical properties (Scheltema, 1961; Willians, et al. 1964). The active settlement of larvae and the successful completion of metamorphosis enable the replenishment and restoration of benthic communities. It is known that in the absence of the necessary substrate, metamorphosis can occur in larvae. So, in *Mytilus edulis* larvae for 40 days at a temperature of 10 °C. This ability is especially strongly

developed in larvae with clearly expressed selectivity of the substrate in their adult parental forms, which most often live in narrow coastal zones. The physical properties of the substrate play a decisive role. Most often, the choice of substrate is greatly influenced by its chemical properties of inorganic and organic origin.

Many years of research have revealed the dependence of the formation of the number of young molluscs depending on the type of bottom soil (Vorobyova, 2024). The highest average indicators of the density of bivalve mollusk settlements are characteristic of a shell with sand and a hard substrate (Table 1.10.). We noted this same regularity in the general indicators of pseudomeiobenthos (Vorobyova, 2021). Juvenile gastropods were noted by us on a shell with an admixture of sand (on average 1101.0±313.4 ind.·m^{-2}) and on a stony substrate with algae. The maximum number of young molluscs was registered in the area of the Gryhorivsky Estuary (black silt, depth 20 m) – 80,000 ind.·m^{-2}.

Table 1.10.

The number of Bivalvia on different substrates and their share in the pseudomeiobenthos and in the total density of the meiobenthos

substrate	ind.·m^{-2}	% from pseudomeiobenthos	% of the total meiobenthos
Muddy	2529.6±461	21.6	0.73
Sand/mud	5847.0±2993.3	37.9	2.63
Shell	5425.3±4162.0	36.8	7.30
Shell/Mul	12145.1±6867.0	36.8	7.52
Shell/sand	9376.6±2603.3	30.3	3.61
Stones, periphyton	2125–15481	41.8–46.0	10.8–12.0

For different areas of the Black Sea, the authors indicate different periods of mass sedimentation of larvae of bivalve molluscs, which is naturally associated with different indicators of seawater temperature in these water areas. When given a choice, mussels prefer rough surfaces of stones and filamentous structures of algae. We conducted research on the dynamics of larval settlement on the substrate of coastal protection structures (travers,

breakwaters) in the coastal zone of the Odesa Bay at temperatures of 12–22 ºC (May-November). Among the larvae of bivalve molluscs that settled on the traverses in mussel growths, as well as on the sandy substrate, mussel and mitilaster larvae with a slight admixture of Cerastoderma prevailed.

As it was said above, with a longer spring warming of the water, the settling of larvae on the substrate can be delayed, which was recorded in our research. In May, at a temperature of 12 ºC, young bivalve molluscs were absent both on the traverses and on the sandy substrate. The first peak of subsidence was characteristic for July (18.2 ºC). By the middle and second half of summer, the number of mollusk larvae decreases, which can be explained by the transition to another age category (macrozoobenthos). The second peak of subsidence (August-September) can be traced on the traverses, which is especially clearly expressed on the upper and lower horizons of concrete structures. On the sandy substrate, the second peak is somewhat smoothed out in the shallowest zones. Minimum numbers are set by mid-November (12 ºC). Juveniles of gastropod molluscs were not found on the sandy, mussel growths were noted only from the end of July (density 2,500–22,000 ind.$\cdot$m^{-2}). In September, their number increases to 11,600 ind.$\cdot$m^{-2}. The maximum numbers are typical for November. It should also be taken into account that meiobenthos, being a valuable forage object for young and some sexually mature fish can be largely subject to being eaten by them in certain seasons of the year.

It should be noted that the dependence between meiobenthos concentration and depth is an important integral factor, because at different depths of the NWBS, the characteristics of the substrate, the dynamics of bottom water layers, and the accumulation of autochthonous and allochthonous organic matter are very different. Thus, with the mass development of phytoplankton, their subsequent settling to the bottom occurs at a depth of more than 10 m (Nesterova & Terenko, 2000; Nesterova, 2008). This factor is especially important for the Black Sea Region, which has heterogeneous and dynamic conditions of abiotic factors.

According to our long-term observations, the sedimentation of mollusca larvae in the NWBS from pelagic to benthic and the successful implementation of their metamorphosis occurs at depths of up to 50 meters (Fig. 1.26). This, as a rule, is characteristic of most of the Black Sea shelf. Further to a depth of 125 m and more, *Modiolus phaseolinus* (Philippi) develops. In zones of increased eutrophication with their characteristic periodical formation of large zones of hypoxia, the possibility of successful development of larvae from the veliconch stage to the size category, which allows them to pass into the category of macrozoobenthos, is sharply reduced. Even with a favorable temperature regime and quality of the substrate, the larvae that settled to the bottom die on masse due to lack of oxygen.

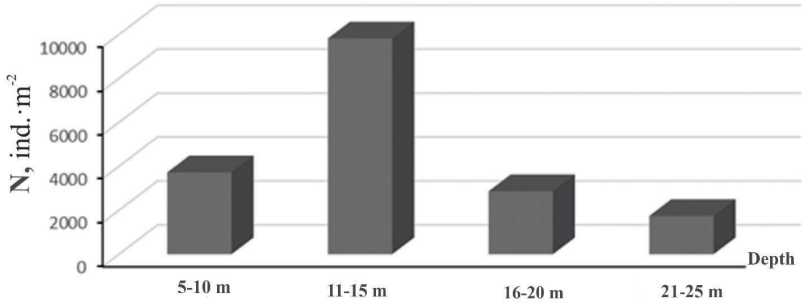


Figure 1.26. Indicators of the average abundance (N, ind.·m^{-2}) of Bivalvia depending on the depth.

The analysis of the distribution of their density of settlements in different areas of the Black Sea (mid-90s) made it possible to establish that the largest number of larvae and young molluscs is on the Caucasian shelf, somewhat smaller on the Crimean shelf, and the lowest on the northwestern shelf. Its shares in the amount of meiobenthos are distributed accordingly: on the Caucasian shelf it was 29.7 %, on the Crimean shelf it was 7.5 %, on the Northwest Territories it was 2.1 % of the total number of organisms. At a depth of more than 15 m, the meiobenthos has a clearly defined nematode-

foraminiferal character, which indicates a complex ecological situation near the bottom.

In the latter case, the food value of meiobenthos is sharply reduced, as well as the possibility of replenishment of macrozoobenthos biocenoses with bivalve molluscs due to the low survival of their larvae and young in these conditions. At a depth of 16–20 m, muddy soils prevailed, only in some cases with the addition of shells.

The most favorable conditions for the development of representatives of pseudomeiobenthos are in the depth range of up to 16 m, then with increasing depth, the number of the considered category of meiobenthos decreases. In the OMR, a greater amount of the temporary meiobenthos component is noted on the shell/sand and mud shell. Juveniles of gastropod molluscs were not found on the sandy, mussel growths were noted only from the end of July (density 2,500–22,000 ind.$\cdot$m^{-2}). In September, their number increases to – 11,600 ind.$\cdot$m^{-2}. The maximum numbers are typical for November.

Thus, our research made it possible to establish the influence of the main environmental factors on the formation of the number of young molluscs and their share of the number of the temporary component and the entire meiobenthos in the NWBS using the example of the Odesa Gulf. The densest settlements of bivalve molluscs are characteristic of the hard substrate, where their share both from the temporary component and in the total number of meiobenthos is the highest (41.8–46.0 % and 10.8–12.0 %, respectively). Smaller indicators of the number of young molluscs in the spring period compared to summer can be explained by their active consumption by young representatives of the ichthyofauna.

3.2. The influence of the oxygen regime on the meiobenthos of the Ukrainian shelf of the Black Sea.

Extreme marine environments cover more than 50 % of the Earth's surface and provide numerous opportunities to study biological responses and adaptations of organisms to stressful living conditions. Extreme marine environments are sometimes associated with ephemeral and unstable ecosystems, but can host abundant, often endemic and well-adapted meiofaunal species. (Ricardo Cardoso Neves, Nuria Sanchez, Roberto Sandulli, et al., (2017). Oxygen is the predominant factor among the abiotic parameters determining habitat conditions and the presense of meiofauna (Coull, 1985). Meiobenthic organisms have relatively large surface areas and mostly high oxygen demans: only a few specialized organisms will prefer hypoxic conditions (Geer, 2009).

Vertical distribution patterns showed that areas with severe oxygen deficiency in the surface sediments contained lower meiofauna than deeper areas. Highest meiofaunal abundance and lowest diversity occurred under lowest oxygen and highest pigment levels, whereas highest diversity occurred under highest oxygen-concentrations and low pigments, as well as high quality of sedimentary pigment (chl a/phaeo) and organic carbon (C/N). Because of their small size, high abundances, short generation times and their close association with the sediment, meiobenthic organisms form an appropriate material for determine the effects of perturbations in aquatic ecosystems. There are species of meiobenthos, which not only can tolerate hypoxia, but also prefer the conditions of acute hypoxia (Sergeeva N., Zaika V., 2013).

The water area of the NWBS, in terms of its hydrochemical characteristics, represents a unique opportunity to study the formation of ecological characteristics of the meiofauna at hypoxic zones in field conditions. Analysis of data for 40 years of continuous research in this part of the Sea made it possible to determine the dynamics of quantitative indicators of both the general meiobenthos and its main large taxa under different oxygen conditions (0–13 $mg \cdot l^{-1}$ O_2) in the bottom layers of water.

The NWBS is an area of particularly high risk of anthropogenic damage to ecosystems. There are many reasons for this, but the fundamental one is apparently the unprecedented size of the specific area of the catchment basin.

The total area of the basins of rivers, entering the northwestern part of the Black Sea is 1,456,000 km^2, while the water area is equal to 278,000 km^2. Consequently, each square kilometre of shelf water area is subject to a load from 52 square kilometres of highly urbanized territory of the basin. Initially this ratio of areas was a positive factor mobilizing great volumes of entry of nutrients from the hinterland of the basin. Thus, the high productivity of the shelf ecosystem was guaranteed. In conditions of highly elevated technogenic chemical stress on the watershed, it has become one of the main prerequistes for anthropogenic degradation (Bogatova Yu.I., Bronfman A.M., Vinogradova L.A., et al.,1990).

Since the mid-1980s, the main problem of the NWBS has been associated with a constant deficiency of dissolved oxygen in the bottom layers of water. This was first described in publications in 1977 (Zaitsev, 1977, 1977b). Many researchers have noted that hypoxia and anoxia on the NW shelf are associated with significantly increased anthropogenic eutrophication (Garkavaya et al., 1982). Large-scale bottom hypoxia over several decades covered 1/3 or more of the entire NWBS water area in the summer and partly in the autumn. This phenomenon was especially acute in the 1980s and 1990s.

The need to oxidize large additional masses of autochtonous organic matter in conditions of restrained vertical water exchange usual for the warm period of the year has determined the active formation on the shelf of wide zones of hypoxia/anoxia near bottom waters. This has been observed previously, but it has been episodic-temporally and local-spatiality. Beginning from 1972, when hypoxia was first recorded on large, expanses, the oxygen deficiency in the near bottom layers has been observed almost annually, occupying almost all of the area frum depths of 4 to 20 m between the Dnieper estuaries. Towards the autumn this process spreads to a depth of 40 m in the open sea. Recently, a tendency has been noted for a decrease in the amount of oxygen in the near bottom layer in summer and spreading on the hypoxia zone.

On average, in the summer period of 1988-1989, the amount of dissolved oxygen in the near bottom layer made up1/9 $mg \cdot l^{-1}$, degree of saturation 22 %

The localization of the benthos biomass is generally, determined by the distribution of the plankton biomass in the upper layers of the pelagic zone. As is known (Zenkevich et al., 1971), the main source of food resources for bottom animals is the population of the surface layers of the ocean. The abundance of organisms of various meiobenthos taxa in a given biotope is determined by the presence of a sufficient amount of food available to them and, accordingly, by a more active colonization of various types of substrates.

The development and functioning of meiobenthic animals are closely dependent on biological processes occurring in the surface layers of the pelagic zone Coull, 1999). Therefore, shifts in the structure of pelagic communities subject to eutrophication have a mirror image in the benthal. The concentrations of various compounds in the upper sediment layer, the oxygen regime, and the rate of chemical exchange between sediments and bottom water change (Zaika, 1992). An increase in the flow of settling suspension changes the granulometric composition of sediment toward fine fractions, and silting of the bottom substrate occurs.

For shelf zones, the degree of development of the autotrophic link of the ecosystem is of particular importance. Progressive eutrophication of the northwestern part of the Black Sea has caused profound changes in the species and quantitative composition of phytoplankton in this water area (Ivanov, 1977). In the 1970s, this phenomenon was characteristic mainly of estuarine waters, and later it began to be observed over most of the area of the northwestern shelf.

Our long-term studies in the NWBS have established that when the hydrochemical regime deteriorates, the dominance of individual species or groups of meiobenthos increases. Under current conditions, the dominant nematode-harpacticoid complex of organisms has been replaced by a foraminifera-nematode complex on the entire northwestern shelf. At the same time, foraminifera often accounted for 79.7–80 % of the total population density in the NWBS (1982–1995). With dissolved oxygen content in the

bottom layers of up to 6–9 mg·l^{-1}, the quantitative indicators of meiobenthos are formed by almost all groups characteristic of a given community. (Fig. 2.1, 2.2).

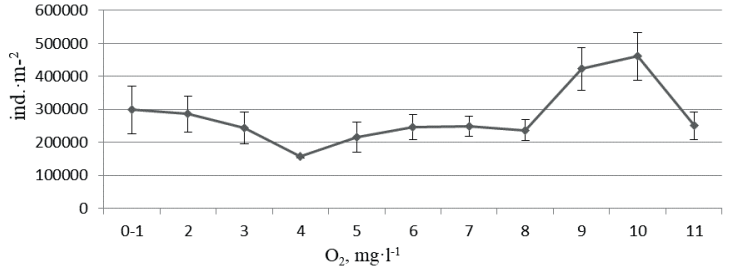


Figure 2.1. Average total abundance of meiobenthos at different oxygen levels at the bottom.

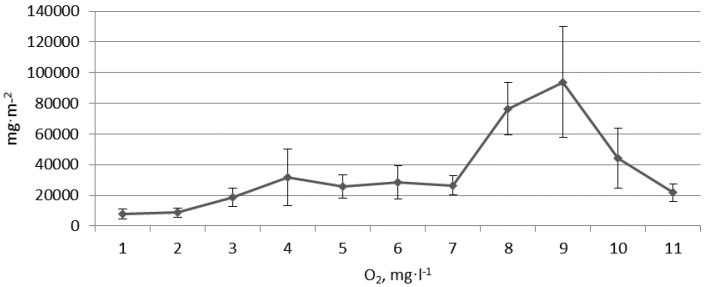


Figure 2.2. Average total biomass of meiobenthos at different oxygen levels at the bottom.

With a low O_2 content in the meiobenthos, small-sized individuals with a short development cycle develop.

The high biomass of meiobenthos under favorable oxygen conditions is an indicator that it is mainly formed by crustaceans and representatives of the temporary component (pseudomeiobenthos).

With oxygen levels from 3.5 to 5 mg·l^{-1}, representatives of five to seven groups are usually present in the meiobenthos. In the meiobenthos of water

areas where the benthic ecosystem experiences significant pressure from various types of pollution, quantitative indicators are 87–100% formed by one or two groups. This is especially typical for estuary areas, bays, estuaries, and gulfs.

There are species of meiobenthos, which not only can withstand hypoxia, but prefer the conditions of acute hypoxia. Our long-term research in the NWBS allowed us to obtain extensive factual material on the study of the features of the formation of the ecological characteristics of the meiobenthos at various oxygen regime indicators in the bottom layers of water. From 1982 to 1998, systematic annual collection of material (in spring, summer and autumn) was carried out to study the meiobenthos of the Ukrainian shelf of the NWBS in complex marine expeditions on research scientific vessels (standard grid – 50 stations). From 1994 to 2017, the reaction of the meiobenthos to the dissolved oxygen content was studied using materials collected in the OMR as an example. A total of 492 quantitative samples were analyzed

Studies in the NWBS (Vorobyova, 1999) showed that with repeated extensive zones of hypoxia and anoxia, the species diversity of Foraminifera sharply decreases, but their population density can reach up to 1-2 million. ind. per sq. m. Scientists have known for a long time that many bottom Foraminifera can live in anoxic conditions. In 2005, unusually high nitrate content in the cytoplasm of Glubobulimina (Foraminifera) was discovered, which live in anoxic conditions at the bottom of the Swedish fjords (Risgaard-Petersen *et al.,* 2006). The authors hypothesized the nitrate respiration of foraminifers, which accumulate a large number of nitrates in their body. Since bottom marine foramirifers living in oxygen-free conditions are very numerous and common organisms, the denitrification they carry out may play a very significant role in the global nitrogen cycle. More primitive forms of nitrate respiration were discovered somewhat earlier.

Many benthic Foraminifera associated with oppressed oxygen environments retain chloroplasts. They provide a metabolic advantage that allows foraminifers to inhabit these habitats. Thus, it has been suggested that many benthic foraminifers are facultative anaerobes (Bernhardt, 1996). It has

now been established that foraminifers can dwell in soil to a depth of 12-15 cm and periodically transfer oxygen-free conditions (Basov and Chusid 1983; Moodley and Hess, 1992). When studying meiobenthos in the northwestern part of the Black Sea, we recorded live Foraminifera in the thickness of the soil up to 10 cm in water areas at depths of 25–90 m (Vorobyova, Kulakova, 2009). The analysis of long-term data allowed us to show the dynamics of the formation of average of Foraminifera abundance at various indices of dissolved oxygen in the bottom layers of water (Fig. 2.3). An analysis of the quantitative indicators of the main taxa of meiobenthos, which form its total abundance and biomass, showed the regularity of this process with different parameters of dissolved oxygen in the bottom layers of water.

To form the ecological characteristics of foraminifera (number, biomass, share in the total number of meiobenthos, etc.), there are two indicator values of dissolved oxygen in the bottom layers of the sea, which determine both the species diversity and the total number of protozoa. The first, which is characteristic of hypoxia (1-4 $mg \cdot l^{-1} o_2$), in which foraminifera are present in the meiobenthos, capable of living at low O_2 levels. The second – 8 $mg \cdot l^{-1}$ O_2 and above, at which oxyphilic species develop.

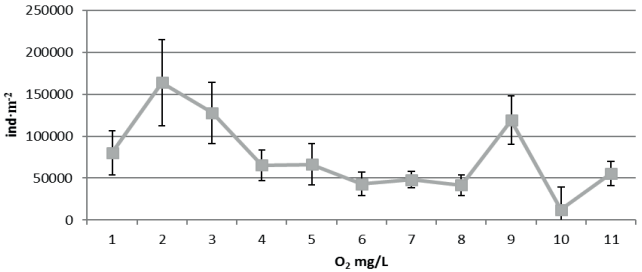


Fig. 2.3. Average indices of the density of Foraminifera settlements (ind.$\cdot m^{-2}$) under different oxygen conditions (Vorobyova, 2021).

As can be seen, a significant concentration of Foraminifera is confined to both very low and high levels of dissolved oxygen. Based on the results obtained, it can be assumed that the first peak is formed by species that

continue to develop during hypoxia. The second peak should relate to oxyphilic species. A similar picture is given for the Sea of Okhotsk (Saidova, 1960), where the author describes two groups of Foraminifera, one of which forms the maximum abundance at a dissolved oxygen content of 4-5 $mg \cdot l^{-1}$ or more, and the second, forming the southern maximum, lives with less dissolved oxygen (about 2-4 O_2 $mg \cdot l^{-1}$).

To determine the significance of foraminifers in the formation of quantitative indicators of small bottom invertebrate animals (meiobenthos) of the OSR ecosystem, we calculated the average indices of portion of Foraminifera in the total number of meiobenthos under different oxygen conditions (Fig. 2.4).

As can be seen, from the presented figure, foraminifers are constantly an essential component of the meiobenthic community of eutrophic water areas of the Black Sea. To some extent they can reflect the quality of the marine environment in the benthal and the formation of quantitative indicators of the rest of the meiobenthic community, which is valuable as a food for young fish and some species of macrozoobenthos.

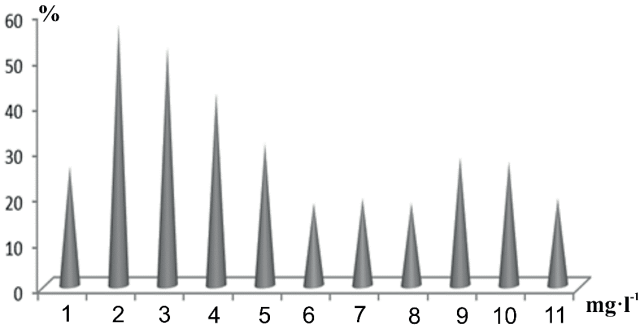


Figure 2.4. Proportion (%) of Foraminifera in the total abundance (ind.·m^{-2}) of meiobenthos under different oxygen conditions. (Vorobyova, 2021).

Nematoda. In order to clarify the distribution boundaries of life on the shelf and beyond, in 1984–1986 we collected samples at depths from 75 to

600 m, covering the lower shelf area and the upper part of the adjacent continental slope of the western Black Sea (Zaitsev Yu.P., Antsupova L.V., Vorobyova L.V. et al., 1987). Representatives of various hydrobionts typical of the Black Sea meiobenthos were found in the samples. However, while most of them were found at depths of 100 m, nematodes of the orders Desmoscolecida and Chromadorida were discovered by Kulakova I.I. at the maximum depth studied – 600 m (Data from Kulakova I.I.). It is evident from the data presented (Table 2.1) that traces of oxygen are still present at a depth of 203 m, and the oxygen-free zone begins deeper. At present, it can be stated that the lower boundary of the meiobenthos distribution is 600–645 m.

Table 2.1.

Vertical distribution of some deep-sea bottom animals in the Black Sea and the conditions of their existence (Zaitsev et al., 1987)

Depth, m	t, ºC	S, ‰	pH	O_2, $ml \cdot l^{-1}$	H_2S, $ml \cdot l^{-1}$	Pigments in the surface layer of sediments, $mg \cdot g^{-2}$	**Nematoda**	
							Number of species	Number $ind. \cdot m^{-2}$
76	7.68	17.86	8.15	4.90	–	0.6	10	12 500
100	7.90	18.02	8.08	4.13	–	0.5–0.9	12	2 400
145	8.55	19.08	7.80	0.27	0.02	0.2–0.3	10	1 900
203	8.73	20.57	7.80	0.10	0.20	7.0	2	1 500
250	9.24	20.89	7.72	0	0.30	2.1	2	500
307	8.83	21.01	7.80	0	0.66	5.9	3	1 500
400	8.90	21.22	7.82	0	2.50	2.1–3.5	2	400
500	8.91	21.30	7.75	0	3.20	2.3	3	500
600	8.90	21.30	7.75	0	3.60	4.1–5.1	2	400

We have proposed several hypotheses. One of them is based on the following conclusions. At all deep-sea stations, increased amounts of carotenoid pigments were found in the surface sediment layer up to 1 cm thick data. The main source of these pigments is phytoplankton cells that have settled to the bottom. However, at depths of less than 100 m, carotenoids are destroyed faster than at 200–600 m; they accumulate, are preserved, and in some cases

form concentrations an order of magnitude higher than in shallow, oxygen-rich shelf area.

With the onset of hypoxia, bottom marine organisms containing a high concentration of carotenoid pigments, such as mollusks, use these compounds as a reserve source of oxygen (Karnaukhov, 1979, 1985). If this is true for nematodes (the individuals found were pigmented), then their presence at depths of up to 600 m may be due to the accumulation of carotenoid pigments here.

Another reason for the introduction of free-living marine nematodes into the anaerobic zone is their assimilation of new food sources, such as, for example, sulfur bacteria and newly synthesized organic substances (Gal'tsova, 1976; Gal'tsova, 1991). Living in a new environment led to adaptations. As V.V. Gal'tsova points out, they developed a new type of ″oxygen-free respiration″, and at the same time, thiobiont forms are capable of switching to the usual aerobic type of respiration in an oxygen environment.

In relation to oxygen, four groups of nematodes have been identified (Boaden, 1977): 1st – oxybionts, 2nd – inhabitants of the transition layer with a reduced content of free oxygen, 3rd – anoxybionts and 4th – facultative anoxybionts. Representatives of the Chromadorida and Desmoscolicida orders, which we found at a depth of 250–600 m, belong to the 3rd group.

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 (Sergeeva, 2000, 2003, Korovchinsky and Sergeeva, 2004) indicate that the deep-water bottom sediments of the Black Sea, which possesses permanent hydrogen sulfide pollution, are the natural habitats for some species of eukaryotic fauna (Protozoa and Metazoa). Accordingsly, it has since been specially stressed that the term “azoic” or “lifeless” is not valid when applied to the anoxic zone of the Black Sea.

Therefore, the completion of the work on the nematodes, the most abundant group metazoan meiobenthos will reveal interesting details of their distribution in the gradient of hypoxia observed with increasing depth of the Black Sea. Now it was detected at depths of 120– 240 m more than 40 forms of nematodes

belonging to one order Desmoscolecida. The maximum size of the group of nematodes honored at a depth of 120–130 m. Permanent hypoxic zone of the Black Sea is an interesting research polygon. Later, in 1987, representatives of meiobenthos (9 species) were discovered at a depth of 300–645 m (Mikhailova, Sergeeva, 1987; Sergeeva, 1988).

There is information (Sergeeva, Kolesnikova, 1996) about the findings of nematodes, harpacticoids and other representatives of the meiobenthos at a depth of more than 600 m, up to 2000 m. The authors cannot state whether these organisms were alive at the time of their discovery or whether they had not yet undergone the process of decomposition. However, the oral report of N.G. Sergeeva (1999) at an international conference about numerous interesting findings at this depth allows us to hope for a new view regarding the vertical distribution of the meiobenthos in the Black Sea. Thus, our assumptions, as well as those of other authors, about the possibility of nematode life in the anoxic zone do not contradict each other, but allow us to consider this hypothesis from several sides.

Our studies have shown that for nematodes, as well as foraminifera, there are two maximum oxygen levels (4 $mg \cdot l^{-1}$ and 8 $ml \cdot l^{-1}$), which determine the formation of the density of nematode taxocene settlements. The maximum average number of nematodes was noted at 1 $mg \cdot l^{-1}$, – 207,056.3±51,388.2 $ind. \cdot m^{-2}$, the minimum – at 4 $mg \cdot l^{-1}$ O_2 – 47,854.5±7,255.7 $ind. \cdot m^{-2}$ (Fig. 2.5).

Their share in the total number of organisms at a content below 4 $ml \cdot l^{-1}$ varied from 31 to 68 % and averaged 47.3 %. With an increase in the content of soluble oxygen in the bottom layers of water, the number of nematodes increases due to the inhabitants of the transition layer with a reduced content of free oxygen (the second group). The maximum indicator is 157,108.1±24,745.0 $ind. \cdot m^{-2}$.

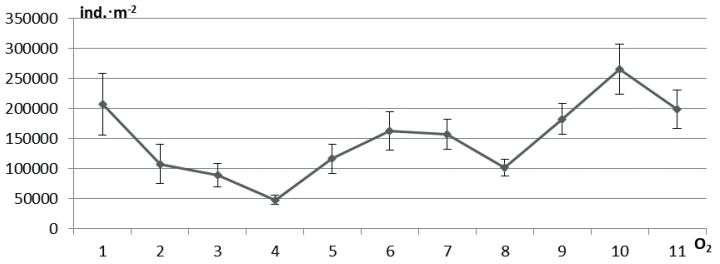


Figure2.5. Average indices of the density of Nematoda settlements (ind.·m^{-2}) under different oxygen conditions.

The minimum density of roundworms was characteristic for 8 ml·l^{-1} O_2 **(**101,572.1±14,527.3 ind.·m^{-2}). The proportion of worms in the total number of meiobenthos varied from 54 to 64 5 % (on average 53.7 %). At high oxygen content, the density of nematodes increases due to the development of oxybiont species. Their proportion in the total number of meiobenthos remains high – on average 53.5 %.

Harpacticoida. All meiofauna appear to have some sensitivity to extended periods of hypoxia, but a wide range in tolerance (from hours to days, weeks or months of exposure) have been observed. Within a given habitat certain species of Foraminifera and Nematoda are typically most tolerant to hypoxia/anoxia while crustacean meiofauna often are the least tolerant. More specifically, the present study harpacticoid copepods as they represent, after nematodes, the second-most-abundant meiofauna group (Giere, 2009) and are known to respond rapidly to hypoxic/anoxic conditions (Modig and Olafsson 1998). Moreover, harpacticoid copepods form an essential link between primary producers and higher trophic levels (Giere, 2009).

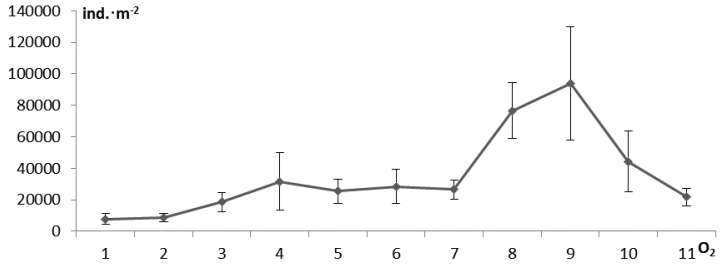


Figure 2.6. Average indices of the density of Harpacticoida settlements (ind.·m^{-2}) under different oxygen conditions.

When considering the significance of harpacticoids in the formation of the total number of meiobenthos, it was shown that their share in it differs significantly and is highest at 4 and 8 mg·l^{-1} of dissolved oxygen (Fig. 2.7.). This confirms our conclusion that for harpacticoids, as well as foraminifera and nematodes, these two indicators are borderline, determining the formation of the main ecological characteristics of these taxa. Most harpacticoid species are very sensitive to the conditions of the surrounding marine environment. In areas experiencing high anthropogenic load, their species diversity and quantitative indicators are extremely poor. Thus, in the Sukhoi Liman, which is in a critical ecological state, Harpacticoida representatives are very rare throughout the entire water area of the liman. Their numbers do not exceed 2,000 ind.·m^{-2}. In the Grigorievsky Liman, the ecosystem of which experiences significant anthropogenic loads, the density of harpacticoid settlements differed sharply and averaged 1.600–24.470 ind.·m^{-2}. Analysis of long-term data on the formation of the number of representatives of the Harpacticoid taxocene showed the following. With a low content of dissolved oxygen in the bottom layers of water (1–3 mg l^{-1}), the average density of crustacean settlements was 11,689 ind.·m^{-2}. It increased sharply at 4 ml·l^{-1} to 31,637.9 ind.·m^{-2}. The average value of the copepod abundance at oxygen of 4–7 mg·l^{-1} was 28,005.1 ind.·m^{-2}. The highest average density of crustacean settlements (Fig. 2.6) was associated with oxygen values of 8-9 mg·l^{-1} (76,399.6±10,961.0 ind.·m^{-2} and 93,890.7±36,112 ind.·m^{-2}., respectively). On

average, for the O_2 range of 8-12 mg·l^{-1}, the abundance of harpacticoids reached an average of 50,934,0 ind.·m^{-2}

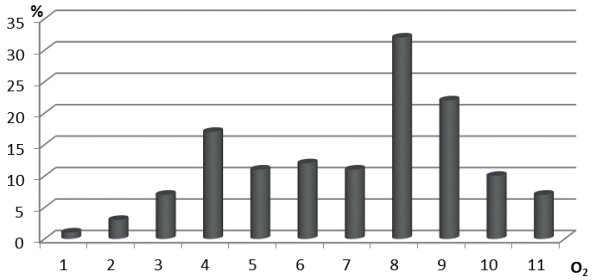


Figure 2.7. Share (%) of Harpacticoidf at different dissolved oxygen content in the bottom layers of water.

Ostracoda. The populations of the Ostracoda taxocene are mostly inhabitants of the upper sublittoral and prefer rocky substrates with an abundant amount of macrophytes on them. They develop well in high-quality environments (Fig. 2.8).

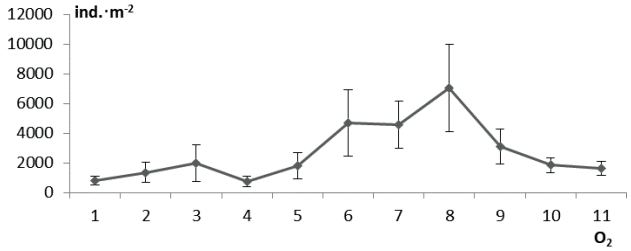


Figure 2.8. Average indices of the density of Ostracoda settlements (ind.·m^{-2}) under different oxygen conditions.

Thus, regular annual sampling on the NWBS for 35 years allowed us to establish the main patterns of formation of the number and biomass of not only the total meiobenthos, but also its main large taxa, which play the main role in the formation of the biodiversity of the meiobenthos and its quantitative

indicators. In addition, a large amount of factual material allows us to assess the quality of the marine environment in the benthal. For this, we used the indices of the ratio of nematodes and harpacticoids at different oxygen regimes in the bottom layers of water. As we can see (Fig. 2.9) on the presented graph, they are highest at a dissolved oxygen content of 1–3 $mg \cdot l^{-1} O_2$.

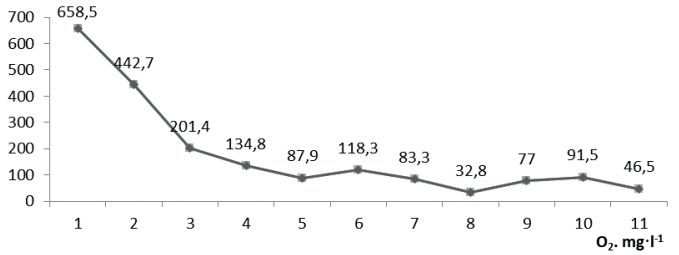


Figure 2.9. Indices of the ratio of Nematoda and Harpacticoida at different oxygen indices.

As is well known, this indicates a critical state of the marine environment. In such a situation, foraminifera-nematode or nematode-foraminifera complex of organisms is usually present in the meiobenthos of the NWBS.

Thus, our long-term research has shown that under hypoxia and even anoxia, the structure of the meiobenthic community of the NWBS changes dramatically. In the second case, meiobenthic biodiversity increases sharply with the development of euryoxybiont forms. However, the total biomass increases only slightly due to the high density of Nematoda and Foraminifera. Harpacticoida account for 10–12 % of the total meiobenthic abundance. In the third case, the meiobenthos is typically represented by stenooxybiont species, and this is where the highest total biomass of the meiobenthic community of organisms occurs.

Thus, our studies have shown that in the bottom layers of water in the North-West Black Sea, two threshold values of oxygen indicators have been identified, which determine the formation of the species richness of the meiofauna and its quantitative indicators.

3.3. Meiofauna of biocenoses of the Ukrainian shelf of the Black Sea.

The first data on the meiofauna of biocenoses off the western coast of Crimea, the Caucasus and in the Bospor Region are in publications of 1965, 1967 (Kiseleva, 1965, 1967) and on the pseudolittoral off the coast of Bulgaria (Marinov, 1975). The study of biocenoses of the northwestern shelf began relatively recently (end of the last century) (Vorobyova, Sinegub, 1986; Vorobyova, Sinegub, Kulakova, 1994; Vorobyova et al., 1996). The study of the meiofauna of various biocenoses of the NWBS became possible thanks to complex expeditions. Meiobenthos sampling was always carried out simultaneously with macrozoobenthos sampling. We used descriptions of biocenoses of the northwestern part of the Black Sea according to I.A. Sinegub.

Biocenosis of **Mytilus galloprovincialis Lamarck.**

In the Dnieper-Bug region, the biocenosis occupied a significant area, mainly in the western, central and southeastern parts. In the Danube-Dniester interfluve – almost the entire Region, with the exception of coastal shallow water areas.

In the mussel biocenosis (research in 1995), meiobenthos was represented by 11 groups: Foraminifera, Nematoda, Harpacticoida, Ostracoda, Halacaridae, Kinorhyncha, Oligochaeta, Polychaeta, juveniles of Bivalvia and Gastropoda, and Balanus larvae. Representatives of eumeiobenthos received the greatest development – up to 99.6 %, where nematodes dominated – 85.5 % of the total number of organisms. For this biocenosis, compared to the others, the minimum average number of meiobenthos representatives was noted. Pseudomeiobenthos was depressed, and juvenile mollusks were practically absent.

The average density of representatives of the temporary component of meiobenthos was 547.7±279.4 ind.·m^{-2}, biomass – 11.2±3.1 mg·m^{-2}. In the formation of general indicators of the density of benthic animals in the mussel

biocenosis, the share of macrobenthos accounted for 15.5 %, meiobenthos – 84.5 %. But the percentage of these two categories of zoobenthos in the formation of overall biomass indicators was 99.27 % (macrozoobenthos), 0.73 % (meiobenthos). The obtained material on the quantitative parameters of meiobenthos in the mussel biocenosis shows that the total number of invertebrates here is relatively low. In the spring of different years, its average values were maximum in 1994, and then decreased from year to year and reached a minimum value in 1996 (Table 3.1).

Table. 3.1.

Average abundance (ind.·m^{-2}) of meiobenthos in the **Mytilus galloprovincialis** biocenosis of the Odesa Region in 1994–1996.

TAXON	1994, May	1994, August	1995, May	1995, August	1996, May	1996, September
Foraminifera	29 972	18 612	12 250	17 225	10 912	10 139
Nematoda	40 333	71 037	43 909	24 075	9 906	45 444
Harpacticoida	25 916	5 350	11 045	21 600	9 625	3 889
Ostracoda	166	125	886	200	75	444
Polychaeta	333	235	954	100	40	1 152
Mollusca	0	100	159	450	3 125	1 100
Permanent meiofauna	98 694	96 037	3 409	2 100	4 500	3 902
Meiofauna (total)	99 056	100 936	65 818	73 900	35 062	72 683

Biocenosis of L **Mya arenaria L.**

The biocenosis formed in the Black Sea relatively recently (Beshevli, Kalyagin, 1964). According to I.A. Sinegub (Vorobyova, Sinegub, 1989) in the Dnieper-Bug region, the Mya arenaria biocenosis occupied a vast area at a depth of 6–20 m on black silts and silted shell rock. In the Danube-Dniester interfluve, the biocenosis occupies a narrow coastal strip (depth 6–12 m) on black silt and silty-sandy soils. In the Mya arenaria biocenosis, a high density of meiobenthos is noted, especially representatives of its permanent component (on average 85.3 % of the total number of organisms). In terms of population density, nematodes dominated (55.8 %), harpacticoids – 24.4 %. In contrast to the mussel biocenosis (Table 3.2), although the occurrence of

foraminifera is high (60 %), their role in the formation of total abundance indicators is insignificant (1.1 %).

Biocenosis **Modiolus phaseolinus (Philippi).**

The most widespread development of the mollusk is typical for a depth of 120 m, where the density of its settlements can reach several thousand specimens per 1 m^2.

Table 3.2.

Average abundance and biomass of the main meiobenthos groups in the biocenosis of the Dnieper-Bug region

TAXON	Average indicators	
	Number, ind.·m^{-2}	Biomass, mg·m^{-2}
Foraminifera	4 576,9 ± 1 345,0	2,1 ± 0,7
Nematoda	290 275 ± 92 750,0	80,4 ± 23,6
Harpacticoida	160 580 ± 72 826,0	962,9 ± 365,2
Polychaeta	10 848 ± 7 077,0	246,9 ± 162,0
Oligochaeta	2 142 ± 1 710,8	5,9 ± 3,0
Mollusca	969 ± 291,8	698,0 ± 21,1

We studied the meiobenthos of the **Modiolus phaseolinus** biocenosis, at a depth of 50–150 m. Foraminifera, Nematoda, Harpacticoida, Halacaridae, Turbellaria, Kinorhyncha, Oligochaeta, Polychaeta, and Bivalvia were found in the **Modiolus phaseolinus**. The most diverse (5–7 groups) meiobenthos is at a depth of 50–70 m. The occurrence of Nematoda in the biocenosis was 100 %, Harpacticoida – 56, Foraminifera – about 40, other groups of eumeiobenthos – from 7 to 25 %. Among the representatives of pseudomeiobenthos, the highest occurrence is of polychaetes (42.3 %), juvenile Phaseolina – 11.5 %, and bivalves – 15.3 %.

As shown (Table 3.3.), the maximum density of pseudomeobenthos is characteristic of a depth of 45–50 m, and the minimum is characteristic of a depth of 80-90 m. Bivalvia is not noted at a depth of 80 –100 m.

Table. 3.3.

Average number (ind.·m^{-2}) of meiobenthos in the biocenosis Modiolus phaseolinus.

Depth, m	Foraminifera	Nematoda	Harpacticoida	Bivalvia	Permanent	Temporary	Meio-(total)
45–50	15 000	220 000	45 000	5 000	295 000	55 000	354 000
50–60	56 400	69 200	16 200	5 000	150 000	20 000	170 000
60–70	12 500	60 000	30 000	12 500	167 000	30 000	197 000
70–80	14 250	105 000	38 000	1 500	161 250	25 000	186 250
80–90	8 000	93 100	6 500	0	100 000	3 000	103 000
90–100	25 000	95 000	5 000	0	122 500	0	122 500

Biocenosis of **Cerastoderma glaucum Poiret** located in the coastal zone of the bay at a depth of 3.5–7.0 m north of the Odesa port and south of Cape Bolshoy Fontan. A characteristic feature is the dominance of harpacticoids – 56.2 %. The subdominant group is nematodes (22.2%). Eumeiobenthos accounted for 83.9 % of the total meiobenthos abundance.

Biocenosis of **Lentidium mediterraneum (Costa)** located in the northern part of the Odesa Bay at a depth of 2.5 m. After the introduction of the bivalve mollusk Mya into the Black Sea, its original area decreased significantly. In shallow water (2.5 m) only five taxa were present in the Lentidium biocenosis: nematodes, harpacticoids, oligochaetes, polychaetes, and larvae of bivalves. The total number of meiobenthos is low – 78,000 ind.·m^{-2}, biomass – 1,201.4 mg.·m2. The dominant group in terms of numbers is harpacticoids (78 %). Pseudomeiobenthos is mainly represented by larvae of Bivalvia.

Biocenosis of **Nereis succinea Leuckart**

A new biocenosis for the northwestern part of the Black Sea was first described by G.V. Losovskaya and L.Yu. Rytikova (1987). We have identified this biocenosis only in the Dnieper-Bug region: located in the north-west of the Odesa Bank (on a sandy shell) and in the central seaward part (on black silts and silted shells). In the Nereis biocenosis, 7 groups of meiobenthos were noted with an average population of 184,660.7 ± 77,249.7 ind.·m^{-2}. Sea mites, Kinorhyncha and Amphipoda were extremely rare and in small numbers. Of the two components of the meiobenthos, 91.7 % was eumeiobenthos, with

harpacticoids playing a significant role here (42 %). As in other biocenoses, nematodes dominated – 54.1 %. The average density of pseudomeiobenthos was 3,300 000 ind.·m^{-2}, mainly due to polychaetes. Mollusks were found in single specimens; oligochaetes were absent.

Biocenosis of **Heteromastus filiformis (Claparede).**

In the northwestern part of the Black Sea, the biocenosis of this Polychaeta is a temporary phenomenon (Sinegub, 1994); it was formed on the site of other biocenoses that disappear due to extensive and prolonged death. In August 1994, the biocenosis of *H. filiformis* was located on muddy soil at a depth of 19–24 m. Meiobenthos is represented by five groups, Kinorhyncha and Polychaeta were recorded as single individuals at one of the stations. Harpacticoida are also rare, their density is low (average 4,166 ind.·m^{-2}). Nematodes and foraminifera were ubiquitous; they accounted for 99.1 % of the total meiobenthos abundance. The density of settlements was dominated by nematodes (225,0–717 50 ind.·m^{-2}), which were 3 times more numerous than foraminifera. The total number varied from 282,0 to 865,0 ind.·m^{-2} (average – 516,250 ind.·m^{-2}), biomass from 72.7 to 616.2 g·m^{-2} (average – 183.6 g·m^{-2}). Thus, a characteristic feature of the meiobenthos biocenosis of *H. filiformis* was the poverty of qualitative composition, a significant predominance of Foraminifera and Nematoda, constituting 88.3–98.8 % of the total number of organisms in different seasons and years.

Biocenosis of **Melinna palmata Grube** noted at a depth of 17 m north of the Odesa Bank on black silts. In terms of population density, nematodes dominated – 81.14 %, 15.4 % of the total number of organisms were Foraminifera. The total number of meiobenthos is quite high – 437,500 ind.·m^{-2}. The main part of the biomass (1,152.6 mg·m^{-2}) was determined by oligochaetes (91.14 %). In the Melinna biocenosis, representatives of meiobenthos predominated in the total number of zoobenthos (85.2 %), and their percentage in the biomass of benthic invertebrates was very high (21.05 %). Thus, in the biocenosis under consideration, meiobenthos is depleted in both qualitative and quantitative indicators. The total number is formed by foraminifera and nematodes (95,000 ind.·m^{-2}). The biomass was

22.2 mg·m^{-2}, i.e., the minimum value for the entire studied area (3.1., 3.2., 3.3., 3.4., 3.5.), end of the last century

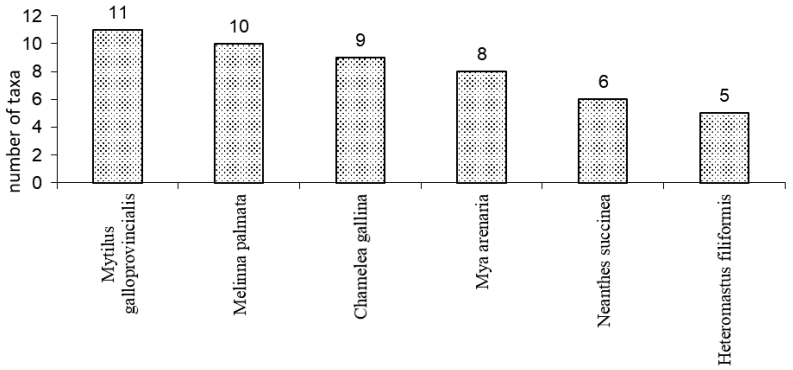


Figure 3.1. The number of large taxa of meiobenthos in the biocenoses of the Odesa Marine Region (end of the last century).

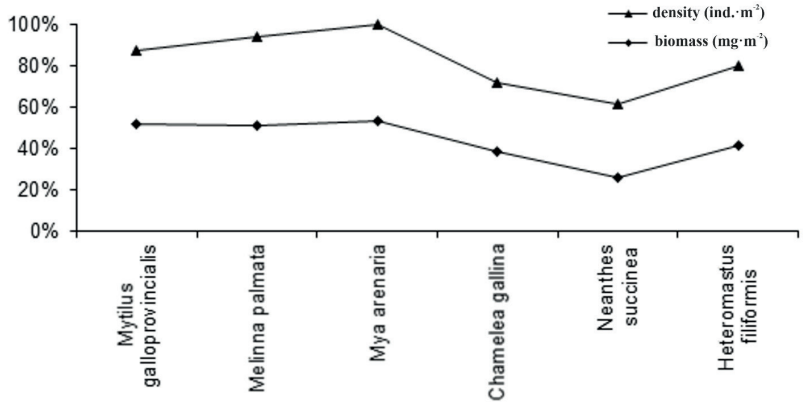


Figure 3.2. Average indicators of the share (%) of settlement density (ind.·m^{-2}) and biomass (mg·m^{-2}) of eumeiobenthos in biocenoses of the Odesa marine region (end of the last century).

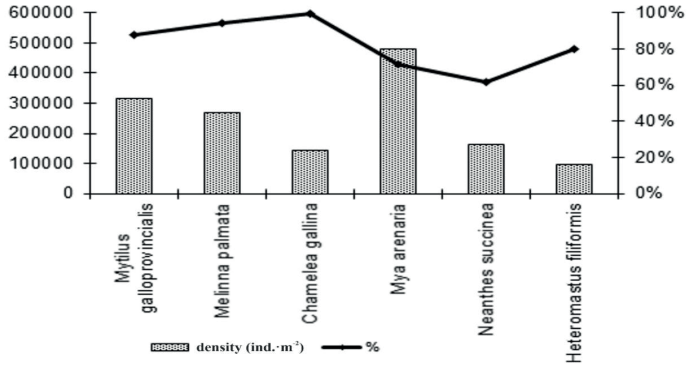


Figure 3.3. Average indicators of settlement density (ind.·m^{-2}) of eumeiobenthos in biocenoses of the Odesa marine region (end of the last century).

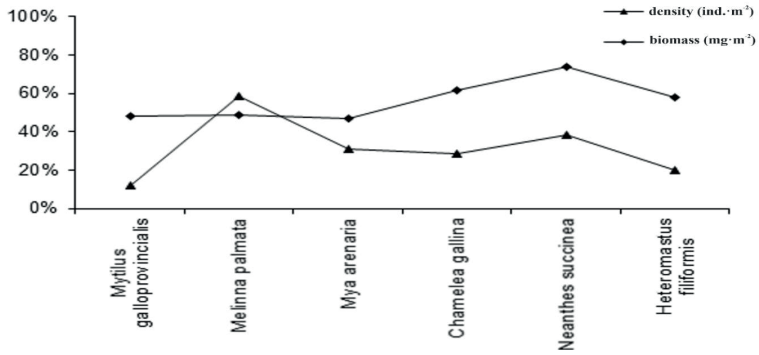


Figure 3.4. Average indicators of the share (%) of settlement density (ind.·m^{-2}) and biomass (mg·m^{-2}) of pseudomeiobenthos in biocenoses of the Odesa marine region (end of the last century)

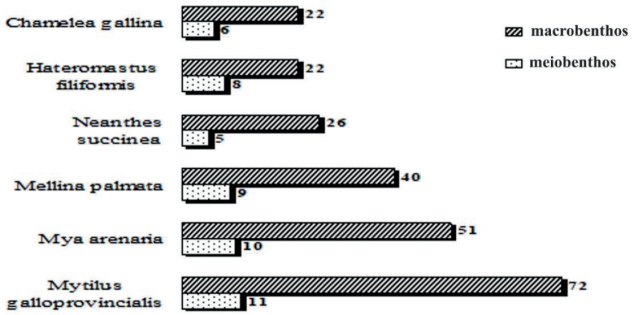


Figure 3.5. Number of meio- and macrobenthos taxa in various biocenoses

Ten years later, a study of the meiobenthos of biocenoses in the Odesa marine region was conducted. The material was the results of processing 122 quantitative samples of macro- and meiobenthos in the OMR 2009 – 2013.

Six types of bottom biocenoses were identified the leading species of which were bivalve mollusks (*M. galloprovincialis, Chamelea gallina* (L.)*, M. arenaria*) and Polychaeta worms (*M. palmata, N. succinea, H. filiformis)*. The largest areas were occupied by biocenoses of *M. galloprovincialis* and *M. palmata*, as well as *Ch. gallina*. In 2009–2013, the highest abundance and biomass indicators were noted in biocenoses in which mollusks were the leading species (Fig.3.6, 3.7).

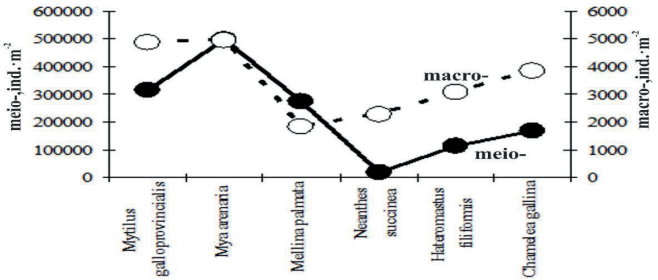


Figure 3.6. Dynamics of meio- and macrobenthos density (ind.·m^{-2}) in various biocenoses

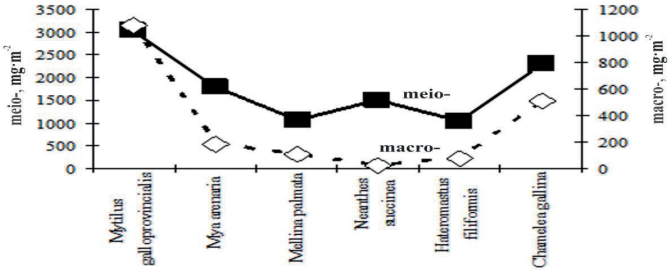


Figure 3.7. Dynamics of meio- and macrobenthos biomass (mg·m^{-2}) in various biocenoses

Biocenosis of ***Mytilus galloprovincialis***. In this biocenosis, compared to the others, the meiobenthos was the most diverse: Foraminifera, Nematoda, Harpaticoida, Ostracoda, Halacaridae, Kinorhyncha, Turbellaria, Oligochaeta, Polychaeta, Bivalvia, Gastropoda (Fig. 3.8).

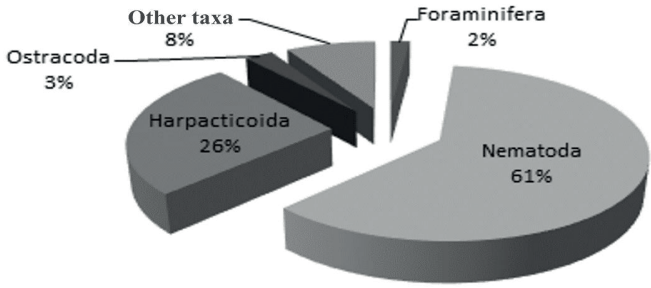


Figure 3.8. Share (%) of the number (ind.·m^{-2}) of various taxa in the mussel biocenosis *Mytilus galloprovincialis* from the total number of meiobenthos

The presence of hard and loose types of substrates allowed the formation of a relatively high concentration of crustaceans: the density of harpacticoids average 94,440 ind.·m^{-2}, ostracods – almost an order of magnitude lower – on

average 8,830 ind.·m^{-2}. It can be stated that the nematode-harpacticoid complex prevailed in the mussel biocenosis. The total number of meiobenthos varied significantly – from 17,000 ind.·m^{-2} to 1,167,500 ind.·m^{-2}, the average is 313,866 ind.·m^{-2}. The total biomass of meiobenthos, as well as the density of meiobenthos settlements varied significantly – from 143.42 mg·m^{-2} to 12,025 mg·m^{-2}. The main contribution to the formation of the total biomass indicator was made by harpacticoids, polychaetes and oligochaetes. Temporary component of meiofauna accounted for 48.2 7 % of the total biomass (1,412.59 mg·m^{-2}).

In the **Melinna palmata** biocenosis, 10 meiobenthos groups were registered during the study period: Foraminifera, Nematoda, Harpaticoida, Ostracoda, Kinorhyncha, Turbellaria, Oligochaeta, Polychaeta, Bivalvia, Gastropoda. Nematodes had the highest population density. Their maximum number was 747,000 ind.·m^{-2} with an average long-term number of 207,607 ind.·m^{-2}. In the *Melinna palmata* biocenosis, the meiobenthos, unlike all other biocenoses, was of a nematode nature. The density of foraminifera and harpacticoid settlements was practically equal (the average number of harpacticoids was 24,985 ind.·m^{-2}, foraminifera – 20,452 ind.·m^{-2}), the share of the named groups was not high – 12.6 % and 9.55% respectively. Representatives of pseudomeiobenthos did not form dense concentrations. The total average density of oligochaetes, polychaetes and juvenile mollusks settlements was at the level of 8,702 ind.·m^{-2}. At 19 % of stations juvenile gastropods were found as single specimens in samples. The average total meiobenthos abundance in the Melinna biocenosis was 276,068 ind.·m^{-2}, with the proportion of its constant component being extremely high – 94.12 %. At 92.85 % of the biocenosis stations, the proportion of eumeiobenthos fluctuated from 88 % to 100 % (Fig. 3.9).

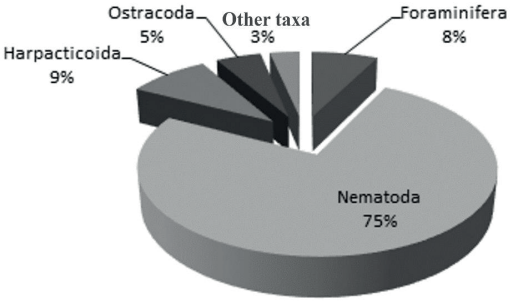


Figure 3.9. Average share (%) of the number (ind.·m^{-2}) of different taxa in the Melinna palmata biocenosis from the total number of meiobenthos.

Biocenosis of ***Chamelea gallina*** within the OMR is distinguished (at a depth of 8–13 m) on sandy soils, in places with an admixture of shells and silt. In the biocenosis *Chamelea gallina*, the meiobenthos was represented by representatives of 9 large taxa: Nematoda, Harpaticoida, Ostracoda, Kinorhyncha, Turbellaria, Oligochaeta, Polychaeta, Bivalvia, Gastropoda. Foraminifera were absent. Two-thirds of the meiobenthos of the biocenosis is represented by its constant component, the rest is represented mainly by polychaetes, the maximum indicator of their density was 44,000 ind.·m^{-2}, and on average – 18,680 ind.·m^{-2}). The participation of various taxa in the formation of the total number of meiobenthos is not uniform (Fig. 3.10). The average total abundance of meiobenthos (16,8817 ind.·m^{-2}) was comparable with that in the Neanthes and Heteromastus biocenoses. The total biomass indicator in this biocenosis was formed mainly by polychaetes (on average 934.0 mg·m^{-2}) and harpacticoids (on average 835.20 mg·m^{-2}). The share of the former in the total biomass was 40.38 %, the latter – 36.1 %. The total biomass indicator was noted at the level of 2,313.89 mg·m^{-2}.

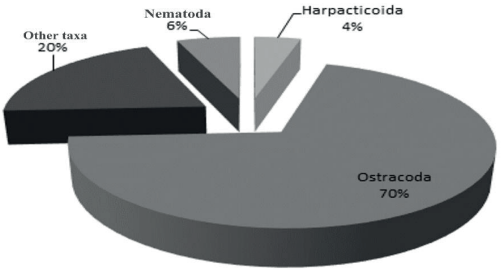


Figure 3.10. Average share (%) of the number (ind.·m^{-2}) of different taxa in the biocenosis *Chamelea gallina* from the total number of meiobenthos.

The meiobenthos of the biocenosis of the **Mya arenaria** biocenosis was represented by 8 groups: Foraminifera, Nematoda, Harpaticoida, Ostracoda, Kinorhyncha, Oligochaeta, Polychaeta, Bivalvia. Kinorhyncha, oligochaetes and mollusks were rarely encountered as single specimens. The main role in the formation of the total biomass of the meiobenthos, despite the comparatively belonged to Harpacticoida, Polychaeta and Oligochaeta – 36.54 %, 29.0 % and 16.25 % respectively (Fig. 3.11). Juvenile bivalves and kinorhynchs were present at one or two stations, as single specimens.

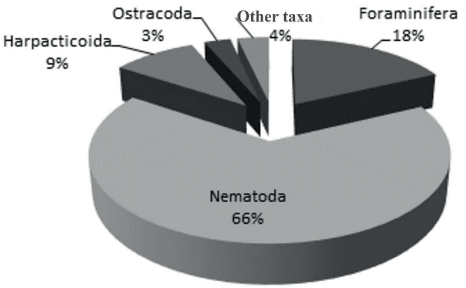


Figure 3.11 Average share (%) of the number (ind.·m^{-2}) of different taxa in the biocenosis Mya arenaria from the total number of meiobenthos.

Biocenosis of ***Heteromastus filiformis*** also refers to temporary biocenoses. The meiobenthos of the *Heteromastus filiformis* biocenosis is represented by five groups: Nematoda, Harpaticoida, Turbellaria, Polychaeta, Bivalvia. Nematodes and harpacticoids were present at all stations belonging to this biocenosis. The average density of nematode settlements was 87,350 ind.·m^{-2} (60.10 % of the total number of meiobenthos). The share of harpacticoids in the total number is significantly lower than that of nematodes – 19.64 % with an average density of 9,700 ind.·m^{-2} (Fig. 3.12). The total number of meiobenthos is not large and averaged 113,250 ind.·m^{-2}, 80.13 % of which was its permanent component.

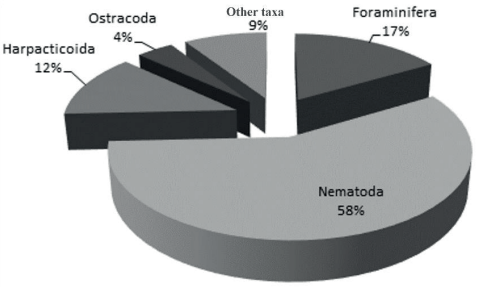


Figure 3.12. Average share (%) of the number (ind.·m^{-2}) of different taxa in the *Neanthes succinea* biocenosis from the total number of meiobenthos.

Among the three groups of pseudo-meiobenthos, relatively larger accumulations were characteristic of polychaetes – 13,550 ind.·m^{-2}. Harpacticoids and polychaetes played the main role in the formation of the total biomass of meiobenthos (average 1,037.15 mg.·m^{-2}). The former accounted for 35.9 % of the total biomass, and the latter 52.52 %. Thus, pseudo-meiobenthos prevailed in biomass in this biocenosis, accounting for an average of 58.2 %.

3.4. Meiobenthos of the Sea Caves of Ukraine.

For the first time, hydrobiological studies were conducted for the Ukrainian shelf of the Black Sea within the framework of a comprehensive scientific research expedition under the program "Sea Caves of Ukraine", which took place from July 24 to August 7, 2010. The object of the study were large semi-submerged grottoes located on the western end of the Tarkhankut Peninsula: "Love", "Chucha" and "Crocodile" and the underwater cave "Tarzanka" in the area of the Atlesh tract. (Vorobyova, Kovtun, Kulakova, L.A. Garlitska and al., 2012).

Underwater caves have long attracted the attention of both scuba divers and hydrobiologists. In the biospeleological literature, the most famous works are those of J. Birshtein (Birshtein, 1985), devoted to the adaptations and evolution of cave animals, including marine ones. However, the vast majority of works are devoted to the study of land and freshwater animals inhabiting caves (Pronin, 2011; Mironov A.N. 2003; Fauna of the caves of Ukraine, 2004). The study of the fauna of sea caves was seriously undertaken only in the second half of the last century, when reliable diving equipment and underwater photo and video equipment suitable for these purposes appeared (Mironov A.N, 2003).

A sharp decrease in the species richness and biomass of marine organisms in cave communities with increasing distance from the entrance to the cave is one of their features (Harmelin,1985). Despite the connection with the sea, the physical and chemical conditions of the environment have formed special conditions and ecological niches in the caves, allowing them to be inhabited, including by a fairly narrow range of stenobiontic organisms that have adapted to life in the dark (Kovtun, 2010).

The meiobenthos of the studied grottoes and caves was represented by its main taxa (Foraminifera, Nematoda, Harpacticoida, Ostracoda, Kinorhyncha, Turbellaria, Oligochaeta Polychaeta, young Bivalvia, Amphipoda, Mysida). Representatives of Nematoda (42 species), Harpacticoida (15 species), eumeiobenthic Polychaeta (8 species) and juvenile

macrozoobenthos polychaetes (pseudomeobenthic) – 12 species, three identified to genus (Table 4.1) have been identified to species level.

Table 4.1.

Species composition of some meiobenthos groups of sea grottoes and caves of the western Crimea (data from Kulakova I.I., Garlitskaya L.A., Bondarenko O.S.)

Taxon	Grotto "Love"	Grotto "Chucha"	Grotto «Crocodile»	«Tarzanka Cave»
Nematoda				
Diplopeltis cirrhatus (Eberth, 1863)			+	
Axonolaimus setosus Filipjev, 1918	+			+
Odontophora angustilaimus (Filipjev, 1918)	+			
Desmoscolex tenuiseta Filipjev, 1922			+	
Paralinhomoeus filiformis (Filipjev, 1918)	+			+
Metalinhomoeus zosterae Filipjev, 1918				+
Metalinhomoeus sp.		+		
Terschellingia pontica Filipjev, 1918		+		
Cylindrotheristus maeoticus (Filipjev, 1922)	м	м		м
Cylindrotheristus oxycercus (De Man, 1888)		+		+
Cylindrotheristus sp.		+		
Monhystera conica Filipjev, 1922	+	+		+
Sphaerolaimus gracilis De Man, 1976		+		
Microlaimus kaurii Wieser, 1954		+		+
Desmodora pontica Filipjev, 1922	+			+
Sabatieria abyssalis Filipyev, 1918	+			
Sabatieria pulchra (G. Schneider, 1906)	+	+		+
Chromadora nudicapitata Bastian, 1865		+		
Chromadorella mytilicola Filipjev, 1918				+
Chromadorita demaniana Filipjev, 1922		+		
Neochromadora poecilosomoides (Filipjev, 1918)		м		+
Spilophorella paradoxa (De Man, 1888)		м		
Spilophorella euxina Filipjev, 1918		+		
Paracanthonchus caecus (Bastian, 1865)	+	+	м	
Halalaimus sp.				+
Anticoma sp.				+
Phanoderma albidum Bastian, 1865			+	
Phanoderma tuberculatum (Eberth, 1863)				+
Oxyonchus dubius (Filipjev, 1918)			+	+
Mesacanthion heterospiculum (Sergeeva, 1974)	+			

Table 4.1 continued

Taxon	Grotto "Love"	Grotto "Chucha"	Grotto «Crocodile»	«Tarzanka Cave»
Enoplus littoralis Filipjev, 1918			м	+
Anoplostoma viviparum (Bastian, 1865)			м	
Anoplostoma sp.		+		
*Viscosia elongat*a Filipjev, 1922		+		+
Viscosia minor Filipjev, 1918	+	м		м
Viscosia cobbi Filipjev, 1918				м
Metoncholaimus demani (Zur Strassen, 1894)				+
Metoncholaimus sp.n.				+
Oncholaimus brevicaudatus Filipjev, 1918		+		+
Oncholaimus campylocercoides Con et. Stekhoven, 1933		+		м
Oncholaimus dujardinii De Man, 1876			+	
Oncholaimus sp.n.		+		
Polychaeta				
Phyllodocidae g. sp.*	+			+
Nephtys hombergii Savigny, 1818*				+
Pholoe synophthalmica Claparède, 1868*				+
Nereidae g. sp. *		+		+
Syllides longocirrata Oerstéd, 1845				+
Brania clavata (Claparède, 1863)		+	+	+
Sphaerosyllis hystrix Claparède, 1863	+	+	+	+
Syllidae g. sp. *		+		+
Microphthalmus sczelkowii Metschnikow, 1865				+
Microphthalmus fragilis, Bobretzky, 1870*				+
Microphthalmus similis Bobretzky, 1870*				+
Dorvillea rubrovittata (Grube, 1855)*				+
Schistomeringos rudolphi (Delle Chiaje, 1828)*				+
Protodorvillea kefersteini (McIntosh, 1869)*				+
Nerilla antennata O. Schmidt, 1848			+	+
Polygordius neapolitanus Fraipont var. *ponticus* Salensky, 1882				+
Protodrilus flavocapitatus (Uljanin, 1877)				+
Pseudomalacoceros tridentata (Southern, 1914)*		+		
Spio filicornis (Müller, 1776)*				+
Prionospio cirrifera Wiren, 1883*	+	+	+	+
Aricidea claudiae Laubier, 1967*		+		
Capitella capitata capitata (Fabricius, 1780)*		+		+
Janua pagenstecheri (Quatrefages, 1865)				+
Harpacticoida				
*Ameira divagans a*f. p*ontica* Nicholls, 1939a				+
Ameira parvula (Claus, 1866)	+	+		+

Table 4.1 continued

Taxon	Grotto "Love"	Grotto "Chucha"	Grotto «Crocodile»	«Tarzanka Cave»
Filexilia brevipes (Kunz, 1954)				+
Canuella sp.	+	+		+
Enhydrosoma caeni Raibaut, 1965	+	+	+	
Enhydrosoma propinquum (Brady, 1880)			+	
Ectinosoma melaniceps Boeck, 1865	+	+		+
Halectinosoma curticorne (Boeck, 1873)		+		
Harpacticus genus				+
Bulbamphiascus imus (Brady, 1872)			+	
Haloschizopera pauciseta Por, 1959a		+		
Robertgurneya similis Noodt, 1955c	+	+		+
Orthopsyllus linearis (Claus, 1866)				+
Parastenhelia spinosa (Fischer, 1860)				+
Tisbe genus				+

+ – the presence of the species, **м** – mass species, *

Nematoda, Harpacticoida and Polychaeta were present everywhere. Ostracoda were found in the Crocodile Grotto and Tarzanka Cave. Turbellaria are also common. The greatest species richness of nematodes, harpacticoids and polychaetes was noted in Tarzanka Cave (Vorobyova L.V., Kovtun O. A., Kulakova and al., 2012).

Free-living nematodes found in the grottoes and cave belong to 6 orders, 18 families and 29 genera (data by I. I. Kulakova). The order Enoplida dominates in the number of species (18). Of these, the following species predominate both in frequency and in quantity: *V. minor, V. cobbi and O. campylocercoides.* There were 9 representatives from the order Monhysterida with *N. poecilosomoides* dominating in quantity and from the order Chromadorida with *C. maeoticus* dominating in quantity and occurrence. The remaining orders are represented by 1–3 species.

Nematoda (11 species, of which the most common is *C. maeoticus*, Harpacticoida (6 species), Ostracoda, Kinorhyncha, Polychaetes (1 eumeiobenthic and 5 pseudomeiobenthic species), Turbellaria, juvenile Amphipoda and a representative of the macrozoobenthos *E. valkanovi*, which was previously only reported for the Bulgarian coast, were found in the meiobenthos of the psammali of the Love Grotto. The largest number of

individuals was noted at the entrance to the grotto – 380 ind.·50 cm^{-3} in the sample, the minimum – in the shaded part of the cave in very fine sand, where harpacticoids, ostracods and polychaetes were noted from the meiobenthos representatives, 20 ind.·50 cm^{-3}.

Three samples were taken from the sandy substrate of the Chucha grotto: one at the entrance and two in a dark blind branch. It should be noted that at the entrance to the grotto, the meiobenthos was poor in both qualitative and quantitative terms. Only nematodes were significantly developed here. At the entrance, they were represented by 10 species and 13 in the blind branch. At the entrance to the cave, representatives of the species *C. maeoticus* and V. minor significantly predominated in numbers. *N. poecilosomoides* dominated at the entrance to the blind branch, and *V. minor* was abundant in both areas. Four species of Harpacticoida and six species of young individuals of macrozoobenthos polychaetes were found.

In the dark part of the "Crocodile" grotto on the sandy ground, nematodes, harpacticoids, ostracods, polychaetes, halacarids, young bivalves and anisopods (*L. savignyi*) were found. Among the small variety of nematodes (8 species), *E. littoralis* dominated in numbers, as well as *A. viviparum and P. caecus*. Polychaeta were present everywhere

In the Tarzanka Cave, the meiobenthos was represented by the largest number of taxa: Nematoda (24 species), Harpacticoida (7 species, most of which were found five meters from the entrance), Ostracoda, Kinorhyncha, Halacaridae, Turbellaria, Oligochaeta, Polychaeta (4 eumeiobenthic and 7 pseudomeiobenthic species), juvenile Bivalvia, many juvenile mysids (*Hemimysis lamornae pontica*), cumaceans (*Cumella limicola*). Among the nematodes, *V. cobbi, On. campylocercoides and C. maeoticus* were common. At the entrance in the surf zone, nematodes predominated (8 species), among which *On. campylocercoides and C. maeoticus* were common. Harpacticoids were represented by 4 species. The area located at the entrance to the cave has the highest diversity of meiobenthic Polychaeta (18 species) among other grottoes, of which eight species are a permanent component of the

meiobenthos (eumeiobenthos) and 10 are representatives of pseudomeiobenthos.

On the surf side, in the dark part of the cave, juvenile mysids *H. lamornae pontica*, juvenile bivalves, turbellarians and water mites were noted. At the entrance to the cave and at a distance of 5 m into it, the number of meiobenthos organisms was 800 ind. and 640 ind in the sample. As you move away from the entrance (10 m, diffused light), the diversity and number of meiobenthos decreases. Here, mainly polychaetes, turbellarians, harpacticoids and a large number of juvenile mysids are present. At a depth of 5 meters, in a zone where there is no light and it is constantly dark, nematodes, polychaetes, turbellarians, sea mites and juvenile macrozoobenthos were found in small quantities – *Nannastacus euxinicus* from Cumacea and from the Isopoda *Cynathia (Elaphagnathia) bacescoi nom. nov.*Recently, they increasingly talk not about cave marine fauna, but about the so-called hidden fauna of marine shelters, which, in addition to stygobionts (inhabitants of cave reservoirs, including groundwater), includes animals inhabiting deep crevices, hidden from external view spaces formed by rock overhangs and coral reefs (Klimchuk, 2007*)* Faunal studies of coastal grottoes and caves of the Tarkhankut Peninsula are still far from complete. Further study of invertebrates – inhabitants of underwater caves in our region will reveal patterns of spatial variation of their fauna and its connection with the surrounding landscapes, the dependence of the population structure on the morphology of karst cavities, their microclimate, hydrodynamic regime and other important characteristics, to establish the features of its seasonal and, in the future, long-term dynamics.

3.5. Interannual dynamics of meiobenthos in the North-West Black Sea

The results of the analysis of long-term studies of the meiobenthos of the northwestern shelf of the Black Sea (1994–1999 and 2005–1015) are presented. It has been shown that the formation of the meiobenthic community depends not only on such environmental factors as the type of substrate,

salinity, oxygen regime, and depth. The formation of its qualitative and quantitative characteristics is also influenced by periodic changes in climatic conditions. These changes are associated with changes in the processes that take place in the near-surface layers of marine areas.

Meiobenthos is a grouping of marine organisms that is able to quickly respond to both acute and chronic environmental stresses. In addition, the formation of its qualitative and quantitative characteristics is influenced by periodic changes in climatic conditions and related changes in the ecosystem of the reservoir. The development and functioning of meiobenthic animals is closely dependent on the biological processes that occur in the surface layers of the pelagial. Changes in the abiotic parameters of the marine environment lead to a significant restructuring and functioning of the entire benthic community of organisms. Changes in the structure of eutrophic pelagic communities are reflected in the bottom layers.

Shifts in the abiotic parameters of the marine environment entail significant changes in the structure and functioning of the entire benthic community of organisms. Their strengthening in the negative direction is especially clearly pronounced in the northwestern part of the Black Sea. Here extensive hypoxia fields with extensive fields of hypoxia with periodically recurring anoxia.

Meiobenthos, having a high fecundity, as a rule, a short life cycle and a fast growth rate, is capable of restructuring its structure and its functional indicators. It is believed that abnormal climatic conditions were observed in 1994, 1998, 2005–2006 and 2009–2010.

It is known that the northwestern part of the Black Sea is a highly eutrophic water area influenced by the flows of three large rivers (Danube, Dnieper and Dniester). Their waters flow through highly urbanized areas and countries with highly developed agriculture.

In this chapter we paid attention to the influence of anomalous external abiotic factors (water temperature, precipitation, runoff volume of the Dnieper River) on meiobenthos. As mentioned, our data refer to 15 years of observations – 1994–1999 and 2005–2015 (Vorobyova, Bolchakov, 2023).

Climatic conditions during this period underwent significant fluctuations. It is believed that they were anomalous in their characteristics in 1998, 2005–2006 and 2009–2010. This is evidenced by indicators of external abiotic factors. Water temperature, precipitation and river runoff. Dnieper. They are given according to the measurements of HMS Odesa-port (Fig. 5.1). The water temperature during the period under consideration varied significantly and its maximum values were noted in the years indicated above. 2010 was remembered for long summer water temperature anomalies. For example, in 2010 the anomaly was 22 %. And in addition, this year was a record year in terms of precipitation (709 mm).

It is known that the summer significant development of diatoms water plant as a signal for the development of copepods, followed by oligochaetes, nematodes, ostracods and others (Gerlach, 1978). At the same time, shifts in the structure of pelagic groups subject to eutrophication are mirrored in the benthal zone.

The concentrations of various compounds in the upper sediment layer change, the oxygen regime and the rate of chemical exchange between sediments and water change. The ecosystem of the Odesa Sea Region is also affected by the runoff of the river Dnieper. The transformed waters of the Dnieper carry million tons of organic matter out of the Dnieper-Bug Estuary. Such number of organic substances in the NWBS leads to a deterioration in the oxygen regime at the bottom, hypoxia and anoxia. The given graph testifies to its dynamism of its runoff (Воробьева, Большаков, 2023).

A significant impact of freshwater runoff is reflected in the ecological structure of phytoplankton. In the spring and summer periods, diatoms and freshwater unicellular algae, freshwater-brackish-water species (42.2 %) are massively developed in the desalinated near-surface layer of water. In its composition, along with marine and brackish-marine species, there are numerous freshwater and freshwater-brackish-water species (Nesterova 2017). The author points out that the analysis of the obtained data showed that the highest phytoplankton numbers were in 2005 during a strong water "bloom" caused by an outbreak of freshwater blue-green algae. At the same time,

diatoms and dinophytes intensively developed in the composition of phytoplankton. An increased abundance of freshwater green algae was noted in 2006 and 2010 and 2013 in the summer. This is due to the approach of desalinated water from the Dnieper-Bug estuary. There are increased indicators of the total annual runoff of the river. Dnieper in the anomalous years we are considering. So, in 1998-1999 the annual runoff amounted to 58.41–57.27 km^{-3}, respectively. This is one third higher than the established norm for 1994–2000. In 2006, the annual runoff (49.29 km^{-3}) exceeded the established figure by 8 cubic km, which is also typical for 2010.

During these years the abundance of meiobenthos was the highest due to the mass development of small organisms with a short development cycle (Fig.5.1.).

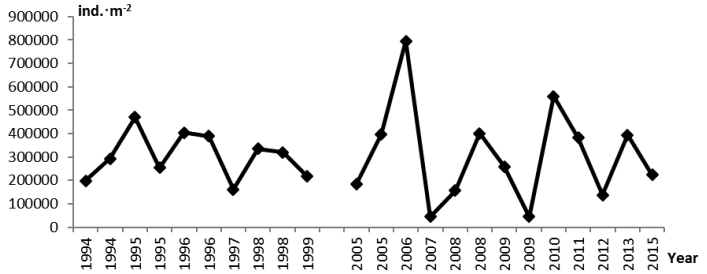


Figure 5.1. Interannual dynamics of the total abundance (ind.·m^{-2}) of meiobenthos

As indicated, the analysis of long-term data showed that in these years the protozoa (foraminifera) and nematodes had the greatest development (Fig.5.2.). It should be noted that, for example, in 2006, these two groups of eumeiobenthos accounted for 76.2 % of the total number of meiobenthos. Among the representatives of temporary component of the meiobenthos only oligochaetes and polychaetes achieved insignificant development.

At the end of the last century the formation of quantitative indicators of meiobenthos was maximum in 1995–1996 and in 1998. The meiobenthos was

dominated by a foraminifera-nematode complex of organisms with a small number of harpacticoids.

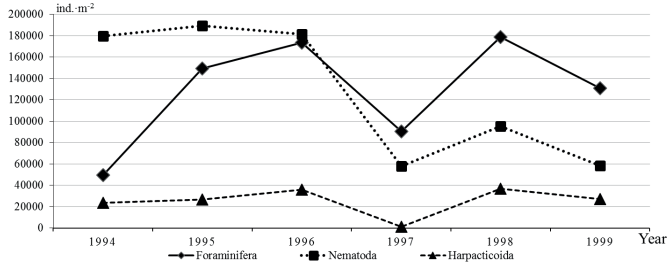


Figure. 5.2. Long-term dynamics of the abundance (ind.·m^{-2}) of Foraminifera, Nematoda and Harpacticoida.

The dominance of Foraminifera in the meiobenthos indicates a high concentration of organic matter near the bottom and a very poor oxygen regime (hypoxia).

In the same three years, the maximum numbers of nematodes are typical (Fig.5.3.). Harpacticoids formed 0.7-9.1 % and in 1998–1999 – 11–12 % of the total number of meiobenthos. The share of these three groups in the six years under consideration was 92.3–98.9 %. Other representatives of the meiobenthos were noted in the samples as single specimens.

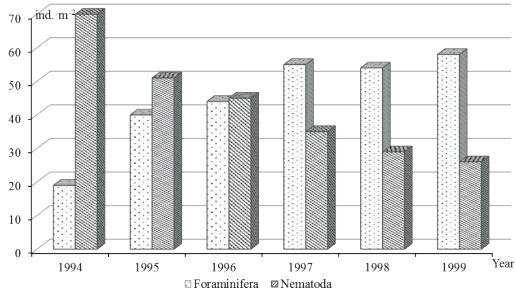


Figure 5.3. Long-term dynamics of the abundance (ind.·m^{-2}) of Foraminifera, Nematoda.

As the analysis of the material showed at the end of the last century and in the first decade of the present, the maximum indicators of pseudo-meiobenthos were in 2006 and 2010 (Fig. 5.4).

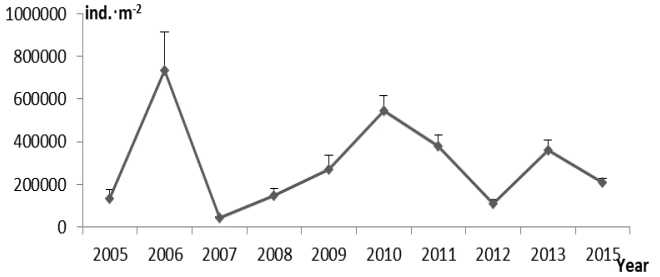


Figure 5.4. Long-term dynamics of the abundance (ind.·m^{-2}) of permanent meiofauna.

However, it can be stated that in 2005–2015 the quality of the environment in Bentali improved somewhat compared to the end of the last century.

As we can see, in 2005–2006, foraminifers took the greatest part in the formation of the total abundance of meiobenthos, accounting for 59.0 % of its total abundance. In the remaining ten years, the proportion of foraminifers in the total abundance of meiobenthos was low (up to 5 %); in 2009 and 2015 it was 11 % and 12.1 %, respectively. It can be assumed that in 2005–2006 the mass development of unicellular algae in the near-surface water layers was the strongest, and in the benthal the accumulation of organic matter was higher than in 2009–2010. And this contributed to the massive development of protozoa in the meiobenthic community of organisms. Thus, if in 2005–2006 the foraminiferal-nematode complex of organisms prevailed, then in 2009–2010 the nematode-harpacticoid complex.

Having annual sampling in summer periods, we could conclude that the maximum density of foraminifera in this period was typical only for 2005–2006. (Figure 5.5).

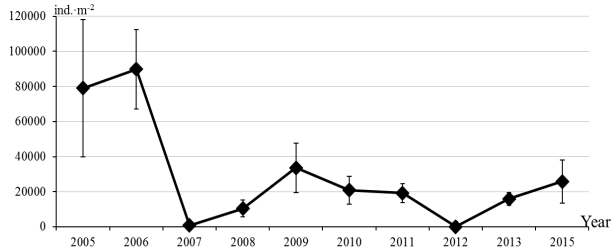


Figure 5.5. Long-term dynamics of the abundance (ind.·m^{-2}) of Foraminifera in different year.

In all years, nematodes dominated in abundance, making up most of the total abundance of meiobenthos – 55,5-80 % and only in 2011 – 48 % of the total abundance. Most species are characterized by a mixed diet. For this, in the northwestern part of the Black Sea, hyper eutrophication creates favorable conditions for the mass development of free-living marine nematodes. The density of nematode settlements reached its maximum values precisely in anomalous years. In 2006 it was 447,086.4±86,885.7 ind.·m^{-2}. In 2010 it was the same as in 2006 – 445,762.5±63,305.3 ind.·m^{-2}. In all other years, it was many times lower (Fig. 5.6).

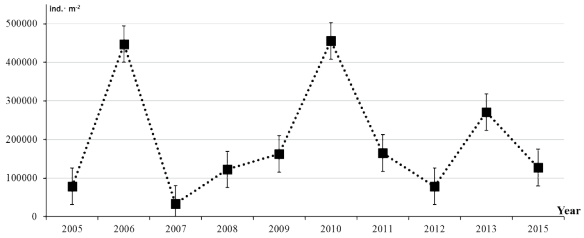


Figure 5.6. Long-term dynamics of the abundance (ind.·m^{-2}) Nematoda in different year.

Representatives of the taxocene Harpacticoida are a subdominant group of meiobenthos in terms of abundance. Their maximum numbers are typical for years associated with abnormal climatic conditions (Fig. 5.7). Their indicators in these years were sometimes 5–9 times higher than in all other years.

In anomalous years, mass sedimentation of microalgae (mainly diatoms) occurs from the near-surface layers of the sea and their further decomposition. At the bottom, this process occurs with a high consumption of oxygen, the creation of hypoxia and the massive development of bacteria and protozoa. Harpacticoids are known to feed mainly on bacteria, protozoa, and diatoms. They collect them from detritus or nibble off algae and grains of sand (Coull 1999, De Troch *et al.* 2005). It is indicated that under certain conditions, harpacticoids can eat from 68 % to 100 % of the biomass of microphytobenthos (Carman *et al*. 1997). A favorable condition for copepods is the presence of a mixture A favorable condition for copepods is the presence of a mixture (Lee *et al.,* 1985) of microalgae (green, blue-green and diatoms). As the author's experiments have shown, the highest survival rate of Harpacticoda up to 100 % is observed on diatom microalgae due to their high nutritional value for crustaceans (Coull, 1999).

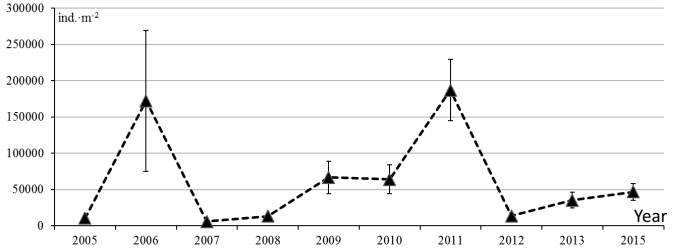


Figure 5.7. Long-term dynamics of the abundance (ind.·m^{-2}) Harpacticoida in different year.

Only in 2011 they dominated in terms of population density (average 178,130.5±42,484.7 ind.·m^{-2}).

However, it can be stated that in 2005–2015 the quality of the environment in the benthal zone improved partly compared to the end of the last century. All other representatives of large taxa (Ostracoda, Halacaridae, Kinorhyncha, Turbellaria, Gastropoda) played a very small role in the formation of the total abundance of meiobenthos. These characteristics (extremely low abundance of crustaceans and juvenile mollusks or their absence) indicate a sharp deterioration in environmental conditions near the bottom and indicators of the food supply for juvenile fish. This situation may affect the conditions of survival and further development of larvae and juveniles of the ichthyofauna.

The density of settlements of benthic foraminifers in the years with anomalous climatic characteristics was higher than in all other years. For example, in 2005 and 2006 their abundance was 78,994.5±39,006.1 ind.·m^{-2} and 89 830.0±22,723.4 ind.·m^{-2}, respectively, and in 2008 and 2009 their abundance was 10,450.0±4,854.0 ind.·m^{-2} and 32,642.9±14,153.6 ind.·m^{-2}, respectively. Foraminifera took the greatest part in the formation of the total abundance of meiobenthos in 2005–2006 and 2009–2010.

As the analysis of the material showed at the end of the last century and in the first decade of the present, the nematode-foraminiferal complex of organisms prevailed in the meiobenthos. It can be stated, that in 2005-2015 the quality of the environment in the benthal zone improved partly compared to the end of the last century.

As can be seen from the presented graph, the maximum density of harpacticoids is confined to the years of the highest temperatures of the surface layers of water and the runoff of the river Dnieper. Under these abiotic factors, a massive development of unicellular algae occurred, which, after dying off, settled to the bottom. They enriched the bottom substrates with organic matter. The same is typical for long-term indicators of the abundance of juvenile polychaetes, which, by their body size belong to the temporary meiobenthos pseudomeiobenthos (Fig, 5.8).

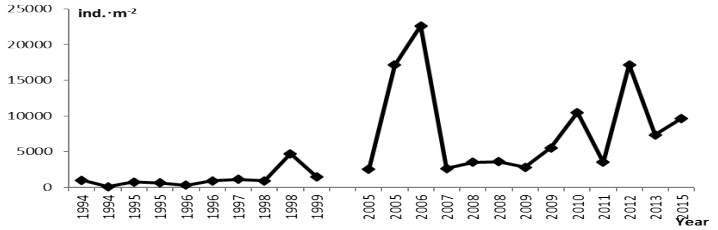


Figure 5.8. Long-term dynamics of the abundance of Polychaeta (ind.·m^{-2}).

We used indicators of the ratio of nematodes to harpacticoids (N_{nem}/N_{harp}). There is evidence in the scientific literature that this indicator can be used in determining the quality of the marine environment (Warwick 1981; Raffaelli, Mason 1981). These authors propose to use the nematode-copepod ratio as an indicator of organic pollution, at which it greatly increases. We have repeatedly used this indicator. It is shown that in water areas subject to strong anthropogenic pollution, this indicator is very high. Our long-term studies in the waters of the northwestern shelf have shown that with a large amount of organic matter in the benthal, the indicators of dissolved oxygen are sharply reduced. The processes of hypoxia are developing. When the content of dissolved oxygen is below 4 mg/l, harpacticoids are found in small quantities (Vorobyova 1999). But the development of nematodes remains at a high level. They become the dominant group of meiobenthos in terms of numbers. In 1994, the average index of the nematode/copepod ratio was 748.7. At the same time, the average abundance of nematodes (180,310 ind.·m^{-2}) and foraminifers (146,500.0 ind.·m^{-2}) totaled for 89.3 % of the total abundance of meiobenthos. In 1998, the abundance of nematodes (996,014) and foraminifers (183,386.0 ind.·m^{-2}) were 85.0% of the total abundance of meiobenthos. In 2005-2006, the indices N_{nem}/N_{harp} were 497 and 469.0, respectively, in 2009 – 204.0, and under normal climatic conditions in 2015 only 6.0 (Figure 5.9).

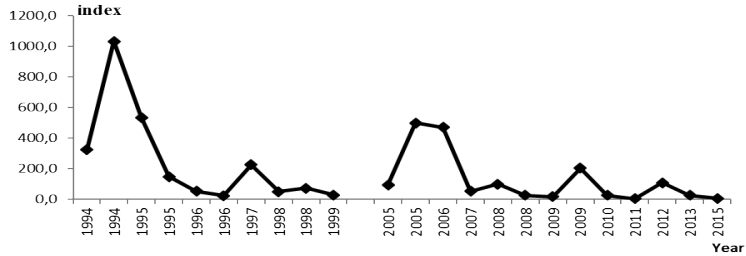


Figure 5.9**.** Ratio indices of abundance (ind.·m^{-2}) Nematoda to abundance (ind.·m^{-2}) Hrpacticoida (N/H), in the Northwestern part of the Black Sea

When comparing the indicators of the ratio of the number of nematodes to the number of harpacticoids and the total number to the total biomass of meiobenthos over 15 years. We can say that the ecological situation of the marine environment in the northwestern part of the Black Sea in the current century has somewhat improved compared to the end of the last century. This is also evidenced by a significant increase in the density of Harpacticoida settlements. In an unfavorable period, the total number of meiobenthos increases sharply, and its biomass indicators fall. The ratio of total abundance and biomass (N_{tot}/B_{tot}), which we used, indicates the mass development of small short-cycle taxa. In our case foraminifera and nematodes. So, in 1994 this index was 1252.1, in 1997 – 1644.6, and in 1998 it was reduced to 229.3. In 2006, this index was 446.5, in 2010 – 583.0, in 2012 – 118.2 (Fig. 5.10).

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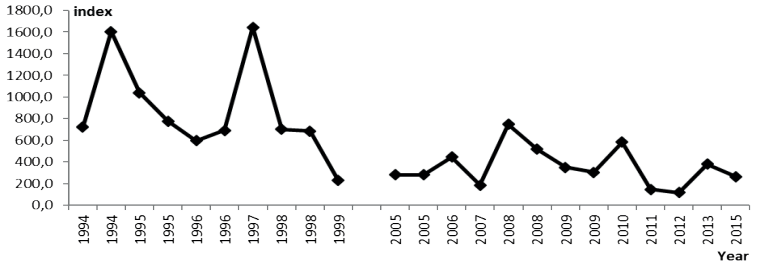


Figure 5.10. Ratio indices of abundance (ind.·m^{-2}) and biomass (mg·m^{-2}) – (N/B) of meiobenthos in the Northwestern part of the Black Sea

Thus, the study of the ecological state of the pelagial and benthal of the northwestern shelf for 15 years made it possible to focus on changes in the meiobenthos parameters under abnormal climatic conditions. An analysis of the indicators of meiobenthos showed that at the beginning of this century, the ecological situation in the considered water area improved somewhat compared to the end of the last century. However, this water area remains a eutrophic zone at the present time. This is especially true for the bottom zone. Our long-term observation of the formation of the meiobenthic community of organisms showed that under chronic anthropogenic impact, the species diversity of meiobenthos in the NWBS is sharply reduced, the dominance of the main groups (Foraminifera and Nematoda) and meiobenthic species increases (Vorobyova,1999). Previously, using the example of the Odesa marine area, it was shown that at a depth of more than 10 m, nematodes dominate on all types of bottom sediments (Vorobyova et al. 1917;). The data obtained show that for years with anomalous climatic conditions, the maximum indicators of the nematode/copepepod ratio are characteristic, it increases, the total number of meiobenthos increases, and the biomass decreases. These trends are typical for many marine ecosystems (Odum, 1986). Biological processes that take place in anomalous climatic years in the water areas under consideration further increase the negative consequences for the quality of the marine environment and the development of benthic communities of invertebrates. It will take more than one year with normal climatic indicators to improve the situation.

3.6. MEIOBENTHOS OF THE CRIMEAN SHELF OF THE BLACK SEA

In 1988–1998 we conducted a study of the meiobenthos of the Crimean shelf. Samples were taken from the research vessel «Professor Vodyanitsky». The most complete survey was carried out in 1988 (Vorobyova, 1999).

Western coast of Crimea. The formation of the water structure in the area is influenced by waters coming from the west and northwest. Three zones

are distinguished in the bottom layer of the western shelf of Crimea: northern coastal (up to the 50-meter isobath), central (up to the 100-meter isobath) and southern (Tereshchenko et al., 1992). The area under consideration is dominated by silts with admixture of *Modiolus phaseolinus* valves. During the study period, the bottom temperature was 6.9–7 ˚C, salinity – 17.98–18.05 ‰. Samples were collected at a depth of 50–200 m.

The depth of 60–125 m is occupied by the *Modiolus phaseolinus* biocenosis, which is characterized by a relatively high number of meiobenthic organisms – an average of 39,200 ind.·m^{-2}.

Our studies were conducted at depths from 50 to 260 m. Samples were collected at three transects located perpendicular to the shore: I – western, II – central and III – eastern.

Foraminifera, Nematoda, Harpacticoida, Kinorhyncha, Oligochaeta, Polychaeta, Turbellaria, and juvenile Bivalvia were noted at various depths. All of the above-mentioned meiobenthos groups were found at depths of up to 50 m. Four to five groups were typical for depths of 50–75 m, and two to three for depths of 90 m, with only nematodes occurring at 100 percent frequency.

The meiobenthos is most diverse in the central section. According to N.P. Tereshchenko (1992), the main reserves of *Modiolus phaseolinus*, which actively participate in the processes of filtration and biosedimentation, are currently located here. The decrease in the number of mollusks and the degradation of the biocenosis in the western and eastern areas of the polygon reflect negative processes in the benthal ecosystem and, accordingly, affect the quantitative and qualitative indicators of the meiobenthos.

The total meiobenthos abundance was unevenly distribute and varied considerably even within the same depth range: at a depth of 50 m – from 17,500 to 345,000 ind.·m^{-2}, 50–100 m – from 30,000 to 23,500 ind.·m^{-2}, up to 150 m – from 35,000 to 150,000 ind.·m^{-2}. The maximum meiobenthos density was noted in the central section. Nematodes dominated in abundance everywhere.

The total biomass of meiobenthos was maximum at a depth of 45–50 m (4,068.0–7,746.5 mg·m^{-2}), its sharp decrease (by 10 or more times) was

observed at a depth of more than 75 m. The minimum value of 5.7 mg·m^{-2} was recorded in the eastern section.

For the western section, where the depth increase is smoother than in the others, and in this connection the environmental conditions are more uniform, a more uniform distribution of the meiobenthos density in general and the main groups that form it is characteristic. Thus, the number of nematodes varied here insignificantly – from 20,000 to 55,000 ind.·m^{-2}, Foraminifera, which were present to a depth of 60 m – from 25,000 to 60,000 ind.·m^{-2}, representatives of the temporary component of meiobenthos – from 5,000 to 10,000 ind.·m^{-2}. Harpacticoids were distributed to a depth of 70 m. The total biomass varied from 43.4 to 1,065.0 mg·m^{-2} (on average for the section – 473.8 mg·m^{-2}).

The central section is characterized not only by a significant quantitative diversity of meiobenthos, but also by higher indicators of its total abundance. The maximum accumulations of animals are confined to the 50–90 isobaths (160,000-270,000 ind.·m^{-2}). With increasing depth, a sharp decrease in the total abundance was observed. Its indicators did not exceed 75,000 ind.·m^{-2} with a minimum of 35,000 ind.·m^{-2}. The average density for the central section is 2.5 times higher than for the western one. The main indicators of the meiobenthos are formed due to the mass development of representatives of the eumeiobenthos, in particular nematodes (Fig. 6.3.). At a depth of up to 90 m, the constant component comprised 76.0–97.8 % of the total number of organisms; from 90 to 150 m, the meiobenthos consisted of 100 % nematodes with a small admixture of Foraminifera at a depth of 150 m.

The maximum value of total biomass was 7746.4 mg·m^{-2}. At a depth of 50–60 m, this value was 3,734.2–4,068.0 mg·m^{-2}; at a depth of up to 80 m, it decreased in different areas by 3–9 times. Deeper than the 80-meter isobath, the average values of total biomass were 39.3 mg·m^{-2} (max. – 90.4 mg·m^{-2}, minimum – 13.3 mg·m^{-2}). On average, the meiobenthos biomass for the section reached 2,003.3 mg·m^{-2}, which is 4.2 times higher than in the western section.

The meiobenthos of the eastern section was characterized by a depleted qualitative composition compared to the western and especially central sections. One to three groups were present in most of the benthal zone:

Nematoda, Foraminifera, and Harpacticoida; only Nematoda had a 100 % occurrence. The main indicators of the meiobenthos density were formed by nematodes. There were no young mollusks in this section. The average total abundance of meiobenthos for the section was 117,000 ind.·m^{-2}. Depending on the depth, the total biomass varied from 5.7 mg·m^{-2} (112 m) – 20.9 mg·m^{-2} (88 m) to 1,659 mg·m-2 (74 m). Among the Foraminifera found off the western coast of Crimea were *Ammonia tepida*, *Cribroelphidium martcobi*, *Streblus perlucida, Lagena perlucida, L. lateralis var. pontica*, and *L. lateralis*. In the western section, their distribution was limited by the 60-meter isobath. In the central section, they were noted at 50 % of stations down to a depth of 150 m. Here, their population density varied from 15,000 to 135,000 ind.·m^{-2}. In the western and central sections, foraminifera accounted for an average of 21.3–21.4 % of the total number of organisms, and in the eastern section, 16.2 %.

As noted above, nematodes were almost everywhere the leading group in terms of settlement density. At a depth of up to 50 m, they formed from 35.4 to 40.9% of the total number of meiobenthos. At a depth of up to 85 m, the number of nematodes on average doubled – from 38.3 % to 100 %. In areas at a depth of more than 90 m, the meiobenthos in most cases was represented only by Nematoda.

The densest concentrations of nematodes are noted in the central section at a depth of 50–100 m (90,000–220,000 ind.·m^{-2}), and the minimum concentrations are found in the western section (9,000–52,000 ind.·m^{-2}). The density of nematode settlements is most evenly distributed in the western and eastern sections.

Harpacticoida were observed in a fairly wide range of depths from 30 to 90 m. Their average abundance for the polygon was 26,900 ind.·m^{-2}, which is an order of magnitude higher than the average abundance in the 1970s (Kiseleva, 1979). The main accumulations of harpacticoids were confined to a depth of 45–78 m in the central and eastern sections. The maximum density of crustaceans was observed here (60,000–80,000 ind.·m^{-2}). In the western section, the abundance of Harpacticoida was the lowest in comparison with other areas of the shelf (on average 11,500 ind.·m^{-2}). In the total abundance of

meiobenthos, the proportion of harpacticoids varied significantly in different areas – from 5.9 to 32.2 %.

The settling of mollusk larvae was most active in the central section at a depth of 45 to 70 m. The maximum abundance was 20,000 ind.·m^{-2}.

Thus, the analysis of the obtained material allows us to conclude that the meiobenthos, in terms of its qualitative and quantitative indicators, is most diverse and rich in the number of organisms and their total biomass in the section of Cape Tarkhankut (central) in the zone of maximum development of *Modiolus/phaseolinus***.** According to available data (Tereshchenko et al., 1992), the main accumulations of mollusks are concentrated at a depth of 55–60 m, where both the biomass of the meiobenthos and its diversity were maximum.

Southern coast of Crimea. The research covered depths from 26 to 240 m. Foraminifera, Nematoda, Harpacticoida, Ostracoda, Kinorhyncha, Turbellaria, Polychaeta and Bivalvia were found. The general characteristics of the structure and quantitative indicators fit into the known pattern of meiobenthos distribution in other areas of the Black Sea depending on depth. During our research, five to seven groups were noted at each station at depths of up to 50 m, three to five groups at depths of up to 75 m, and only nematodes were present at depths of up to 80 m and more. The total number and biomass are formed mainly by representatives of eumeiobenthos, its quantity increased with increasing depth (on average at a depth of up to 50 m – 91.3 %, up to 75 m – 92.6, 75–100 m – 98.9 %).

Depth 25–50 m. The total number of meiobenthos varied from 120,000 to 204,000 ind.·m^{-2} (average 159,428 ± 10,026 ind.·m^{-2}). Nematoda dominated at all stations, accounting for 64.7 % of the total number of meiobenthos (70.8–81.2 % at the Meganomsky section). In most cases, harpacticoids occupied a subdominant position in terms of settlement density (average 14.3 %). Their numbers varied from 500 to 36,000 ind.·m^{-2} (average 21,357 ± 7,539 ind.·m^{-2}). Foraminifera were found everywhere (1700–25000 ind.·m^{-2}, on average 14,821 ± 5,283 ind.·m^{-2}). Role in the formation of the total number

of meiobenthos: minimum – 2 %, maximum – 25.6 % of the total number of invertebrates. The total biomass fluctuated widely – 30.36–1,621.5 mg·m^{-2}.

At depths of up to 75 m, nematodes and polychaetes were noted everywhere. The average density of the former differed slightly from that at shallower depths (on average, 761,180 ± 25,580 ind.·m^{-2}); at most stations, they clearly dominated (37.5–88.8 % of the total number of organisms). The density of harpacticoids was identical to that at shallower depths (on average, 21,806 ± 5,549 ind.·m^{-2}). The total biomass at the studied site, as in the first case, varied widely (130.7–1,094.1 mg·m^{-2}).

At a depth of more than 75 m, only nematodes were noted in the amount of 500-68,000 ind.·m^{-2}. In the sample from a depth of 200 m, there were single specimens of nematodes. At a depth of more than 200 m, no living representatives of meiobenthos were found.

Thus, the densest accumulations of meiobenthos were noted at a depth of up to 50 m. Nematodes were found everywhere and dominated in numbers. Among the representatives of pseudomeiobenthos, the leading role in occurrence and numbers belonged to polychaetes. Larvae and juveniles of bivalve mollusks were noted mainly up to the 50-meter isobath, polychaetes – up to 86 m. The average density indicators of representatives of the temporary component of the meiobenthos are practically uniform for the two depth ranges under consideration (11,928.5 ± 4,201 ind.·m^{-2} and 10,955 ± 676 ind.·m^{-2}).

A high density of meiobenthos (174,000 ind.·m^{-2}) was noted for the Terebellida community. As in other areas, nematodes dominated (58.6 %), but other groups also played a significant role (harpacticoids – 20 % of the total abundance, polychaetes – 14 %). The density of foraminifera and kinorhynchs was 6,000 and 4,000 ind.·m^{-2}, respectively. At station 3,780 (depth 71 m), where only Nephthis and Terebellida were found, the meiobenthos was very depleted (45,000 ind.·m^{-2}) and was represented only by Nematoda – 88.8 % and Polychaeta.

In the **Mytillus** community, the average density of meiobenthos is relatively high – 16,4102 ± 18,990 ind.·m^{-2}. Its maximum values were recorded at stations 3789, 3797 (20,400 ind.·m^{-2}, respectively). Representatives of

pseudomeiobenthos made up about 10 % of the total abundance, mainly due to polychaetes. Settled larvae of bivalve mollusks were recorded only at station 3784. The dominant group is nematodes (on average 55.4 %), the subdominant is harpacticoids (14.4 %).

In the ***Modiolus phaseolinus*** community, the density of meiobenthos was somewhat lower than in the previously considered ones – on average 141170 ± 44020 ind.·m^{-2}. Nematodes dominated (73.9 %), foraminifers and harpacticoids played an insignificant role. Here, the settling and survival of benthic animal larvae is difficult (pseudomeobenthos makes up only 2.4 % of the total abundance).

Table 6.1.

Average abundance (ind.·m^{-2}) of meiobenthos in different biocenoses

Biocenosis	Meiobenthos				
	Nematoda	Foraminifera	Harpacticoida	Others	Total number
Gouldia	112 000	40 000	24 000	16 000	192 000
Terebellida	102 000	36 000	6 000	130 000	174 000
Mytillus	91 028	18 685	23 678	30 711	164 102
Phaseolina	104 330	25 000	10 000	1 836	141 166
Mytillus and Phaseolina	34 875	18 375	20 250	8 250	71 750

Thus, in the studied area, the average density of meiobenthos is highest at a depth of 20–50 m (15,9428 ± 10,026 ind.·m^{-2}). Representatives of the permanent component make up 91.3–98 %, and of the temporary component –up to 8.7 %. The low role of pseudomeiobenthos in the total abundance of meiobenthos indicates unfavorable environmental conditions for the formation and functioning of benthic communities.

Analysis of the material collected in the summer of 1991 (depth 19–90 m) confirmed the principle of spatial distribution of meiobenthos at different depths. At depths of up to 50 m, the total abundance and biomass were higher than in deeper water zones. Here, many groups had a 100 % occurrence rate (Nematoda, Harpacticoida, Polychaeta, Oligochaeta); Kinorhyncha and juvenile mollusks were noted at 84.6 % of stations. The occurrence rate of

other groups (foraminifers, ostracods, cyclopoids) was 76.9%; 61.5%; 61.5%, respectively. The total abundance of meiobenthos varied from 360,000 to 938,000 ind.·m^{-2}. In population density (38,000–677,000 ind.·m^{-2}) nematodes dominated (on average, 53.2 % of the total number of meiobenthos organisms); the subdominant group – Harpacticoida (10,000–677,000 ind.·m^{-2}) on average for the specified depth constituted 24.4 % of the total number of meiobenthos. The share of other eumeiobenthos groups is insignificant.

Among the representatives of the time component, polychaetes predominated, their numbers were distributed relatively evenly in the depth ranges of up to 25; 25–40; 40–50 m (24,000–27,000, 36,000–40,000, and 25,000-22,000 ind.·m^{-2}, respectively). Juvenile bivalve mollusks were distributed in a mosaic pattern, forming the most significant accumulations on silts and silted shells (up to 53,000–82,000 ind.·m^{-2}).

At depths of more than 50–90 m, nematodes, harpacticoids, polychaetes, and oligochaetes were recorded everywhere. These four groups were distributed within the studied area from minimum to maximum depth. The total number of meiobenthos varied considerably (142,000–1,400,000 ind.·m^{-2}). The maximum values were noted near Cape Tarkhankut and in the Anapa area (53 and 61 m).

As in shallower zones, nematodes dominated in terms of settlement density (on average, 66.2 % of the total number of meiobenthos). Their number in different areas of the Crimean shelf varied from 100,000 to 867,000 ind.·m^{-2}.

The number of harpacticoids at 50–75 m averaged 287,000 ind.·m^{-2}, sharply decreasing with increasing depth (average 38,000 ind.·m^{-2}). The subdominant group accounted for an average of 23.5 % of the total meiobenthos. It is necessary to note the significant development of kinorhynchs in the zone under consideration. At all stations up to 90 m, their average number was 20,000 ind.·m^{-2}, which is almost 3 times higher than the density of their settlements at depths of up to 50 m.

At a depth of more than 50 m, the percentage of pseudomeiobenthos is almost half as much – 7.7 %. The most successful settling of mollusk larvae

occurred at a depth of up to 50 m, as in 1988, polychaetes and oligochaetes were found up to 90 m. Thus, the Crimean shelf is characterized by a significant diversity of meiobenthos with high indicators of total abundance and biomass. Nematodes dominated in density. Harpacticoids almost always occupied a subdominant position.

3.7. Meiofauna as an indicator of the quality of the environment in the waters of the NWBS.

Our planet is changing, and one of the most pressing challenges facing the scientific community revolves around understanding how ecological communities respond to global changes. The consequences of anthropogenic impacts on marine ecosystems are most clearly determined not so much by chemical and physical methods, but by biological ones. Only biological methods are capable of assessing the consequences of pollution based on the degree of disturbance to aquatic ecosystems (Vinberg, 1981).

Among marine benthic invertebrates, the meiobenthos as a whole and its individual representatives at the species level and at the level of major taxonomic ranks are capable of performing the greatest indicator role. Representatives of the meiofauna have high fecundity, mostly short life cycles and rapid growth rates, high metabolic intensity, playing an important role in the balance of organic matter in bottom sediments. When calculating the overall production and energy balance of the ecosystem, it is necessary to take into account the fact that small benthic invertebrates play a large role in energy transformation and that a significant proportion of the total energy flow passes through them (Vorobyova L.V., Kulakova I.I., 1998).

Among the different categories of organisms, meiofauna offer several advantages for the study of marine benthic ecosystems. Four taxonomic groups are valuable for predicting global changes: foraminifers (especially calcareous forms), nematodes, copepods and ostracods. Global change has a general negative effect on meiofauna, with important consequences on benthic food webs (Zeppilli, D., Sarrazin, J., Leduc, D. et al., 2015). The author of the monograph has already pointed out that the Ukrainian shelf of the Black Sea

differs sharply in its characteristics from the shelf zones of other states. First of all, this is shallow water and the enormous influence of fresh water runoff from large rivers (Danube, Dnieper, Dniester). Formation of various types of bottom sediments, salinity and oxygen regime in the bottom layers of water, the influx of large amounts of organic matter with river runoff from a highly urbanized catchment area. At the same time, this water area has a large reserve of commercial representatives of ichthyofauna and marine invertebrates. All this requires constant environmental monitoring of the state of the quality of the marine environment of this important section of the shelf zone of the Black Sea. The northwestern shelf is a natural marine laboratory, the study of which allows us to obtain answers to the influence of many different environmental factors on its biological diversity and quantitative indicators.

Since the early 1970s, the term "monitoring" has entered the lexicon of ecologists and has become widely used; monitoring studies have become a priority. In connection with the increasing anthropogenic impact on the biosphere, monitoring of this influence is of particular importance, i.e., an observation system that allows us to identify changes in the state of the biosphere under the influence of human activity (Bakanov, 1997, 1998).

At present, it is becoming clear that the currently used methods of physical, chemical and sanitary-microbiological analysis cannot provide a full assessment of human impact on the environment. Therefore, for the comprehensive impact of a whole range of diverse anthropogenic impacts on aquatic ecosystems, it is necessary to use biological analysis methods (Bezmaternykh 2007).

The possibility of using meiobenthos in assessing the quality of the marine environment has been pointed out in recent decades by Black Sea researchers (Sergeeva, 1993, 2003; Vorobyova, 2000; Gomoiu, 1985, 1987, 2005). Such conclusions have become possible thanks to long-term monitoring observations in various seas, as well as in-depth studies of an increasing number of meiobenthos groups and their relationship to various natural and anthropogenic environmental factors, both at the species level and at the level of large taxa. Using long-term observations of the dynamics of qualitative and

quantitative meiobenthos characteristics, we identified those that can serve the greatest role as indicators in assessing the quality of the marine environment and predicting the consequences of various forms of anthropogenic impact. One important indicator that should be used in monitoring observations is changes in the species diversity of marine communities. This typically responds to anthropogenic changes by reducing the faunal composition of aquatic organisms. With the formation of extensive hypoxia fields in the NWBS, and especially in the zone of influence of the Danube River, the taxonomic diversity of meiobenthos is sharply reduced. According to the authors, in 1990, in most of the specified water areas, the oxygen content in the bottom layers of water did not exceed 2 $mg \cdot 1^{-1}$; in many areas, zero values were noted. During this period, the meiobenthos was very poor and only four groups were recorded (Foraminifera, Nematoda, Oligochaeta and Polychaeta). Moreover, the proportion of Foraminifera in the total population density reached 79.7%; the proportion of nematodes 19.3 %.

Using data from long-term observations of the dynamics of qualitative and quantitative characteristics of meiobenthos, we identified those that can best serve as indicators in assessing the quality of the marine environment and predicting the consequences of various forms of anthropogenic impact.

In the meiobenthos, the population densities of its mass groups are closely interconnected, and when environmental conditions change, the ratio of their numbers can change very quickly (Zaika B.E., Zagorodnaya Yu.A., Kolesnikova E.A., Machkevsky V.K. et al., 1977).

As the oxygen level deteriorates, the harpacticoid density decreases (Raffaelli, 1981), with particularly dramatic changes observed at bottom oxygen levels below 4 $mg \cdot 1^{-1}$ (Vorobyova, 1999). Furthermore, the ratio of nematode population density to harpacticoid population density (the nematode-copepod ratio) increases with increasing ecosystem stress. We have extensively used this indicator to assess environmental quality in the NWBS.

The more environmental conditions deviate from the norm, the higher this indicator (by tens and even hundreds of times). The value of using qualitative and quantitative meiobenthic indicators also lies in the possibility

of making short-term and long-term forecasts for the formation of stocks not only of forage macrozoobenthos but also of commercial fishes of the benthic and demersal complexes. Juvenile wrasses, gobies, mullets, and other fish, as well as carnivorous representatives of the macrozoobenthos, widely feed on harpacticoids, ostracods, small polychaetes, and other organisms. During hypoxia and associated fish kills, meiobenthos reserves decline sharply, significantly reducing feeding areas for juvenile fish. We calculated that while harpacticoid reserves in Zhebryanskaya Bay fluctuated between 7,680 and 343,200 tons in the spring and summer from 1982 to 1984, they ranged from 0,490 to 61,680 tons in 1990 to 1993. Meiobenthos reserves have increased significantly in recent years.

Due to its biological characteristics, meiobenthos, like no other representative of bottom communities, is able to quickly respond to changes in the physical and chemical parameters of the environment. Representatives of the permanent component of meiobenthos have a number of specific features that are significant when analyzing the consequences of anthropogenic impact: a) almost all meiobenthos lack planktonic larvae, which makes it difficult for them to replenish those affected by negative impact; b) most representatives of meiobenthos have short development cycles, which allows us to track changes in the community over a relatively short period of time (Mokievsky, 2009).

Of all benthic invertebrates, meiobenthos is best suited for such analysis. It has the ability to quickly restructure its indicators due to the short cyclicity of reproduction and the rapid restoration of high numbers of some species of large taxa under unfavorable environmental conditions.

In our ecological monitoring of certain marine water areas, the ecosystems of which experience various types of anthropogenic impact, we most often used the characteristics of the abundance of meiobenthos organisms, the number of large taxonomic groups, the nature of dominance, the ratio of large taxa (nematodes to harpacticoids), the ratio of the total number of meiobenthos to its total biomass. An essential point in monitoring studies of the marine environment is the choice of test objects capable of integrally reflecting the ecological situation during the observation period. In

the meiobenthos, such indicator groups can be foraminifers, nematodes, and ostracods, which acquire various morphological and quantitative changes under unfavorable conditions.

At present ecologists are increasingly use of the protozoa Taxocene Foraminifera as a test object for environmental monitoring of water areas subject to anthropogenic influences (Bresler, Vl., Yanko, 1995)

Many scientists have fully justified the use of foraminifera as indicators of the marine environment subject to anthropogenic impact. Some species of benthic Foraminifera can be used as a test object for pollution of the aquatic environment with heavy metals (Yanko, V.V., Troitskaya, T.S., 1987, Yanko, Anmand, M., Kaminski,1998).

In the scientific literature, data are presented that under extremely unfavorable conditions in the benthal of eutrophic waters, Foraminifera can be the dominant group of meiobenthos in numbers. For several decades, monitoring studies of the quality of the marine environment of the northwestern Black Sea indicated a dominant population density of representatives of the nematode-foraminiferan or foraminiferan-nematode complexes of meiobenthic organisms (Vorobyova, 1999; Vorobyova and Kulakova, 2009).

Foraminifera have very fast reproduction times, and the adaptation of their individual species to mass reproduction at very low oxygen levels in the bottom layers of water. At high levels of organic matter, foraminifera can form clusters that are tens of times denser than in areas with lower trophic levels. (Vorobyova, 1999). In addition, under high anthropogenic load, protozoa can receive significant damage to the structure of their shell. For example, benthic foraminifera (*Amphistegina lobifera, Pseudotriloculina subgranulata, Cibicides advenum*) can be used as a test object for pollution of the aquatic environment with heavy metals precisely because of these characteristics (Yanko V, Anmand M., Kaminski M., 1998).

In the late 1980s – mid-1990s, both in the Danube-Dniester interfluve and in the Dnieper-Bug region, the foraminifera density increased sharply not only in the summer-autumn period, but even in the spring. As noted above, in

1990, the most critical situation developed in the northwestern part of the Black Sea, when almost the entire shelf zone was occupied by hypoxia in the bottom layers. Under these conditions, the total number and biomass of meiobenthos were formed by almost two groups (foraminifera and nematodes), the share of which in the total number of meiobenthos was 94.98 %. Foraminifera dominated everywhere in terms of settlement density – on average 74.5 % of the total number of organisms (on average 985,833 ind.·m^{-2}, maximum – 3,052,500 ind.·m^{-2}). In the Dnieper-Bug region, the structure of the meiobenthos was similar. The density of foraminifera was somewhat lower than in the Danube influence zone (on average 611,175 ind.·m^{-2}, max 1,850,000 ind.·m^{-2}). In the following 3 years, foraminifera retained a leading role in the total number of meiobenthos. For example, in July 1992, the number of protozoa on silts in the Danube-Dniester interfluve varied within 152,000-1,492,000 ind.·m^{-2} (on average for the region 451,000 ind.·m^{-2}). At the same time, from the total number of meiobenthos at most stations it reached 77.7-91.9 %, and on average for the region – 75.3 % (in most of the polygon the oxygen content at the bottom did not exceed 2.7 mg·1^{-l}). In autumn, their average abundance was 551,350 ind.·m^{-2} (maximum 1,794,000 ind.·m^{-2}). At the same time, in Karkinitsky Bay, where the bottom layers of water had a fairly good oxygen regime (4.8-7.35 mg·1^{-l}) and with a salinity of 17.88 ‰, the number of foraminifera was 30,000–202,000 ind.·m^{-2}. On silty soils with oxygen deficiency, foraminifera almost everywhere occupied a leading position in the formation of the total number of meiobenthos (on average 68.4 %). On the northwestern shelf, one species, *Ammonia tepida*, accounts for 60 % to 91 % of the total number of foraminifera. The species *Ammonia tepida, Haynesina anglica*, *Aubignuna perlucida* can also serve as an indicator of desalination.

To assess the quality of the environment, the following are used two critical values of dissolved oxygen in the bottom layers of the sea are used, determining both the species diversity and the total number of protozoa, their biomass, share in the total number of meiobenthos, etc. The first, characteristic of hypoxia (1– 4 mg·l^{-1}O$_2$), is that Foraminifera are present in the meiobenthos,

capable of living at low levels of O_2. The second – 8 mg·l$^{-1}O_2$and above, at which oxyphilic species develop (Vorobyova, 2021).

As can be seen from the presented graph the maximum number of foraminifera is typical at low dissolved oxygen levels. Such indicators show a critical ecological situation at the bottom. At the same time, the proportion of foraminifera is also highest during hypoxia. Their maximum proportion is on average more than 50%. The most common and widespread species under such conditions is *Ammonia tepida* Cushman, found almost everywhere both on silty soil at depths of up to 45 m and on sandy soil.

As is known, Nematoda are the most common representatives among the meiobenthic community of organisms. There is practically no marine biotope where nematodes are not present. In addition, having high population rates, they often act as the dominant group. The dominance of the foraminifera-nematode or nematode-foraminifera complex in terms of numbers can serve as an indicator of a very complex ecological situation in the bottom layers of marine waters.

Nematoda can serve as test objects that respond to technogenic pollution by restructuring the chemo-receptor organ of nematodes, an atypical remodeling of the organism. It has been established (Sergeeva, 1991, 2003) that the presence of extreme conditions in the marine environment, among which heavy metals play a special role, can cause abnormal development of nematodes in ontogenesis.

Our studies have shown that for nematodes, as well as foraminifera, there are two maximum critical oxygen levels (4 mg·l$^{-1}O_2$ and 8 mg·l$^{-1}O_2$), which determine the formation of the density of nematode taxocene settlements. The maximum average number of nematodes was noted at 1 mg·l$^{-1}O_2$, – 207056.3+51388.2 ind.·m^{-2}, the minimum – at 4 mg·l^{-1} – 47854.5+7255.7 ind.·m^{-2}.

Long-term studies of the meiobenthos of the Odesa marine region have shown that nematodes played a significant role in the formation of the total number of meiobenthos at different depths and on different types of bottom sediments.

In all years, nematodes dominated in abundance, making up most of the total abundance of meiobenthos – 55,5 – 80 % and only in 2011 – 48 % of the total abundance. Most species are characterized by a mixed diet. For this, in the northwestern part of the Black Sea, hyper eutrophication creates favorable conditions for the mass development of free-living marine nematodes. The density of nematode settlements reached its maximum values precisely in anomalous years. In 2006, it was 447,086.4±86,885.7 ind.·m^{-2}. In 2010 it was the same as in 2006 – 445,762.5±63,305.3 ind.·m^{-2}. In all other years, it was many times lower (Fig. 7.1).

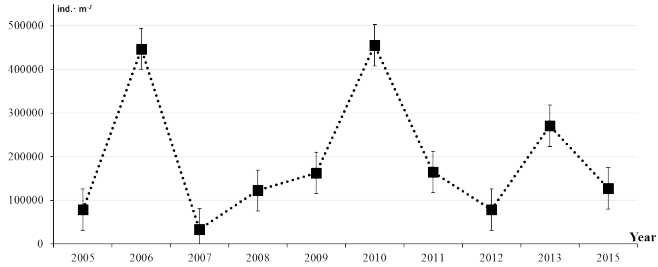


Figure 7.1. Long-term dynamics of the abundance (ind.·m^{-2}) Nematoda in different years.

As we see in the graph, the maximum nematode population densities were observed for the atypical critical situations described by us (Vorobyova, Bolshakov, 2024) in the summer period of these years. As indicated, the mass development of unicellular algae in the surface layers of the sea and their settling on the bottom contributed to a very high accumulation of both autochthonous and allochthonous organic matter there. Further processes led to a sharp deterioration in the ecological state of the bottom layers and the development of hypoxia there. This allowed nematodes to be the dominant group of meiobenthos in terms of numbers and determine the peaks of their development. The experience of many years of research suggests that the mass species could be representatives of Chromadorida and Desmoscolicida, which,

according to Boaden's classification ((Boaden, 1977), are classified as anoxybionts or facultative anoxybionts in relation to oxygen. Earlier, according to Kulakova I. I. (Zaitsev et al.,1998) representatives of the orders Chromadorida and Desmoscolicida were found at a depth of 250–600 m.

Recent studies have shown that ostracods are perhaps the most remarkable group of indicator organisms that can be used to monitor the state and dynamics of aquatic ecosystems.

Recently, Ostracoda have been increasingly used in monitoring studies as indicators of the state and dynamics of water in marine ecosystems. Ostracoda are especially good as bioindicators because after their death, their shells remain in the ground and can be used to reconstruct the appearance of the originally existing communities in polluted waters. Based on a comparison of thanatocenoses and biocenoses in polluted and cleaner waters, it is possible to determine the degree of destruction of the original complexes under the influence of anthropogenic impact.

Anthropogenic pollution leads to a reduction in the species richness of ostracod complexes, changes in their structure and, ultimately, to the complete extinction of these animals. Ostracodes do not survive in conditions of severe pollution.

The obtained data on the species composition and abundance of ostracods are a real basis for diagnosing the state and monitoring the environmental situation in the contact zone “coast-sea”.

Naturally, when conducting an ostracod analysis to determine the current ecological state of the area under study, the most common species encountered alive are first taken into account.

Unfortunately, we have not used ostracods to assess the quality of the marine environment. In our group of meiobenthologists, ostracods of the northwestern Black Sea have only become the subject of study in the last decade.

As indicated above, the density of harpacticoid settlements decreases sharply when the dissolved oxygen content is below 4 $mg \cdot l^{-1}$ and that the proportion of crustaceans is maximum under favorable conditions. Many specialists, taking into account these features of harpacticoids, use the ratio of

the number of nematodes to the number of harpacticoids (nematode-copepod ratio). The higher this index, the more difficult the ecological situation in the benthal and vice versa. Thus, the ratio of the abundance of harpacticoids to nematodes can serve as an indicator for indicating environmental pollution. This indicator is especially effective in studying eutrophic and hypereutrophic water areas.

There is information in the scientific literature that this indicator (N_{nem}/N_{harp}) can be used in mesotrophic water bodies to determine the quality of the marine environment. R. Warwick (1981), D. Rafaelli and K. Mason (Raffaelli, Mason, 1981), V. Galzova (1991). These authors suggest using the nematode-copepod ratio as an indicator of organic pollution, it increases significantly. We have used this indicator many times. It has been shown that in waters subject to strong anthropogenic pollution, this indicator is very high. Our long-term studies in the highly eutrophicated waters of the northwestern shelf have shown that at a low level of oxygen dissolved in the bottom layers of water (below 4 $mg \cdot l^{-1}$), harpacticoids are found in small quantities (Vorobyova 1999). This indicates a massive dominance of nematodes and a sharp decrease in the density of crustacean settlements. Thus, in 1994, the index of this ratio was 748.7. At the same time, the average number of foraminifera (146,500 $ind. \cdot m^{-2}$) and nematodes (180,310 $ind. \cdot m^{-2}$) together constituted 89.3 of the total number of meiobenthos. In 1998, the number of foraminifera (183,386 $ind. \cdot m^{-2}$) and nematodes (996,014 $ind. \cdot m^{-2}$) together constituted 85.0 % of the total number of meiobenthos. In 2005–2006, the N_{nem}/N_{harp} indices were 497 and 469.0, respectively, in 2009 – 204.0. Under normal climatic conditions in 2015 – 6.0. In an unfavorable period, the total number of meiobenthos increases sharply, and its biomass indicators fall. The ratio of total abundance to biomass (N_{total}/B_{total}), which we used, indicates the mass development of small short-cycle taxa. In our case, foraminifera and nematodes. So, in 1994 it was 1252.1, in 1997 – 1644.6, and in 1998 it decreased to 229.3. In 2006, this index was 446.5, in 2010 – 583.0, in 2012 – 118.2 (Fig. 7.2, 7.3).

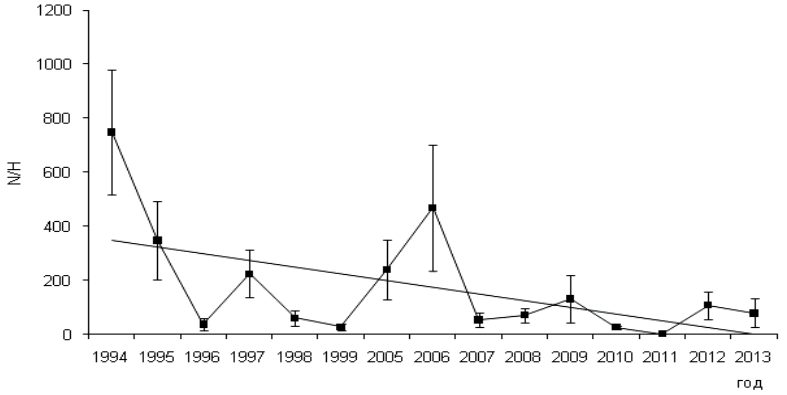


Figure 7.2. Average long-term ratio of nematode settlement density to harpacticoid settlement density (Odesa marine Region)

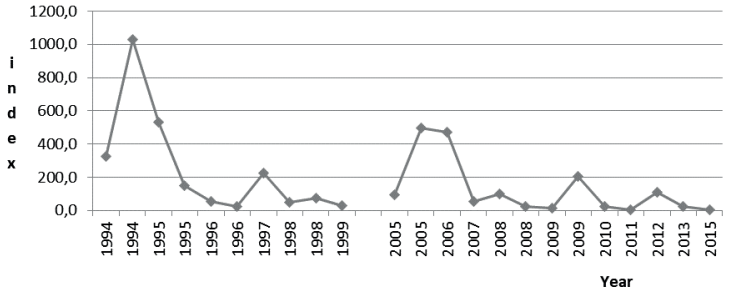


Figure 7.3. Ratio indices of abundance (ind.·m^{-2}) nematodes to abundance (ind.·m$^{-2)}$ harpacticoid (N/H), in the Northwestern part of the Black Sea

When comparing the ratio of nematode numbers to harpacticoid numbers and the total number to the total biomass of meiobenthos over 15 years, we can say that the ecological situation of the marine environment in the northwestern part of the Black Sea in the current century has improved somewhat compared to the end of the last century. This is also evidenced by a significant increase in the density of harpacticoid settlements (Fig. 7.4)

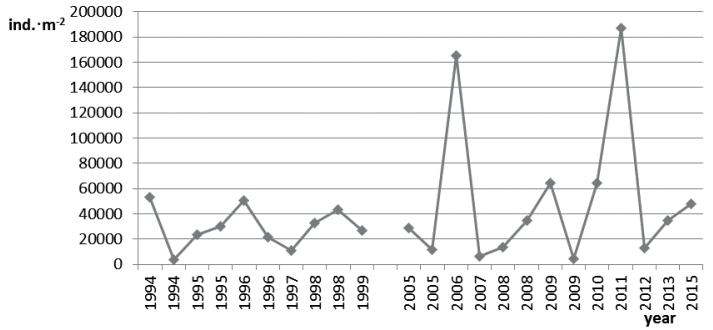


Figure 7.4. Interannual dynamics of the number of Harpacticoida (ind.·m $^{-2}$) in the Northwestern part of the Black Sea (Odesa Marine Region)

As can be seen from the presented graph, the maximum density of harpacticoids is associated with the years of the highest temperatures of the surface layers of water and the Dnieper River runoff. Under these abiotic factors, there was a mass development of unicellular algae, which, after dying, settled to the bottom, enriching the bottom sediments with organic matter. This is also typical for long-term indicators of the number of juvenile polychaetes, which, by their body size, belong to pseudomeiobenthos (Fig. 7.5). (Vorobyova, Bolshakov, 2024)

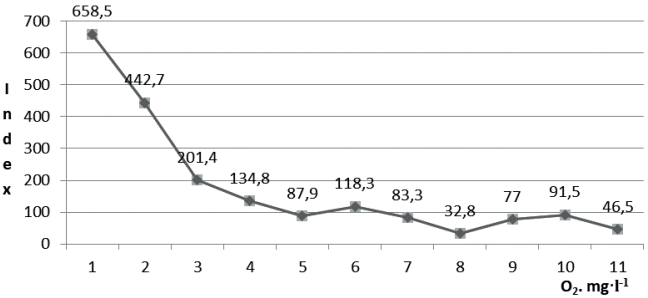


Figure 7.5. Indices of the ratio of the number of nematodes to the number of harpacticoids under different oxygen conditions.

Every year, anthropogenic pressure on marine waters areas. The ecological state of their ecosystems significantly worsens. The productivity of water bodies decreases, which causes great losses to the national economy and recreational use of coastal waters. Ecologists closely monitor these processes, using numerous tests to determine the factors and degree of pollution of the marine environment. For this, various test objects are used both at the level of individual species of large taxa and indices of the ratio of their numbers. Thus, we have given an example of using the index of the ratio of the number of nematodes to the number of harpacticoids (N_{nem}/N_{harp}) in our studies.

Warwick [Warwick, 1986] proposed an excellent method, the so-called "ABC method" (abundance/biomass comparison) – comparison of abundance and biomass. The proposed method is based on the construction of the so-called K-dominance curves This method is widely used by hydrobiologists in their research. We decided to use the same principle, but somewhat simplified the method for obtaining this index. As our long-term research in the NWBS has shown, with the formation of large permanent areas with minimal oxygen content at the bottom, the dominance of small-sized short-cycling species in the meiobenthic community sharply increases. We used the ratio of only the total abundance of meiobenthos to its total biomass. That is, we were interested in obtaining the number of meiobenthos individuals per mg. The maximum indices indicated a crisis situation for bottom animals and that in the meiobenthos biodiversity was sharply decreasing and the dominance of small-sized species of one or two large taxa was increasing (Fig. 7.5.).

In the NWBS, with an oxygen content of up to 4 $mg \cdot l^{-1}$, the total number of meiobenthos is formed by either a foraminifer-nematode or a nematode-foraminifer complex of organisms. With an improvement in the oxygen regime, the indices decrease. This method can be used not only by meiobenthologists, but also by ecologists from various agencies monitoring the quality of the marine environment of government agencies.

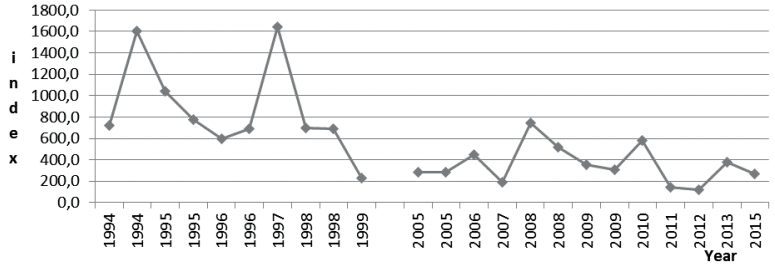


Figure 7.5. Ratio indices of abundance (ind.·m^{-2}) and biomass (mg·m^{-2}) – (N/B) of meiobenthos in the Northwestern part of the Black Sea (Vorobyova, Bolshakov, 2024).

During the expedition on the Bulgarian research vessel "Akademik" (23.09 – 13.10.2003) in the western part of the Black Sea at a depth range of 15 – 125 m, 141 core samples were taken at 60 stations with the help of a multi-corer (h – 10 cm).The analysis of the obtained data allowed us not only to describe the taxonomic composition of the meiobenthos of the western (Bulgarian, Romanian, Ukrainian) shelf of the Black Sea, but also to determine the features of the formation of quantitative parameters and spatial distribution of the permanent and temporary components of the meiobenthic community. We also analyzed the ratio of the number of nematodes to the number of harpacticoids, as well as the ratio of the total number to the total biomass as an integral indicator of the quality of the marine environment. The results showed that the most problematic water areas in the studied period were areas of the Ukrainian shelf and partly the Bulgarian shelf (Fig. 7.6).

The Danube River runoff has an influence on the formation of biological diversity and quantitative indices of bottom invertebrates from north to south from the Ukrainian to the Bulgarian shelf. This is well evident from the number of assemblages present in different parts of the shelf.

The correlation of quantitative indices of meiobenthos at a 15 m depth varied markedly. Their high values in the Varna area and the Ukrainian shelf give evidence of the severe anthropogenic impact in these areas.

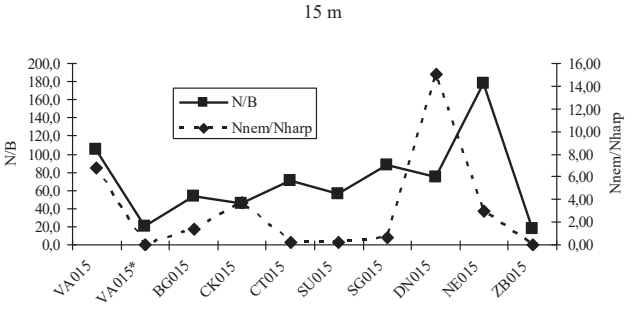


Figure 7.6. Ratio of N_{Nem}/N_{Harp} and N_{total}/B_{total} of meiobenthos at a 15 m depth (VA, BG, CK – Bulgarian shelf, CT, SU, SG – Romanian shelf, DN, NE, ZB – Ukrainian shelf).

A critical situation has been marked in the area of Zhebriansky Bay, where only Polychaeta (22,902 ind.·m^{-2}) have been found. It should be noted that at station VA015 the diversity of meiobenthos also was also very low. Here there were 3 taxa (Nematoda, Polychaeta and Bivalvia) with very low density of communities.

The correlation of quantitative indices illustrates the influence of the Danube River on the environmental situation.

The indices of the ratio of the total number and biomass of meiobenthos in different areas (depth 25m) of the western shelf differ significantly (Fig. 7.7). The maximum indices of eumeiobenthos and the minimum indices of its total biomass are characteristic of the Ukrainian shelf, and for the Bulgarian shelf, only in the Varna area, here they are close to the indices of the Ukrainian shelf. The predominance of nematodes and foraminifers in the meiobenthos of these two water areas may indicate a more complex ecological situation, making them less valuable as a food source for young fish compared to other areas.

Thus, the ratio of quantitative indicators illustrates the influence of the Danube River on the ecological situation.

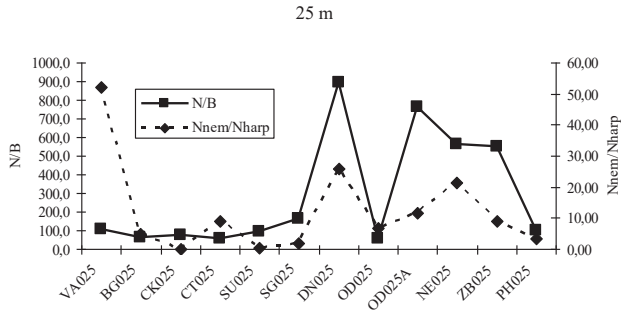


Figure 7.7. Ratio of N_{Nem}/N_{Harp} and N_{total}/B_{total} of meiobenthos at a 25 m depth. (VA, BG, CK – Bulgarian shelf, CT, SU, SG – Romanian shelf, OD, NE, ZB, PH – Ukrainian shelf).

The constant taxa at a depth of 35 m (at 75–100% of stations) were Nematoda and Harpacticoida.The diversity of meiobenthos was more stable on the Romanian shelf (with 6 groups at each of 3 transects). Eumeiobenthos made up in different areas from 80 to 100 % of the average amount of individuals (Fig. 7.8).

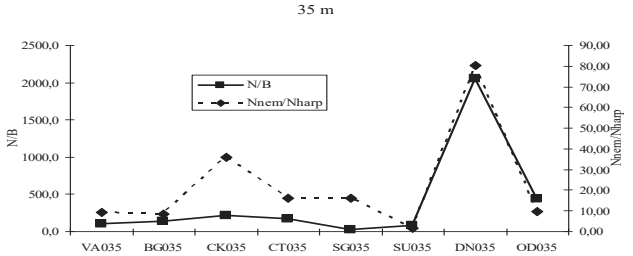


Figure 7.8. Ratio of N_{nem}/N_{harp} and N/B of meiobenthos at 35 m depth (VA, BG, CK – Bulgarian shelf, CT, SU, SG – Romanian shelf, DN, OD– Ukrainian shelf).

In different areas (45 m depth) the eumeiobenthos made up from 74.0 to 96.0 % of the average amount of individuals. The abundance of the meiobenthic organisms in the 45 m zone at different stations fluctuated from 4 714 ind.·m^{-2} (Sta. DN045) to 449 152 ind.·m^{-2} (Sta. SU045), average total density – 169 500 ind.·m^{-2}. The biomass varied from 30.8 mg·m^{-2} to

35 080.6 mg·m^{-2}, average biomass – 1,358.5 mg·m^{-2}, the most characteristic components being Nematoda, Harpacticoida and Polychaeta. The abundance of meiobenthic groups was: Nematoda with an average – 65.6 %, Harpacticoida – 15.0%, Polychaeta – 8.5%, Foraminifera – 7.6%.

The maximum index of the correlation of nematode-harpacticoid abundance is the highest in the Kaliakra area (Fig. 7.9).

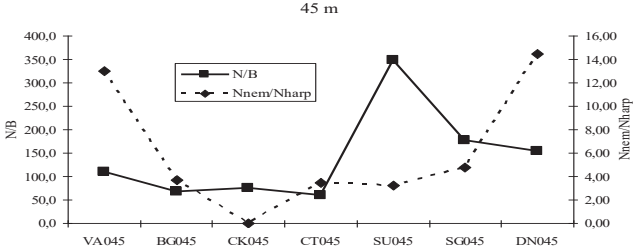


Figure 7.9. Ratio of N_{Nem}/N_{Harp} and N_N/N_B of meiobenthos at a 45 m depth.

There were from 4 to 10 groups of the meiobenthos at each transect (65 m depth). The highest diversity was at Sta. BG065 (10 taxa). The diversity of meiobenthos was more stable on the Romanian shelf (at each of 3 transects – in 6 groups). In different areas eumeiobenthos made up from 80 to 100% of the average amount of individuals (Fig. 7.10).

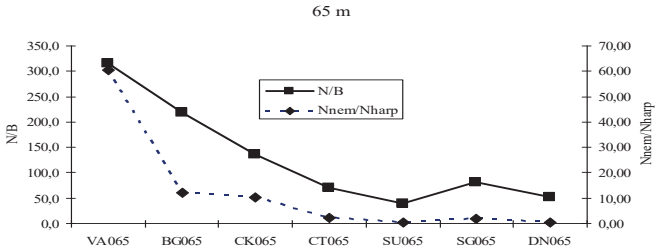


Figure. 7.10. Ratio of N_{Nem}/N_{Harp} and N_N/N_B of meiobenthos at 65 m depth.

The average abundance of the meiobenthic organisms in the 65 m zone fluctuated from 10 446 ind.·m^{-2} (Sta. DN065) to 402 584 ind.·m^{-2} (Sta. CK065), the average total biomass – from 5.1 mg·m^{-2} to 1914.0 mg·m^{-2}. The most characteristic components were Nematoda and Harpacticoida

I. I. Kulakova tested a method for assessing the ecological quality status (EcoQ) of the aquatic environment of the coastal area of the Danube delta was tested using the example of the meiobenthos and nematode communities. Meiobenthic richness (S), Shannon diversity index (H‘), Pieloux evenness index (J), maturity index (MI), cp%, feeding groups, trophic diversity index (ITD) was calculated for three different sites of the coast area of the Danube delta (Table 7.1). The purpose of this study is to provide an assessment of the ecological state of direct anthropogenic load during dredging at the coastal area of the Ukrainian Danube delta, using meiobenthos and nematodes as biological indicators of environmental quality.

In this study, a method for assessing the ecological state of quality (EcoQ) of the aquatic environment of the coastal zone of the Danube Delta was tested using the example of meiobenthos and nematode communities. For three different sections of the coastal zone of the Danube Delta, the richness of the meiobenthos (S), Shannon diversity index (H‘), Pielou evenness index (J), maturity index (MI), cp%, food groups, and trophic diversity index (ITD) were calculated (Table 7.1).

To assess the EcoQ (ecological quality) classes of the study area, the threshold values of these indices proposed by Moreno *et al.* (2011) and Semprucci *et al.* (2014a, b) (Table 7.2).

The purpose of this study is to provide an assessment of the ecological state of direct anthropogenic load during dredging at the coastal area of the Ukrainian Danube delta, using meiobenthos and nematodes as biological indicators of environmental quality.

Table 7.1.

Meiobenthic richness (S), Shannon's diversity index (H'), Pielou's evenness index (J), maturity index (MI), %, feeding groups (food groups), trophic diversity index (ITD) calculated for three different areas of the coast area of the Danube delta (Kulakova, 2022).

Faunal parameters	Dredging	Dumping	Background stations
Meiobenthic richness (S)	6	9	11
Nematode Shannon index (H′)	0.7±0.2	1.7±0.1	1.9±0.1
Nematode Pielou index, J	0.7±0.1	1.0±0.0	1.0±0.0
Nematode maturity index (MI)	1.5±0.2	2.3±0.1	2.6±0.1
c-p1	0	0	0
c-p2	61.0±10.3	64.0±5.8	51.8±6.7
c-p3	2.9±3.3	35.5±6.0	36.0±4.8
c-p4	0	0	11.1±4.1
c-p5	0	0.5±0.5	1.1±0.8
1A	4.2±4.2	23.4±5.1	22.0±3.4
1B	59.6±13.4	57.7±5.3	52.4±6.4
2A	0.7±0.7	8.8±3.5	11.1±3.6
2B	2.2±2.2	10.0±2.6	14.6±3.4
ITD	0.6±0.1	0.5±0.1	0.4±0.1

Table 7.2.

Thresholds considered to evaluate the EcoQ of the study area according to Danovaro *et al.* (2004), Moreno *et al.* (2011) and Semprucci *et al.* (Kulakova, 2022).

Faunal parameters	High	Good	Moderate	Poor	Bad
Meiobenthic richness (S)	≥16	16<S<12	8<S<11	4<S<7	≤4
Nematode Shannon index (H′)	>4.5	3.5<H<4.5	2.5<H′<3.5	1<H′≤2.5	0<H′≤1
Nematode maturity index (MI)	>2.8	2.8≤MI<2.6	2.6≤MI<2.4	2.4≤MI<2.2	≤2.2
Nematode c-p 1 and c-p 2	0–20 %	20–40 %	40-60	60-80	80-100
Nematode c-p 3 and c-p 4	80–100 %	60–80 %	60-40	20-40	0-20
ITD	0.25	0.25<ITD≤0.4	0.4<ITD≤0.6	0.6<ITD≤0.8	1

3.8. Tendenzii Main Tendencies for Development of Meiobenthos in Conditions of Anthropogenic Stress (Ukraine in Northwestern Black Sea)

The consequences of anthropogenic impact on marine ecosystem are most evident when biological methods. Only these methods it possible to evaluate the consequences of pollution and degree of degradation of the aquatic ecosystem. It may be determined by using a combination of biological indices, the most important of which are quantitative and qualitative characteristics of the development of plankton and benthos communities.

Of the two types anthropogenic stress-acute and chronic, we have been able to observe the main tendencies of meiobenthos development during table continuous effect for a sufficiently long period of time. Data have been analyzed on water areas under significant anthropogenic pressure. Mach attention was paid to determining the main factors of meiobenthos development in conditions of heavy anthropogenic eutrophication. This process today has a great influence on marine biota. It influences biological communities of all trophic levels in the water column as well, as in sediments shifts in the structure of pelagic structures subject to eutrophication have a mirror reflection in the benthic zone. The concentrations of different compounds in the upper sediment layer, the oxygen regime and rates of chemical exchange between sediment and near bottom water are changed. The increase in the stream of setting suspended matter changes the granulometric composition of the deposit to fine fractions which cause siltation of sediments.

The northwestern Black Sea (NWBS) is the most eutrophic part. Transformations in marine environmental parameters cause significant changes in the structure and functioning of all of the benthic community. Negative changes show well expressed areas of hypoxia with periodic mass mortalities. The chronic stress reaction is manifested in all meiobenthos parameters, and at the level of large taxonomic ranks and species.

From these long-term observations, we have selected those parameters which illustrate the main tendencies of meiobenthos development in present day conditions.

During chronic anthropogenic influence the meiobenthos species diversity sharply decreases. When broad areas in NWBS of hypoxia occur, especially, in the zone of influence of the Danube, the taxonomic diversity of

meiobenthos is reduced. Usually, representatives of 2–4 large Taxons (Foraminifera, Nematoda, Oligochaeta, Polychaeta) are present.

In 1989–1991 in most of the above-mentioned area the oxygen content in the near bottom water lager did not exceed 2 $mg.^{-1}$ O_2. In many areas it was very low as only four groups were recorded (Foraminifera, Nematoda, Oligochaetes, Polychaetes). An example of a water body under anthropogenic pressure is the Sukhoi liman (or lagoon). There is a large trading part, a ship repair Factory, Floating dock situated along its shores. The liman meiobenthos is represented by 2–3 groups (mainly nematodes, foraminifers with a slingt mixtire of either harpacticoids or polychaetes).

Hyper eutrophication of NWBS and linked with it the great areas of hypoxia and mass mortalities have led to a great impoverishment of the Foraminifer Faunistic composition. Usually only six have been recorded on the north-western shelf: *Ammonia tepida, Ammonia compacta, Porosonian martcobi, Haynesina anglica, Nonion motagordanus u Canolifera parkerae*.

Changes in the structural functional characteristics in marine macrophytobenthos in conditions of eutrophication and different kinds of technogenic pressure have caused a charp decrease in the taxonomic composition of marine mites. Of the characteristic 17 species of Halacarids in the 1970s in the post decade *Aqauaopsis brevipalpus, Rhombognathus notops, Rh. Pascens, Thalassarachna affinis u Halacarus procerus* have been developing. Large scale shore enforcement operations with washing of sand of another granulometric composition have a negative influence on the Faunistic composition of interstitial meiofauna. If for coarse grain sand of NWBS, there are 52 characteristics interstitial meiofauna species, then for artificial fine grain – 21 species. For example the numbers of nematode species for washed beaches was reduced from 29 to 16, Harpacticoids from 9 to 1, Osracods (9 species), Halacarids (4 species), Polychaeta and Archiannelida (3 species) have not been detected in fine structure sands.

The dominance of the main meiobenthos group and species has been enhanced.

It has been established that during deteriorating hydrochemical conditions in NWBS the dominance of separate groups and species of meiobenthos is enhanced. In present day conditions on the northwestern shelf and partially on the Crimean, a change in dominating nematode-harpacticoide assemblage to foraminifere-nematode has occurred. The foraminifer fraction in the total density of the settlement often reaches 79.7–80 %.

When the oxygen content in the near bottom water layers is within the range of 7.5 to 4.2 $mg \cdot l^{-1}$ the quantitative characteristics of meiobenthos are formed practically according to all characteristic's groups of the community. When the oxygen content is between 4.5 and 3.0 $mg \cdot l^{-1}$, the meiobenthos is made up of 5-7 group. In those water areas where the ecosystem of the benthic zone is under stress of different kinds of pollution (oxygen lower than 2.5 $mg \cdot l^{-1}$) 87-100 % the qualitative indices of meiobenthos are formed from 1–2 groups. This is particular for estuarine zones, bays.

In NWBS the most complicated ecological situation tock place at the end of the 1980s and the beginning of the 1990s. In this period at depth of 1-35 m Foraminiferes of Nematodes dominated in density. In benthic areas lacking oxygen the foraminifer density sometimes reached 80–100 % of total meiobenthos count. Then due to certain factors of the hydrochemical regime the situation improved, and in 1995 foraminifers and nematodes were replaced by harpacticoids. The graphs illustrate the per sent ratio of foraminifers, nematods and other groups of meiobenthos in area under different anthropogenic load. The indicator role of foraminifers is especially important for assessing changes in benthic environmental quality. Upon lowering of oxygen content in the water, the foraminifer density not only decreases, but even abruptly increases as the oxygen content is reduced in the near bottom layers and the species diversity is reduced. During long term hypoxia this group is usually represented by a few species and by the development of one of them – *Ammonia tepida*.

The total meiobenthos abundance increases and its total biomass decreases.

The significance of meiobenthos in the life of water bodies is determined first of all, by that in spite of its small dimensions, representatives of meiofauna having very high abundance contribute significantly to the formation of qualitative parameters of benthic communities. The high density of settlements is one of the main meiobenthos features which allows it to play an important part in biotope, trophic and energetic interrelations between hydrobionts.

The representative of meiofauna being very fertile, having a short life cycle and highly intensive metabolism are important for the balance of organic matter in bottom sediments.

Long term observations of the dynamics of total meiobenthos abundance have shown that the numbers of individuals increase as the organic matter accumulates in the benthic zone. For example, in Zhebriansky Bay, the value of total nitrogen increases from spring to autumn four-fold, total phoshorus – 1,5 times.

Its mean multiyear index for the spring period was 235516 ind.$\cdot m^{-2}$. For the autumn period it was 3 time higher. The foraminifer density corresponds with hydrochemical parameters: in spring – 146592 ind.$\cdot m^{-2}$; in summer 340590 ind.$\cdot m^{-2}$ and autumn – 568263 ind.$\cdot m^{-2}$.

The reaction of meiobenthos to unfavorable environmental conditions is expressed in a sharp rise in the meiobenthos density in those individuals with minimum dimensions and having a short life cycle. Naturally, in this case the total meiobenthos abundance increases while its total biomass decreases. For the first time we have been able to use the index of the relation of total meiobenthos abundance to its total biomass to evaluate the condition of benthic communities. The worse the environment conditions, the higher the index of the relation of abundance to biomass. In chronic ecological stress each milligram of total biomass contains more meiobenthos specimens.

The date in Figure show that heterogeneous of the state of eutrophication in different areas allow to analyze the dynamics of this index and consequently the dynamics of the environmental in the benthic zone temporally.

Long term negative influence on marine ecosystem is expressed in the reduction of species diversity of meiobenthos, and the enhanced dominance of

separate groups and species. Mass development occurs in those groups, which have the smallest size and the shortest life cycles. Under stress conditions the total biomass of meiobenthos decreases, and the total abundance increases.

The average mass of one individual per unit of area decreases when the hydrochemical regime worsens, and the index of the ratio of total abundance and total biomass increases, correspondingly. In hypereutrophic water areas the excess of small, short cycle representatives of meiobenthos lowers its total energetic potential which is significant for the formation of a favourable, good quality feeding ground for benthic fish larvae and fry.

Our long-term research and systematic sampling at a single station grid allowed us to establish patterns in the formation of qualitative and quantitative meiobenthos indicators under the influence of key environmental factors. The literature currently contains information on their impact on various marine ecosystems. This chapter describes the influence of substrate type, depth, temperature on the formation of the meiobenthic community.

The need to study the influence of various environmental factors on the formation of the meiobenthic community of organisms in the NWBS is due to the fact that the Ukrainian shelf, in terms of its hydrological and hydrochemical parameters, differs significantly from other areas of the Black Sea.

Of particular interest are the results of studies on the influence of the oxygen regime on the meiobenthos. Thus, the data presented demonstrate that we are examining the formation of meiofauna abundance of the Ukrainian shelf of the Black Sea at the following dissolved oxygen levels: 1) 0–3 to 4 mg $L^{-1}O_2$; 2) 5–7 mg $L^{-1}O_2$; 3) 7 or more to 12 mg $L^{-1}O_2$. In the first case, the meiobenthos contains a few species, primarily from two large taxa (Foraminifera and Nematoda, with minimal numbers of polychaetes and oligochaetes). Thus, our long-term research has shown that under hypoxia and even anoxia, the structure of the meiobenthic community of the NWBS changes dramatically. In the second case, meiobenthic biodiversity increases sharply with the development of euryoxybiont forms. However, the total biomass increases only slightly due to the high density of Nematoda and Foraminifera. Harpacticoida account for 10–12 % of the total meiobenthic

abundance. In the third case, the meiobenthos is typically represented by stenooxybiont species, and this is where the highest total biomass of the meiobenthic community of organisms occurs. Thus, our studies have shown that in the bottom layers of water in the NWBS, two threshold values of oxygen indicators have been identified, which determine the formation of the species richness of the meiofauna and its quantitative indicators.

An analysis of long-term dynamics of meiofauna abundance and biomass indicators allowed us to describe the characteristics of these indicators' development even during periods of critical climate change. It is worth highlighting the interesting results of our research on the meiofauna of the Sea Caves of Ukraine, which have attracted the attention of Black Sea scientists from other countries.

CHAPTER 4.
STUDY OF MEIOBENTHOS IN CONTACT ZONES OF THE NORTHWESTERN SHELF OF THE BLACK SEA

Introduction.

In the second half of the last century, interest in the study of the boundary layers of the sea began to grow rapidly, in development of the ideas of V. I. Vernadsky. In the first half of the last century, the scientist formulated the doctrine of the biosphere and, operating with macroscale biological structures, identified four static condensations of life in the World Ocean. One of them is plankton in the pelagic zone and the second is the bottom one. In addition, he distinguished the coastal sea and Sargassum condensations (Vernadsky, 1968). It is indicated (Aizatullin, Lebedev, Khailov, 1979) that if the physical and chemical effects of the boundary layers, as a rule, are inaccessible to a direct observer, then the biological effects are obvious. In Ukraine, the study of contact zones of the sea dates back to 1960-1964 (Vinogradov, 1969; Zaitsev, 1960, 1961, 1967, 1970). The importance of studying ecological processes that occur at the outer boundaries of the Sea has been pointed out in many works (Vinogradov, 1966, 1969; Zaitsev, 1982, 1998; Zaitsev, 1986).

In marine ecosystems, four contact zones were identified: the "surface layer of seas and oceans (sea – atmosphere)", the "ocean – land" contact zone (or more narrowly "coast – sea"), the "sea – rivers" contact zone, and the "bottom layer of the water column – surface of the ocean (sea) floor" contact zone (Vinogradov, 1969). It is clear from the names of these contact zones that they cover vast areas of marine ecosystems and, in terms of their hydrological, hydrochemical, and biological parameters, differ significantly from the open waters of the seas and oceans. Later, Yu. P. Zaitsev called the hydrosphere regions at the boundaries of different environments contour biotopes (Zaitsev, 2006).

Contour biotopes (Zaitsev, 1985; Zaitsev, 2006) are populated by specific contour biocenoses and are classified as follows: aerocontour (sea – atmosphere boundary), psammocontour, lithocontour, pelocontour (sea –

muddy shore and bottom), potamocontour (boundary between sea and river water masses), biocontour (Zaitsev, 1986, 2002). The northwestern part of the Black Sea is interesting because all four contact zones are present in its waters, which have a great influence on the formation of marine biota. If we consider the diversity of contour biotopes in each of the contact zones, we can state that the contact zone “shore-sea” is the richest in them, where all the above-mentioned contour biotopes are present. The most homogeneous is the contact zone “sea – muddy shore and bottom” (pelocontour).

For the Black Sea, only two contour biotopes have been described in sufficient detail to date: for the first time for the World Ocean, monographic descriptions of the structure, biodiversity and features of the boundary contact zone – the "sea-atmosphere boundary" (Zaitsev, 1960, 1970, 2015, etc.) and the psammocontour using the example of the meiofauna of the pseudo- and supralittoral of sandy beaches (Marinov, 1975; Vorobyova, Zaitsev, Kulakova, 1992) have been presented.

As was indicated in Chapter 1, the study of the meiofauna of the Black Sea was started by L.V. Vorobyova at the Institute of Marine Biology in 1973. First of all, attention was paid (1973-1981) to the meiofauna of two contour biotopes – the psammocontour and the lithocontour. Since 1982 – to the study of species diversity, quantitative indicators and other ecological characteristics of the meiofauna of the remaining contour biotopes of the Ukrainian shelf of the Black Sea.

4. 1. Study of meiofauna of the contact zone " shore -sea" (psammocontour, lithocontour, pelocontour).

In the upper sublittoral of the Black Sea (10-11 m), the richest food base for fish larvae and juveniles is formed. Earlier, studies of the end of the last century (Vorobyova, 1999) and the first decades of the 21st century were devoted to these issues (Vorobyova, Kulakova, Sinegub et al., 2017; Vorobyova, Kulakova, Bondarenko, Portyanko, 2019; Vorobyova, 2021; Vorobyova, 2021a). The characteristics of the meiobenthos of the upper sublittoral of the Odesa Bay can be interpreted for the coastal zones of the water areas adjacent to it in order to determine the location and size of bottom areas with the best food supply for juvenile fish.

PSAMMOCONTOUR.

Interstitial meiofauna supralittoral and mediolittoral sandy beaches of the Black Sea.

The main term "meiofauna" was used firstly by M.F. Mare (Mare, 1942). The term "interstitial" for microfauna, inhabiting in the spaces between the particles of sand, filled with water, was introduced by Nichols (Nichols, 1935). Later Remane (Remane, 1952) used term "mesopsammon", and for interstitial environment – "mesopsammal".

"Interstitial fauna" and "mesopsammon" can be used, according to Zinn (Zinn, 1968), as synonyms for the whole microfauna of precipitation interstitial medium, and mainly − for freshwater psammon and mostly for brackish-water psammon, inhabiting groundwaters. Zinn suggests using of the term "thalassopsammon" for the marine interstitial environment.

Made compilation of data on interstitial meiofauna of sandy beaches of the Black Sea (on the example of the Odesa Coast). Sandy beaches, one of the contour of the sea habitat is regarded as the zone of interpenetration marine, freshwater and soil fauna.

Along with the pelagial and benthal, the contour or marginal biotopes are forming a specific category of habitats in the marine environment. For a long time, these biotopes, located at the sea-atmosphere, sea-shore and sea-river interfaces have not attracted researchers' attention as they were considered of no particular interest (Zaitsev, 2006). Boundary of the "sea-sandy beach" as a habitat is represented by sandy beaches with their above-water (supralittoral), semi-aquatic (pseudolittoral) and underwater (upper sublittoral) surfaces, where different and intensive physical, chemical and biological processes elapse, which consequences affect not only in a narrow zone of the sea psammocontour, but also far beyond it in the sea, as well as in the direction of land (Vorobyova, Zaitsev, Kulakova, 1992). Here the special conditions for the existence of aquatic organisms are formed. On the one hand, this area is subjected to a number of extreme influences, such as tides, wave activity, temperature, lighting, etc. (Alexandrov, Zaitsev, Goncharov et al., 2012).

At least half of the nearly 3,500 km of the Black Sea coastline is occupied with the sandy beaches, and in a region such as its north-western part, where the length of the coast from the Cape Tarhankut (Ukraine) to the Cape Kaliakra (Bulgaria) is about 1100 km, sandy beaches, including the islands and spits, stretching more than 1,000 km. This gives the reason to believe that sandy supralittoral and pseudolittoral form the major, if not the main, proportion of the sea marginal (contour) biotopes, located on the outside of the water's edge line (Vorobyova, 1999).

There is only fragmentary information about certain types of invertebrate animals referred for the sea edge. As for the supralittoral, it can bravely be considered as a "white spot" in hydrobiological studies. Unfortunately, in our country, in contrast to the other, the researches of the external contour of the sandy sea is not well developed, which can be explained, on the one hand, by the complexity of research; on the other – by underestimation of the research results both in theory and in practice

In the foreign literature extensive summary on the matters discussed above already exists. A large proportion of it is dedicated to faunistics, morphology and ecology of three groups: turbellarians, nematodes and harpacticoids, possessing with high species diversity and a large number (Galtsova, 1984; Ax, 1974; Boaden, 1963; Bush, 1968; Faubel, 1976; Leates, 1987; Laubier L 1967; Uzunov, 1974, 1977, 1978).

The coastal part of the Black Sea at a depth of 5 m is currently the least studied area. Splash zone, and especially supralittoral, previously considered as little-inhabited, has not been studied at all for a long time. Only a few decades ago, when scientists from various countries have shown that the interstitial meiofauna of these sea areas is very rich in species and quantitatively, interest in studying the sandy beaches of the Black Sea has increased dramatically.

As is known, any synecological study have several stages, on the first of which investigation of the organisms' species composition is carried out. Due to the fact that only a few groups of interstitial meiofauna of the Black Sea

sandy beaches have enough complete lists of species, this stage will be relevant and necessary for a quite long time.

The next step is obtaining of quantitative indicators determination of population densities and their biomass, which are necessary to reflect the heterogeneity of the abiotic conditions, existing within the considered habitat. Very poor information about the total number of the interstitial meiofauna, as well as about its various groups and individual species, the temporal and seasonal dynamics of these indicators in the NWBS required our close attention.

External relations of the Sea passing through its contour biotopes, and contour communities first and in the most tangible form face the influence of external factors. It is explained not only by the peripheral position of the biological contours of the sea, but also by the fact that many allochthonous substances in the marine environment accumulating in its habitats (Zaitsev, 1987).

We consider sandy beaches as a kind of ecotone, which is characterized by the influence of the sea, land and atmosphere. Legitimacy of this view to the sandy parts of the coast proves the presence of faunas, heterogeneous according to the origin, in the biotope. Thus, over the years we have explored the species composition and the densities indices for representatives of the order of mites (Vorobyova, Kulakova, 1987, 1988). It was shown that both soil and marine fauna species are typical for sandy beaches. However, among both of them there are specific species, peculiar only for certain biotope.

However, among the meiobenthos representatives most of the animal throughout its lifecycle refer with its small size to the current category. B. Bougis (Bougis, 1950) proposed to include groups such as Nematoda, Gastrotricha, Kinorhyncha, Harpacticoida, Halacaridae, Foraminifera, Tardigrada, and others, to a constant component of the meiofauna, which are preferred not be viewed as static, but as a taxonomic category (Mack-Fira, 1968). To the temporary component B. Bougis (Bougis, 1950) and A.D. McIntyre (McIntyre, 1969) attribute representatives of macrobenthos in the early stages of development, that can have a very high population density.

L.L. Chislenko (Chislenko, 1961) proposed the term “eumeyobenthos” or “eumesobenthos” for the permanent component, and for the temporary – “pseudomeiobenthos” or “pseudomesobenthos”. In justifying the appropriateness of these terms, the author emphasize that they do not reflect the temporary or permanent membership of these two groups to mesobenthos, as this feature cannot be the main. In our research we use both the generally accepted terminology and the terminology of Chislenko L.L.

Unfortunately, contour biotope “coast-sea”, which plays a very important role in the life of the upper sublittoral, remains today the least studied. This fully applies to the sandy beaches of the Black Sea, which occupy thousands of kilometers of coastline and forming a large, if not the major, part of the contour biotopes of the sea, located on the outside of the water line.

The presence in the Odessa Region of sandy beaches with different granulometric composition of sediments (from small- to coarse-grained) allowed to use them as a model to describe the basic regularities of structure formation and the spatial distribution of meiofauna in interstitial of different parts of the Black Sea coast.

A varied composition and rich, according to number, marine meiofauna, characterize the interstitial of the Black Sea sandy beaches (pseudo- and supralittoral): Turbellaria, Nematoda, Gastrotricha, Cyclopoida, Harpacticoida, Ostracoda, Polychaeta, Archiannelida, Oligochaeta, Acarina, Mollusca. Representatives of the most groups are identified to species. Turbellaria, Nematoda and Harpacticoida are found in the sands of all types, but each group is represented by the greater number of species in the coarse-grained sand. Some organisms − Halacaridae, Polychaeta − are confined only to the coarse-grained sand. Others, giving a clear preference for one of three types of sediments, may occur in the sands of a similar structure, but with a lower density. Thus, medium-grained sands are settled by invertebrates, that are typical for either the first (coarse-grained), or for the third (small-grained) type, but their density is usually low.

One of the determining factors in the formation of the interstitial meiofauna species composition of beaches is the granulometric composition of its sandy sediment. Abundant meiofauna develops there, where interstitia are large enough, the sand is washing and well aerating. The most diverse is meiofauna of coarse-grained sands; it is presented with nine taxa of invertebrates: Turbellaria, Nematoda, Harpacticoida, Ostracoda, Arhiannelida, Polychaeta, Oligochaeta, Halacaridae, and juvenile Mollusca). Turbellaria, Nematoda, Gastrotricha, Harpacticoida and Oligochaeta are characterized for small-grained sands.

Annual average characteristics of interstitial meiofauna density on pseudolittoral for different seasons are in 1,5−3 times higher than in the supralittoral.

The maximal annual average characteristics of the meiofauna density on the coarse-grained sandy beaches are confined to May and June (3,480 and 2,878 ind.·100 cm^{-3}, respectively for the layer of 0–10 cm), medium-grained sands – to June and July (3,490 and 1950 ind.·100 cm^{-3} respectively), small-grained sands – to June (1,020 ind.·100 cm^{-3}). Two number maximums are observed on the supralittoral of the coarse-grained sediments – in May and September. The average annual meiofauna number indices in the medium- and small-grained sands are observed from April to July.

Along the vertical total interstitial meiofauna is distributed unevenly. Typically, animals form denser clusters in the splash zone microhorizon of 4-10 cm in the sands of all three types, which is true for the daylight period. At night, the crustaceans rise to the upper layers (Vorobyova, Zaitsev, Kulakova, 1992). On supralittoral sand-level of 30-50 cm is populated more intensively in coarse- and medium-grained sands.

TURBELLARIA. Turbellaria is one of the least studied groups of the Black Sea meiofauna, despite the fact, that the first papers (Pereyaslavzeva, 1891) refer to the end of the past century. For the Odesa coast at different times the following species were indicated: *Endocelis ovata* Schm., *Monocelis agilis* Schm. and *Macrostomum hystrix* Oerst., *Aphanastoma deversicolor* and *Promestoma bilineatum*, Chislenko, *M. lineata*, *M. longiceps*, *Phaenocora*

salinarum subsalsa, *Procerodes lobata* and *Monocelis lineate* (Beklemishev, 1882; Buchinsky, 1885; Uljanin, 1879).

Quantitative indicators of pseudo- and supralittoral's turbellarians were carried out only (Marinov, 1975) for the Bulgarian coast. The author shows three species: *Archotoplana flexilis* Ax, *Cyclogynopora biarmata* Steinbock, *Pseudomonocelis ophiocephala* O. Schm. It is also noted, that the maximum density of worms in pseudolittoral under 1 m^2 was 89,800 ind.

Our research has shown that in the quantitative relation Turbellaria almost in all cases dominate along with Nematoda and Oligochaeta, forming the densest clusters in March-April and October. Turbellaria are found in the sandy beaches' interstitial everywhere and year-round. According to different seasons of a year their contribution to the total number of organisms in the splash zone is 0,6–98 % in the coarse-grained sediments, 2,8–75 % − in the medium, and 2,8–100 % − in the small-grained sediments. On the spray zone share of turbellarians makes up in average 0–57% of the total meiofauna for the different types of sand. Long-term average annual indices of the turbellarians' density on the pseudolittoral: in coarse-grained sand during winter – 66,1 ind.·100 cm^{-3}, spring – 185,9 ind.·100 cm^{-3}, summer – 175,7 ind.·100 cm^{-3}, autumn – 154,8 ind.·100 cm^{-3}; in the medium-grained sand during spring it is 207,9 ind.·100 cm^{-3}, in summer – 43,2 ind.·100 cm^{-3}, autumn – 24,5 ind.·100 cm^{-3}; in the small-grained sand during spring – 92,8 ind.·100 cm^{-3}, summer – 88,5 ind.·100 cm^{-3}, autumn – 34,0 ind.·100 cm^{-3}. On the spray zone in the coarse-grained sand in one and three meters from splash the turbellarians' population density throughout the all depth of sediments (0 to 60 cm) averaged to 1,0–18,2 ind.·100 cm^{-3}.

NEMATODA. Nematodes in the sandy beaches are represented by 41 species, belonging to four orders, 17 of which are typical also for the open waters of the Black Sea north-western part (Vorobyova, Zaitsev, Kulakova, 1992; Vorobyova, 1999; Vorobyova, Kulakova, 2009). According to I.I. Kulakova the most prevailing species of interstitial are *Enoplus euxinus* Fil., *E. littoralis* Fil., *E. maeoticus* Fil., *E. brevis* Fil., *Monhystera filiformis* Bastian, *M. conica* Fil. and *Cobbionema arcocerca* Fil.

The nematodes' proportion in the total number of meiofauna in the sands of different structures is the lowest in the pseudolittoral (average 4−17 %). Here with in the coarse- and medium-grained sands it is higher on the depth of 4–10 meters, and in the small-grained – in the near-surface layer. On the pseudolittoral nematodes dominate in the lower layers (4–10 cm), where their quantity in the near-surface layer (0–4 cm) is maximal in spring (average – 50–55 ind.·m^{-3}). In the layer of 4–10 cm they form large accumulations in spring (average – 115 ind.·m^{-3}) and in autumn (average – 68 ind.·m^{-3}).

Proportion of nematodes in the total quantity on the spray zone is in several times higher (especially in medium-grained sands); the maximum average index is 62 %. The maximum density of nematodes was observed in the coarse-grained sand in the upper part of spray zone in autumn on the depth of 10–30 meters (average 100 − 140 ind.·m^{-3}), in the medium-grained sand – in the summer in 1 and 3 meters from splash on the depth of 0–30 cm (65 – 70 autumn ind.·100 cm^{-3}); in the small-grained sand – during summer in the near-surface horizon in 1 and 3 meters from the water's edge (40–60 ind.·m^{-3}).

GASTROTRICHA. Representatives of the interstitial meiofauna (class Gastrotricha) at supralittoral, pseudolitral and sandy beaches of the Black Sea are widespread in the beach sediment loads. The main habitat in the NWBS is sand of the small-grained structure. They were detected by us in the small quantities also in the medium-grained sands, but not in the coarse-grained. According to the long-term researches two species of Gastrotricha – X*enotrichula beauchampi* and *Turbanella cornuta* – are the permanent component of meiofauna, the third species of Gastrotricha − *T. cornuta* – wasn't noted after 1975 year. Gastrotricha is a common specie for splash zone and it is rarely found on the spray zone, while the representatives of the family Turbanellidae are typical for both pseudolittoral and for the spray zone.

Gastrotricha are found in the interstitial much of the year, their density varies widely. The maximal rate is 395 ind.·100 cm^{-3}.

Gastrotricha are present on pseudolittoral from March to October, the rest of the year they are rare component of meiofauna. In April they reach a significant development as a dominant group of meiofauna according to

quantity. In spring and autumn Gastrotricha' share of the total interstitial meiofauna on the different microhorizons varies from 55 to 100%, in the summer it is no more than 25 %.

In the splash zone density of Gastrotricha distributes unevenly regarding to vertical. Lower microhorizon (4-10cm) is populated by them more intensively, especially in the spring and fall. Thus, in April and May density of Gastrotricha in the near-surface layer is 104 in the middle, and on the bottom – 198 ind.·100 cm^{-3}. On pseudolittoral reach maximum development from May to July (average 183–363 ind.·100 cm^{-3} for the both microhorizons).

Gastrotricha live throughout the year at various depths on a supralittoral in the beach drifts depth from the near-surface layer to the groundwaters level. In spring and autumn, they adapt a thicker layer of sand – from 10 to 50 cm. In summer, they migrate to the upper layers and are not commonly found deeper than 30 cm. The maximum density index of Gastrotricha on supralittoral in a meter away from splash averages 395 ind.·100 cm^{-3} (April), in 3 meters from splash it is 76 ind.·100 cm^{-3}.

HARPACTICOIDA. For the first time interstitial copepods were described by Wilson (Wilson, 1932) in his monograph, he showed that harpacticoids are adapted to habitation in the interstitial water. Nichols (Nichols, 1935), that was first, who introduced the term "interstitial", described harpacticoids of this unique habitat from the various parts of the world; he showed morphological adaptation of copepods to this peculiar habitat.

Along with nematodes harpacticoids are the most mass group in psammon (Schmidt, 1974, 1976, 1978; Swedmark, 1964; McIntyre, Munro, Steele, 1969). It was established, that depending on the mechanical structure of sand (from small to large) dominance comes from nematodes to harpacticoids.

According to L. V. Vorobyova on the studied coastal sites harpacticoids were represented by nine species, eight from which – *Stenocaris pontica*, *Harpacticus littoralis*, *Nitocra spinipes*, *N. affinis*, *N. pusilla*, *Ectinosoma melaniceps*, *Arenopontia subterranea*, *Ameira parvula* – are confined to coarse-grained sand. In interstitial of medium-grained sands such species as

Arenopontia subterranea, *A. parvula N. pusilla*, *E. melaniceps, N. pusilla*. *E. melaniceps* were commonly found. Only one species − *Paraleptastscus spinicauda trisetosa* – is typical for the small-grained drifts. We found, that the proportion of harpacticoids in the total number of meiofauna during the year widely varies, and increases from small – to coarse-grained sands. Harpacticoida is a dominant group on a population density in the coarse-grained sands. Their quantity on pseudolittoral in spring ranged from 235 ind.·100 cm^{-3} to 2931 ind.·100 cm^{-3} in different years. In the summer, the density of their populations ranged from 639 ind.·100 cm^{-3} to 1,360 ind.·100 cm^{-3}. They considerably dominate on pseudolittoral in the layer of 4–10 cm year-round, which is true for the light period of the day. Our studies of the dynamics of the vertical distribution of harpacticoids settlement density have revealed that during night hours, crustaceans migrate to the 0–4 cm microhorizon (Vorobyova, Zaitsev, Kulakova, 1992). On supralittoral density of harpacticoids is distributed unevenly throughout the year in both the vertical and horizontal directions with minimal characteristics in winter. Copepods are concentrated mainly in the layers of 20–30, 30–40, 40–50 cm (125–194ind.·100 cm^{-3}). The maximum concentrations are typical here in autumn at a depth of 40–50 and 50–60 cm (max. – 1,792 ind.·100 cm^{-3}). The harpacticoids' density in the spring-summer period decreases with distance from the splash zone. They form a significant concentration at a distance of 3 meters from the water at supralittoral horizons of 30–40 and 40–50 cm in the autumn, migrating into the deeper layers of sandy sediments.

OSTRACODA. The overwhelming majority of the marine ostracods refers to the benthic animals, living on the surface of bottom sediments. Lives of many species are associated with macrophytes. The most significant contribution to the study of the Black Sea ostracods were made by Marinov (Marinov, 19750 and Shornikov (Shornikov, 1967). Some species have adapted to living in the sandy sediment interstitial. On the Odesa sandy beaches on pseudo- and supralittoral they are represented by seven species: *Loxoconcha pontica*, *L. nana*, *L. elliptica*, *Microcythere longiantennata*, *Parvocythere hartmanni*, *Hemicythere bulgarica*, *Leptocythere multipunctata*.

They occur from March to October. The spatial distribution of crustaceans is closely related to the mechanical structure of sandy drifts. The main habitat is coarse-grained sand; the densest clusters are formed on pseudolittoral (layer of 4–10 cm, in the supralittoral they mostly concentrated at a depth of 30–50 cm). Medium-grained sand is a habitat for single specimens only in the splash zone. In the small-grained sand they were not found. Their share of the total number of interstitial meiofauna is insignificant and does not exceed 6 %, they are characterized by low population density (4-122 ind.·100 cm^{-3}).

ACARINA. As mentioned above, researches of the sandy beaches have particular interest because this habitat is Region of the marine, freshwater and soil fauna mixing. The simultaneous study of the marine fauna and soil mites' faunistic composition on the sandy beaches' pseudolittoral and supralittoral have allowed to get another one confirmation that the examined area of the sea coast is a transition zone (ecotone) between the two neighboring climax communities, where they are interpenetrating. The literature provides information on the study of the coastal waters' mites, particularly in the coastal sandy beaches (Konners-Ionescu, 1968, 1970, 1973; Krantz, 1976; Petrova, 1972, 1973, 1976, 1978; Vorobyova, 1977, 1992). According to Preston (Preston, 1978), representatives of suborder Mesostigmata were marked in the sands of the Herd Island (England) beach. During the exploration of the Bulgarian groundwaters' fauna (Petrova, 1972) species of marine mites, hitherto unknown to the Black Sea, have been discovered and described as well as a new species *Rphreaticus phreaticus* sp.n. and subspecies *Actacarus illustrans bacescui* (Konnerth-Ionescu, 1970).

On the studied coast area, we found the following types of marine and soil mites: marine: *Actacarus pygmaeus* Schulz, 1936; *Halacarus prozerus* Viets, 1927; *H. capuzinus* Zohman, 1893; *H. floridearum* Zohman, 1889; soil: *Rhodacarus olgae* Scherbak, 1974; *Rhodacaropsis inexpectatu*s Willman, 1935; *Mediorhodacarus tetranodulus* gn. sp. Scherbak, 1976; *Tyrophagus putrescentiae* Schrank, 1884; *Halolaelaps nodosus* Willrftan, 1952; *H. saproincisus* Hyatt, 1956; *Hydrogamasus* sp. Troess., 1890; *Typhlodromus soliger* Rib., 1916; *Brevipalpus obovatus* Dannadicu, 1952; *Hypoaspis aculifer*

Canestrini, 1883; *H. hesediausi* Oudemmans, 1900; T*etranychus carpini* Oudemans, 1902 (Vorobyova, Zaitsev, Kulakova, 1992).

Marine mites are found from May to October in the coarse-grained sands, in the medium-grained sands they are rare. Unlike most of the groups, more dense clusters are confined to supralittoral. Soil mites on supralittoral are usually found in the layers of 0–10, 10–20, 20–30, and in a less degree – in the layer of 30–40cm; marine mites commonly inhabit the horizons of 20–30, 30–40 and 40–50 cm (before the level of groundwaters). The closest contact of the marine and soil fauna's representatives occurs on supralittoral zone, located in 3 meters from the water's edge. On pseudolittoral some soil mites are found in the near-surface layer of 10–0 cm, marine species occupy interstitial spaces of the splash zone in layers 0–4, 4–10 and 10–20 cm. Population density of marine mites ranged from 10 ind.·100 cm^{-3} to 74 ind.·100 cm^{-3} in the different seasons.

Study of interstitial meiofauna of sandy beaches is very important at this time. Changes that occur in marine ecosystems to climatic and anthropogenic factors, particularly evident in the contour biotopes. Sandy beaches, which are located on the border of the sea and the coast, influenced both by land and sea, and from the atmosphere. The greatest human impact on species diversity and quantity of experiences interstitial meiofauna of sandy beaches in the metropolitan areas (port facilities, sanitary sewage, waterworks, etc.), and in areas where the influence of flow of river water.

MEIOBENTHOS OF THE SEA OF AZOV ("coast-sea" contact zone).

One of the smallest basins of the Atlantic Ocean, the Sea of Azov, has an area of 38 thousand km^2, an average depth of 8 m, with a predominant depth of 9–13 m. Depths less than 5 m occupy a narrow coastal zone, while depths of 5–10 m account for 50.2 % of the total area (Zenkevich, 1963). A characteristic feature of the sea is the weak indentation of the coast and the presence of several bays. The largest of them, Taganrog, juts deep into the land in the northeastern part of the sea. Near the western coast is the Sivash Bay

system, separated from the Sea of Azov by a narrow spit (Arabat Spit) and connected to it by a strait.

The Azov Sea is surrounded by a vast drainage area (the area of the Don and Kuban basins alone reaches 480 thousand km^2), which is home to 14 million people, with developed industry and intensive agriculture. Flowing into the sea, some rivers form estuaries (Obitochny, Miussky, Yeysky, etc.). An important feature that determines many abiotic and biotic parameters of the Sea of Azov is its connection with the Black Sea through the Kerch Strait. Its length is 45 km and its width is from 3.7 to 42 km. The inflow of water into the Sea of Azov from the Black Sea is 33 km^3/year.

In the Azov Sea, the currents are unstable and depend on wind activity. The horizontal circulation of waters is cyclonic in nature; in the central part, the currents swirl counterclockwise. During our studies, the minimum salinity values (less than 5 ‰) were in the Taganrog Bay (Bogatova, Garkavaya, 1989), and the maximum (in the surface layer – 13 ‰ and in the bottom layer – 15.5 ‰) were noted at the entrance to the Kerch Strait.

In recent decades, anthropogenic successions of the Azov Sea ecosystem have become the object of close study in the interests of science and the national economy. This reservoir has always been considered one of the most productive seas on Earth. The resolution of the V Congress of the All-Union Hydrological Society (September 1986) indicated the need for a comprehensive study of the meiobenthos of the Azov Sea due to the lack of data on the faunistic composition and indicators of settlement density of both the meiobenthos as a whole and its individual groups. A comprehensive study of the meiobenthos of the Azov Sea was conducted for the first time by scientists from our Institute.

The obtained information about such an important element of biota will allow us to evaluate and forecast the formation of commercial resources for the future. Of particular interest in this aspect is the study of such meiobenthos groups as crustaceans (especially Ostracoda), Oligochaeta, and young mollusks. With a reduction in river flow and further salinization of waters, we

should expect the penetration of marine species of meiobenthos into the western, central, and eastern parts of the sea in the future.

in July–August 1983, we conducted a comprehensive survey of the Sea of Azov, which allowed us to obtain a fairly complete description of the state of its ecosystem in this period based on hydrochemical and hydrobiological parameters. Meiobenthic samples were collected at 23 stations (Fig. 1.1), covering various areas of the sea and Taganrog Bay.

Foraminifera, Nematoda, Harpacticoida, Ostracoda, Kinorhyncha, Turbellaria, Oligochaeta, Polychaeta, juvenile Bivalvia and single gastropods were found in the meiobenthos of the Azov Sea. Of the listed groups, the species diversity of the meiobenthos was determined by only five of them (Nematoda, Harpacticoida, Ostracoda, juvenile mollusks). Nematodes were present everywhere, the occurrence of ostracods and harpacticoids were 94.5 % oligochaetes – 63,2 %, foraminifers and juvenile bivalves – 57.9 % each. The remaining groups can be considered random, since they were noted only once.

Spatially, the total number of meiobenthos was distributed very unevenly. It varied in different areas of the sea depending on the type of soil, hydrological and hydrochemical conditions from 2,300 to 570,000 ind.·m^{-2} (Table 4.1). The average population density of different groups was as follows: Foraminifera-1,079 ind.·m^{-2}, Nematoda – 14,944 ind.·m^{-2}, Ostracoda – 45543 ind.·m^{-2}, Harpacticoida – 15,104 ind.·m^{-2}, Oligochaeta – 14,203 ind.·m^{-2}, Polychaeta – 712 ind.·m^{-2}, mollusks – 9,275 ind.·m^{-2}. The biomass of meiobenthos varied from 562 to 18,060 mg·m^{-2}.

In the Taganrog Bay, bottom sediments are mainly represented by silts and silted shells. Fluctuations in salinity at the bottom in different areas are from 4.28 to 10.60 ‰. Nematoda, Harpacticoida, Ostracoda, Foraminifera, Polychaeta and juvenile bivalve mollusks were found. The total number and biomass of the bay, formed by Nematoda, Harpacticoida, Ostracoda, varied within 61,875–179,250 ind.·$m^{-2}$and 9.5–1,657 mg·m^{-2}, respectively.

The upper reaches of the bay are characterized by absolute dominance of ostracods in the total number of meiobenthos (95.8%). Harpacticoids

predominated in the rest of its water area (36.2–43.9 % of the total number of organisms). The subdominant group was nematodes. Together, these three groups accounted for 73.1–96.5 % of the total meiobenthos in the Taganrog Bay (an average of 84.9 %).

The density of nematode settlements is very heterogeneous (minimum – 2,500 ind.·m^{-2}, maximum – 45,000 ind.·m^{-2}), their largest accumulations are typical for areas with a salinity of more than 6 ‰. Harpacticoids were not found in the upper reaches of the estuary at a salinity of 4.8 ‰, in the rest of the water area, as salinity increased, their numbers increased from 22,625 to 120,000 ind.·m^{-2}.

Taganrog Bay is the main feeding area for young fish, most of which consume crustaceans and worms. Based on the results of our research, we can consider that in the early 1980s the food supply for young fish was satisfactory

In the eastern part of the Azov Sea (depth 6.5–11 m), silty soils prevailed, and only in the shallowest zone was there sandy-shell soil. We did not find only turbellarians. In most cases, harpacticoids dominated in terms of settlement density. The number of ostracods is small (Table 1.1.).

The meiobenthos is quite diverse. The total number was within the range of 12,650 to 43,750 ind.·m^{-2}, the total biomass – from 5.19 to 418 mg·m^{-2}.

This can be explained by their intensive consumption by young fish, which are characterized by significant accumulations in this water area. The same can be said about other representatives of the meiobenthos.

In the central part of the Sea, at a depth of 10–13.5 m and a salinity of 10.6–11.6 ‰, the density of meiobenthos settlements was significantly heterogeneous – from 73,000 to 612,500 ind.·m^{-2}. At each station, its diversity was determined by four to seven groups, the minimum of which was confined to zones with maximum salinity (nematodes, harpacticoids, ostracods, and oligochaetes). The meiobenthos was most diverse in waters with a salinity of 10.1–10.6 ‰, where only foraminifers and turbellarians were absent from the meiofauna representatives specified for the Sea of Azov.

Table 1.1.

Average abundance (N, ind.·m^{-2}) and biomass (B, mg·m^{-2}) of meiobenthos in different areas of the Azov Sea.

Group		Area	West	Central	Eastern	Southern
Foraminifera	N	325.0	0	0	1 531.0	3 282.0
	B	0.2	0	0	0.79	0.7
Nematoda	N	24 800.0	19 937.0	22 050.0	4 060.0	3 875.0
	B	9.4	7.5	8.3	1.54	1.47
Harpacticoida	N	51 550.0	12 250.0	6 070.0	3 500.0	2 166.0
	B	515.5	122.6	60.7	35.0	21.6
Ostracoda	N	50 175.0	57 500.0	106 900.0	2 100.0	11 041.0
	B	1 906.0	2 220.0	4 062.0	79.8	419.8
Oligochaeta	N	687.0	12 652.0	41 675.0	3 312.0	12 687.0
	B	7.5	139.2	458.4	36.4	139.5
Polychaeta	N	600.0	0	725.0	650.0	875.0
	B	13.8	0	16.6	14.9	20.1
Bivalvia	N	2 300.0	13 625.0	20 026.0	3 593.0	830.0
	B	165.6	980.0	1 873.0	258.6	59.7
Meiobenthos, total	N	13 0467.0	115 968.0	203 445.0	18 748.0	32 856.0
	B	2 619.1	3 449.2	6 479.1	426.0	662.0

The formation of the total abundance indicators was determined here mainly by Ostracoda, Oligochaeta and Nematoda. In various areas, ostracods accounted for 23.7–70.6 % of the total number of organisms (41.9 % on average), oligochaetes – 3.2–34.6 % (18.7 % on average), and nematodes – 5.3–52.9 % (21.8 % on average). Thus, at the central part of the sea, the dominant group in terms of numbers was ostracods. Oligochaetes and nematodes acted alternately as the subdominant group. Juvenile bivalve mollusks were present almost everywhere, the maximum indicator for the entire Sea of Azov was 57,000 ind.·m^{-2}.

The central part is characterized by relatively high biomass of meiobenthos, most of which was determined by ostracods and young bivalves. For example, at station 26, out of a total biomass of 18,060 mg·m^{-2}, ostracods accounted for 16,440 mg·m^{-2}.

In the western part of the Sea, the meiobenthos is qualitatively poorer than in the central part. Its diversity at most stations was determined by five groups (Nematoda, Harpacticoida, Ostracoda, Oligochaeta and mollusks). The distribution of meiobenthos density indicators was relatively uniform

(103,750– 197,500 ind.·m^{-2}). A characteristic feature is the clear dominance of ostracods in the total number of organisms. On average, for the area under consideration, they amounted to 55.1 %, the density of shell crustacean's settlements varied from 21,875 to 142,500 ind.·m^{-2}. A significant concentration of juvenile mollusks was noted in the southwestern part – from 207,50 to 33,750 ind.·m^{-2}.

The area adjacent to the Kerch Strait was characterized by heterogeneity of the qualitative composition of meiobenthos and a significant range of its quantitative indicators during the study period. Three to six groups were present at each station. The total number of meiobenthos varied from 12,650 to 60,500 ind.·m^{-2}. Ostracoda – averaged 17.2 %, Nematoda – 13.1 %, Oligochaeta – 32.5 % of the total number of organisms.

An analysis of the ratios of the average indicators of the population density of various meiobenthos groups showed that ostracods accounted for the most of the total number of organisms – an average of 45.15 %, while nematodes, harpacticoids and oligochaetes accounted for 14.85 %; 14.97 % and 14.08 %, respectively. As can be seen the highest biomass indicators are confined to the central and western regions.

Of the two components of meiobenthos – eumeiobenthos and pseudomeiobenthos – the first was predominant in all areas of the Azov Sea; it accounted for 57.1–97.3 % of the total meiobenthos, and this was especially clearly expressed in the western part and in the Taganrog Bay.

FORAMINIFERA. The faunistic composition of the Foraminifera of the Sea of Azov is formed by relict forms of the Ponto-Caspian, Black Sea immigrants and endemics (Yanko, Vorobyova, 1990): *Miliamina furca* (Brady), *Mayerella brotzkajae (*Mayer*), Ammonia novoeuxi-nica* Stschedrina et Mayer*, A. parasovica* Stschedrina et Mayer*, A. tepida (*Cushman*), Cornuspira minuscula (*Mayer*), Elphidium caspicum azovi-cum Jnko, ssp.n., Haynesina anglica* Murray*, Porosonion subgranosus mediterraneum Jnko, ssp.n., Quinqueloculina seminulum (Linne), Trichochyalus aguajoi (*Bermudes*), Quinqueloculina oblonga (*Montagnu*), Discammina imperspica Jnko, Rotaliammina ochracea (Williamson), Aubignyna perlucida (*Heron-

Allen et Earland*), Canalifera parkerae* Jnko*, Crib-roelphidium powyanum (*d'Orbigny*), Elphidium ponticum* Dolgopolskaya et Pauli*, Nonion metagordanus (*Kornfeld*), Porosononion martcobi pon-ticum Jnko, ssp.n..*

Most Foraminifera are represented by shallow-water and cold-water species. During the period of research (1976, 1983), the number of Foraminifera in the total number of meiobenthos increased significantly (from 3.5–11 to 11–40). Penetrating from the Black Sea through the Kerch Strait, foraminifera are distributed in accordance with the direction of the main vectors of bottom currents in the western and central parts of the Azov Sea, right up to the middle of the Taganrog Bay (Vorobyova, 1999). In the latter, the species diversity of Foraminifera is determined by 8 species, among which *M. brotzkajae* is most widely distributed over the water area of the bay; its population density is extremely low. In the upper reaches of the estuary, with a salinity of the bottom layers of water of 4.28–6.8 ‰, foraminifera were not found. In the central part they are few in number (single specimens in samples), and only in the southern part and in the area of the mouth of the estuary their density in different years was 5,000–6,300 ind.·m^{-2}.

In the open part of the Sea of Azov Foraminifera are represented by 17 species (Yanko, Vorobyova, 1990), among which the most common were *A. parasovica, A. tepida, A. novoeuxinica, H. anglica, E. caspicum azovicum*. The density of settlements of representatives of the foraminiferal complex in different seasons varied from 2,875 to 165,000 ind.·m^{-2}. The accumulation of organic matter in the benthal is also of great importance for the active development of representatives of this group. Due to the hydrodynamic features of the bottom layers of water and the intensity of photosynthetic processes in the near-surface horizons of the pelagic zone, the densest accumulations of foraminifera are confined to the central and eastern parts of the Azov Sea.

NEMATODA. The study of nematodes was started by I.N. Filipiev (1922). He noted 15 species of free-living nematodes. According to I.I. Kulakova (Vorobyova, Kulakova, 1989, 1990), the diversity of nematodes in the Sea of Azov is determined by 23 species belonging to 5 orders:

Rhabdodemania pontica Platonova, *Oxystomina elongata (*Butschl*i), Oxystomina sp., Enoploides brevis* Fil*., Viscosia minor* Fi*l., Halalaimus wodjaniskii* Sergeeva, *Halalaimus sp., Anoplostoma viviparum* (Bastian*), Dichromadora cephalata* Fi*l., Neochromadora poecilosomoides* Fil*., Prochromodorella mediterranea* Mico-letzki, *Sabatieria quadripapillata* Fil*., Monchystera conica* Fil*., Paramonchystera proteus Wieser, Cylindrotheristus maeoticus* Fil*., Theristus litto-ralis* Fil*., Terschellingia longicaudata* de Man, *Eleutherolaimus longus* Fil*., Sphaerolaimus gracilis* de Man, *S. ostreae* Fil*., Microlaimus sp., Parodontophora quadristicha* Timm, *Diplopeltis sp.*

Studies on the western shelf of the Black Sea have shown that nematodes generally make up 50–90% of the total number of organisms (Vorobyova, 1985; Kulakova, Vorobyova, 1987). The Azov Sea is an example of a water body in which nematodes often yield their leading role to other groups in terms of population density. Thus, their population density in the western part is

14.8% of the total number of organisms, in the eastern part and in the Kerch Strait area – 16.5 and 17.8 %, respectively. During the study period, roundworms dominated in the central region (28.1%) and Taganrog Bay (33 %) (Vorobyova, Kulakova, 1990).

In the Sea of Azov, the number of Nematoda averaged 17,000 ind.·m^{-2}. The highest density and biomass were noted in the central and western parts of the sea (38,000 ind.·m^{-2} and 14.4 mg·m^{-2}, respectively) and in the Taganrog Bay area (45,000 ind.·m^{-2} and 2.85 mg·m^{-2}, respectively). If we consider the distribution of nematodes depending on the type of soil, then the most abundant are silts and silted shell rock, which are mainly characteristic of the Azov Sea. On shell rock and sand, located in a small area in the eastern part, the number of nematodes was insignificant. The greatest species diversity of nematodes was noted in the central part of the Sea.

HARPACTICOIDA. Representatives of the Harpacticoida order are a significant component of the meiobenthos of the Azov Sea. With a wide range of density indicators of their settlements in various areas of the benthal (6,000–120,000ind.·m^{-2}), they accounted for an average of 20.9 % of the total number of organisms in the Azov Sea. According to Vorobyova L.V., the species

diversity of the group under consideration is determined by 13 species.: *Canuella perplexa* T. et A. Scott, *C. furcigera* Sars, *Ectinosoma abrau* Kristhagin, *Harpacticus flexus* Bradi et Robertson, *H. uniremis* Kröyer, *Tisbe furcata* Baird, *Metis ignea* Philippi, *Nitocra hibernica* Brady, *N. lacustris (*Schmankevitsch*), Limnocletodes behningi* Borutzky, *Laophonte longicaudata* Boeck, *Cletodes tenuipes* T. Scott, *Cletocamptus confluens (*Schmeil*).* The most extensive range is found in *Limnocletodes behningi* (50 % of occurrence) and *Canuella perplexa* (38 % of occurrence). The highest rates of species diversity of harpacticoids are characteristic of silty soils (Table 1.2).

The formation of the qualitative composition and density of harpacticoid settlements is spatially heterogeneous. The maximum number of species was noted by us in the western part of the Sea (*Canuella perplexa, Limnocletodes behningi, Cletocamptus confluens, Cletodes tenuipes, Nitocra hibernica, N. lacustris, Ectinosoma abrau, Tisbe furcata, Harpacticus uniremis)*. For the central and eastern regions, we indicate 4 species each: *Canuella perplexa, Limnocletodes behningi, Nitocra hibernica, Ectinosoma abrau* in the first region and *Canuella perplexa, Limnocletodes behningi, Ectinosoma abrau, Harpacticus flexus* in the second.

Table 1.2

Species diversity of Harpacticoida in various soils of the Azov Sea.

Species	Silt	Silt, shell	Sand, shell
Canuella perplexa	M	+	+
C. furcigera	–	+	–
Ectinosoma abrau	+	+	+
Limnocletodes behningi	M	+	–
Cletocamptus confluens	+	–	–
Cletodes tenuipes	+	–	–
Nitocra hibernica	+	+	+
N. lacustris	+	–	–
Harpacticus flexus	–	–	+
H. uniremis	+	–	–
Tisbe furcata	+	–	–
Metis ignea	+	–	–
Laophonte longicaudata	+	–	–

Note: M – mass species,

In the southern part, which is under the most significant influence of the Black Sea waters, there are both widespread species (*Limnocletodes behningi*

and Canuella perplexa) and those that prefer only waters with increased salinity (*Metis ignea and Leophoute longicoudata*). Thus, only one species (*Canuella perplexa*) was recorded by us in all areas of the Azov Sea, where the salinity of the bottom layers of water was higher than 6.2 ‰.

Canuella perplexa developed to the maximum in the Taganrog Bay, where their density reached 120,000 ind.·m^{-2}, constituting 90–100% of the total number of harpacticoids, at the entrance to the bay – from 60 to 90%. In the central and southern parts of the Azov Sea, *C. perplexa* reached 30–40%. This species was found at salinity from 4.2 to 12.3 ‰, clearly preferring zones with minimal salinity values, which are under the direct influence of river runoff. In addition to the Taganrog Bay, this species was found by us in the zone of influence of the Kuban River. It is necessary to note the clear gravitation of *C. perplexa* to silted shell rock and sand with shell rock.

The distribution features of the common species *Limnocletodes behningi, Ectinosoma abrau* are described in the monograph (Vorobyova, 1999).

If we consider the values of harpacticoids in the total number of organisms in different parts of the Azov Sea it was highest in the Taganrog Bay, where harpacticoids made up 12–44 %. In the central part, their role was small and did not exceed 0.1–9 % of the total number of organisms (average – Table 1.3.).

Table.1.3.

Distribution of harpacticoids in different areas of the Azov Sea.

District	Number of species	of the total number of organisms	Average abundance, ind.·m^{-2}
Western	9	19.7	12 230
Central	4	4.0	4 130
Eastern	4	23.4	5 280
Kerch Strait	5	24.5	3 250
Taganrog Bay	2	33.1	64 420

OSTRACODA. The species diversity of ostracods and their spatial distribution features were described by E.I. Shornikov (1965, 1966, 1967).

These data were presented in our monograph (Vorobyova, 1999). Our studies showed that ostracods were distributed over almost the entire water area of the Azov Sea. The exception was the southern part, where their density was minimal. Significant accumulations were confined to the Taganrog Bay – the number reached 218,700 ind.·m^{-2}. Maximum accumulations were 432,500 ind.·m^{-2} (Table 1.4).

Table 1.4.

The number (ind.·m^{-2}) of Ostracoda and their share (%) in the total number of meiobenthos (Vorobyova, 1999).

Station number	Depth, m	T,˚C	‰	O_2, mg·l^{-1}	Number, ind.·m^{-2}	% in the total number
Silty						
11	6.0	20.8	4.2	4.71	218750	95.1
34	8.0	21.9	11.2	5.7	218750	21
1	9.0	20.5	15.4	5.13	1375	10.9
31	9.0	23.2	11.6	5.4	115000	63.4
33	10.0	21.6	10.7	4.7	142500	72.2
27	10.5	21.2	12	5.2	73750	70.5
3	11.0	23.5	11.8	4.4	7500	31.1
19	11.0	23.5	12.1	4.9	24375	40.3
20	12.0	21.1	12	5.4	10750	11.1
Silted shell						
9	5.5	20.2	8.8	6.41	10125	5.6
10	7	21	6.86	4.82	16000	25.8
12	9.5	20.9	9.9	5.24	1000	5.9
14	10	21.2	10.7	5.84	16827	22.2
18	11	23.5	12.7	4.5	7500	26.6
16	12.5	22.5	11.7	5.84	48125	38.5
17	13	21	9.1	6.2	26250	25.3
26	13	22.2	11.7	4.82	432500	70.6
Sand shell						
8	7.5	21	10.6	4.87	5000	28

Ostracods play a significant role in the meiobenthos of the Azov Sea, reaching 70–73 % of the total number in some areas. The distribution of their density is very uneven. Analysis of the collected material showed that the minimum abundance indicators are characteristic of sand with shell rock (average – 1,800 ind.·m^{-2}). Their average density on silt and silted shell rock

during our observations was 63,400 and 17,900 ind.·m^{-2}, respectively. However, in the total number of organisms, the share of ostracods on silt was on average 44 %, and on silted shell rock almost 3 times less. In the Taganrog Bay, ostracods achieved maximum development in its northern part at a salinity of the bottom layers of water of 4.28 ‰. Here, the density of their settlements reached 218,750 ind.·m^{-2}. In fact, the meiobenthos was represented almost exclusively by this group.

OLIGOCHAETA. Representatives of the bottom group (temporary meiofauna) are of great importance for the ecosystem of the Sea of Azov as a food source for juvenile benthic fish. In the benthal of the Sea of Azov in the summer period, their occurrence averaged 73.6 %. They formed the densest clusters on silty soils and silted shell rock (1,136 and 25,750 ind.·m^{-2}, respectively). Oligochaetes play a relatively significant role in the formation of the total number of meiobenthos, varying from 12.1 to 14.1 % depending on the type of soil. The number of oligochaetes on silts was 1,250–22,620 ind.·m^{-2}. They are few in number on sand and shell rock. The eastern part of the Azov Sea and the Taganrog Bay oligochaetes were the poorest in worms (average – 3,322 and 687 ind.·m^{-2}, respectively), which can be explained by their active consumption by young fish of the benthic complex. In the western part of the sea and in the Kerch Strait area, the number of oligochaetes is almost the same and averaged 12,500 ind.·m^{-2}. In quantitative terms, the central part of the sea is the richest in oligochaetes – an average of 41,675 ind.·m^{-2}.

POLYCHAETA. Polychaeta at the Sea of Azov usually play a minor role in the total number of organisms. Their occurrence is very low; during our studies, they were recorded only at seven stations, mainly in the central part of the Sea. The density of polychaetes varied from 125 to 3,000 ind.·m^{-2}. The minimum salinity at which they were detected was 8.8 ‰. They were present on silty soils only at two stations out of ten. At one of them (125 ind.·m^{-2}), the proportion of polychaetes in the total number of meiobenthos was extremely low – 0.7 %, at the second – 3.9 % with a population density of 2,600 ind.·m^{-2}. On silted shells, the highest number of Polychaeta were noted in Taganrog Bay (3,000 ind.·m^{-2}), where they constituted 16 % of the

remaining meiobenthos. On sandy ground and shells – 3.3–5.5 %. In the Azov Sea, M.I. Kiseleva (1987) found 12 species of polychaetes, which belong to the category of macrozoobenthos. The author points out that they reach their greatest diversity in the southwestern part. The Berdyansk and Taganrog bays, as well as the central part of the sea, are the poorest in species. High concentrations of biomass are given for the northern part, the central region, and the southwestern Region.

LARVAE AND JUVENILES OF BIVALVES. Our material contains larvae and juveniles of Bivalvia that had a fairly wide distribution area. They were absent only in the northwestern corner of the Sea and were found in ingle specimens in the area near the Kerch Strait. The distribution of larvae and juveniles of bivalves in the benthal corresponds to their spatial distribution in the pelagic zone. According to E.V. Nastenko (1989), among the temporary representatives of zooplankton, bivalve larvae developed noticeably in the summer, making up 31% of the total biomass of all zooplankton organisms. As the author points out, the maximum values of their quantitative indicators are concentrated in the eastern half of the sea. Analysis of our materials showed that the settling of larvae in the benthal and their subsequent normal development also occurred most successfully in the eastern half of the sea. The maximum density of juvenile mollusks is confined to the center of the sea (6,150–57,000 ind.$\cdot m^{-2}$). In the total number of meiobenthos, mollusks in the Taganrog Bay amounted to 2.7–5 %, in its immediate vicinity – from 0.8 to 17%. In the central part, their role in the formation of the total number and biomass of meiobenthos is more significant and reached, on average, 35 %, and in the southwestern part – 14.5 %.

MEIOFAUNA OF THE SUBLITTORAL OF THE ODESA MARINE REGION

We studied the meiofauna of the upper sublittoral of the Odesa marine regionat the end of the last century (1993–1998) and at the beginning of the 21st century (2012, Vorobyova L.V, 2022) The main attention was paid to the study of the formation of quantitative indicators of meiobenthos depending on the depth and type of bottom substrate (Fig. 1.1).

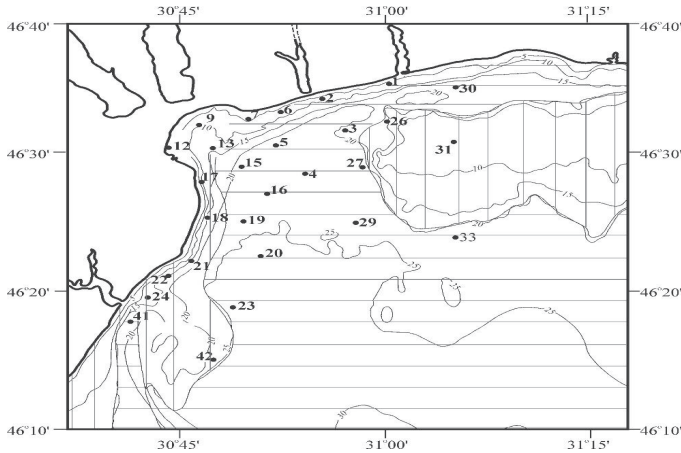


Figure 1.1. Map-scheme of sampling in the Odesa marine Region

The Gulf of Odesa is an area of the NWBS lying to the west of the line connecting the capes Severny and Bolshoi Fountain. In its northern part, the depth increases less rapidly than in the central and southern parts. The bottoms of the Bay down to a depth of 6–7 m are represented by slightly silty, dense fine-grained sand, on the surface of which mussel accumulations are found in the form of individual druses and spots. Near capes Severny, Bolshoy Fountain and in some other parts of the coast, to a depth of 2–4 m, there are ridges of stones. At a depth of 7–9 m, the sands are replaced by silted shell rock. At a depth of 9.5–11.0 m at a narrow strip 100–200 m wide from Cape Lanzheron in the north to Cape Bolshoy Fountain in the south and further to the Chernomorka passes the mussel ridge (Zagorovsky, Rubinshtein, 1916), seaward of which there is an extensive field of mussel silt.

The most complete survey was carried out in August 1993, when sampling was carried out at ten sections (33 stations) with the aim of determining the distribution of qualitative and quantitative indicators of meiobenthos in the narrow coastal strip of the bay at a depth of 2.5 to 15.5 m. The characteristics of the structure and quantitative indicators of meiobenthos are given on the basis of processing and analysis of more than 200 quantitative samples.

During the study period, 11 taxonomic groups were registered: Foraminifera, Nematoda, Harpacticoida, Ostracoda, Halacaridae, Turbellaria, Kinorhyncha, Oligochaeta, Polychaeta, larvae and juveniles of Bivalvia and Gastropoda, Balanus.

The distribution of representatives of individual groups and their density within the bay is uneven, which is explained by the mosaic nature of environmental conditions in the benthal zone: the type of soil, the amount of oxygen dissolved in the bottom layers of water, the dynamics of the bottom layers of water, etc., which determine the development and functioning of the meiofauna.

The meiofauna is most diverse at a depth of 2.5–5.0 m. As a rule, crustaceans (harpacticoids with a small admixture of ostracods) dominate here in terms of population density, and nematodes are the subdominant group. Noteworthy is the relatively low number of foraminifers in the total of meiobenthos (0–7.0 %). The maximum density of meiobenthos was noted at a depth of up to 5 meters.

Throughout the studied water area, eumeiobenthos was the most abundant, and with increasing depth it increased (at 5 m on average 85.3 %, at 10 m – 98.3 %).

As analysis of the ratios N_{tot}/B_{tot} at various depths of the Odesa Bay showed that at most stations their range was within 45.0–88.7, which may indicate a relatively good state of the marine environment in the upper sublittoral. In most of the water area, meiobenthos was represented by a family – nine groups. Harpacticoids dominated in numbers everywhere, nematodes were the subdominant group. The percentage of these two groups in the total number of meiobenthos ranged from 62 to 92.6 %.

At a depth of 10 m, the meiobenthos was noted to be qualitatively depleted. Three to five groups were found at each research site. The foraminiferal-nematode complex prevailed here. Representatives of these two groups of meiobenthos in different parts of the Bay ranged from 67.2 to 93.8 % of the density of the entire meiobenthos.

During the research period (the material was presented by 96 quantitative samples collected in 2012, in the coastal zone of the Odesa Bay), from 13 groups of meiobenthos were found on various substrates: Foraminifera, Nematoda, Harpacticoida, Ostracoda, Halacaridae, Kinorhyncha, Turbellaria, Oligochaeta, larvae and juveniles of Polychaeta, Bivalvia, Gastropoda, Balanus (Vorobyova, 2022). There are 9 large taxa on the sandy substrate, 12 on the shell, and 10 taxa on the stony substrate with algae cover. An analysis of the distribution of individual meiobenthic on various substrates showed their significant differences. Nematoda dominated on the sandy substrate. The main role was played by polychaetes and juvenile bivalves. In the periphyton of rocky substrate, the meiobenthos consisted of 10 large taxons. Turbellaria, Kinorhyncha and Gastrotricha were absent. The total number of meiobenthos varied from 59,000 ind.·m^{-2} to 341,000 ind.·m^{-2} (on average 156,107 ind.·m^{-2}). The proportion of eumeiobenthos in the total number of organisms was 67.4%. On the mixed substrate, the formation of the total abundance of meiobenthos occurred mainly due to 6 groups (Nematoda, Harpacticoida, Ostracoda, Oligochaeta, Polychaeta, juveniles of Bivalvia). Concentration of the total meiobenthos varied from 83,000 ind.·m^{-2} to 146,500 ind.·m^{-2} (on average 120,500 ind.·m^{-2}). Nematoda dominated, the subdominant group was Harpacticoida. The paper considers the formation of quantitative indicators of the main groups of meiobenthos (Foraminifera, Nematoda, Harpacticoida, Ostracoda, Halacaridae, temporary meiofauna) depending on the type of substrate (Vorobyova, 2022).

In the upper sublittoral of the Black Sea (10–11 m) the richest food base for fish larvae and juveniles is formed. The purpose of our research is to study the formation of quantitative characteristics of representatives of large taxa (total abundance and biomass) of the meiobenthic community in the upper sublittoral of the Odesa Bay. Earlier, studies of the end of the last century (Vorobyova, 1999) and the first decades of the 21st century were devoted to these issues (Vorobyova et al., 2017; Vorobyova et al. 2019; Vorobyova 2021; Vorobyova 2021a).

At the same time, Turbellaria, Kinorhyncha and Balanus larvae were noted only in one sample out of 96. Representatives of eumeiobenthos predominated in various biotopes, which accounted for 61.5 % on stony substrate, 72.7 % on shell rock, 67.6 % on sandy and on mixed one – 64.7 %. Thus, the proportion of the total abundance of these two categories of meiobenthos in the entire study area was within the same limits. The total number of meiobenthos on different substrates varied significantly. It was minimal on mixed substrate, and maximal – on rocks with algae.

The total biomass of meiobenthos on different types of substrates ranged from 1,893 mg·m^{-2} to 3,101 mg·m^{-2}. The permanent (eumeiobenthos) component played the main role in the formation of the total abundance of meiobenthos, whereas the decisive role in the formation of the total biomass belonged to the pseudomeiobenthos (temporary component). So, on sandy substrate, it was 81.6 %, on a shell – 79.4 %, on stones with algal overgrowth – 74.6 %, on a mixed substrate – 78.6 %.

The analysis of the distribution of individual meiobenthic taxa on various substrates showed their significant differences. Nematoda dominated on the sandy substrate, Ostracods were absent. This is due to their ecological features and the possibility to develop mainly on the algal substrate. Juvenile Gastropoda were also absent. Most of the total abundance was formed by eumeiobenthos, accounting for 67.4 % of the total number of organisms. The total biomass (variations from 437.4 to 5,764.4 mg·m^{-2}) averaged 2,807.5 mg·m^{-2}, which was mainly formed by representatives of pseudomeiobenthos (81.6 %). The main role in the latter was played by polychaetes and juvenile bivalves.

On the shell rock, the total abundance of meiobenthos varied from 2,500 ind.·m^{-2} to 269,000 ind.·m^{-2} (average 143,300 ind.·m^{-2}), the main part of it was formed by eumeiobenthos (72.7 %). Nematoda prevailed, leaving 54.1 % of the total. The total biomass was slightly lower than on the sandy substrate – an average value made 1,893 mg·m^{-2} (the range is 125.4–7,675.8 mg·m^{-2}). These parameters, were formed mainly by polychaetes and bivalves as well as on the

sand. Turbellarians, Kinorhyncha were met with single specimens. The remaining representatives of large taxa had a low abundance.

In the periphyton of rocky substrate, the meiobenthos consisted of 10 large taxa. Turbellaria, Kinorhyncha and Gastrotricha were absent. The total abundance varied from 59,000 ind.·m^{-2} to 341,000 ind.·m^{-2} (156,107 ind.·m^{-2} on average). The proportion of eumeiobenthos in the total number of organisms was 67.4 %. The proportion of pseudomeiobenthos was quite high (32.6 %). The total biomass of meiobenthos varied widely – 739.38 mg·m^{-2} to 5,873.0 mg·m^{-2} (3,104.42 mg·m^{-2} on average). Harpacticoida dominated, Nematoda was the subdominant group. Thus, crustaceans and juvenile bivalve mollusks mainly developed on the stony substrate among algal fouling, which was also reflected in the study of the lithocontour of the northwestern part of the Black Sea (Vorobyova at al., 2019). The relatively high accumulation of nematodes is associated with silt that deposited on the settlements of Bivalvia.

On the mixed substrate, the formation of the total abundance of meiobenthos occurred mainly due to 6 groups (Nematoda, Harpacticoida, Ostracoda, Oligochaeta, Polychaeta, juveniles of Bivalvia). Indicators of the total abundance varied from 83,000 ind.·m^{-2} to 146,500 ind.·m^{-2} (average – 120,500 ind.·m^{-2}). Nematoda dominated, the subdominant group – Harpacticoida. The proportion of eumeiobenthos in the total abundance of organisms was 64.7 %. The total biomass of meiobenthos ranged from 1,805.1 mg·m^{-2} to 3,708.6 mg·m^{-2} (2,458.3 mg.m^{-2} on average). The main role in its formation belonged to pseudomeiobenthos – 78.5 % of the total meiobenthos biomass. The main part of the biomass of pseudomeiobenthos was formed by polychaetes – 49.4 %.

LITHOCONTOUR. One of the extremely important contour biotopes for marine ecosystems, which determines biodiversity, the formation of a food base for hydrobionts of various trophic levels, is the lithocontour (Vorobyova, Kulakova, Bondarenko, Portyanko, 2019; Zaitsev, 1985.)**.** The seas and oceans are characterized by the presence of many solid surfaces located both at the very edge of the water and at the bottom of sea areas with a different range of depths. These include numerous underwater rocks, which can be of various

shapes and sizes. Reefs of various lengths and occupied areas; the rocky substrate is most often located in the upper sublittoral of the seas or on the pseudolittoral. The lithocontour includes both hydraulic structures (breakwaters, traverses), and mooring piles, sea buoys, etc.

In the waters of the OMR the largest accumulations of underwater rocks are concentrated in the area of Cape Bolshoy Fontan, Dacha Kovalevsky, in the area of Capes Langeron, Odesa Severny, etc. (Vinogradov, Khutornoy, 2013)

All these various natural or artificial surfaces are usually initially covered with a bacterial film. Microorganisms stimulate the development of unicellular organisms and microalgae on these substrates, and then they are populated by macrophytes and various animals, which are characterized by an existence attached to one place.

The rocky substrate is of great importance in the life of many representatives of the Black Sea ichthyofauna. Thus, many species of gobies, small southern sticklebacks, and blennies use the rocky substrate to lay eggs. The lithocontour attracts young fish of many bottom fish with a variety of food resources formed in the fouling. Young gobies, mullet, etc. feed on small polychaetes, mollusks, and crustaceans, mainly harpacticoids and ostracods. Attached macrophytes and invertebrates form a specific formation – marine fouling.

Marine technical structures as a vital substrate are one of the varieties of lithocontour.

Despite the accessibility of the "coast-sea" zone and its shallowest lithocontour biotope, studies here have been conducted only sporadically and which mainly relate to macrozoobenthos. With the growth of technical progress, marine waters are experiencing an ever-increasing pressure of various types of anthropogenic loads: the impact of river runoff, discharge of domestic waters, construction and clearing of approach channels to port waters and large-scale anti-landslide coastal protection structures. However, it should be taken into account that a significant increase in the coastal zone of the seas

of artificial hard substrates on which phyto- and zoofoulings are formed cannot be attributed to a negative factor for marine coastal ecosystems.

Numerous facts and information contained in publications testify to the uniqueness of these substrates, functioning as biotopes, the specificity of the population formed on them, and the need to distinguish marine fouling and its biotopes into a category of phenomena that has no less independent status than other ecological and biotopes units of the halosphere (Protasov, 2011).

The macrophyte substrate is much more complex than the ground substrate, since it is a living organism associated with numerous external factors and their biological characteristics. Providing shelter to a rich and diverse population of animals and plants, the macrophyte is simultaneously a component of the thicket community, being included in the food chains of epibenthic organisms and releasing dissolved organic matter into the environment (Khailov, 1971, 1970).

A. A. Protasov (Protasov 1982) believes that the term "periphyton" should become a single term for the population of solid substrates and that this concept is much broader than "fouling". Periphyton, the author points out, is a collection of organisms of various life forms, whose vital activity is closely linked to the interface between solid substrate and water. It is known that, according to the teachings of

V. I. Vernadsky, the largest "accumulations" of life in the ocean are observed only in the boundary layers (Vernadsky, 1968). One of such manifestations is expressed in the contact zone at the interface between the solid and liquid phases. The ecological and biotopic approach to determining the main groups of organisms in the hydrosphere made it possible to identify several environments (Protasov, 2008, 2011), one of which is the interface between the liquid and solid phases (water-solid substrate). The biotope is called by the author "periphytal", and its population "periphyton". In the periphyton, not only attached edifying forms are of great importance, but also mobile ones, which, along with macrozoobenthos forms, are represented by the meiobenthic community of marine organisms. Mobile forms (planon) play a significant role in periphyton communities and very often prevail over

attached forms (Protasov, 2011). The author considers the ecotopic grouping of hydrobionts as a set of organisms inhabiting the largest biotopes in the contour and internal regions of the hydrosphere and convergently possessing a number of adaptations that are close in nature, allowing the most efficient use of resources in the conditions of these biotopes [Protasov, 2010; Protasov, 2012).

Anthropogenic interference in the life of coastal ecosystems is very diverse. One example of the impact on the coastal zone is the large-scale coastal protection works that began in the Odesa Gulf in the late 1950s and early 1960s. At present, a system of concrete traverses and breakwaters covers a coastline of about 20 km. The latter forms artificial basins, most of which have a weak water exchange with the open sea. Many organisms of coastal fouling are food for animals and humans, bioindicators of the habitat.

MEIOFAUNA OF PERIPHYTON OF NATURAL LITHOCONTOUR. Throughout all the decades, the Institute of Marine Biology has periodically conducted a study of the periphyton meiofauna. As noted above, the first studies date back to the mid-80s, when studying the sea mites of the Odesa Gulf (Vorobyova, Yaroshenko, 1982). In the mid-90s and at the beginning of this century, attention was paid to the formation of the taxonomic composition and quantitative indicators of the meiofauna of fouling of artificial substrates. In 2012-2015, studies were conducted to study the periphyton of the lithocontour in the coastal zone of the Odesa Gulf and Zmeiny Island.

As indicated (Vorobyova, Kulakova, Bondarenko, Portyanko, 2019), the materials for scientific analysis were quantitative samples collected in the fouling of the lithocontour of natural substrates at the area of the Odesa Gulf and Zmeiny Island. For artificial substrates of the Odesa Gulf (coastal protection hydraulic structures), the characteristics of the meiobenthos were described based on materials from 2013 with the involvement of data from the end of the last century.

Meiobenthos of the fouling thickets of various macrophytes of the natural lithocontour of the coastal zone in the period 2012–2015 at a depth of 3.0–10.7 m contained representatives of the following large taxa of

meiobenthos: Foraminifera, Nematoda, Ostracoda, Harpacticoida, Halacaridae, Turbellaria, Oligochaeta, eumeiobenthic polychaetes, juveniles of macrozoobenthos organisms: Polychaeta, Bivalvia, Balanus, Amphipoda, Cumacea, Isopoda. Kinohryncha and Gastrotricha were absent. Foraminifera, Turbellaria, and Oligochaeta were rarely found in the periphyton of the lithocontour.

The taxonomic composition of the meiobenthos in different areas of the lithocontour of the coastal zone differed slightly, which was previously established for macrozoobenthos. The maximum diversity of this category of zoobenthos was characteristic of the Odesa Gulf the area at the Hydrobiological Station of the Odesa National University (Fig. 1.2).

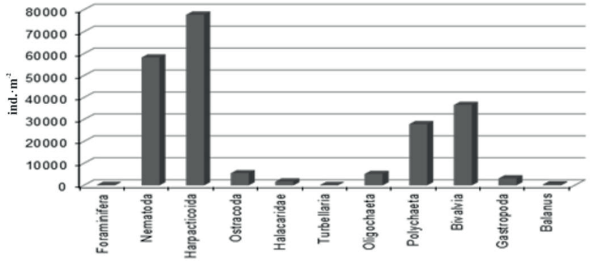


Figure.1.2. Average density (ind.·m^{-2}) of different taxa in the periphyton of rocky substrate, 2014.

The presented monograph (Vorobyova, Kulakova, Bondarenko, Portyanko, 2019) shows that crustaceans (harpacticoids and ostracods) dominated in the eumeiobenthos of the periphyton of a natural rocky substrate, which together accounted for a third of the total number of organisms. The total number was formed mainly by eumeiobenthos, the density of which averaged 69.6 % for the polygon. Study of the community of free-living Nematoda. According to the data of I.I. Kulakova, 26 species belonging to 7 orders, 17 families, and 23 genera were identified among the nematodes on the rocky substrate. *V. minor, O. campylocercoides, V. glabra, M. demani, P. caecus, S. pulchra,* and *T. pontica* dominated. (Table 1.5). According to Kulakova I.I. of the indicated nematode species, 58 % are found only in the Black Sea, 27 % are inhabitants of the Black and Mediterranean Seas, the rest

(15%) are extremely common species: Black, Azov, Mediterranean, Baltic, Barents, North, White Seas. Species of the order Monhysterida generally had low occurrence (9.1–19.0 %) and minimal quantitative indicators (on average 30–947 ind.·m^{-2}). From the order Chromadorida, 3 species were recorded with dominance in occurrence (63.6 %) and prevalence in population density (on average 3.511 ind.·m^{-2}) *Paracanthonchus caecus*.

Table 1.5.

Species composition of nematodes in the meiobenthos community on a rocky substrate in the area of the Hydrobiological Station (Odesa Bay).

Taxon	TG	$N_{cp.}$
Anticoma acuminata (Eberth, 1863)	1A	505
Viscosia glabra (Bastian, 1865)	2B	1318
Viscosia elongata Filipjev, 1922	2B	736
Viscosia minor Filipjev, 1918	2B	4846
Viscosia cobbi Filipjev, 1918	2B	172
Metoncholaimus demani (Zuz Strassen,1894)	2B	1391
Oncholaimus campylocercoides De Coninck end Stekhoven ,1933	2B	3955
Pontonema zernovi (Filipjev, 1916)	2B	130
Symplocostoma tenuicolle (Eberth, 1863)	2B	30
Oxystomina elongata (Butschli, 1874)	1A	141
Bathylaimus cobbi Filipjev, 1922	1B	130
Neochromadora poecilosomoides (Filipjev, 1918)	2A	606
Spilophorella euxina Filipjev, 1918	2A	478
Paracanthonchus caecus (Bastian, 1865)	2A	3511
Desmodora sp.n.	2A	264
Camacolaimus bathycola Filipjev, 1922	2A	706
Monhystera ampullocauda Paramonov, 1926	1B	300
Daptonema maeoticum (Filipjev, 1922)	1B	300
Theristus latissimus Filipjev, 1922	1B	30
Sphaerolaimus ostreae Filipjev, 1918	2B	130
Linhomoeus sp.	1B	168
Paralinhomoeus filiformis (Filipjev,1918)	1B	121
Terschellingia pontica Filipjev, 1918	1A	947
Axonolaimus ponticus Filipjev, 1918	1B	276
Sabatieria pulchra (Schneider, 1906)	1B	2599
Quadricoma pontica Filipjev, 1922	1A	30

Note: TG – trophic group: 1A – "selective detritivores", 1B – "non-selective detritivores", 2A – "scrapers", 2B – omnivores and "predators"; Ncp. – average nematode population density (ind.·m^{-2}).

The species composition of Harpacticoida according to V.V. Portyanko algae fouling includes 19 species from the following families: Ameiridae (1),

Miraciidae (4), Dactylopusiidae (2), Ectinosomatidae (3), Harpacticidae (2), Laophontidae (5), Tisbidae (1), Parastenheliidae. During the period under consideration, Harpacticoida dominated among the meiobenthos representatives in terms of settlement density, accounting for 53.2–80% of the total number of organisms. Analysis of harpacticoid participation in the formation of the total meiobenthos biomass showed that in the overwhelming majority of cases they provided this process. Ostracoda belong to an insufficiently studied group of invertebrates in the NWBS. In 2012, the distribution of Ostracoda numbers in the fouling of the rocky substrate was very mosaic. The average density of ostracod settlements in the study area was 17,615.0 ind.·m^{-2}. The average share of shell crustaceans in the total density of the meiobenthos is 8.3 %, in the total number of the permanent component (eumeiobenthos) – 17.74 %. Due to their very low body mass, their role in the total biomass of meiobenthos is minimal on average – 2.5%.

It has been shown that in addition to the above-mentioned meiobenthos groups, representatives of the temporary component (pseudomeobenthos) played a significant role in the formation of quantitative indicators of meiobenthos: oligochaetes, polychaetes, and juvenile bivalves and gastropods.

The fauna of polychaetes belonging to the meiobenthos is formed by both juvenile macrozoobenthic species (pseudomeobenthos), temporarily present in this community, and representatives of the permanent component (eumeiobenthos). In total, 22 species of Polychaeta worms from 11 families were recorded in the meiobenthos (according to Bondarenko A) during the study period: Phyllodocidae (2 species), Polynoidae (2), Sigalionidae (1), Nereidae (3), Syllidae (3), Protodrilidae (1), Spionidae (5), Capitellidae (2), Terebellidae (1), Pectinariidae (1) and Sabellidae (1). Juvenile individuals of the Nereidae family were quantitatively dominant (15,772 ind.·m^{-2})

Most frequently registered *Salvatoria clavata* (Claparède, 1863) (100 %) и *Exogone naidina* Örsted, 1845 (77,8 %). The dominant species in terms of numbers was S. clavata. The eumeiobenthic polychaete worm complex of the coastal rock and stone community of the OMR is represented by five species: *Syllides longocirratus* (Öersted, 1845), *Salvatoria clavata* (Claparède, 1863),

Exogone naidina Öersted, 1845, *Protodrilus flavocapitatus* (Uljanin, 1877) и *Fabricia stellaris* (Müller, 1774).

In addition to the above-mentioned meiobenthos groups, representatives of the temporary component (pseudomeobenthos) played a significant role in the formation of quantitative indicators of meiobenthos: oligochaetes, polychaetes, juvenile bivalves and gastropods. In the OMR, a significant part of the number and biomass of meiobenthos also belongs to representatives of its temporary component (pseudomeobenthos), which is of great importance in the formation of the biodiversity of the benthic marine biota, its quantitative indicators, as well as in the formation of the food base for juvenile fish of the benthic and benthic complexes.

Our studies have shown that in the fouling of rocky substrates, Bivalvia on average accounted for 20.0 % of the total number of meiobenthos. In pseudomeiobenthos, they were often the dominant group. In periphyton, their share in the total biomass of meiobenthos was 21.6 %, in the biomass of pseudo-meiobenthos – on average 26.3 %.

ZMEINY ISLAND.

We have obtained interesting data on the formation of the meiobenthic community of organisms on a rocky substrate in the coastal waters of Zmeiny Island (Vorobyova, Kulakova, Bondarenko, Portyanko, 2019). The data presented in the monograph are the first information on the general characteristics of the meiobenthos (species composition, abundance, biomass) and its individual representatives in the fouling of rocky placers along the coast of Zmeiny Island. Special studies on the biological diversity of the meiobenthos of this water area and adjacent areas have never been conducted before. Based on the processing of samples collected in 2012-2015, a study was made of the species composition and quantitative characteristics of nematodes and harpacticoids, ostracods, and meiobenthic polychaetes. For the first time in the NWBS, the issue of the association of various large taxa with various types of macrophytes and mussel fouling was considered.

It has been established that specific lithophilic benthic communities have formed in the coastal zone of the Island, distinguished by high biomass and species diversity. As we have indicated above, the biota of the coastal waters of the island represents a reserve gene pool for the entire northwestern shelf. Due to it, biological restoration of areas of the Black Sea experiencing hypoxia occurs, as well as the consequences of other negative anthropogenic impacts, ending in the mass death of bottom inhabitants over vast areas. The food value of meiobenthos for larvae and juveniles of commercial fish of the bottom complex of the Danube region is highest in the immediate vicinity of the Island.

The analysis of the material allowed us to consider the compositions of meiobenthos on various types of macrophytes. Samples were collected on various algal substrates (on green algae of the genera Cladophora and Enteromorpha; on red algae of the genera Ceramium, Polysiphonia, Laurencia, Corallina) (Fig. 1.3, 1.4). The abundance of meiobenthic organisms is certainly associated with the diversity and quantity of microalgae on macrophytes. Among the fouling of macrophytes with a cylindrical thallus (Cladophora Ceramium), attached diatoms predominate in quantitative terms, while in fouling with a lamellar form, cyanobacteria and mobile species of diatoms predominate (Garkusha O. P., 2016).

Nematoda, Harpacticoida, Ostracoda, Halacaridae, Oligochaeta, Polychaeta, Bivalvia, Gastropoda, Cirripedia were found in the fouling of the above-mentioned algae. Many representatives of these large taxa have adaptations for living on the algal substrate. Nematodes have the ability to lead an attached lifestyle on macrophytes. They attach to the algae with a sticky secretion of the tail glands. Despite the fact that harpacticoids are very mobile animals, many species are well adapted to living in the surf zone, which is characterized by various algal foulings.

In the fouling of Cladophora sp. in different years, 5–7 large taxa of meiobenthos were found. In this type of fouling, harpacticoids dominated, ostracods occupied a subdominant position. Harpacticoids made the greatest contribution to the total abundance indicator – 61.6 % (on average 109,000 ind.$\cdot m^{-2}$), the subdominant group – ostracods had a settlement density

of 38,000 ind.·m^{-2} – 19.7 %. Foraminifera, gastrotrichs, kinorhynchs, and juvenile gastropods were absent from the samples.

On the rocky substrate with Ceramium, the total number of meiobenthos was represented by almost equal shares (48.6 % – eumeiobenthos and 51.4 % –pseudomeiobenthos). Among the permanent component, harpacticoids stood out with the maximum settlement density, the share of which in the total number of meiobenthos reached 26.6 %.

In the fouling of Corallina, the total number of meiobenthos was formed by two-thirds by representatives of the eumeiobenthos (on average 73.2%). Here, as on Ceramium, Ostracoda dominated – 35.9 % of the total number of organisms, subdominants in terms of numbers were Harpacticoida and Polychaeta (21.1 % and 18.4 %, respectively). It should be noted that the highest accumulations of nematodes were noted on Corallina (Fig. 1.3, 1.4).

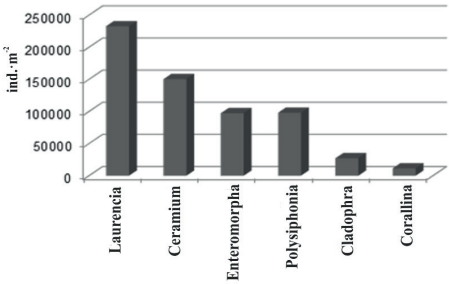


Figure. 1.3. Number (ind.·m^{-2}) of meiobenthos in the fouling of various macrophytes.

Thus, in the fouling of the rocky substrate in the coastal area of Zmeiny Island, the diversity of the meiobenthos was determined by 5–8 large taxa: Nematoda, Harpacticoida, Ostracoda, Halacaridae, Oligochaeta, Polychaeta, juvenile Bivalvia and Gastropoda. Foraminifera, Gastrotricha, Kinorhyncha, Turbellaria, Oligochaeta were absent from the samples. Nematodes were not found on Cladophora in 2013 and 2015, Balanus are rare in the fouling of Ceramium, Cladophora, Carollina.

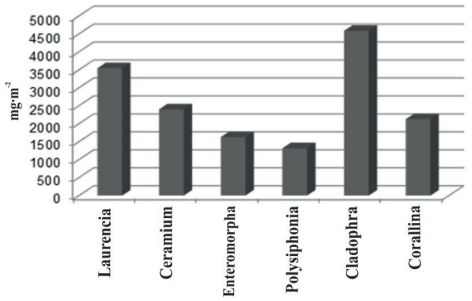


Figure 1.4. Biomass of meiobenthos (mg·m^{-2}) in fouling of various macrophytes.

As can be seen from the presented table (Table 1.6), the average indicators of the total number of meiobenthos in the fouling of various macrophytes varied significantly, the same applies to the indicators of the total biomass.

Таблица 1.6.

Indicators (average) of total abundance (ind.·m^{-2}) and biomass (mg·m^{-2}) of meiobenthos in the fouling of rocky substrate. Zmeiny Island 2013–2015.

Macrophytes	Total abundance (ind.·m^{-2})	Proportion (%) of eumeiobenthos	Total biomass (mg·m^{-2})	Proportion (%) of eumeiobenthos
Enteromorpha	97,330	85.29	1.628	14.71
Cladophora	27,272	61.32	4.585	39.68
Ceramium	150,375	63.25	2.399	37.75
Corallina	11,500	72.19	2.127	28.81
Polysiphonia	98,000	77.10	1.315	23.90
Laurencia	232,750	47.90	3.545	53.10

The maximum density of invertebrates was observed in the fouling of Laurentia, among the representatives of the eumeiobenthos, ostracods dominated (amounting to 42.2 % of the total abundance, the second – 48.7 % It should be noted that gastropods, which have only been found on Cladophora, inhabited the fouling of Laurentia.

The minimum density indicators were characteristic of the Corallina, here the lowest diversity of meiobenthos was noted (5 groups). The total number of eumeiobenthos is formed by ostracods, harpacticoids, it should be noted that the highest accumulations of nematodes were noted here.

The highest biomass values characteristic of Cladophora and Laurentia were formed due to Harpacticoida, Polychaeta and Bivalvia. The graphs provided (Fig.1.5, 1.6) give an idea of the formation of quantitative indicators of the main meiobenthos groups in fouling of different types.

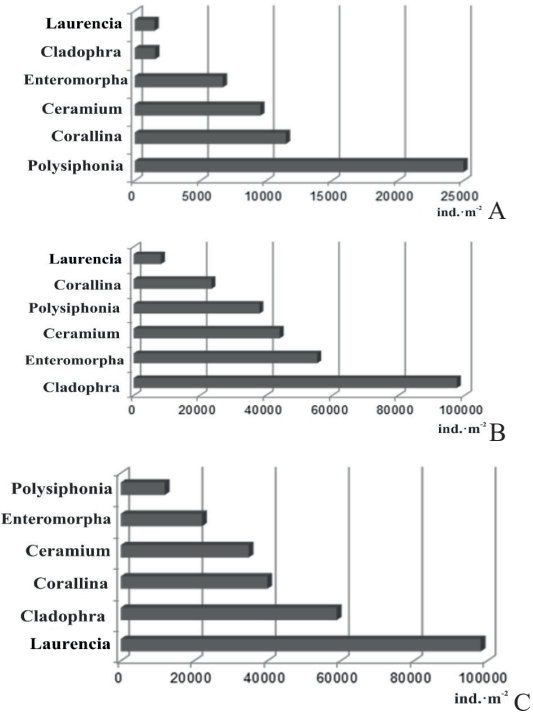


Figure 1.5. Population density of different meiobenthos groups in fouling of rocky substrate of Zmeiny Island (A – Nematoda, B – Harpacticoida, C – Ostracoda).

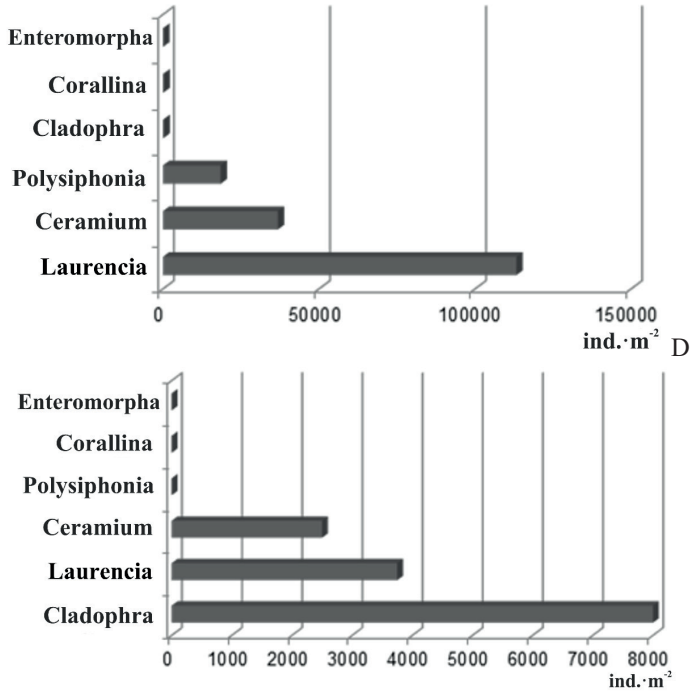


Figure 1.6. Density of settlements (ind.·m^{-2}) of different meiobenthos groups in fouling of the rocky substrate of Zmeiny Island (D – Gasropoda, E – Polychaeta).

Artificial substrate (traverses, breakwaters).

The study of the meiofauna of the fouling of hydraulic structures in the Odesa Gulf is part of the complex research periodically conducted at the IMB NAS of Ukraine over the past 40 years. The results of studies on the formation of the meiobenthic community of organisms were reflected by us in many publications (Vorobyova, 1999; Vorobyova, Sinegub Portyanko, Kulakova 2024).

Coastal protection and anti-landslide construction, which began in the coastal zone of the Odesa region in the 1950s, was a serious interference in the life of the coastal biota. Hydraulic structures changed the system of coastal sea currents and led to the formation of semi-enclosed water areas – ″buckets″ with

low water exchange where previously there was a regular change of water masses. The historically formed biocenosis of coastal rocks and stones was covered with a layer of sand. The change of soils led to a decrease in the area of solid substrates with the flora and fauna inhabiting them. By now, the system of concrete traverses and breakwaters covers a coastline of about 20 km. In time, coastal protection works coincided with a number of negative processes that manifested themselves in the ecosystem of the northwestern part in the late 1960s – early 1970s.

Based on the results of the study of fouling in the Black Sea and using the unique opportunities for this, we have periodically conducted research in this zone over several decades. In doing so, various tasks were set, the results of the solution of which were reflected in publications of different years (Vorobyova, 1999; Vorobyova, Sinegub, 1994, 2000).

By now, a powerful fouling belt has formed on concrete structures in the Odesa Bay, which has a complex effect on the coastal ecosystem. In the fouling of traverses and breakwaters, along with macrozoobenthos, a community of meiofauna organisms, rich in diversity and quantitative indicators, is developing, which in its structure has much in common with that of the mussel biocenosis of natural substrates of the northwestern shelf of the Black Sea.

Kinohryncha and Gastrotricha were not found during our observations, Foraminifera, Turbellaria, and Oligochaeta were rarely encountered in the periphyton of the lithocontour. The absence of the above-mentioned taxa in the meiobenthos does not detract from the quality of the food supply for many representatives of the juvenile ichthyofauna and some macrozoobenthos forms due to the fact that the taxa that form the total abundance and biomass have both a comparatively larger body mass and their caloric value. The first studies conducted on the formation of qualitative and quantitative characteristics of the meiobenthic community in the periphyton of concrete structures showed that almost all the types of algal overgrowth considered were dominated by the density of settlements of eumeiobenthos representatives. Its main indicators were formed by harpacticoids and ostracods. Only on Ceramium were the

shares of eumeiobenthos and temporary representatives of the meiobenthos practically equal.

The number of meiobenthos on the concrete substrate was almost three times lower than in the benthal of the Odesa coast during the same period. At the same time, on soft substrates 93.3 % of it was formed by eumeiobenthos, while in the periphytal of concrete structures, the constant component was 49.72 %. The main difference and significance of meiobenthos in the periphyton is the formation of a very large biomass of meiofauna compared to artificial substrate. Thus, a special taxonomic structure of the meiobenthic community is formed, a food base is created for the young of many bottom and bottom fish, as well as for some representatives of the macrozoobenthos, and which plays a very important role in the formation of the biological resources of the sea. Juvenile bivalve mollusks actively settle on the concrete surface of the traverses and breakwaters, which, having reached sexual maturity, enrich the pelagic zone with their larvae. The larvae of the mollusks, after settling in the benthal, will replenish the bottom biocenoses with new individuals.

The need to take measures to improve the quality of the marine environment in the coastal areas of the Odesa marine region raised the issue of constructing artificial reefs. Certain studies were needed to select suitable materials for these works.

The expansion of the scale of work and increasingly stringent requirements for the search for biologically positive structures and materials have necessitated the need to conduct experimental work to study the formation of fouling on the following substrates: shell rock, concrete, rubber and granite, which can potentially be used in landslide prevention work and the construction of artificial reefs.

In the Odesa Gulf, we conducted observations over a period of 20 weeks (from 02.06 to 27.10.1992) on the rate of colonization of the following substrates by meiofauna: rubber, shell rock, granite and concrete.

Usually, it takes a week for the diatom film to form on the introduced substrates, which in some periods can even outpace bacteria. The presence of bacterial and diatom films is a significant factor for the active settling of

zoofouling larvae and the manifestation of vagal meiofauna. For the former, it facilitates attachment, for the latter, it serves as food.

A month after the immersion of the substrates in the marine environment, a sharp change in the ratio of the number of permanent and temporary components of the meiofauna occurs. The proportion of larvae and juvenile individuals of macrozoobenthos is from 51.5 % to 69 % on various substrates. The maximum indicators of the meiofauna abundance were formed in the fifth to sixth week of exposure on all artificial substrates. Analysis of the material allows us to assume that in the summer period, 1 month is enough to form a meiobenthic community on different substrates introduced into the marine environment. In all likelihood, during this period, a fairly significant development of microflora, hyphal cells and spore cultures of higher marine fungi occurs on all substrates, and the development of algae reaches its maximum.

Harpacticoida in the fouling cenosis of artificial substrates had a low number for most of the spring-summer period. Their number increased sharply by August, reaching a maximum in September – 65,000 ind.·m^{-2}. During the research period, 17 species of harpacticoids were found in the periphytal of artificial pools. In the 90s of the last century, according to data of Garlitska 23 species of harpacticoids were present here.

The density of ostracods was minimal (1,600 ind.·m^{-2}) in May, and by June–August it had increased by 3–4.5 times. Their highest average abundance (17,500 ind.·m^{-2}) was in September and remained at this level in November, when the water temperature dropped to 12 °C.

As a result of the study of the species composition of free-living nematodes in this biotope, 40 species were found, belonging to 5 orders, 18 families and 29 genera (data of I.I. Kulakova). Of these, 35 nematode species were recorded on the traverses, and 20 species were recorded on the bottom with sandy substrate.

The average number and biomass of pseudo-meiobenthos are comparable with the indicators for natural substrates. Polychaetes dominate in terms of numbers – 53.6 % of the total temporary component of meiobenthos;

the subdominant group is Bivalvia. Among the settled bivalve larvae, the mussel and Mytillaster with a small admixture of Cerastoderma predominated. Their first peak of settling is usually confined to May. If the water warms up late, their settling may be delayed. The first peak of settling is usually observed in June at a water temperature of 16–18.2 °C. In the second half of summer, the number of young mollusks in the fouling cenosis decreases, which is explained by their transition to a different age category – macrozoobenthos. The second peak of settling is clearly expressed in September, which usually continues actively until November. Gastropoda larvae were found only at the end of July – 2,500–22,000 ind.·m^{-2}. By September, their number increased, with maximum figures typical for November.

In 2023, it became necessary to conduct a comparative analysis of the current state of the meiobenthic community with the data of 1991. Over the past decades, the ecological situation in the NWBSM has changed somewhat for the better (Vorobyova, Bolshakov, 2023). However, the destruction of the Kakhovka hydroelectric power station and the flow of large amounts of fresh water into the NWBS water area made their own adjustments.

Studies in 2023 showed that the current state of the zoobenthos of the periphyton of concrete coastal protection structures on the Odesa coast was formed both under conditions of constant eutrophication and under the influence of the influx of a large volume of fresh water into the water area of the northwestern part of the Black Sea (NWBS) during the breach of the Kakhovka Dam, which occurred in early June 2023. In the current period, representatives of 10 groups were noted in the meiobenthos of the periphyton of coastal protection structures: Nematoda, Harpacticoida, Ostracoda, Turbellaria, Halacaridae, Gastrotricha, Oligochaeta, Polychaeta, Bivalvia, Balanus. The average total abundance of meiofauna was 896,203±99,230 ind.·m^{-2}, while eumeiobenthos was represented by 44.8% (401,946±76,703 ind.·m^{-2}). The share of representatives of the temporary component was 10.4 % higher (494,257±77,148 ind.·m^{-2}).

Compared to 1991, the ratio of the number of individual meiobenthos groups and their share in the total indicators of the entire meiobenthos has

changed. Thus, if in 1991 nematodes dominated in number (56.2 %), then at present the dominant group in terms of density of settlements was young Bivalvia – on average 290,724±61,492 ind.·m^{-2} (32.4 %). Such a high number of young bivalves on the surface of hydro structures explains the predominance of mollusks 20 mm in size in macrozoobenthos, which will ensure further good development of populations of *M. galloprovincialis* and *M. lineatus.* The total number of meiobenthos is 6.4 times higher than at the end of the last century. The density of harpacticoid settlements increased by 7.41, young mollusks by 42.1, polychaetes by 15 times. The same was observed with the density indicators of eumeiobenthos (401,946 ind.·m^{-2}) and pseudomeiobenthos (494,257 ind.·m^{-2}). The former is 3.4 times higher, and the latter is 21 times higher in modern times than in 1991.

The significant development of meiobenthos in the modern period can be explained by several reasons. First, compared to the end of the last century, the ecological situation in the NWBS has improved. Secondly, the influx of other quality Kakhovka waters led to the death of a large number of phyto- and zooplankton in the surface layers of the sea. Dead organic matter settled on the bottom and on the surface of concrete structures served as concentrated food for meiobenthos, most of whose representatives are saprophages. In addition, meiobenthos, which is mostly related to first-order consumers, will contribute to the further development of second- and third-order consumers, which include macrozoobenthos and juvenile ichthyofauna (Vorobyova L.V., Kulakova I.I., Sinyogub I.O. et al., 2024).

Meiobenthos the area of the Ukrainian Antarctic station "Akadkmik Vernadsky"

In 1987, scientists from our Institute took part in a complex scientific expedition of hydrobiologists from several Institutes to the shores of Antarctica (the area of the Ukrainian Antarctic station "Akademik Vernadsky"). Samples of meiobenthos were collected in the sublittoral and littoral of Galindez Island, as well as in the sublittoral of the Argentine Islands, for which we are grateful to I.A. Sinegub (*Vorobyova L.V., Kulakova I.I., Sinyogub I.O. et al.,1998)*. Due

to the fact that the coastal waters of Antarctica are characterized by homogeneous hydrobiological conditions, the formation of the structure and quantitative indicators of the meiobenthos were determined mainly by the nature of the bottom sediments. The benthic macrofauna off the coast of Antarctica is distinguished by its enormous diversity and significant endemism in terms of species (Ushakov, 1958), which is probably also characteristic of representatives of the meiobenthos. During the research period in the aquatic area of Galindez Island of the Argentine Archipelago, the salinity of the surface horizon waters varied in the range from 29.1 to 31.2 ‰, and that of the bottom horizon – from 30.8–32.5 ‰ (Dotsenko et al., 1977). According to the authors, temperature fluctuations were 1.2–0.1 °C and 1.2–0.6 °C in the surface and bottom horizons, respectively. Bottom sediments in the places where meiobenthic samples were collected in the upper sublittoral were represented by silty silts with various impurities, and in the shallow waters of Galindez Island – by rocky substrate.

The meiobenthos of the Argentine Islands region during the study period was characterized by significant diversity even at the level of groups of large taxonomic ranks and was represented by invertebrates typical of this community: Foraminifera, Nematoda, Harpacticoida, Ostracoda, Halacaridae, Oligochaeta, Polychaeta, Turbellaria, and juvenile individuals of Bivalvia. The diversity of the meiobenthos varied significantly depending on the sampling site (Table 1.7.). As can be seen from the presented material, the number of groups at the sites varied from one to seven.

At the supralittoral of King George Island, among coarse sand with pebbles at a depth of 30 cm in water filtered from the wells, nematodes (500 and 10,425 ind.·l), harpacticoids (0-17 ind/l), turbellarians (9 and 42 ind /l), oligochaetes (at each station 17 ind/l) were found. In the littoral, as indicated above, samples were taken with a quantitative frame. Here only nematodes were found (7,500 and 27,500 ind.·m^{-2}) and in one sample – oligochaetes (2,500 ind.·m^{-2}). Thus, even on the basis of such a small amount of material provided to us, it can be assumed that with further special studies of the interstitial meiofauna in the supralittoral and littoral zones of the islands of the

Argentine archipelago, a more diverse meiofauna should be expected in the first of the indicated zones. In the Black Sea, our studies have shown that in December-January, the interstitial meiofauna of the supralittoral is significantly richer in qualitative and quantitative terms than in the pseudolittoral (Vorobyova, 1999).

Table 1.7.

Taxonomic composition of the meiofauna of the Argentine Islands.

Depth m	Taksons
55	Nematoda, Harpacticoida, Ostracoda, Oligochaeta, Polychaeta
14	Nematoda, Harpacticoida, Oligochaeta, Polychaeta
32	Nematoda, Harpacticoida, Ostracoda, Oligochaeta, Polychaeta
17	Nematoda, Harpacticoida, Ostracoda, Halacaridae, Turbellaria, Polychaeta
10,6	Nematoda, Harpacticoida, Ostracoda, Polychaeta
18	Foraminifera, Nematoda, Harpacticoida, Ostracoda, Turbellaria, Oligochaeta, Polychaeta
17	Nematoda, Harpacticoida, Oligochaeta, Polychaeta
38	Nematoda, Harpacticoida, Oligochaeta, Polychaeta
25	Foraminifera, Nematoda, Harpacticoida, Ostracoda, Halacaridae, Polychaeta
0,1	Nematoda
0,2	Nematoda
0,2	Nematoda, Harpacticoida
0,2	Halacaridae
0,1	Nematoda, Harpacticoida
supralittoral	
0,3	Nematoda, Turbellaria, Oligochaeta
0,3	Nematoda, Harpacticoida, Turbellaria, Oligochaeta
littoral	
Nematoda	
Nematoda, Oligochaeta	

The study of the interstitial meiofauna of the Antarctic coasts is interesting in connection with the assumption that its qualitative and quantitative characteristics should be richer than those of the flora and macrofauna. According to some authors, they are extremely poor for the littoral of Antarctica. Thus, V. G. Averintsev points out that the dry zone (littoral) of this region is characterized by the absence of life (the presence of meiofauna was not taken into account). As the author points out, only in very

limited areas is the development of the filamentous alga *Uloirix australis* noted during the short Antarctic summer. Life is more diverse in the littoral of the Antarctic Peninsula: filamentous green and red algae, a lot of diatoms, and the mollusk *Patinigera polaris* have been found here (Averntsev, 1972). According to I. A. Sinegub (Sinegub, 1998), turbellarians, amphipods and gastropods were found on coastal rocks in the littoral zone.

Three groups of meiobenthos were recorded on coastal rocks (depth 0.1–0.2 m): Nematoda, Harpacticoida and Halacaridae. Of eleven samples, nematodes were found in nine. The range of fluctuating density of settlements is from 0 to 75,000 specimens-m'' (average – 1,735 ind.·m^{-2}). Harpacticoida were found in four cases – 503,237,500 ind.·m^{-2} (average – 53,409 ind.·m^{-2}). Marine mites were present in only two samples (on average – 14,318 ind.·m^{-2}). The most qualitatively diverse and having the highest density indicators was the meiobenthos at station 7 in the discharge zone of untreated domestic wastewater of the Antarctic station. Here, instability of the characteristics of organic and mineral biogenic substances was found (Dotsenko et al., 1997). In this zone, the density of nematodes is in the tens, and harpacticoid is hundreds of times higher than at other stations at the same depths and with the same substrate characteristics.

Sublittoral. At depths of 10.6–55 m, the nature of the bottom substrate is diverse (Gozhik et al., 1997). Most of our samples were collected on gray silts, less often on rocky substrate and green silt. At each station, 4 to 7 groups of meiobenthos were represented. Only nematodes, harpacticoids and polychaetes were noted everywhere. The occurrence of other groups was low (Table 1.7).

A characteristic feature of the sublittoral meiobenthos is its considerable diversity (Foraminifera, Nematoda, Harpacticoida, Ostracoda, Halacaridae, Turbellaria, Oligochaeta, Polychaeta). The indicators of the meiobenthos settlement density were distributed unevenly, which is typical for this community of organisms. It has been repeatedly indicated in the literature that even in biotopes that at first glance appear homogeneous, meiobethic organisms have very heterogeneous quantitative parameters (Gray et al., 1971;

Vorobyova et al., 1991). In addition to physical factors, biotic factors are also of great importance in the formation of the structure and functioning of the meiobenthic community. As is known, bacteria, along with the organic matter they decompose, serve as the basis of food for meiobenthos and can also determine its localization in a particular biotope. One of the probable reasons for the mosaic distribution of meiobenthos may be the number of representatives of macrozoobenthos and ichthyofauna. The quantitative indicators of both individual groups and the entire meiobenthos have changed within wide limits (Table 1.8.).

Table 1.8.

Quantitative characteristics of meiobenthos in the sublittoral.

Takson	Abundance intervals ind.·m^{-2}	average ind.·m^{-2}	proportion of the total number of meiobenthos
Foraminifera	1200–1875	341.6	0.32
Nematoda	110–25400	733378.8	48.4
Harpacticoida	170–56000	25507	33.41
Ostracoda	200–4000	942.2	9.0
Halacaridac	10	–	–
Turbellaria	280–1200	164.4	1.64
Oligochaeta	300–12000	1922.2	1.51
Polychaeta	30–18000	5153	4.8

On the rocky substrate, 4-5 groups of meiobenthos were noted; the main role in the formation of the total number was played by nematodes and harpacticoids (75.2-94 %). The latter dominated, comprising 65.7–71.7 % of the total number of organisms. Only in one case (station 23) did ostracods dominate in terms of settlement density (71.8 %). On gray silts with varying proportions of sand or gravel, crustaceans were a subdominant group in terms of numbers. Here, the densest accumulations were formed by nematodes (74.3–85.2 %).

In different areas of benthic soils with loose bottom substrate, the total number of meiobenthos varied from 14,700 ind.·m^{-2} to 342,000 ind.·m^{-2}. Its high value is typical for a closed bay near Galindez Island, where the upper layer of bottom sediment (according to Gozhik et al., 1997) is a liquid film 5–6 cm thick (gray silt, accumulation zone). However, with such a high value (2,243,200 ind.·m^{-2}), the meiobenthos is represented by only four groups (nematodes, harpacticoids, oligochaetes and polychaetes). Nematodes accounted for 85.2 % of the total number. Ostracoda were noted here in small quantities (2,000 ind.·m^{-2}).

At the remaining stations with silt, the total number of meiobenthos was 25,200–170,875 ind.·m^{-2}. The highest figures were at the station, which, according to I. A. Sinegub (1998), is characterized by the highest macrozoobenthos biomass for the entire studied region. Here, the meiobenthos is represented by six groups of organisms.

Foraminifera in the sublittoral were found only at two stations with a population density of 1200 ind.·m^{-2} and 1875 ind.·m^{-2}, respectively. In a work devoted to Foraminifera of the east coast of Antarctica (Shchedrina, 1958), it was shown that their fauna at any depth consists of endemics, bipolar species and forms with a worldwide distribution, mainly the so-called "deep-sea cosmopolitans", associated only with depth. Probably, the shallow depths of the sampling sites determined such a low abundance of foraminifera.

Nematoda, as indicated above, were found in all samples. Their minimum number was 110-27,600 ind.·m^{-2}. Significantly larger accumulations were found in other zones (109,000-133,000 ind.·m^{-2}. The proportion of nematodes in the total number of meiobenthos varied from 75.2 to 95.1%.

Harpacticoids were present, lower density values are typical for rocky substrate, however, when macrophytes develop on it, the number of harpacticoids is higher (49,600 ind.·m^{-2}). At the same time, their dominance in the total number increases (71.7 %). On silty substrate, their average number is 24,550 ind.·m^{-2} (min – 3,000 max – 56,000 ind.·m^{-2}). The frequency of occurrence of Ostracoda was 55.5 %. They were noted both on rocky substrate (750–1,530 ind.·m^{-2}) and on silts (200–4,000 ind.·m^{-2}). The maximum density

of ostracods in the supralittoral zone refers to rocky substrate with macrophytes. The share of ostracods in the total number of meiobenthos in most cases is small – 0.6–5.5 % and only once they prevailed in comparison with all other groups.

The frequency of occurrence of oligochaetes is quite high – 77.7%, most often on a silty substrate, where their density varied from 300 to 12,000 ind.·m^{-2}. At depths of 10.6-1.8 m, oligochaetes were noted only at one station – 800 ind.·m^{-2}.

Polychaeta belongs to three groups of meiobenthos with 100 % occurrence. Minimum value was found on rocky substrate – 30–250 ind.·m^{-2}. On silts their density varied from 300 to 1,800 ind.·m^{-2}, and the share in the total number of meiobenthos was from 2.9 to 11.1 %.

Meiofauna of some Estuaries of the northern Black Sea Region.

There are 21 estuaries on the coastal section between the Danube and Dnieper rivers (Adabovsky, Bolshakov *et al*, 2006), some of which are connected to the sea. The hydrodynamic activity of water in open estuaries depends on river runoff, wind and water exchange with the sea. In closed estuaries, it depends mainly on wind activity. It should be emphasized that our studies did not provide data on the meiobenthic community of organisms in the Black Sea estuaries. We studied the meiofauna of the Grigorievsky (Maly Adzhalyksky), Tiligulsky, Sukhoy, Dofinovsky and Khadzhibeysky estuaries. The most in-depth, long-term studies relate to the Grigorievsky estuary, which were always carried out in conjunction with other hydrobiological studies.

Small Adzhalitsky Estuary or Grigorievsky Liman

Grigoryvsky (Small Adzhalyk) Estuary is located 30 km to the east of Odesa. It is a relatively small coastal estuarine water body that formed in the flooded mouth of the Adzhalyk River. Its current length is about 7.3 km, width is up to 1.2 km (average – about 0.8 km), the area of the water surface is about 6.02 km. The water in the estuary is brackish (salinity is 10–13 ‰, max.

18 ‰). In its natural state, the estuary was separated from the Sea by a narrow (up to 125 m) sand bank, the height of which did not exceed 1.3-1.7 m. From the south, the estuary is connected to the Black Sea by a shipping channel (built in 1974) 3 km long, 165 m wide and 14 m deep. Due to this, the estuary was artificially transformed into a sea bay, the embankment and banks were transformed. From the north, the Maly Adzhalyk River flows into the estuary. The water temperature in summer is up to +22, +26; in winter the estuary freezes. Bottom sediments are represented by clays and sands, covered with a layer of silt.

In the 70s of the twentieth century, the estuary was connected to the Sea by a permanent shipping channel, and its water area was deepened. At present, in the shipping channel, brought to the top part, and near the berths of the port of Yuzhny, TIS (Transinvestservis) and a number of other enterprises, the depths have been increased to 13–19 m and dredging operations are ongoing. Large-scale dredging operations to one degree or another affected up to 70 % of the bottom area. Currently, the ecosystem of the Grigoryvsky Estuary consists of components of natural and anthropogenic origin. More than 770 species and subspecies of various hydrobionts have been found in the structure of biotic components (Vinogradov et al. 2012). The ecosystem of the Estuary is under the powerful influence of water masses entering the adjacent part of the sea from the Dnieper-Bug estuary.

The relevance and scientific importance of studying the meiofauna of the Grigoryvsky Estuary is determined primarily by the fact that the meiofauna of this estuary had not been studied before our studies. Secondly, the water area of the estuary, under the influence of natural and significant anthropogenic influences, undergoes constant changes in abiotic conditions. We have been studying the meiofauna of the estuary for more than 30 years.

The study of the meiobenthos of the Grigoriev's Estuary as a community of organisms is of great importance for its ecosystem. In 1992-2003, annual sampling was carried out throughout the entire water area of the estuary (Fig.1.7.) in spring, summer and autumn. In subsequent years (until 2017), sampling was carried out only in the coastal zone.

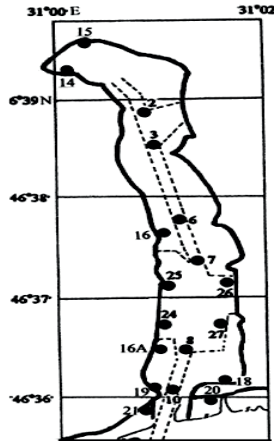


Figure 1.7. Scheme of standard sampling stations in the Grigorievsky Estuary and the adjacent part of the Black

The meiobenthos of the Grigorievsky Estuary is of marine nature. It includes representatives of 12 groups of large taxonomic rank: Foraminifera, Nematoda, Harpacticoida, Ostracoda, Halacaridae, Turbellaria, Kinorhyncha, Oligochaeta, Polychaeta, larvae and juveniles of Bivalvia and Gastropoda, and cypris larvae of Balanus. Foraminifera, Nematoda, and Harpacticoida are found almost everywhere, determining the formation of the number and biomass of the meiobenthos. Even in the spring-summer period, low occurrence is typical for Halacaridae (27 %), Turbellaria (16 %), Gastropoda (44 %), and larvae of Balanus (33 %).

In all seasons of the year, the permanent component (eumeiobenthos) predominates in the meiobenthos. Thus, for coastal stations, its share is 77.6–84.8% of the total number, for a depth of 2–13 m – 93.0–99.8 %. The main core of the eumeiobenthos of the estuary is represented by nematodes and harpacticoids, in the adjacent part of the sea – nematodes, harpacticoids and foraminifers (Vorobyova, 2008).

The spatial distribution of meiobenthos in the Grigorievsky estuary is uneven and depends on a number of factors: soil type, depth, salinity, presence of algal substrate, the magnitude of anthropogenic load, etc. According to the

main characteristics (species diversity, total number and biomass of meiobenthos), several zones can be distinguished in the Grigorievsky Estuary: the upper, middle and lower parts of the estuary, coastal areas with a depth of up to 1.0 m.

In the upper reaches of the estuary, the substrate is represented by black silt everywhere and the depth is from 12.5 to 16.5 m. The upper reaches of the estuary are characterized by the ubiquitous presence of Nematoda. The occurrence of Foraminifera for the study period averaged 91.5 %, Harpacticoida – 86.4 %, and Bivalvia larvae 57.6 %. Polychaetes, oligochaetes, and ostracods were somewhat less common (47.4 %, 39.0, and 35.6 % respectively). The remaining groups were noted sporadically.

The middle part of the estuary (st. 6, 7, 25, 26) has relatively uniform depths (14–16.5 m), the soils are represented by black silts. Salinity fluctuates slightly in different years, the oxygen regime in the overwhelming majority of cases is favorable for the development of benthic organisms. A characteristic feature of the meiobenthos of this area is that, with a few exceptions, it is represented by a permanent component (eumeiobenthos). Thus, the average long-term indicator of the share of the eumeiobenthos in the total number of organisms was 99.33 %. Foraminifera and nematodes were noted everywhere in all years of research. The average long-term indicator of the occurrence of Harpacticoida is 87.1 %, Kinorhyncha – 62.3 %, Bivalvia – 33.7 %. Other representatives of the meiobenthos are rare. Among the eumeiobenthos, nematodes predominate, their share in the total number reaching an average of 64.9%, which can be explained by the nature of the soil. The subdominant group is Foraminifera (21.51 %). The share of harpacticoids is on average 10.9%.

In the lower reaches of the estuary (st. 8, 10, 24, 27) samples were taken at a depth of 14.5–15 m; salinity in different years in this area fluctuated at the bottom from 15 ‰ to 17.6 ‰. Meiobenthos consisted of 71.62 % nematodes, with their occurrence being 100%. Foraminifera were also characterized by a high occurrence rate of 99.8 % during the long-term study period, however, their role in the formation of the total meiobenthos abundance was often

insignificant, and on average over 14 years their share was 11.98 %. The maximum abundance (1,162,500 ind.·m^{-2}) was recorded in the fall of 2003. It should be noted that in the lower reaches of the estuary, as well as in its middle part, the meiobenthos practically consists of its permanent representatives, with eumeiobenthos accounting for an average of 99.0% As can be seen, pseudo-meiobenthos is poor, with an average occurrence rate of oligochaetes of 52 % and polychaetes of 45.4 %, their contribution to the total number of meiobenthos is negligible. In terms of meiobenthos settlement density (in contrast to species diversity), the coastal part stands out sharply from the rest of the water area with its low rates in autumn, winter and spring. Only in summer do they approach those of the main part of the benthal. In contrast, biomass indicators are much higher in the coastal part due to the development of representatives of the temporary component (larvae and juveniles of macrozoobenthos).

The share of pseudomeiobenthos in the deep-water part of the estuary fluctuates from 4.1 – 36.2 % of the total number of organisms, and in the coastal area – from 30.6 % to 89.0 %.

Long-term observations of the dynamics of the total number and biomass of meiobenthos in the Grigoryvsky Estuary showed (Vorobyova, 2008) that quantitative indicators of maximum development reached in 1994, 1997 and 2006. (Fig. 1.8, 1.9, 1.10, 1.11).

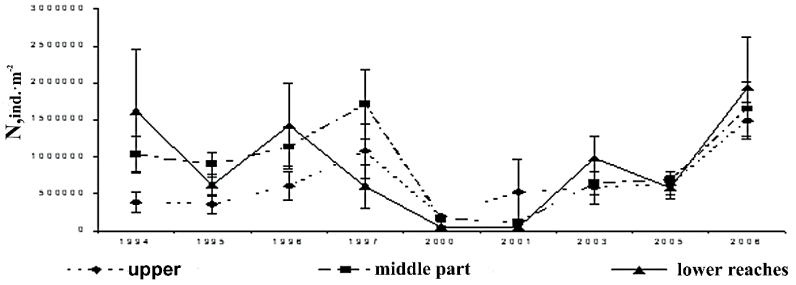


Figure1.8. Long-term dynamics of the number of meiobenthos in the upper, middle part and lower reaches of the Grigoryvsky Estuary.

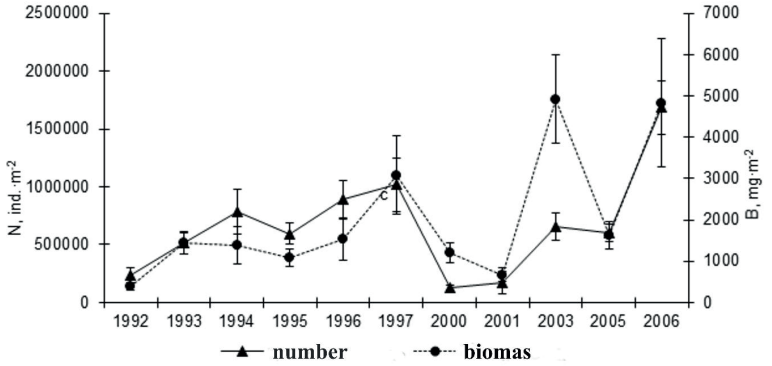


Figure 1.9. Long-term dynamics of quantitative indicators of meiobenthos in the Grigoryevsky Estuary.

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The obtained data made it possible to analyze the structure and qualitative indicators of meiobenthos in different seasons of the year (Vorobyova, 2008).

The total number of organisms in the estuary had an extremely wide range of values. Nematodes dominated in terms of population density – on average 1,785,000 ind.·m^{-2} or 68.9 % of the total number of meiobenthos. The significant range of fluctuations in the total population density of meiobenthic organisms (minimum – 177,000, maximum – 2,710,000 ind.·m^{-2}) is noteworthy, which serves as an indirect indicator of the heterogeneity of the conditions of the marine environment in the benthal. Roundworms dominated quantitatively everywhere, making up on average 74.1 % of the total number for the entire water area.

Systematic constant observations in 4 seasons of the year for more than 10 years allowed us to assess the quality of the estuary's aquatic environment based on meiobenthic indicators.

The ratio of the number of nematodes to the number of harpacticoids (N/H) was used, as well as the ratio of the total number indicators to the total biomass of meiobenthos (N/B).

As can be seen from the presented graph, the most difficult ecological situation in the estuary was observed in 1994–1996 and in 2005.

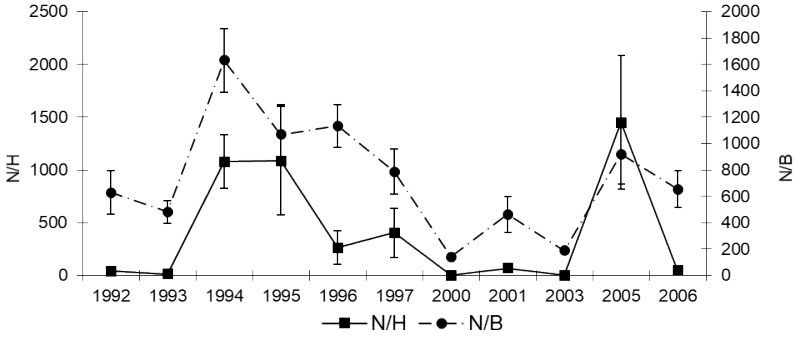


Figure 1.10. Long-term dynamics of environmental quality indices in the Grigoryevsky Estuary.

Nematoda

The development of anthropogenic eutrophication processes occurring in the northwestern part of the Black Sea could not but affect the structure and dynamics of the density of both the entire meiobenthos and nematodes in this estuary. Long-term studies conducted from 1992 to 2001 showed that nematodes are the dominant group of meiobenthos in terms of settlement density in the Grigorevsky estuary, accounting for 28.2 to 87.2 %. However, the quantitative indicators of nematodes vary significantly both at different stations and in different seasons and years.

Before the research of I.I. Kulakova, there was no information about the nematodes of this water. A number of works are devoted to the study of free-living nematodes of the Grigoryvsky Estuary, in which the taxonomic composition is indicated, and an assessment of their functional role in the meiobenthos is given (Kulakova, Torgonskaya, 2000; Kulakova, 2006, 2008). In the studied estuary, nematodes were found at almost all the stations studied and constituted one of the dominant groups of meiobenthos in terms of occurrence, amounting to an average of 70 – 75 %.

Of the known species of free-living nematodes for the northwestern part, 35 species belonging to 4 orders were noted in the Maly Adzhalyk Estuary: *Araeolaimus zostearae* (Filipjev 1918), *Axonolaimus ponticus* Filipjev 1918, *Ax. setosus* Filipjev 1918*, Leptolaimus steineri (*Filipjev 1922), *Tershellingia pontica* Filipjev 1918*, T. longicaudata* De Man 1907*, Metalinchomoeus zosterae* Filipjev 1918, *Paralinchomoeus filiformis* (Filipjev 1918), *Eleutherolaimus longus* Filipjev 1922, *Sphaerolaimus gracilis* De Man 1976, *S. ostreae* Filipjev 1918, *Monhystera filiformis* Bastian 1865, *M. conica* Filipjev 1918, *Monhystera sp., Theristus sabulicola* (Filipjev 1922), *Theristus sp., Cylindrotheristus longicaudatus* (Filipjev 1922), *C. maeioticus* (Filipjev 1922), *Sabatieria pulchra* G.Schneider 1906, *Chromadora nudicapitata* Bastian 1865, *Chromadora sp., Neochromadora poecilisomoides* Filipjev 1918, *Spillophorella euxina* Filipjev 1918, *Chromadorella sp., Paracanthonchus caecus* Bastian 1865, *Anticoma acuminata* (Eberth 1865), *Oxystomina elongata* (Butschli 1874), *Halalaimus ponticus* Filipjev 1922, *Anoplostoma viviparum* Bastian 1865, *Catalaimus sabulicola* (Filipjev 1918), *Enoploides brevis* Filipjev 1918, *Trypiloides marinus* Butschli 1874, *Oncholaimus brevicaudatus* Filipjev 1918, *Viscosia glabra* (Bastian 1865), *V. minor* Filipjev 1918 (Kulakova, 2008).

The greatest species diversity is noted in the central and southern parts of the estuary, where silts predominate. Despite their great species diversity in the Grigorevsky Estuary, only some species have 100 % occurrence, the highest population density and high-density indices in all seasons of the year. These are species such as: *S. pulchra, Ax. ponticus, T. pontica, P. caecus*.

According to Kulakova I.I. order Monhysterida dominates in terms of the number of species (40 %), the highest percentage of species from this order is observed in the deep-water part of the estuary. A high percentage of species from the order Enoplida is characteristic mainly of coastal areas (26 %). Species from the order Chromadorida are noted in all study areas (20 %). The order Araeolaimida is represented by a small number of species in certain study areas (14%). Comparing the species composition of nematodes in the study

area with other areas of the Black Sea, it can be noted that in terms of the number of species, the Grigorievsky Estuary is not inferior to the Odesa Gulf.

Increased trophicity leads to changes in the ecosystem, in which ecological niches are captured by species that are best adapted to the newly formed environmental conditions. Nematodes are precisely those organisms that find favorable conditions for their development in soils enriched with organic matter.

The average nematode population density over the entire study period varied from 560,909 ind.·m^{-2} to 10,785,000 ind.·m^{-2} (on average 39% of the average density of the entire meiobenthos). The average nematode biomass varied from 0.8 to 58.2 mg·m^{-2} (on average 4 % of the average biomass of the entire meiobenthos).

In her publications, I. I. Kulakova provides data on the quantitative parameters of nematodes on various types of substrates. High species diversity of nematodes was noted on silts (28 species), of which the following can be considered dominant species: *Sabatieria pulchra, Terschellingia pontica, Axonolaimus ponticus and Paracantonchus caecus*, which were found in all seasons of the year. The occurrence of these species averaged from 64 to 96.2 %. In the marine area adjacent to the estuary, 16 species were noted. Here, as in the first two biotopes, *T. pontica* and *S. pulchra dominated*. The occurrence of these species in all seasons was quite high (on average 58.3 % and 83.3 %, respectively). In terms of population density, *S. pulchra* also leads in comparison with other species, reaching maximum values in the summer (on average 15,129 ind.·m^{-2}).

Using the generally accepted classification, I. I. Kulakova divides all nematodes of the Grigorievsky Estuary into 4 trophic groups and noted that each biotope of the studied area is characterized by a certain ratio of these groups. In the estuary, non-selective detritophages (1B) play the main role in all types of soil, accounting for 34.8 – 57.0 %. Selective detritophages (1A) prevailed on silted shells and in the coastal part (44.5 and 31.7 %, respectively). The size structure of the nematode community is also described.

The dynamics of nematode population density in different seasons of the year in various study areas undergoes significant changes (Kulakova, 2008). Comparing the quantitative indicators of nematodes directly in the estuary in the seasonal aspect for the entire study period, it should be noted that they reach their maximum development in the summer.

When analyzing the dynamics of the ratio of meiobenthos groups over the entire period of research in different years, a general tendency towards an increase in the nematode-foraminiferal complex is observed. If in 2000-2003 the role of harpacticoids in the total density of meiobenthos was noticeable (66 %), then in 2005–2007 their role decreases (10.6 %), nematodes prevail in terms of settlement density (71 %).

The dominance of nematodes among the diversity of meiobenthos groups indicates a high trophicity of the estuary. Nematodes are precisely those organisms that find favorable conditions for their development in soils enriched with organic matter. Thus, among the indicated nematode species, the role of oxyphilic representatives of the Chromadorida order in the estuary is not high, while species of the Monhysterida order, which are less demanding of water quality, predominate. An increase in trophicity leads to changes in the ecosystem, in which ecological niches are captured by species that are best adapted to the prevailing environmental conditions.

A long-term study of nematodes in the Grigorievsky Estuary allows us to state that the level of qualitative and quantitative development of free-living nematodes is comparable to the level of nematode development in these indicators in the northwestern part of the Black Sea, which is characterized as a highly trophic region (Kulakova, 2001, 2006). A long-term study allowed to obtain extensive first and new information about the faunistic composition, spatial distribution of quantitative indicators of various populations of this important. These studies confirm the important role of nematodes in the functioning of estuary ecosystems.

Harpacticoida

Grigorievsky Estuary is one of the water bodies for which information about harpacticoids was extremely scarce until the early 90s of the last century. It can be argued that the long-term study of the harpacticoid by Garlitska L.A. allowed to first new information about the faunistic composition, spatial distribution of quantitative indicators of various populations of this important taxon of meiobenthos.

According to data from Garlitska L.A. (Garlitska, 2000, 2004, 2005, 2008) long-term studies of the meiobenthos of the Grigorievsky Estuary made it possible to expand the list of harpacticoids to 44 species. During the observation period, the order Harpacticoida was represented by 38 species (Table 1.9.), belonging to 17 families: Ameiridae, Canthocamptidae, Canuellidae, Cletodidae, Dactylopusiidae, Darcythompsoniidae, Ectinosomatidae, Harpacticidae, Huntemanniidae, Laophontidae, Leptastacidae, Miraciidae, Peltidiidae, Tachidiidae, Tegastidae, Thalestridae and Tisbidae (Garlitska, 2008).

Long-term studies of the meiobenthos of the Grigorievsky Estuary have allowed us to expand the list of harpacticoids to 44 species. belonging to 17 families: Ameiridae, Canthocamptidae, Canuellidae, Cletodidae, Dactylopusiidae, Darcythompsoniidae, Ectinosomatidae, Harpacticidae, Huntemanniidae, Laophontidae, Leptastacidae, Miraciidae, Peltidiidae, Tachidiidae, Tegastidae, Thalestridae and Tisbidae. In the shallow coastal zone, the quantitative development of harpacticoids is higher than at medium and large depths (Table1.9.). At the same time, the maximum values of the number of species and the indices of species richness are confined to depths of 3-9.5 m, and the minimum – to depths of 10–17 m.

In the upper and lower reaches of the Estuary, the harpacticoids account for about 15.0 % of the total density of meiobenthos, in the middle part – 10.9 %, and in the coastal area they are the dominant group, averaging 45.1 %. In general, the distribution of harpacticoids in the estuary is uneven and depends on a number of factors (type of soil, depth, presence of algal substrate, etc.).

Despite the high values of the total number of registered and expected species, in terms of the low level of both α- and β-diversity, it is closer to the estuary regions of the Dniester and Danube, noticeably inferior to the Karkinitsky Gulf and the open part of the NWBS.

Table 1.9.

Harpacticoida of the Grigorievsky Estuary (Garlitska, 2008).

SPECIES	Literary data (until 1993)	Modern data (2000–2005)	
		until 0,3 м	4—17 м
Alteutha typica	—	*	—
Ameira parvula	+	18,9*	70,7*
Amphiascopsis cinctus	+	—	—
Asellopsis sarmatica	—	2,7	4,9
Canuella perplexa	+	—	—
Canuella sp.	—	91,9*	68,3
Dactylopusia tisboides	—	*	7,3*
Delavalia elisabethae	—	21,6*	28,0*
Delavalia palustris	—	18,9*	6,1*
Diarthrodes nobilis	—	*	—
Ectinosoma melaniceps	+	62,2*	62,2*
Enhydrosoma garienis	—	78,4*	76,8*
Halectinosoma curticorne	—	2,7	1,2
Harpacticus flexulosus	—	48,6*	15,9
Harpacticus flexus	+	5,4	*
Harpacticus littoralis	+	13,5	1,2
Harpacticus longiantennata	+	—	—
Harpacticus obscurus	—	*	1,2
Laophonte setosa	+	24,3*	23,2*
Leptocaris brevicornis	—	2,7	—
Mesochra aestuarii	+	2,7	1,2
Mesochra heldti	—	2,7	—
Mesochra lilljeborgii	+	—	—
Mesochra pontica	—	70,3*	6,1
Mesochra pygmaea	+	2,7*	—
Microarthridion fallax	—	35,1*	—
Microarthridion littorale	+	18,9*	92,7*
Nannomesochra arupinensis	—	2,7*	—
Nannopus palustris	—	18,9*	29,3*
Nitocra lacustris	+	—	—
Nitocra spinipes	+	—	—

Table 1.9 continued

SPECIES	Literary data (until 1993)	Modern data (2000–2005)	
		until 0,3 м	4—17 м
Nitocra typica	—	29,7*	11,0
Paradactylopodia brevicornis	—	2,7*	2,4
Paraleptastacus spinicauda	—	—	2,4
Paramphiascopsis longirostris	—	—	2,4
Parathalestris dovi	—	16,2	—
Paronychocamptus sp.	—	16,2	—
Schizopera compacta	—	29,7*	64,6*
Tegastes longimanus	—	—	3,7
Tisbe battagliai	—	*	19,5
Tisbe bulbisetosa	—	*	—
Tisbe furcata	+	*	*
Tisbe histriana	—	13,5*	—
Tisbe marmorata	—	*	—
Tisbe tenella	+	—	—
Total	16	35	26

Note: * – the species was present in qualitative samples in 1993.

In the seasonal dynamics of harpacticoids of this estuary, some difference in the distribution of these crustaceans at different depths can be noted. In the spring months, in the shallow zone of the estuary, an increase in their share of the total number of meiobenthos organisms was observed (from 18.1 to 26.4 %), and at depths of 4–17 m it decreases almost 2 times (from 30.1 to 16.7 %). At the beginning of summer, a wide amplitude of fluctuations in the abundance of harpacticoids is characteristic for all depths (on average, 39.7–448.4 thousand specimens m−2 in shallow water and 5.9–199,000 ind.·m^{-2} at depths of 4–17 m). At the beginning of autumn, harpacticoids are in a depressed state relative to the deep-water part (6.6 % of the total abundance of meiobenthos) and nematodes and foraminifera come out on top in terms of numbers, while in the coastal zone, on the contrary, September is characterized by the highest rates of harpacticoids both in the total number (41.5 %) and in the total biomass of meiobenthos (63.7 %).

In addition to the analysis of the density, biomass and proportion of harpacticoid copepods, using the material from 2001-2005 as an example, L.A.

Garlitska examined the seasonal dynamics of young individuals and the sexual structure of the community.

According to Garlitska L.A. the peak of reproduction of harpacticoids in the Grigorievsky Estuary at a depth of 4-17 m occurs earlier (March-April) and is shorter, while in shallow water it occurs in May-July. Most likely, this is due to the fact that the deep-water community is monodominant, with the unconditional dominance of a single species*, M. littorale* (see below), and the overall picture of the dynamics of the taxocene is determined by its population dynamics. In shallow water, the community is polydominant, and differences in the timing of reproduction of mass species, replacing each other throughout the summer, can determine the long period of presence of females with eggs and copepodites in the samples.

Complex of environmental factors. As indicated in the methodology, in order to identify a complex of related factors influencing the integral indicators of the harpacticoid taxocene (total abundance and total number of species in a sample), a step-by-step multiple regression analysis was carried out with successive exclusion of insignificant factors (at a significance level of $p>0.05$). The initial model included: the nature of the soil (on a scale of "silt – silted sand – sand"), the presence of shells, the presence of macrophytes, depth, oxygen content (mg·l−1) in the bottom layer of water, temperature, salinity (Garlitska, 2008).

A study of the Estuary Halacaridae in the period 1996-2001 (Helmboldt, 2001) showed that the following species were noted in the estuary in spring and summer: *Rhombognathus tonops, Rhombognathides pascens, Copidognathus brachystomus and Agauopsis brevipalpus*. The dominant species, as in the Tiligul estuary and in the coastal zone of the Odesa coast, was a representative of the subfamily Rhombognathinae Viets (*R. tonops*): occurrence rate 100 %, density index 108.9, dominance index 0.28. Comparison of the species composition of the tick taxocene of the Grigorievsky and Tiligulsky estuaries and the coastal zone of the Odesa coast (Helmboldt, 2001b) showed that the Acarofauna of the Grigoryevsky Estuary is more similar to that of the Odesa coast (4 common species, 89%) than to the

Tiligulsky estuary (3 common species, 75 %), which was also shown earlier (Vorobyova, Yaroshenko, 1982)

The study of the meiobenthos of the Grigorievsky Estuary made it possible to refine the data on the density of Kinorhyncha settlements in the northwestern Black Sea. It was believed that the average number of Kinorhyncha in the Black Sea could reach 10,000 ind.·m^{-2} (Marinov, 1990). Our studies of the last decades on the Black Sea shelf made it possible to adjust the ideas about the quantitative indicators of Kinorhyncha in various areas of the Black Sea towards their increase (Vorobyova, 1999). Here they form relatively dense clusters in all seasons of the year. The average numbers of Kinorhyncha (Table 1.10.) indicate that in winter, spring and summer of 1992-1993 they were within the same limits, and only in autumn was the average number two times lower. Among many areas of the NWBS, the highest occurrence of Kinorhyncha is characteristic of the Grigorievsky Estuary. The share of kinorhynchs in the total number of organisms is small (0.1-2.2%), which is also typical for other marine ecosystems of the World Ocean.

Table 1.10.

Interannual dynamics of quantitative indicators (ind.·m^{-2}) of Kinorhyncha and their share (%) in the total number of meiobenthos (Vorobyova, 2008).

Month, year	Grigorievsky estuary			Adjacent part of the sea		
	interval	average	%	interval	average	%
XI 1992	1333-1770	6400	2,2	0	0	0
II 1993	0-52670	12330	2,0	0	0	0
V 1993	0-30000	11693	1,8	0-533	177	0,17
VIII 1993	9166-24170	11466,2	1,7	0	0	0
VI 1994	0-80000	21250	1,0	0-7500	3300	1,6
VIII 1994	0-7500	750	0,1	750-2500	1250	0,5
XI 1994	0-225000	4500	0,9	0	0	0
V 1995	0-17500	5000	0,5	0-7500	3500	0,6
VIII 1995	0-2500	681,8	0,1	0	0	0
X 1996	0-10000	3050	0,45	0	0	0
VI 1997	2500-170000	48000	1,1	0-2500	800	0,23
X 1996	0-10000	3630	0,4	0	0	0
IX 1997	0-7500	2500	0,4	0-800	82,5	0,17
VI 2000	0	0	0	0	0	0
XI 2001	0	0	0	0	0	0
V 2003	0-3000	800	0,4	-	-	-
VIII 2003	0-27500	9545	0,8	-	-	-

Table 1.10 continued

Month, year	Grigorievsky estuary			Adjacent part of the sea		
	interval	average	%	interval	average	%
XI 2003	0-17500	5555,6	1,3	-	-	-
IV 2005	0-18000	5363,6	2,8	-	-	-
VIII 2005	0-20000	7091	0,8	-	-	-
XI 2005	0-26000	7454,5	1,2	-	-	-
VI 2006	2500-40000	14318,2	0,8	-	-	-

The figures given in the table show sharp differences in the formation of kinorhynch population density indicators in the estuary and the adjacent marine part, where sandy substrate predominates.

The obtained data on the qualitative composition and quantitative indicators of the meiobenthos of the Grigoryvsky Estuary and the adjacent marine area show their significant heterogeneity. The diversity of the meiofauna, both in the spring and in the autumn periods of 1996, is significantly richer in the estuary. Thus, in May, the meiobenthos here was represented by ten groups, in the autumn – eight. In the marine part – accordingly, six representatives of a large taxonomic rank in the spring and only three in the autumn. In addition, the average density of organisms in the estuary was 1–2 orders of magnitude higher than in the adjacent marine part. This pattern also extended to biomass indicators. It can be concluded that a richer food base for larvae and juvenile fish of the bottom and bottom complexes was formed in the Estuary.

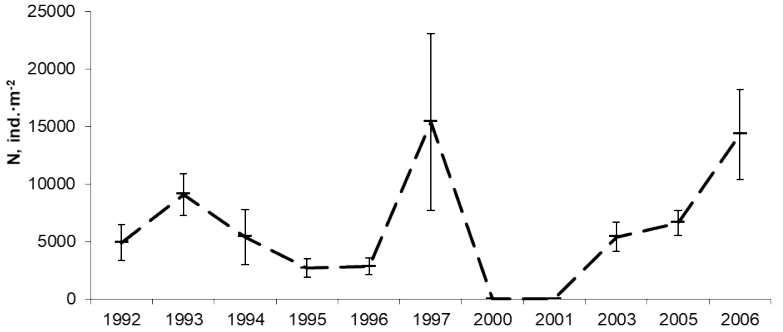


Figure 1.9. Long-term dynamics of the number (ind.·m^{-2}) of Kinorhyncha.

Sukhoi Liman

Sukhoi Liman is an estuary on the Black Sea coast in the Odesa region of Ukraine near Odesa. Sukhoi Liman is currently connected to the sea by a 14-meter-deep shipping channel, and its lower reaches are actually a sea bay. The upper part is shallower (up to 1.5 m), the northern and western parts are separated by a dam and turned into freshwater ponds. At the right bank of the estuary is the sea trade port of Chornomorsk, on the left bank are the Black Sea fishing port and the ferry crossing of the Black Sea Commercial Port. The location of two large ports on a relatively small water area of the estuary undoubtedly exerts significant anthropogenic pressure on the formation of biota and meiobenthos in particular. The salinity of the water at the mouth of the estuary is 16.05–17.3 ‰, in the central part – 5-28–18.06‰, the content of dissolved oxygen in different areas fluctuates from 3.63 $mg \cdot dm^{-3}$ to 9.7 $mg \cdot dm^{-3}$ (Adabovsky, Bogatova, Bolshakov al., 2006). The study of the meiobenthos of the Sukhoi Liman began in 1993 and continued periodically over many years.

The meiobenthos of the Sukhoi Liman, as well as the adjacent marine area, is poor in its diversity and is closely dependent on the processes occurring both in the estuary itself and in the Dnieper-Bug region of the northwestern part of the Black Sea. The composition and abundance of meiobenthos are determined by the representatives of the permanent component of this community. Pseudomeiobenthos has a very low population density. Its share in quantitative indicators does not exceed 0.3 %. In the early 1990s, representatives of 5 taxa (Foraminifera, Nematoda, Harpacticoida, Oligochaeta, and Polychaeta) were discovered in the estuary. In 2002, we already discovered representatives of 8 groups here: Foraminifera, Nematoda, Harpacticoida, Ostracoda, Polychaeta, Kinorhyncha, Turbellaria and Bivalvia. It should be noted that in almost all years of research, the number of meiobenthos was formed by foraminifera and nematodes. Such a picture may be an indicator of an extremely complex ecological situation in the bottom layers of the estuary. The number of certain of its representatives varied widely (14,000–100,000 ind.$\cdot m^{-2}$). Nematoda constituted one of the dominant groups.

At stations located in the coastal zone (splash), their number varied from 4,000 to 38,000 ind.·m^{-2}, constituting 10 – 75 % of all meiobenthos groups.

The nematode fauna of the Sukhoi Liman is represented by 14 species from 4 orders (Kulakova, 2006). The species diversity of the nematode taxocene varied widely at different stations. The upper reaches of the estuary and the zone adjacent to the sea part are the richest in species composition and diversity.

For the first time, the species composition of nematodes is indicated for Sukhoi Liman. The main share in abundance (81%) and biomass (86%) on the silts were the following species: *S. pulchra* and *T. pontica*. On the silted shell, the following species dominated: *P. caecus* and *N. sabulicola*. In the marine area adjacent to the estuary, three species dominated in abundance: *E. littoralis, P. caecus* and *S. pulchra*, the role of other species in abundance in this area was higher than in the estuary. A high percentage of occurrence in the estuary is characteristic of only a few species. The dominant species are *S. pulchra* and *T. pontica* (85.7 % each), the subdominant species *is C. maeoticus* (57.2 %). The remaining species found in the estuary had occurrence rates ranging from 14.3 to 42.8 % (Kulakova, 2006).

The species diversity of the nematode taxocene varied widely at different stations. The upper reaches of the estuary and the zone adjacent to the sea part were the richest in species composition. In the indicated areas, the number of species in the nematode taxocene was large, but each was represented by a small number of individuals. In this case, the diversity indices estimated by Shannon were the highest, and the Simpson indices were minimal). At stations located in the middle of the estuary, the dominance of only one or two species among a small diversity was noted.

A high percentage of occurrence in the estuary is characteristic of only a few species. The dominant species are *Sabatieria pulchra* and *Terschellingia pontica* (85.7% each), the subdominant species is *Cylindrotheristus maeoticus* (57.2%). The remaining species found in the estuary had a percentage of occurrence from 14.3 % to 42.8 %. Thus, it can be stated that in the Sukhoi estuary, free-living nematodes are represented by a small number of species.

The quantitative indicators of nematodes are formed almost exclusively by two or three species. This may reflect the extremely complex ecological situation in the benthal of the estuary. In the marine part adjacent to the estuary, the diversity of nematodes during the period of our studies was significantly higher.

Tiligulsky Estuary.

Tiligulsky Estuary is an estuary in the Odesa and Nikolaev regions of Ukraine, on the Black Sea coast. Its length is 80 km, width is 0.2-3.5 km, maximum depth: 19 m The area of the estuary is about 170 km².

The study of the meiobenthos of the Tiligul estuary was first started in 2000 (Vorobyova, Kulakova, 2006) previously there was no information about this category of zoobenthos. The studies of the fauna of free-living nematodes in the Tiligul Estuary were conducted in its coastal part (supra- and sublittoral), as well as in deep water (1.3–13.0 m). The meiobenthos of the estuary is characterized by a high diversity of small benthic invertebrates of the following taxa: Foraminifera, Nematoda, Harpacticoida, Ostracoda, Halacaridae, Turbellaria, Oligochaeta, Polychaeta, larvae and juveniles of Bivalvia and Gastropoda.

In analysis of the quantitative indicators of the meiobenthos of the estuary showed that harpacticoids and ostracods dominate among the representatives of the permanent meiofauna – on average, 43.3% and 28.3% of the total number of organisms, respectively. The average density of harpacticoid settlements was 107,997 ind.·m^{-2}, ostracods – 70,464 ind.·m^{-2}. The clear dominance of crustaceans, the subdominant position of nematodes and very low numbers of foraminifera indicate that the ecological state of the estuary was good during the study period.

The Tiligul estuary is characterized by a low number of foraminifera.

Studies of the fauna of free-living nematodes in the Tiligul Estuary were conducted in its coastal part (supra- and sublittoral), as well as in deep water (1.3 – 13.0 m).

In the meiobenthos of the Tiligul Estuary, nematodes constitute the dominant group both in terms of occurrence (100%) and settlement density.

The number of nematodes varied from 7,500 to 155,000 ind.·m^{-2} (average – 41,250 ind.·m^{-2}). The share of nematodes in the total number of meiobenthos was from 5 to 80 %. When comparing the quantitative indicators of nematodes with other estuaries and research areas in the NWBS, their values can be noted that their values are not high (Kulakova, 2006).

It should be noted that there was information (Vorobyova, Yaroshenko, 1982) only about marine mites (*Rhombognathus tonops*, *Rh. pPoscens, Copidognathus ponteuxius pectiniger*). The maximum number of galacariids was recorded on the algal substrate (615,000) The maximum number of Halacariida was recorded on the algal substrate (615,000 ind). This estuary is also characterized by the highest average number of sea mites in the summer period (Гельмбольдт, 2001, 2006).

According to Helmboldt M.V. a distinctive feature of the Tiligul Estuary compared to the sea coast is the presence in the plant biocenoses, in addition to red and green algae, also flowering aquatic plants (Ruppia and Zanihelia) and charophytes. It was on these plants that the predominant species were *Rh. tonops* and *C. magnipalpus*.

The average number of sea mites in the Estuaries for the summer months per1 m^2 of area is higher than in the same period in the coastal areas of the sea (41,400 and 12,400 ind. respectively). The maximum number of galacarias per 1 m^2 of substrate (615,000 specimens) was recorded in the Tiligulsky Estuary. This reservoir is also characterized by the highest average number of mites in the summer (133,500 ind/m^2 and 119,100 ind. kg-1 of algae).

A study of the estuary Halacaridea in the period 1996-2001 (Helmboldt, 2001) showed that in spring and summer the estuary was home to species: *Rhombognathus tonops*, 91 *Rhombognathides pascens*, *Copidognathus brachystomus* и *Agauopsis brevipalpus*.

The dominant species, as in the Tiligul Estuary and in the coastal zone of the Odesa coast, was a representative of the subfamily Rhombognathinae Viets (*R. tonops*): occurrence rate 100 %, density index 108.9, dominance index 0.28. Comparison of the species composition of the tick taxocene of the Grigorievsky, Tiligulsky estuaries and the coastal zone of the Odesa coast

(Helmboldt, 2001b) showed that the acarofauna of the Grigorievsky estuary is more similar to that of the Odesa coast (4 common species, Ks – 89 %) than to the Tiligulsky estuary (3 common species, Ks – 75 %), which was also shown earlier (Vorobyova, Yaroshenko,).

The maximum number of halacariids was recorded on the algal substrate (615,000 ind.). This estuary is also characterized by the highest average number of sea mites in the summer period.

The clear dominance of crustaceans, the subdominant position of nematodes and the very low abundance (1.1 % of the total number of meiobenthic organisms) of Foramnifera may indicate that the estuary ecosystem is in good ecological condition.

Fish species: *Planiliza haematocheilus* (Pilengas), *Neogobius melanostomus* (Round goby), *Atherina boyeri*, *Gobius niger* (Black goby), *Neogobius fluviatilis* (Sand Goby). The young of four representatives of these fish (except for the (Pilengas) Planiliza haematocheilus) feed on meiobenthos.

The meiofauna of the Khadzhibeysky Estuary

Khadzhibeysky Estuary is an estuary on the Black Sea coast located 7 kilometers northwest of Odesa. The estuary is about 31 km long, 0.5-3.5 km wide, has an area of about 70 km², and is up to 15 m deep. The salinity of the estuary is 5-6 ‰. Greatest depth: 15 m Area: 112 km²

The meiofauna of the Khadzhibeysky Estuary had not been studied before our studies. The meiofauna in the Khadzhibeysky Estuary is represented by the following groups of invertebrates: Nematoda, Harpacticoida, Ostracoda, Turbellaria, Oligochaeta, Acarina, Bivalvia. In the coastal zone (depth 0–10 cm) in winter, only three groups with a minimum number of individuals were present in the splash zone. Ostracoda dominated in number (8 ind.·100 cm^{-3}), the subdominant groups were Oligochaeta and Nematoda. In spring, samples were collected during March and April. In early March, only Oligochaeta (10 ind.·100 cm^{-3}) and Ostracoda (47 ind.·100 cm^{-3}) were found in the samples. The highest concentrations of meiofauna organisms were reached in April, where 3 groups were present: Oligochaeta (60 ind.·100 cm^{-3}), Ostracoda (26 ind.·100 cm^{-3}) and Nematoda (4 ind.·100 cm^{-3}). With the warming of the

sand in the summer months (June), an increase in the number of meiofauna groups to seven was observed.

Oligochaeta (161 ind.·100 cm^{-3}) and Turbellaria (64 ind.·100 cm^{-3}) dominated in abundance. At a distance of 1 m from the water's edge (supralitoral), five meiofauna groups were noted with Oligochaeta predominating in abundance (18 ind.·100 cm^{-3}). In the sublittoral, where samples were taken at a distance of 1 m from the water's edge and at a depth of 0.5 m, Harpacticoida (45 ind.·100 cm^{-3}) and Oligochaeta (18 ind.·100 cm^{-3}) dominated in abundance.

It can be noted that the role of nematodes in the total number of meiofauna in the coastal part of the estuary is not significant and amounts to only 2 to 9% (according to Kulakova I.I.). The highest role in both occurrence and density is noted mainly in Oligochaeta and Ostracoda, in the summer months the role of Turbellaria and Harpacticoida increases, the remaining representatives of the meiofauna were present episodically.

Samples were also collected in the estuary at stations characterized by depths of 1.8–8 m, where gray silt predominated. Meiobenthos was represented by five groups: Harpacticoida, Ostracoda, Nematoda, Oligochaeta, and Foraminifera. The total number of meiobenthos fluctuated within 2,160–26,533 ind.·m^{-2}. The highest percentage of occurrence was noted for Harpacticoida and Ostracoda (83 % each). The subdominant group was Nematoda (60 %). Oligochaeta were detected at two of the six stations, and Foraminifera at one. Nematoda dominated in terms of settlement density, with an average population of 7,105 ind.·m^{-2}. It should be noted that in the Khadzhibey Estuary, compared to other studied estuaries, the population of nematodes is low; its fluctuation limits in the summer period ranged from 0 to 17,600 ind.·m^{-2} at certain stations. Halacaridae in the Khadzhibey Estuary (Vorobyova, Yaroshenko, 1982): *Rombognathus pascens, Copidognathus ponteuxius pectiniger, Aqauopsis. brevipalpus.*

Fish species: *Planiliza haematocheilus* (Pilengas), Cyprinus (Carp), *Sander lucioperca*-судак, Ctenopharyngodon idella (White Amur), Neogobius melanostomus (Round Goby), Neogobius fluviatilis (Sand Goby). For the

young (size up to 6–7 cm) of most of these fish, meiobenthos represents a good food source.

4.2. CONTACT ZONE "RIVER-SEA" (POTAMOCONTOUR)

Objective data on the formation of the meiobenthic community of organisms in the river-sea contact zone could be obtained in the estuarine waters of the largest River that brings its fresh water to the Black Sea. Due to the unique hydrodynamic and hydrochemical conditions, estuarine areas differ significantly from water areas remote from rivers. This is especially true for the Danube River. Its waters bring up to 77.4 % of the total river runoff to the NWBS. Changes in the composition and quality of water entail changes in the structure of plankton and benthic communities. One of the "hot spots" for the introduction of exotic species of aquatic organisms are river mouths, deltas and estuaries (Zaitsev, Polikarpov, 2002). The first studies at the river-sea boundary have already revealed a large number of exotic species.

Since 1982 to the present, the IMB of the National Academy of Sciences of Ukraine has been conducting annual (often in all seasons of the year) comprehensive observations of the hydrobiological characteristics of the Ukrainian waters of the estuary coast of the Danube River: hydrology, hydrochemistry, ecology of pelagic and benthic organisms (Fig. 2.1.)

It is well known that the formation and development of human society is connected with rivers. Since historical times, rivers have been used as sources of fresh drinking water, communication routes, for fishing and fish farming, forest harvesting, irrigation and irrigation of land, water supply for the population. They are used to supply water to industrial enterprises and obtain electricity. Rivers have great aesthetic and recreational value, being places of recreation and various sports activities. They serve as collectors, water receivers during drainage reclamation of wetlands. But in addition to all the positive characteristics of river runoff, it can also have a significant negative impact on the quality of sea waters in the water areas that are in the zone of their influence.

Therefore, in addition to ongoing hydrochemical analyses (Vorobyova, Garkavay, Nesterova, 1995), the peculiarities of the formation of pelagic and benthic communities in the estuarine water areas of three large rivers of the Northwest Territories have been studied for many decades.

The zone of mixing of river waters with sea waters is a narrow belt (from hundreds of kilometers for large rivers to hundreds of meters for small ones), which plays an exceptional role in the formation of the quality of the environment in the adjacent marine ecosystems. Estuarine regions (regions of marginal filters), occupying less than 10 % of the ocean surface and less than 0.5 % by volume, take more than 90 % of sedimentary matter, metals and salts arriving from land; this area accounts for more than 30 % of primary production (Lysitsyn, 1983). Phytoplankton creates significant amounts of suspended matter here.

In the Black Sea, the rivers Danube Dnieper, Southern Bug and Dniester account for three quarters of the river's flow, which is why its northwestern part differs sharply in its hydrological, hydrochemical and biological characteristics from all other regions.

Along with the nature of bottom sediments, the salt regime plays an important factor in the formation of the species richness and quantitative characteristics of bottom invertebrates of the estuarine coast. In this area, salinity mainly depends on the intensity of fresh runoff and varies from 0 to 18 ‰. According to the regime of salinity, V.S. Bolshakov, (1970) identified three groups of water masses in the northwestern part of the Black Sea: river (estuarine) with a salinity of 4–5.9 ‰, surface, where the salinity in the horizontal direction is rapid, often abrupt, increases to 10–12 ‰. The third is bottom water, where 65 % of river water is transformed into sea water (up to 16.5 ‰).

The study of the formation features of the meiobenthic community of organisms throughout all the years of observations was carried out by Dr., Prof. Vorobyova L.V., Ph.D. Kulakova I.I. From 1998 to 2011, the study of the Harpacticoid taxocene (species diversity, features of the spatial distribution of qualitative and quantitative characteristics) was carried out by Ph.D.

Garlitska L.A. She summarized the material (1998-2010) in her Ph.D. dissertation "Ecology of Harpacticoida (Crustacea, Copepoda) of the northwestern part of the Black Sea". 2010. From 2008 to 2023, the study of the harpacticoids of the considered water area was continued by Ph.D. Portyanko V.V. If Kulakova I.I., Garlitska L.A. and Portyanko V.V. conducted a study of two large taxa (nematodes and harpacticoids), then Vorobyova L.V. analyzed the features of the formation of general indicators of large taxa of meiobenthos.

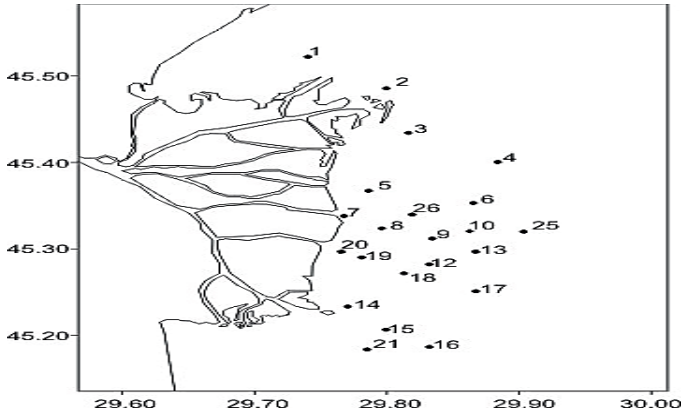


Figure 2.1. Map of general area of sampling station in the mouth of the Danube

The set of groups of meiobenthos of the Danube estuary is similar to the meiobenthos of the northwestern shelf of the Black Sea outside the estuary (Vorobyova, 1999; Vorobyova, Kulakova, Garlitska, 2012; Vorobyova, 2012). This is explained, first of all, by the peculiarities of the hydrological regime of this zone. The waters of the Danube, falling on the coast, spread in a thin (1-3 m) surface layer. Only in this layer, coastal desalination depends on the nature of the distribution of river flow along the length of the sea edge of the delta. The lower layers of the seashore are occupied by fairly homogeneous waters, significantly more saline than surface waters (Bolshakov, 1970). Long-term studies have shown that nematodes and harpacticoids predominate in most of the water area.

We conditionally divided the water area of the estuarine coast into three zones: the 1st is located 2-5 km from the Bystry, Vostochny and Starostambulsky mouths, the second – at a distance of 9-11 km from them, and the third at a distance of more than 15 km up to the soil dumping. In the first zone meiobenthos is represented by practically all taxa characteristic of it. The total number and biomass of meiobenthos, as can be seen from the graphs presented, is significantly inferior to their indicators in the rest of the studied water area (Fig. 2.2).

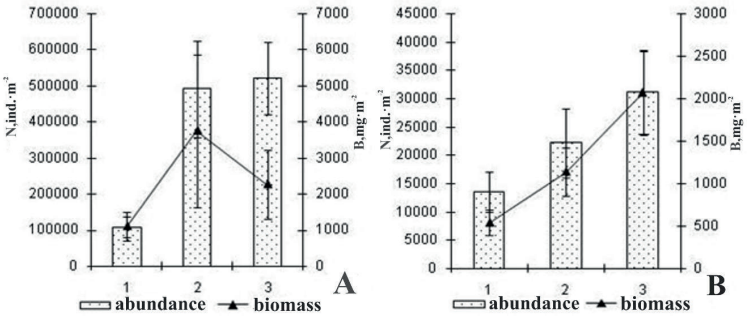


Figure 2.2. Average long-term indicators of abundance (ind.·m^{-2}) and biomass (mg·m^{-2}) of eumeiobenthos (A) and pseudomeiobenthos (B) in the estuarine water area of the Danube River (1-3 zones of the estuarine).

The dominant group in terms of abundance is harpacticoids, the share of which is 46.8 % of the total number of organisms. The subdominant group is nematodes, the average long-term population density of which is 36,182 ind.·m^{-2} (25 % of the total number). Due to the fact that hydrodynamic processes do not contribute to the deposition of organic matter in the benthic of this zone, this may explain the weak development of both foraminifera and oligochaetes here. It should be noted that only in this zone, albeit in very small quantities, Halacaridae were noted, but they were absent in the samples when moving towards the sea.

In the second zone, a sharp increase in both the total abundance and the biomass of temporary and permanent components is observed. The density of

harpacticoids increases almost four times, making up 43.4 % of the total number of organisms. Together with nematodes, they occupy a leading position in the density of settlements, their share in the total indicator of abundance reaches 87.1 %. A sharp increase (more than 20 times) in the number of foraminifera and by an order of magnitude in the number of oligochaetes indicates that at a distance of 10 km or more from the mouth of the river, bottom currents significantly decrease their speed.

A significant amount of organic matter comes from the surface layers of the water, which accumulates in.

The main part of the biomass in the second zone is formed by harpacticoids (73.4 %) and representatives of pseudomeiobenthos (23.3 %). Thus, the share of other representatives is only 3.3% of the total biomass. These indicate that in the second zone a good food base is formed for the hydrobionts inhabiting Benthal. Currently, there are numerous data on the consumption of meiobenthos by juveniles of commercially important fish species and macrobenthos. Among representatives of the meiobenthos in the food lumps of fish, harpacticoids are most often found, and mainly those that live on the surface of the sediment.

In the third zone, the total number increases a little more, and the biomass remains almost at the same level. In this water area, there is a change in the meiobenthos structure, 17.1 % of the total abundance is accounted for by foraminifera. The density of oligochaetes increases by 2.5 times. The density of harpacticoids decreases almost twice. Small-sized forms (foraminifera, nematodes, etc.) account for about 80 % of the total number of organisms, therefore the quality of meiobenthos as a food object decreases.

Of all representatives of the meiobenthos of the Danube estuarine coast, nematodes and harpacticoids (faunistic composition – Chapter 1), spatial distribution of abundance and biomass, their role in the formation of general quantitative indicators of the meiofauna were the most studied.

NEMATODA. Among the large taxa of meiobenthos, the longest and most regular studies relate specifically to nematodes, which were carried out by I.I. Kulakova (from 1982 to the present). Her numerous publications

provide interesting and scientifically important data on the taxonomic composition of nematodes, the patterns of formation of their quantitative characteristics and spatial distribution depending on the main environmental factors in the zone of influence of the Danube River.

The results of Kulakova I.I.'s study of the features of the ecological characteristics of the nematode taxocene in the zone of influence of the Danube waters were presented in many publications (Kulakova,2007, 2015, 2020, 2022). The results have been received from benthic surveys in the autumn period of 1983, 1998, 2003, 2005 in different parts of the estuarine areas, adjacent Zhebriansky Bay, and also directly in the Kiliya delta of the Danube (Kulakova, 2007).

This information was subsequently supplemented. Free-living nematodes of the Danube estuarine coastal zone (results of benthic surveys carried out in autumn in 1983, 1998, 2003, 2005, 2008, 2010) were represented by 46 species of 31 genera, 12 families and 4 orders. (Enoplida – 16 species, Chromadorida – 10 species, Monhysterida – 16 species, Araeolaimida – 4 species). Dominant species were identified with a frequency of occurrence of 70–96 % (Kulakova, 2015). In the taxocene of the delta region, these are *Mesotheristus setosus* and *Sabatieria pulchra*. In the foredelta region – *S. pulchra, Terschellingia pontica* and *Axonolaimus setosus.* In the seaward area – *S. abyssalis* and *Ax. setosus.* The calculated values of the indices by frequency of occurrence indicate a reduced taxonomic diversity of nematode communities in the delta and delta-front areas, compared to its average expected level for the nematode fauna of the entire estuarine coastal area The use of indices of taxonomic distinctiveness in the environment of the study area can lay the foundation for further monitoring of biodiversity changes on a spatial scale.

Interest in the Nematoda fauna of the Kiliya Danube Delta, the seaside and the adjacent Zhebriyanskaya Bay is associated with the importance of identifying the features of the Danube's influence on the structure and functioning of the nematode community.

The data of Kulakova I. on the analysis of samples collected from 1982 to 1998 show that on the coast, nematodes were noted everywhere, but their

share in the total number of meiobenthos varied from 20.3 % to 47 %. They can be classified as subdominant.

It should be noted that according to the results of studies (Vorobyova, 1999), the structure of the meiobenthos of the studied water areas of the Danube coast has the most simplified structure compared to other areas of the NWBS. The density of nematodes in the studied period was quite high in the silt biotope and varied from 81,750 to 666,524 ind.·m^{-2}. It was significantly lower in the sand biotope with an admixture of shell rock (from 5,750 to 48,433 ind.·m^{-2}).

According to I.I. Kulakova the Nematoda of the studied areas includes 50 species belonging to 4 orders (Enoplida – 16 species, Chromadorida – 11 species, Monhysterida – 18 species, Araeolaimidae – 5 species. Nematodes are distributed rather unevenly within the studied water area. On the Danube coast, the nematode fauna is represented most diversely, where 46 species have been recorded.

Of the 28 nematode species found in the muds, only *S. pulchra* and *T. pontica* can be considered dominant, with a high percentage of occurrence (67 and 56%). At many stations, these species reached a population density of about 82,350 – 142,848 ind.·m^{-2}. Subdominant species by occurrence are *Ax. setosus, Sph. ostreae, P. caecus, M. rotundicapitata.*

In Zhebryanskaya Bay, 28 nematodes species were found. The leading role in the number of species belongs to the orders Monhysterida (50 %) and Chromadorida (23 %). The average density of nematodes in the bay, which is characterized mainly by silt stations, is lower than the silt biotope on the coast and amounted to 83,118 ind.·m^{-2} (average biomass is 201.8 mg.·m^{-2}). Only one species, *S. pulchra*, dominated both in frequency and in population density (frequency – 70 %, average density – 31,174 ind.·m^{-2}).

In the Danube Delta branches, only six nematodes were identified to species level out of the entire diversity; the rest require further study. Species from the order Monhysterida (*M. rotundicapitata, C. longicaudatus, M. setosus*) dominate in terms of occurrence and population density. The density of nematodes varied from 24,000 to 148,000 ind.·m^{-2}. Species diversity

decreases from the seashore to the mouth of the Danube. The Shannon index values were (from 1.43 to 0.59), respectively.

The material – from November 2004 to November 2019 (Kulakova, 2020) – showed that the nematode fauna is represented by 69 species of 37 genera, 18 families and 6 orders. An increase in the number of species was observed in each of the orders from the river mouth to the seaward part. The Monhysterida and Enoplida orders dominated in terms of the number of species. The preferred trophic grouping was non-selective detritivores (1B). The distribution of quantitative indicators of nematode density in different areas varies significantly: from 1000 ind.·m^{-2} to 682,500 ind.·m^{-2}. On average, it amounted to 119,474 ind.·m^{-2}. Biomass varied from 1.3 mg·m^{-2} to 425.4 mg·m^{-2}, with an average of 57.4 mg·m^{-2}. In low-water years, there is an increase in the number of nematodes compared to high-water years. There are reasons to talk about the formed nematode fauna in the Ukrainian part of the Danube estuary region, which constantly undergoes quantitative changes under the influence of naturally changing environmental conditions, as well as man-made loads.

Estimations have been made for evaluation of the statistical significance of differences between the groups of stations in the delta (A), avandelta (C) and marine areas (B) comparison of the degree of variability of average values of rank similarity (R statistic) of all (pairs) groups of stations for the study areas (ANOSIM). The contribution of each species into intergroup similarity (indicator species) and intergroup difference (discriminant species) have been carried out on the basis of values of functions of similarity (S) or differences (D) (the relation of absolute values of the contribution of the species to standard deviation (Std), (SIMPER). In the taxocene of the marine part (B) first ranking are *Ax. setosus, S. abyssalis, Anticoma acuminata* and *V. minor*. Of all dominating species of nematodes only one species S. pulchra, can be identified for all three given taxocenes (Kulakova, 2022).

In the northwestern part of the Black Sea, free-living nematodes are one of the dominant groups of meiobenthos. The works (Kulakova, 1989; 2002; 2006, 2008, 2012, 2015, 2020; Kulakova, Torgonskaya, 2000; Kulakova,

Vorobyova, 2019; Vorobyova, Kulakova, 1998, 2005, 2009; Vorobyova, Kulakova et al. 2016) provide an analysis of the state of free-living nematodes in the meiobenthos of the Odesa Gulf, Zhebriyanskaya Bay and other areas of the NWBS. The study of the ecological and taxonomic diversity and the features of the quantitative development of free-living nematodes in the Danube coastal area, which has a high degree of eutrophication compared to other areas of the Black Sea, is very relevant (Table 2.1.). The formation of meiobenthos in this area can be influenced not only by the large natural variability along the estuarine gradient (e.g., the type and dynamics of sediments, the presence of oxygen, temperature and flow velocity), but also by active anthropogenic impact (e.g., dredging and soil dumping) (Kulakova, 2022).

Based on the results of the analysis of materials from 2004–2009, I. I. Kulakova concluded that nematodes were observed everywhere in the study area, their share in the total number of all meiobenthos fluctuated from 12.6 % to 71 %. According to Kulakova I.I the nematode fauna is represented by 33 species, mainly representatives of the order Monhysterida (15 species), Enoplida (10 species) and Chromadorida (8 species).

The presence of species from these orders is typical for areas where river and sea waters mix, while in open sea areas the nematode fauna is represented by species from the other 6 orders. On the coast, among the diversity of species in density and occurrence, the following dominate at most stations: *S. pulchra, Sph. ostreae, V. minor*. Such a distribution of nematodes is typical for eutrophic waters.

In the modern period, Kulakova I.I. published new data, the basis of which – the study is based on the results of benthic surveys carried out in November 2015 and August 2018 and 2020 in the area of the “Danube-Black Sea” navigable canal (Kulakova, 2022). The suitability of using meiobenthic communities and especially the nematodes-based indices to assess the ecological quality of the Ukrainian Danube delta coastal area was tested in one control and two sites impacted by dredging/dumping activities.

Table 2.1.

Species diversity of nematodes and quantitative indicators in different parts in the estuarine waters of the Danube.

Species	number, ind.·m^{-2}	biomass, mg·m^{-2}
Axonolaimus ponticus	38	0.05
Terschellingia pontica	12764	6.13
Metalinchomoeus zosterae	44	0.04
Sphaerolaimus gracilis	1432	0.36
Sphaerolaimus ostreae	2931	2.29
Monhystera longicapitata	210	0.03
M. collaris	710	0.04
M. ampulocauda	918	0.24
M. rotundicapitata	3333	0.83
M. conica	214	0.06
Monhystera sp.	139	0.02
Theristus maeoticus	139	0.04
Th. setosus	421	0.13
Cylindrotheristus longicaudatus	631	0.11
Sabatieria pulchra	14811	7.70
S. abissalis	7914	7.12
Chromadora poecilosomoides	250	0.05
Ch. mitilycola	543	0.08
Chromadora sp.	833	0.05
Prochromadorella mediterranea	44	0.01
Cyatolaimus sp.	44	0.01
Paracantonchus caecus	788	0.05
Cobbionema acrocerca	3256	0.49
Halalaimus ponticus	1716	0.43
Oxystomina elongata	543	0.28
Anoplostoma viviparum	1744	0.44
Enoplus littoralis	3750	4.50
Enoplus sp.	176	0.03
Enoplolaimus conicus	167	0.50
Enoplolaimus sp.	139	0.03
Bathylaimus cobbi	1207	0.22
Viscosia minor	2888	0.72
V. glabra	1044	0.84
Average	**65778**	**1.03**

The values of the taxonomic richness of the meiobenthos varied from 6 taxa in the dredging sites to 9 taxa at background stations. According to the species richness, the ecological quality in the dredging area fell into the Poor class (EQS), while the background and dumping areas into the Moderate class.

According to Kulakova I.I. the Shannon index (H‘) of the nematodes in the dredging sites varied from 0 to 1.8. Low values of these indices indicate Bad ecological status in the dredging sites and Poor in the rest. There was a high percentage of c-p2 (r-strategists) in all sites. Average values of the maturity index (MI) varied from 1.5 ± 0.2 in the dredging sites to 2.3 ± 0.1 at dumping and 2.6 ± 0.1 at background stations. The Maturity Index also indicates that the dredging site is in Bad condition, the dumping one is in Poor and the background stations are in Moderate. on-selective deposit feeders (1B) dominated at most stations. According to the values of the trophic diversity index (ITD), the study area can be classified as Poor. For the study sites, species that can be considered potential biological indicators are evinced.

According to Kulakova I.I. low biodiversity, an increase in the number of common opportunists, a decrease in the maturity index towards the river mouth, and a predominance of non-selectiv deposit feeders were recorded. This may indicate unstabl hydrological and hydrochemical conditions in this part of the Danube delta coastal area. Low MI values indicate a disturbed/contaminated environment. An increase in ITD values due to the marked dominance of one trophic group (1B) also indicates an increase in stress in the dredging site. The results of the analysis show that the species marked with the greatest contribution to the average intra-complex similarity (S) – indicator species in a particular area simultaneously act as discriminator species, reaching the maximum values of the dissimilarity function (D). For the study areas, species have been identified that can be considered as potential indicators.

Thus, in the taxocene of the dredging sites, these are *M. rotundicapitata, M. conica*, and *S. pulchra*. In the dumping sites, these are *S. pulchra, T. longicaudata, S. ostreae,* and *A. ponticus*. In the area of background stations – *S pulchra, T. longicaudata* and *A. ponticus*. The results obtained on the ecological status of the Danube delta coastal area using the example of the meiobenthos and nematode communities can help further assess the degree of anthropogenic impact and control the loss of ecosystem functioning.

The material – from November 2004 to November 2019 (Kulakova, 2020) showed that the nematode fauna is represented by 69 species of 37 genera, 18 families and 6 orders. An increase in the number of species was observed in each of the orders from the river mouth to the seaward part. The Monhysterida and Enoplida orders dominated in terms of the number of species. The preferred trophic grouping was non-selective detritivores (1B). The distribution of quantitative indicators of nematode density in different areas varies significantly: from 1000 ind.·m^{-2} to 682500 ind.·m^{-2}. On average, it amounted to 119,474 ind.·m^{-2}. Biomass varied from 1.3 mg·m^{-2} to 425.4 mg·m^{-2}, with an average of 57.4 mg·m^{-2}. In low-water years, there is an increase in the number of nematodes compared to high-water years. There are reasons to talk about the formed nematode fauna in the Ukrainian part of the Danube estuary region, which constantly undergoes quantitative changes under the influence of naturally changing environmental conditions, as well as man-made loads.

The results have been received from benthic surveys in the autumn period of 1983, 1998, 2003, 2005 in different parts of the estuarine areas, adjacent Zhebryanskaya Bay, and also directly in the Kiliya delta of the Danube (Kulakova, 2007).

Estimations have been made for evaluation of the statistical significance of differences between the groups of stations in the delta (A), avandelta (C) and marine areas (B) comparison of the degree of variability of average values of rank similarity (R statistic) of all (pairs) groups of stations for the study areas (ANOSIM). The contribution of each species into intergroup similarity (indicator species) and intergroup difference (discriminant species) have been carried out on the basis of values of functions of similarity (S) or differences (D) (the relation of absolute values of the contribution of the /'-species to standard deviation (Std), (SIMPER). In the taxocene of the marine part (B) first ranking are *Ax. setosus, S. abyssalis, Anticoma acuminata* and *V. minor*. Of all dominating species of nematodes only one species S. pulchra.

Harpacticoida.

24 species of Harpacticoida were recorded for the seashore down to a depth of 21 m: *C. perplexa, H. abrau, L. brevicornis, H. longiantennata, H. flexus, M. fallax, M. littorale, D. palustris, D. tethysensis, S. neglecta, A. parvula, N. lacustris, N. hibernica, M. aestuarii, C. staphylinus, E. caeni, E. longifurcatum, E. garienis, C. tenuipes, C. confluens, L. behningi, N. palustris, A. sarmatica,* и *O. mohammed.* These species were previously indicated by Monchenko V.I *Мончeнко В.И. (*Мончeнко, 1967, 1969).

According to Garlitska the list has been expanded with 10 more species – *M. pygmaea, E. melaniceps, P. beduina, L. elongata, H. mathoi, P. longirostris, S. compacta, N. serrata, S. herdmani* и *T. histriana.* Most of these species are common on the northwestern shelf of the Black Sea. Eight species of harpacticoid copepods belonging to the families Ameiridae (2), Cletodidae (1), Ectinosomatidae (2), Miraciidae (2) and Tachidiidae (1) were found in the bottom samples. During the observations of 2005 and 2008, only four of them were noted as common. These were *M. littorale*, the abundance of which varied from 0.1 to 1015.0 thousand ind.·m^{-2}, averaging 153.5 thousand ind.·m^{-2}; *P. beduina* (0.2-295.0 thousand ind.·m^{-2}, on average 27.9 thousand ind.·m^{-2}), *E. garienis* (1.2-16.0 thousand ind.·m^{-2}, on average 3.0 thousand ind.·m^{-2}.

Garlitska L.A. expanded and supplemented the list of harpacticoids of the Ukrainian part of the northwestern shelf of the Black Sea from 52 species (indicated in the literature until the early 1990s) to 116 species. Ten species are indicated for the Black Sea for the first time, one species is new to science. For the first time, a comparative analysis of harpacticoid communities of different areas of the NWBS was carried out, the specificity of Harpacticoida communities at different depths and substrates, as well as their seasonal dynamics, were revealed.

The number and biomass of harpacticoids in this area varies depending on the season. In May – June, the abundance of harpacticoids is the highest, reaching a maximum of 2,800.0 thousand ind.·m^{-2} (on average 173.0 thousand ind.·m^{-2}), and their share accounts for 34.1 % of the total number of meiobenthos and 56.7 % of the total biomass. By the end of

summer, the number of harpacticoids decreases by more than 2 times (on average 81.8 thousand ind.·m^{-2}), in parallel with this, their share in the meiobenthic community also decreases – to 9.0 % of the total number and to 16.8 % of the total biomass. In October-November, the lowest density indicators are recorded – from 0 to 131.3 thousand ind.·m^{-2} (on average 22.0 thousand ind.·m^{-2}), although at the same time the share in the total number and biomass of meiobenthos increases (on average 19.9 and 27.0 %, respectively).

According to the archive data of the Institute of Biological of the National Academy of Sciences of Ukraine, in the mid-1980s – early 1990s in the Danube region in the summer (July) on average 62.6 thousand ind.·m^{-2} of benthic copepods were counted, which is quite comparable with modern values. In autumn (October) the numbers did not exceed 8,000 ind.·m^{-2}, which is significantly lower than the data obtained during our observations. Long-term studies of the meiobenthic community of Zhebriyanskaya Bay show that during this period unfavorable conditions for the development of crustaceans often developed, namely: a decrease in the oxygen content in the bottom layer of water during the period of development of stable temperature stratification (Garkavaya, Bogatova, Berlinsky, 1998).

Several works published in the late 1960s were devoted to the diversity of harpacticoids in the lower reaches and delta of the Danube. The local fauna is formed by marine, brackish-water and freshwater euryhaline species. A total of 24 species were noted for the coastal waters down to a depth of 21 m (Monchenko, 1967, 1969, 1974).

As a result of the research of L.A. Garlitska, which was carried out on a larger area in comparison with previous studies of the water area and a larger range of depths (3.8–45.0 m), the list was supplemented by 10 more species: *M. pygmaea, E. melaniceps, P. beduina, L. elongata, H. mathoi, P. longirostris, S. compacta, N. serrata, S. herdmani and T. histriana.* Most of these species are often found on the northwestern shelf of the Black Sea (Table 2.2.).

During observations in 2005 and 2008, only four of them were noted as frequently occurring in the Danube estuary coastal area. These are

Microarthridion littorale, the abundance of which varied from 100 to 1,015,000 ind.·m^{-2}, averaging 153,459 ind.·m^{-2}; *Pseudobradya beduina* (200–295,000 ind.·m^{-2}, 27,863 ind.·m^{-2} on average), *Enhydrosoma garienis* (1,200–16,000 ind.·m^{-2}, 2,980 ind.·m^{-2} on average) and a representative of the genus Halectinosoma (200–50,000 ind.·m^{-2}, 5,976 ind.·m^{-2} on average), which, unfortunately, was not identified to the species level. It should also be noted that, compared to 2005, in 2008 the number of species in this water area decreased to five.

Table 2.2.

List of species of Harpacticoida (Crustacea, Copepoda) in the estuarine waters of the Danube (Portyanko, 2017.)

Species	Life form*	Year and month			
		2005	2008		
		V	VI	VIII	X
Ameira parvula	not_int	+			
Delavalia palustris	epiben	+			
Halectinosoma sp.	silt_dw	+	+	+	+
Enhydrosoma garienis	epiben	+	+	+	+
Microarthridion littorale	epiben	+	+	+	+
Nitocra hibernica	not_int	+			
Pseudobradya beduina	silt_dw	+	+	+	+
Schizopera compacta	epiben	+	+		+
Total		**8**	**5**	**4**	**5**

***** not_int – non-specific interstitial, epiben – epibenthic, silt_dw – silt-burrowing

The analysis of data similarity shows that the stations are similar in species composition and harpacticoid settlement density. Only one taxocene with a pronounced dominance of *M. littorale* can be distinguished here. This epibenthic species accounted for an average of 80.1 % in 2005 and 2008. The subdominant species at most stations is the silt-boring *P. beduina* (14.5 %). In general, this taxocene is identical to the complex distinguished in 1998.

The abundance of harpacticoids on different types of soil varies significantly. Compared to other biotopes, harpacticoids populate silt more actively: the average abundance is 62.4 thousand ind.·m^{-2}, which is 22.8 % of the total number of meiobenthic organisms. In biotopes of sand and silted sand

with an admixture of shells, the density of harpacticoids averaged only 0.8 and 14.3 thousand ind.·m^{-2}, respectively.

As the depth increases, the quantitative indicators of harpacticoids also increase. A sharp difference is observed between the depths of 3.8–5.0 m (on average 0.9 thousand ind.·m^{-2}) and 5.1–10.0 m (on average 50.0 thousand ind.·m^{-2}), and the maximum values are confined to the range of 15.1–20.0 m (on average 103.8 thousand ind.·m^{-2}). It turned out to be interesting that with such a significant difference in the actual values of the number at depths from 5.1 to 20.0 m, the proportion of harpacticoids in the total number of meiobenthos remains practically unchanged (27.1±2.9 %).

Thus, comparing the data covering an eleven-year period, it can be said with complete confidence that in the mouth area of the Danube on the silt substrate there is a stable taxocene formed by epibenthic and silt-burrowing species with a strictly expressed dominance of *M. littorale*. In general, the spatial distribution of harpacticoids here is uneven. However, it should be noted that abundance indicators above 100.0 thousand ind.·m^{-2} are more often recorded at southern and seaward stations (Garlitska 2011)

During the 2005 and 2008 surveys, only four of them were noted as frequently occurring: *Microarthridion littorale*, whose abundance varied from 100 to 1,015,000 ind.·m^{-2}, averaging 153,459 ind.·m^{-2}; *Pseudobradya beduina* (200–295,000 ind.·m^{-2}, averaging 27,863 ind.·m^{-2}), *Enhydrosoma garienis* (1,200–16,000 ind.·m^{-2}, averaging 2,980 ind.·m^{-2}) and a representative of the genus Halectinosoma (200–50,000 ind.·m^{-2}, averaging 5,976 ind.·m^{-2}), which, unfortunately, was not identified to the species level. It should also be noted that, compared to 2005, in 2008 the number of species in this area decreased to five.

Thus, comparing the data covering an eleven-year period, it can be said with complete confidence that in the estuary zone of the Danube River on the silt substrate there is a stable taxocene formed by epibenthic and silt-burrowing species with a clearly expressed dominance of *M. littorale*. In general, the spatial distribution of harpacticoids here is uneven. However, it should be

noted that abundance indicators above 100,000 ind.·m^{-2} are more often recorded at southern and seaward stations.

Harpacticoida in the waters of the Danube estuary coast, as well as on the entire shelf of the North-West Black Sea, play an important role in maintaining quantitative indicators of meiobenthos (Vorobyova, Portyanko, 2014)

The study of the Harpaticoida taxocene was continued in 2010–2017 by PhD V.V. Portyanko. During this period of research, 8 species of Harpacticoida were discovered (Table 2.2.), belonging to the families Ameiridae (2), Cletodidae (1), Ectinosomatidae (2), Miraciidae (2) and Tachidiidae (1).

To obtain more accurate data, the results were analyzed for the summer periods of all years. He found that in the summer seasons in the estuarine deep-water area of the Danube, the number of harpacticoids (average 44346 ± 9040 ind.·m^{-2}) and biomass indicators (average 865.71±391.67 mg·m^{-2}) varied significantly. The peak of the average number of harpacticoid copepods were 27,800 ind.·m^{-2} and was noted in 2011. In 2015 and 2016, a decline in the number of copepods we noted.

During the periods of maximum quantitative values during 2010–2013, harpacticoids dominated in most of the water area of the estuary of the Danube River, accounting for an average of 42.2 % of the density of the entire meiobenthos. The share of harpacticoids in the total biomass of meiobenthos was on average 53 %. The lowest indicators of the percentage of harpacticoid copepods in the quantitative indicators of the meiobenthos (9.63 % and 1.31 % of the total number and biomass, respectively) were noted in 2015. Biomass indicators of harpacticoids for the period 2010–2017 reflected the indicators of abundance, and the highest value were registered in 2013 and was 1,818.7 mg·m^{-2}.

Statistical reliability is confirmed, and thus we can talk about the presence of a potamocontour. According to the salinity gradient, the cluster analysis showed the presence of 5 groups harpacticoids according to salinity

in the deep-water region of the NWBS: 0.2 – 0.5 ‰, 1.5 – 3 ‰, 5 – 8 ‰, 10 – 13 ‰ and up to 16 ‰ (V.V. Portyanko).

Based on the data obtained during the study of the spatial distribution of harpacticoids in the mixing zone of river and sea waters, in the estuarine part of the river basin contour of the Danube River, it is shown that indicators of the number and biomass of harpacticoid copepods have a directly proportional power dependence on salinity (the coefficient of determination of which is 0.8). The highest numbers and biomass of harpacticoid copepods are observed at a salinity of about 16 ‰ (76,667 ± ind.·m^{-2} and 1,426.7 ± 550 mg·m^{-2}, respectively (Vorobyova, Polischuk, Nesterova, Sinegub, Kulakova, Bondarenko, Portyanko, et al., 2917). The percentage contribution of harpacticoid copepods to the formation of quantitative indicators of meiobenthos depended on salinity indicators. The share of harpacticoids in the abundance of meiobenthos tended to decrease (R2 = 0.7684), and the percentage share of harpacticoids from the total biomass (R2 = 0.7697) increased with increasing salinity.

During the periods of maximum quantitative values during 2010–2013, harpacticoids dominated in terms of numbers in most of the water area, in the Danube estuary, constituting on average 42.2 % of the density of the total meiobenthos. The share of harpacticoids in the total biomass of the meiobenthos was on average 53 %. The lowest indicators of the percentage of harpacticoid copepods in the quantitative indicators of the meiobenthos (9.63% and 1.31 % of the total number and biomass, respectively) were noted in 2015.

Based on the data obtained from the study of the spatial distribution of harpacticoids in the zone of mixing of river and sea waters, in the estuarine part of the Danube River basin contour, it was shown that the abundance and biomass indicators of Harpacticoida have a directly proportional power dependence on salinity (the coefficient of determination of which is 0.8). The highest indicators of the abundance and biomass of harpacticoid copepods are observed at a salinity of about 16 ‰ (76,667 ±12,03ind.·m^{-2} and 1,426.7 ± 550 mg·m^{-2}, respectively). The percentage contribution of harpacticoid copepods to the formation of quantitative indicators of meiobenthos depended on salinity

indicators. The proportion of harpacticoids in the abundance of meiobenthos tended to decrease (R2 = 0.7684), and the percentage of harpacticoids in the total biomass (R2 = 0.7697) increased with increasing salinity.

Analysis of the long-term dynamics of the harpacticoid potamocontour during 2010–2017 showed (according to Portyanro V.V.) that the peak of the harpacticoid population falls on 2011 and is 96581 ind.·m^{-2}, and the biomass on 2013 (1,818.6 mg·m^{-2}). The lowest indicators of population and biomass were registered in 2015 – 5,500 ind.·m^{-2} and 8.8 mg·m^{-2}. Correlation analysis showed that the quantitative indicators of the harpacticoid potamocontour significantly increase with increasing salinity (coefficient of determination R^2 = 0.851). At a salinity of 16.1 ‰, the highest values of abundance and biomass are observed (76,667 ind.·m^{-2} and 1,226 mg·m^{-2}, respectively).

Polychaeta. Polychaetes are an essential component of the meiobenthos, whose contribution to its total biomass is often comparable to that of the eumeiobenthos. (Vorobyova, A.S. Bondarenko, 2007). A peculiarity of the taxocene of polychaetes of the estuarine coast was the almost complete absence of representatives of the eumeiobenthos complex. The low variety of substrate types and, most importantly, the specifics of this contact zone and the high level of trophicity of the coast of the Danube River may be the main factors preventing the development of polychaetes, a permanent component of the meiobenthos in this area (Vorobyova, Bondarenko, 2009).

Data on the species composition of meiobenthos polychaetes of the Northwest Territories until the beginning of the 2000s. were quite poor. Thus, 7 species of meiobenthic polychaetes were recorded in Yagorlytsk Bay, of which the most widespread are *Salvatoria limbata* (Clap., 1868), *P. dumerilii* and *Protodorvillea kefersteini* (McIntosh, 1869) (Vorobyova, 1999).

The study of polychaetes belonging to the meiobenthos (young macrozoobenthos forms and typical meiobenthos) was successfully studied for many years by PhD A.S. Bondarenko. According to her data, in the Odesa maritime region in 2005, 2007, and 2008. 4 types of polychaetes worms of eumeiobenthos and juvenile individuals of 14 species of polychaetes (pseudomeiobenthos) were registered (Bondarenko, 2010, 2017). For the

Danube region in the winter period (January, 2005), 9 species of meiobenthos polychaetes were indicated (Vorobyova, Bondarenko, 2008).

In the estuary area of the Danube River (according to A.S. Bondarenko), juveniles of 15 species of the Polychaeta belonging to 8 families were recorded during the study period. The family Spionidae was represented by the largest number of species (5 species). The most frequently encountered and dominant species in pseudo-meiobenthos were *A. succinea* and *P. cornuta* (adults have planktonotrophic larvae). Thus, the species structure of the temporary community of juvenile polychaetes to a certain extent reflects that of their larvae in meroplankton.

As is known, the larvae of the above-mentioned species are among the most common representatives of meroplankton in this area (Aleksandrov, 1998). In addition, it is indicated that the Danube coastal area is the main nursery for developing larvae of benthic invertebrates of the NWBS. There is evidence that since the early 1990s, the proportion of Polychaeta larvae in the NWBS plankton has increased from 1.5 to 3 times, this was most pronounced in the Danube region (Aleksandrov, Zaitsev, 1998; Aleksandrov, 2008). The total number of juvenile polychaetes in the study area varied significantly.

The highest numbers of juvenile polychaetes in the Danube region were recorded in the autumn (November 2004, September 2005). During periods of active settling of larvae in the benthal, the density of juvenile polychaetes varied from several hundred to 63,750 ind.$\cdot$m^{-2} (November 2004), 76.89 % of this maximum was accounted for by *P. cornuta*. At this time, the number of juvenile polychaetes significantly exceeds that of adult specimens: in November 2004 and September 2005, the density of juveniles was an order of magnitude higher than that of macrozoobenthos polychaetes and accounted for more than 90 % of the total number of polychaetes in the benthos.

Juvenile *A. succinea* were recorded in significant numbers only in November 2004. The frequency of occurrence of the dominant juvenile species varied depending on the season of the study and was 25.0%. For *A. succinea* in May 2005 and 75.0–81.3 % during the seasons of active transition of larvae to the benthal; the occurrence of *P. cornuta* varied from 10.0 % (December

2010) to 82.5–83.3 % during the periods of mass settling. *P. cirrifera* and *H. filiformis* were characterized by high occurrence rates. The minimum occurrence rate of *P. cirrifera* (15.0 %) was recorded in May 2005, the maximum – in November 2004 and April 2010 (62.3 % each). Despite the fact that this species is relatively few in the macrozoobenthos of the Danube region, its larvae actively settle here. The maximum number of young *P. cirrifera* reached 23,000 ind.·m^{-2} (April 2010), while in most cases its number was several hundred ind.·m^{-2}.

H. filiformis was also characterized by a high occurrence, which fluctuated within 20.1–62.5 %. Despite the high frequency of detection of this species in pseudo-meiobenthos, no mass migration of its larvae to the benthal was recorded. The abundance of its young in the meiobenthos varied from several specimens to 2,000 ind.·m^{-2} and in most cases were represented by several hundred ind.·m^{-2}.

Considering the distribution features of juvenile polychaetes at different depths, it should be noted that in the Danube coastal area in autumn, juvenile individuals of *A. succinea* and *P. cornuta* were most abundant at depths from 7 to 20 m, where numerous settlements of their adult forms are noted in the macrozoobenthos. At greater depths, the number of juveniles of these species was significantly lower. Juvenile individuals of *P. cirrifera* most actively developed depths of 20–24 m.

A feature of the polychaetes taxocene of the estuarine coastal zone is the almost complete absence of representatives of the eumeiobenthos complex, which, in their ecology and biology, like a number of other groups of meiobenthic invertebrates, are very selective organisms in relation to the environment and sensitive to changes in its quality. The only representative of the eumeiobenthos, *P. flavocapitatus*, was found in this area extremely rarely at sea stations located at a depth of 20–24 m (station no. 25, September 2005 and station no. 13, April and September 2010). The low diversity of substrate types and, most importantly, the high trophic level of the Danube River coastal zone may be the main factors preventing the development of polychaetes, a

permanent component of the meiobenthos, in this area (Bondarenko A. S,.2011*)*.

During this period, juvenile specimens of *A. succinea and P. cornuta* were most abundant at a depth of 7 to 20 m, where numerous settlements of their adult forms were noted in the macrozoobenthos. Juveniles of *P. cirrifera* most actively explored the depth of 20–24 m. The almost complete absence of representatives of the eumeiobenthos complex became a feature of the taxocene of polychaetes near the estuary. The low diversity of substrate types and, most importantly, the specificity of this contact zone and the high level of trophicity of the seashore of the river. The Danube may be the main factors hindering the development of polychaetes of the permanent component of the meiobenthos in this area.

Considering the features of the distribution of polychaetes juveniles at different depths, it should be noted that on the Danube coast in autumn, juveniles of *A. succinea and P. cornuta* were most abundant at a depth of 7 to 20 m, where numerous settlements of their adult forms are noted in the macrozoobenthos. Juveniles of *P. cirrifera* most actively explored the depth of 20–24 m (Bondarenko, 2011)

Polychaetes are an essential component of the meiobenthos, whose contribution to its total biomass is often comparable to that of the eumeiobenthos. (Vorobyova, A.S. Bondarenko, 2007

4.3. Contact zone “Muddy bottom” (Pelocontour).

In terms of its physicochemical properties, this is the largest sea-muddy bottom boundary (pelocontour) and is a specific biotope on the bottom of the Black Sea. In coastal estuaries and lagoons, the pelocontour, as in the Black Sea, makes up a large part of the bottom and can begin already from the water's edge (Zaitsev, 2006; Zaitsev, Polikarpov, 2002). It is on the pelocontour of the sea, under the thermocline layer and to a depth of 35–40 m, that hypoxia and anoxia zones are formed in summer and autumn, where freezes occur – mass deaths of bottom invertebrates and fish.

In the northwestern part of the Black Sea, despite its shallowness, bottom sediments at depths greater than 10–15 m are most often represented by silts. This biotope consists of silts, silted sand and shells. Such habitats lack capillary spaces accessible to meiobenthos organisms. In such conditions, animals, including harpacticoids, cannot move freely and are forced to either push apart particles of bottom sediment or live on its surface. Since organic detritus is deposited and oxidized at the bottom, and the molecular-diffusion flow of dissolved oxygen into the sediments is too weak, the number of aerobic bacteria in sediments already at a depth of 10–20 cm drops by 2 orders of magnitude (Aizatullin, Lebedev, Khailov, 1979). Studies conducted on the northwestern shelf in 2003 showed that on a silty substrate at depths from 35 m to 90 m, harpacticoids live in the 0–2 cm microhorizon (Vorobyova, Kulakova, 2009).

The peculiarity of the faunal composition of the pelocontour meiobenthos is that it is close in composition to the surrounding bottom biotopes, but is characterized by impoverishment even at the level of large taxonomic groups (Gastrotricha, sea mites are absent; representatives of pseudomeiobenthos are few). The total number of meiobenthos varies significantly depending on the depth. The minimum indicators are noted at a depth of up to 11 m (on average 166,506±2,695.2 ind.·m^{-2}). Analysis of the long-term dynamics of the quantitative indicators of meiobenthos showed that their maximum values are characteristic of 2006 (on average 795,768±177,922 ind.·m^{-2} and 5,838.13±1,741.03 mg·m^{-2}). In subsequent years, they declined sharply, increasing only in 2010–2011. (Vorobyova, 2017).

The meiobenthos of the pelocontour of the Odesa Sea Region is represented by almost all groups, the main quantitative indicators are formed by Foraminifera, Nematoda and, to a lesser extent, Harpacticoida, Oligochaeta, Polychaeta and juvenile bivalve mollusks. The spatial distribution of the density and biomass of meiobenthos across the considered water area is very uneven, the maximum indicators of the total number of meiobenthos are characteristic of the Odesa Bay area and the water area directly adjacent to it,

and the total biomass, in addition to the specified water area, is also in the area adjacent to the Grigorievsky Estuary.

At the pelocontour, the total abundance of meiobenthos varies significantly depending on the depth of sampling. The lowest indicators are characteristic of depths of ten meters and less (on average 166,506±2,695.2 ind.·m^{-2}). At greater depths (up to 25 m), the total abundance of meiobenthos increases to 317,743 ± 2,167.4 ind.·m^{-2} – 419,257±1,839.8 ind.·m^{-2}). The formation of this indicator is due to eumeiobenthos (94.13–97.86%), mainly Foraminifera and Nematoda.

The Nematoda-Foraminifera complex of organisms dominates (Fig. 3.1.). The subdominant group in terms of numbers – Harpacticoida is represented at a depth of up to 15 m (22.36–26.5 %). It is necessary to note the very low density of settlements of representatives of the temporary component of meiobenthos. The total share of oligochaetes, polychaetes and juvenile bivalve mollusks in the total number of meiobenthos does not exceed 5% at a depth of up to 16 m. At a depth of 16–25 m it is even one and a half to two times lower.

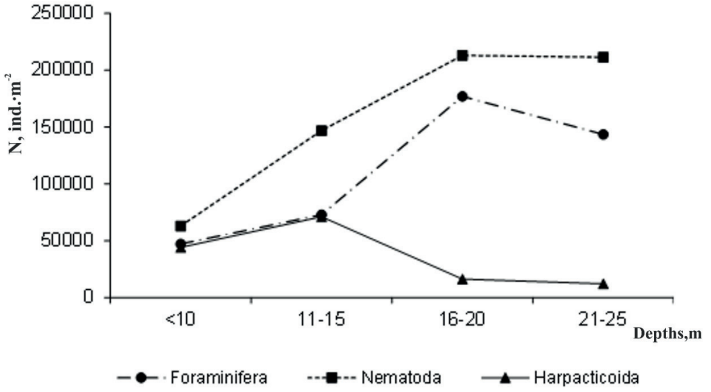


Figure 3.1. Distribution of abundance (N, ind.·m^{-2}) of the main meiobenthos taxa at different depths.

As already noted, the oxygen regime in the bottom layers of water is of significant importance for the formation of the total number and total biomass of meiobenthos. With the development of hypoxia (and sometimes anoxia) in the bottom layers of water, the diversity of meiobenthos is sharply reduced and usually its qualitative and quantitative characteristics are formed at the expense of 2-4, sometimes 5 groups. Crustaceans and young bivalves react especially sensitively to a decrease in dissolved oxygen in water. As previous studies have shown, with a deterioration in the oxygen regime (below 4 $mg \cdot l^{-1}$), the density of harpacticoids decreases sharply, only the density of some species of foraminifera can increase significantly, while they can make up to 75–98 % of the total number of organisms of the meiobenthos group (Vorobyova, 1999). Analysis of multi-year data allowed us to reflect (Fig.3.2) the seasonal dynamics of quantitative indicators of meiobenthos.

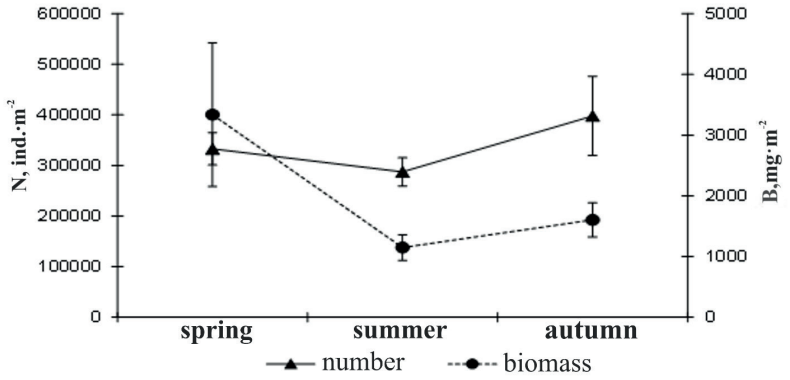


Figure 3.2. Seasonal dynamics of total abundance and biomass of pelocontour meiobenthos.

The total abundance in spring and summer differs significantly (332,933 ± 3,337.9 $ind. \cdot m^{-2}$ and 287,445 ± 1,148 $mg \cdot m^{-2}$, respectively). Thus, the meiobenthos of the pelocontour of the Odesa Sea region differs from other contour biotopes in the impoverishment of fauna even at the level of large taxa, the predominance (sometimes up to 97.4 %) in the total abundance of foraminifera and nematodes.

According to Kulakova I.I. in the studied area (pelocontour), 50 species of nematodes belonging to 5 orders were found. The number of species differs on different substrates. The most diverse in terms of species nematode fauna was noted on muddy soils, at a depth of 17–24 m. 35 species were recorded here. On silted shell (depth 6–10 m) and sand with an admixture of shell (depth 6–10 m), nematodes are represented more poorly (29 and 23 species, respectively) (Table 3.1). Assessment of the species richness of nematodes (DMg) in the OMR showed that at individual stations the highest values of this index were recorded (from 2.1 to 3.5), which indicates a large number of nematode species in them, each of which is represented by a small number of individuals. At most stations, the values of the nematode species richness index are low (from 0.3 to 1.5) (Kulakova, 2017).

Nematodes were found at almost all studied stations and constituted one of the dominant groups of meiobenthos in terms of occurrence (93.8 – 100 %) and density of settlement (61.1 % of total meiobenthos), while their share in biomass was only 21.3 %. Nematode density indicators at stations ranged from 0 to 1,870 thousand individuals·m−2 biomass – from 0 to 355.30 mg·m^{-2}. The average values of these indicators were, respectively, 180.8 ± 33.7 thousand ind.·m^{-2} and 33.22 ± 6.28 mg·m^{-2} (Table 3.1) The quantitative indicators of nematodes and their percentage ratio to the total density of meiobenthos varied significantly over the years. This indicates the heterogeneity of benthic conditions in this area.

The main habitat of meiobenthic organisms is the capillary spaces that exist between soil particles.

The nature of the substrate, its granulometric composition, the concentration of organic matter in it are probably the most important natural ecological factors that determine the spatial distribution of small benthic animals. It was established that there is a connection between the density of nematode settlement and the type of soil. The average number and biomass of nematodes varied widely. The poorest in terms of quantitative indicators of nematodes is the biotope of sand with an admixture of shells. Biotopes of gray and black silts of the OMR are characterized by high indicators of density and

biomass of nematodes (Table 3.2.). Average density of settlement (N ± mN thousand ind.·m^{-2}), average biomass (B ± mB mg·m^{-2}) of nematodes on different types of substrates in the Odesa Sea Region

Table 3.1.

Average population density (N ± mN thousand ind.·m^{-2}) and average biomass (B ± mB mg·m^{-2}) of nematodes in the Odesa Marine Region.

Year, month	N			B		
	N ± m_N	Min	Max	B ± m_B	Min	Max
2005, IV	71.9±15.5	6.4	272.0	13.68 ±2.94	1.22	51.68
2005,VIII	41.4±6.8	3.5	145.0	7.86±1.29	0.67	27.55
2005, XII	327.1±68.8	1.6	1547.5	50.85±11.48	0.00	294.03
2006, VI	445.9±82.1	20.0	1870.0	84.72±15.59	3.80	355.30
2007, VIII	32.4±5.9	0.6	86.0	5.90±1.14	0.11	16.34
2008, VIII	120.6±30.4	6.6	580.0	22.91±5.78	1.25	110.20
2008,XI	189.1±45.8	2.0	800.0	35.93±8.71	0.38	152.00
2009, VII	173.6±31.2	3.0	577.5	32.99±5.93	0.57	109.73
2009, X	30.9±14.2	0	338.0	5.89±2.70	0.00	64.22
2010,VI	392.3±43.6	3.7	1150.0	74.30±8.46	0.71	218.50
2011, VII	163.2±26.3	17.0	558.0	30.36±5.05	3.23	106.02
Average	180.8±33.7			33.22±6.28		

Note: N – average population density; B – average biomass, mN and mB – error of the mean value

Table 3.2.

Average population size (N ± mN thousand ind.·m^{-2}) and average biomass (B ± mB mg·m^{-2}) of nematodes on different types of soil in the Odesa Sea Region.

Substrate	N			B		
	N ± m_N	Min	Max	B ± m_B	Min	Max
Silt	270.0±52.9	37.9	755.0	50.90±10.06	7.22	143.45
Silted shell	129.1±40.1	23.4	312.0	24.53 ±7.63	4.45	59.26
Sand mixed with shell	80.7±25.8	12.5	159.1	15.34± 4.90	2.38	30.22

Note: N is the average population density; B is the average biomass; mN and mB are the error of the average value

In the silt biotope, the dominant species in terms of population density were: *S. pulchra* (1.0– 09.8 thousand ind.·m^{-2}), *T. pontica* (4.6 – 93.0 thousand ind.·m^{-2}). The subdominant species in terms of density were *E. brevis* (up to 70.5 thousand ind.·m^{-2}) and *S. ostreae* (up to 32.6 thousand ind.·m^{-2}).

The high-density index values of these species (35.6 and 19.3, respectively) were determined by their large biomass.

In the silted shell biotope, the density of the settlement is dominated by *S. pulchra* (4.3–69.2 thousand ind.·m^{-2}), *T. pontica* (3.6–75.8 thousand inds·m^{-2}) and S. ostreae (1.0–26.3 thousand ind.·m^{-2}). The density index of these species is quite high (46.4; 37.9 and 29.3, respectively). The density of the settlements of *Enoplus sp*., *M. conicum, V. minor, Halalaimus sp.* is inferior to that of the above-mentioned species and varies on average from 3.5 to 8.6 thousand ind.·m^{-2}, however, due to high biomass and occurrence, the density index is significant (33.7; 40.1; 49.4 and 36.9, respectively).

In the spring period on the silt, it ranged from 6.4 to 272.0 thousand ind.·m^{-2} (average 82.56 ± 17.12 thousand ind.·m^{-2}). Their share on the muds from the entire meiobenthos varied from 24.9 to 56.5 %. In the summer period of the study, the highest density of nematode settlements was observed. On muddy soils it ranged from 2.5 to 1,150.0 thousand ind.·m^{-2} (average 361.2 ± 67.4 thousand ind.·m^{-2}). Their share on the muds from the entire meiobenthos varied from 30.3 to 76.5 %. On the silted shell, the density of nematodes settlements was 3.0–840.0 thousand. ind.·m^{-2} (average 255.8 ± 77.3 thousand ind.·m^{-2}). Their share of the total meiobenthos varied from 54.2 to 75 %. In the autumn period, the density of nematode settlements decreases. On muddy soils it ranged from 1.0 to 800.0 thousand ind.·m^{-2} (average 145.1 ± 38.0 thousand ind.·m^{-2}). Their share of the total meiobenthos varied from 25 to 77.6 %. On silted shells, the minimum density of organisms was 1200 thousand ind.·m^{-2}, the maximum – 290.0 thousand ind.·m^{-2} (average 33.7 ± 9.6 thousand ind.·m^{-2}). The share of the total meiobenthos varied from 14.8 to 91.3 %. Sand with an admixture of shells is characterized by a small number of nematodes. Their share of all meiobenthos organisms ranged from 23 to 45.3 %. The density of nematode settlements was 0 – 122.0 thousand ind.·m^{-2} (average 20.9 ± 9.4 thousand ind.·m^{-2}).

In the central and southern parts of the region, at a considerable distance from the coast and with depths of 20 m and more, *S. abyssalis* dominates

among the resident species, which accounts for 37 to 56 % of the nematode population density. In the coastal zone at depths of up to 10 meters with a predominance of sandy substrate, in addition to *S. abyssalis* (35 % of the population density), *S. pulchra* (12 to 35 %) is of great importance. In the Odesa Bay, not far from the port, only *S. pulchra* dominates on black mud (24–35 %). It is known that the ecological niches of these closely related species diverge along the spatial axis. *S. abyssalis* prefers the upper layers of sediment with sufficient oxygen content, while *S. pulchra* lives in the layer of sediment with a reduced oxygen content, often in muddy substrates.

The dominance of nematodes in meiobenthos indicates a high trophic level of this water area. Nematodes are organisms that find favorable conditions for their development in soils enriched with organic matter. Thus, among the indicated nematode species, the role of oxyphilic representatives of the order Chromadorida in the OMR is low, and species from the order Monhysterida, which are less demanding on the quality of the environment, prevail. An increase in trophic level leads to changes in the ecosystem, in which ecological niches are occupied by species that are most adapted to the existing environmental conditions.

In the OSR, V.V. Portyanko (2017) analyzed the ecological characteristics of harpacticoids of the silt substrate based on 158 samples collected along a standard grid of stations over many years. The features of the formation of the density of harpacticoid settlements of the Odesa marine region were analyzed using the following types of silt substrate: 1) "gray silt"; 2) "gray silt-mussels", 3) "gray silt-sand", 4) "gray silt-shell", 5) "gray silt-sand-shell". To according V.V. Portyanko the fauna of Harpacticoida of the pelocontour is characterized by the presence of epibenthic and burrowing forms. These include some or many representatives of the families Ectinosomatidae [Hicks Coull 1983], Cletodidae [Fleeger 1979; Bell 1979; Coull Dubley, 1985], Huntemaniidae [Bodin 1972; Wells, 1963; Coull, Dubley, 1985], Miraciidae [Fleeger 1979; Bell 1979; Bodin, 1972; Chertoprud et al 2006], Tachidiidae [Fleeger 1979; Bell 1979; Coull. Dubley, 1985], Canuellidae (Wells 1963).

The species composition of the harpacticoid pelocontur includes 21 species from 17 genera and 13 families.

On grey silts 21 species were found, and on black silt only 6 species of harpacticoids were found, which are common to these two types of substrates. The highest occurrence was noted for five species (*A. parvula parvula, E. melaniceps, E. gariene, N. minuta, T. marmorata*) and was 90 % on grey muds and 70 % to 80 % on black muds. Harpacticoids, found only on grey muds, had occurrence rates from
10 % to 85 %. The most numerous on both types of substrates were two epibenthic species (*E. gariene, N. minuta*), two non-specific interstitial species (*A. parvula parvula, A. longirostris*), one silt-burrowing species (*E. melaniceps*) and one phytal species (*T. marmorata*). As a detailed analysis of the material showed (Portyanko. 2017), the highest number of harpacticoids was observed in mussel settlements with gray and black silts (358,500 ind.·m^{-2} and 178,300 ind.·m^{-2}, respectively).

To study the dynamics of the number, and accordingly the biomass, of harpacticoids of the pelocontour of the Odesa marine region, data from summer observation periods were used (Fig. 3.3., 3.4.) from the total meiobenthos.

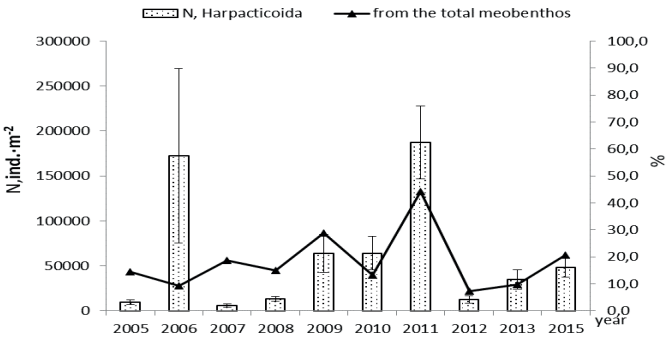


Figure 3.3. Long-term dynamics of the number of harpacticoids in the pelocontour of the Odesa marine region

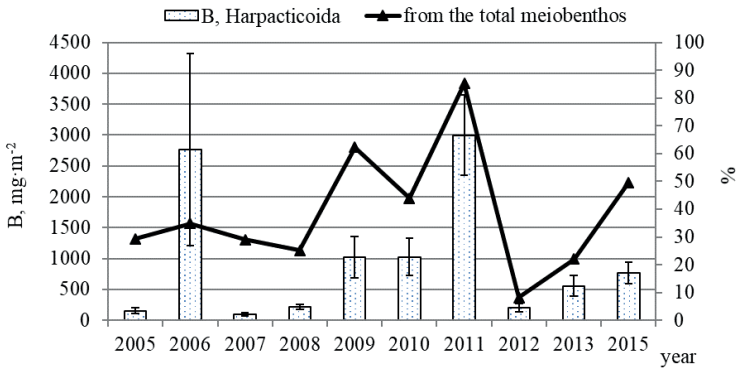


Figure 3.4. Long-term dynamics of harpacticoid biomass in the pelocontour of the OMR

The share of the harpacticoid contribution to the total number of meiobenthos is the highest on gray silts with a mussel component (49.4 %) and an admixture of shells (31.4 %). It should be noted that in two cases, namely in 2006 and 2011, there was a sharp increase (from 3 to 18 times), and then a sharp drop (from 14 to 28 times) in the number and biomass of harpacticoids. (Vorobyova, Bolshakov, 2024) However, in the years preceding the surges in quantitative values, large-scale "blooms" of water were recorded in the study area. Thus, in 2005, rapid development of diatoms and dinoflagellates with a total biomass of 6,557.3 $mg \cdot m^{-3}$ was observed in the coastal area (Nesterova, 2017) and in 2010, for the entire study period, the strongest "bloom" of water occurred, caused by blue-green algae, the biomass of which reached 6.2 $kg \cdot m^{-3,}$ and the area of the "bloom" spot was about 80 km^2 (Aleksandrov et al. 2012).

According to the literature, phytoplankton sedimentation occurs throughout the bloom period. Its major part (76 %) is remineralizer in the water column after the bloom, and the remaining amount (24 %) settles and forms phytodetritus (Rousseau et al., 2000), which is the main source of organic matter for the benthic system The type of sediment receiving the settling phytoplankton is a key factor determining the rate of bottom remineralization i.e. the finer the sediment, the longer this process can take – from late spring

to late summer (Boon & Duineveld, 1998). In addition, occasional decreases in oxygen levels or anoxia can slow down the decomposition of phytodetritus (Kristensen, 2000). Thus, at significant concentrations, for example during a water bloom, the sedimented phytoplankton can remain on the surface of bottom sediments and be a food source for harpacticoids. Taking into account all of the above, as well as the conditions characteristic of the bottom sediments of the Odesa marine region (NWBS, 2006), it can be said with certainty that the reason for the sharp increases in the number and biomass of harpacticoids during the indicated observation periods were the previous years, in which there was a significant accumulation of sedimented organic matter.

Of interest is the analysis of the share of harpacticoids in the total number and biomass of meiobenthos. The highest percentage of these indicators was observed in 2011 and amounted to 44.2 % (187,292 ind.$\cdot m^{-2}$) of the number and 85.1% (44.15 mg$\cdot m^{-2}$) of the biomass, and the lowest in 2012 – 7.4 % (12,789 ind.$\cdot m^{-2}$) and 8.2 % (8.17 mg$\cdot m^{-2}$), respectively. In other years, the situation was not so clear. In 2006, the number and biomass of harpacticoids were also significant (172,640 ind.$\cdot m^{-2}$ and 2,762.23 mg$\cdot m^{-2}$), while the contribution of these crustaceans to the number was only 8.8 %, and the share in the biomass was 36.4 %. The main areas of harpacticoid accumulation are concentrated at depths of 20 m along the Odesa coast.

The works of many authors (McIntyre, Murison, 1973.) Galtsova, Vladimirov, 1988; Galtsova, 1991 etc) confirm the existence of direct or indirect connections between the abundance of meiobenthos depending on the depth. On the pelocontour of the Odesa marine region, the density of harpacticoid settlements varied significantly depending on the depth (Fig.3.5.).

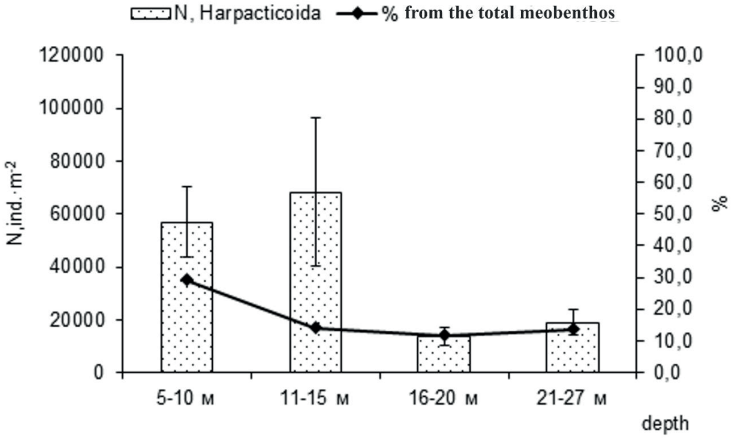


Figure 3.5. The number and proportion of harpacticoids of the pelocontour of the OMR at different depthsfrom the total meiobenthos

In shallow water (5–10 m), the occurrence of crustaceans was 97.8 % with an average density of 56,849±13,231 ind.·m^{-2}. The proportion of harpacticoids in the total number of eumeiobenthos was relatively high and averaged 31.5 %. The average density of harpacticoid settlements increases at a depth of 11–15 m (68,286±28,189 ind.·m^{-2}). The occurrence of crustaceans was 84.4 %, the proportion of harpacticoids in the total number of eumeiobenthos averaged 23.8 %. Very large accumulations of harpacticoids were observed in 2006 (1,405,000 ind.·m^{-2} and 1,702,000 ind.·m^{-2}) on black and gray silts, respectively, and also in 2011 on black silt with an admixture of shells – 362,000 ind.·m^{-2}. With increasing depth (16–20 m), the occurrence of harpacticoids decreases to 74.7 %. At the same time, as can be seen in the presented figure, the density of their settlements decreases by 5 times and during the period of our observations, the average long-term indicator was 13,655±3,399 ind.·m^{-2}. At the same time, the role of harpacticoids in the formation of the total number of meiobenthos is sharply reduced and their share is on average only 5 %. With an increase in depth of more than 20 m, the number of harpacticoids increases, but on average remains almost at the

previous level and is 18899±4899 ind.·m^{-2}. The maximum density of their settlements was in 2009 on black silt – 190,000 ind.·m^{-2} and in 2011 on gray silt – 216,000 ind.·m^{-2}.

The density of harpacticoids is not uniform throughout the year. This is determined by the temperature of the bottom layers of water, the content of dissolved oxygen at the bottom, and food resources for crustaceans. Long-term observations in the OMR allowed V.V. Portyanko to obtain average values of the density of harpacticoid settlements in different seasons of the year (Fig.3.6).

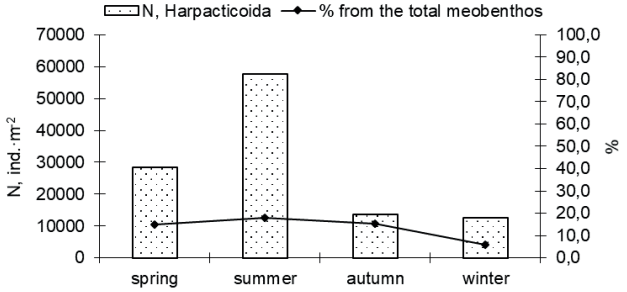


Figure 3.6. Seasonal dynamics of the number of harpacticoids in the pelocontour of the OMR for 2005–2015.

The proportion of harpacticoids in the total number of meiobenthos remains virtually at the same level from spring to autumn (16 %±0.9 %) and decreases significantly in winter (5.9 %). In autumn, the density of harpacticoid settlements decreases sharply which may be due to both the peculiarities of the development and reproduction of copepods, their consumption in the summer, and the peculiarities of the hydrological and hydrochemical conditions of the environment.

References

Adabovsky V.V., Bogatova Yu.I. et al. Estuaries of the northwestern Black Sea region. Hydrological –hydochemical and biological features of functioning // In the book. "The northwestern part of the Black Sea: biology and ecology (1967 – 2003)" – K.: Naukova Dumka, 2006. – pp. 358 – 371. (In Russian).

Adrianov A. Some features of the biology of kinorhyncha (Cephalorhyncha, Kinorhyncha) // Ecology of the sea, – 1991, No. 39. – pp. 57 –62. (In Russian).

Aizatulin T.A., Lebedev V.L., Khailov K.V. Ocean. Active surfaces. – L.: Gidrometeozdat. – 1979. – 192 P. (In Russian).

Aleksandrov B.G. Hydrobiological bases of management of the state of coastal ecosystems of the Black Sea. – Kyiv: Naukova Dumka, – 2008: 343 p.

Alexandrov B.G. Practical implementation of V.I.'s ideas Vernadsky in solving current problems of marine ecology / In the book: "Ecology and matrimony", Collection of Sciences. prac univ. ekol. knowledge of the Odessa state Sci. libraries im. M. Gorky, VIP. 3. – Odessa: "Drukarskiy Dim" – 2008. – pp. 157 – 163. (In Russian).

Aleksandrov B. G., Vorobyova L. V., Kulakova I. I., Garkusha O. P., Rybalko A. A., Portyanko V. V. Hydrobionts community of the marginal biotope of the silt – sand pseudolitoral in the sea of Azov. Environmental safety of the coastal and shelf zones and integrated use of shelf resources. Sevastopol, – 2011, issue 25. volume 1. – pp. 362–374. (In Russian).

Aleksandrov B.G., Kharitonova Yu.V. Careful monitoring of zooplankton in the sea waters of Ukraine and their environmental compliance with the standards of the EU Directive on the Marine Strategy. – Odessa – 2019. – 33 p.

Alexandrov B.G., Zaitsev Yu.P. Black Sea biodiversity in eutrophication conditions // Conservation of the Biological Diversity as a Prerequisite for Sustainable Development in the Black Sea Region. Dordrecht: Kluver Academic Publ., – 1998 – pp. 221 – 234.

Alexandrov B.G., Zaitsev Yu.P., Goncharov A.Yu., Kurilov A.V., Garkusha, A.B. Zotov, // Problems in the Study of edge structure ecological communities. 3rd International Conference. Saratov – 2012 – pp. 11–16 (In Russian).

Alvarez Zarikian C.A., Blackwelder P.L., Hood T., Nelsen T.A., Featherstone C.// Ostracods as indicators of natural and anthropogenically – induced changes in coastal marine environments. Coasts at the Millennium, Proc 17th Int Conf Coastal Soc, Portland, – 2000 – pp. 896–905.

Apostolov A., 1968 Neue und bemerkenswerte Harpacticoida Ruderfusskrebse (Crustacea, Copepoda) aus dem Kustengrundwasser // Ibid. 80, N 5. -pp. 395 – 402.

Apostolov A., Zwei neue Harpacticoidenarten (Crustacea, Copepoda) aus dem Schwarzmeerbecken // ZooL Anz., – 1967. 179, N 3/4. – S. 309 – 310.

Apostolov A., Harpacticoides des eaux saumaitres et des etanges cotieres // Zool. Anz., – 1973. 191, N 3/4. – pp. 281 – 293.

AverentsevV.G. Bottom polychaete worms Errantia of Antarctica and Subantarctic based on materials of the Sovchet Antarctic expedition (1955 –1958) // Studies of the fauna of the seas, 11 (19). – L.: Science. – 1972, Issue 3 – pp. 88 – 293. (In Russian).

Ax P., Monographie der Otoplanidae (Turbellaria). Morphologie und Systematik. –Mainz. Abh. Akad. Wiss. und. Lit. Math. –naturwiss. Kl. Mikrofauna Meeresbodens; – 1955. Bd. 13, S. 502 – 796.

Ax P., Neue interstitielle Macrostomida (Turbellaria) der Gottingen Acanthomacro –stomum und Hoplopharynx. // Mainz. Abh. Acad. Wiss. und Lit Math. –naturwiss. Kl. Mikrofauna Meeresbodens; – 1974. Bd. 8, – S.14 – 17.

Bacescu E. Kinorhinchi – reprezentanti ai unei clase de animale nouă pentru fauna romînească // Comm. Acad. R.P.R. – 1956. – 6, N 4. – pp. 543–549.

Bacescu M., Gomoiu M.T., Dumitrescu E. Quelques considerations sur la dynamique des organismes de la zone médiolittoral sableux en Mer Noire // Rapp. Comm. int. Mer Medit. – 1968. – 19, N 2. – pp. 37–41.

Bacescu M., Müller G., Gomoiu M. Cercetari de ecologie bentala in marea neagra – analiza cantitativa, calitanava si comharata a faunei bentale Pontice // Ecologue marina. – Edit. Acad. Rep. Soc. Romania. – 4. – 1971: – pp. 1–357.

Baden P., Grasing in the interstitial habitat: a review. // Brit. Ecol. Soc. Symp. – 1962 Vol. 4 – pp. 299 –303.

Bakanov A.I. Method of ranking hydrobiological data depending on the ecological situation in a reservoir // Biol. int. water. – 1997. No. 1. – pp. 53–58. (In Russian).

Bakanov A.I. Using combined indices for monitoring freshwater bodies for zoobenthos // Water resources. – 1998. Vol. 25. No. 5 – pp. 108–111. (In Russian).

Bartsch I. Marine mites (Halacaridae: Acari): a geographical and ecological survey // Hydrobiologia. − 1989. − Vol. 178, №1. – pp. 21−42.

Bartsch I. Halacarinae (Acari: Halacaroidae) from the northwestern Black Sea: A review // Mitt. Hamb. zool. Mus. Inst. − 1998. − Vol. 95. − pp. 143−178.

Bartsch I. First record of Copidognathides from the Black Sea (Copidognathinae, Halacaridae, Acari) // Entomol. Mitt. zool. Mus. Hamburg. − 1999. − Vol. 13, №161. – pp. 139−145.

Bartsch I.: Actacarus ponticus, a new marine mite from the Black Sea (Arachnida, Acari, Halacaridae// Senckenbergiana biologica. − 1999. − Vol. 78, №1/2. − P. 141−151.

Basov, I.A., Chusid, T.A. On the biomass of benthic foraminifera in the sediments of the Sea of Okhotsk. // Oceanology – 1983 –23(4) – pp. 648–655 (In Russian)

Beklemishev V.N., On the fauna of the Turbellaria Odessa Bay and flowing into it the. // Izv. Biol. NII and Biology. Art. in Perm. State. University. – 1882. 5, – pp. 177–207. (In Russian).

Bell S.S., Coul B.C. Field evidence the shrimp predation regulates meiofauna // Oecologia – 1978 – 35(2) – pp.141 – 148.

Bernhardt I.M. Survival, ATP pool, and ultrastructural characterization of benthic foraminifera from Drammensfjord (Norway): response to anoxia // Marine micropaleontology – 1996. – Vol. 28, – pp. 5–17.

Beshevli L.E., Kolyagin V.A. On the discovery of the mollusk *Mya arenaria* L. (Bivalvia) in the northwestern part of the Black Sea // Vestnik zool. 3 – 1967 – pp. 83 – 85. (In Russian).

Bezmaternykh D.M. Zoobenthos as an indicator of the ecological state of aquatic ecosystems in Western Siberia // State Publ., Bibliot. Siberian Branch of the Russian Academy of Sciences. In –t water and ecological problems. – Series. Ecology. Issue 85 –2007 – pp. 3–87 (In Russian).

Birshtein Ya A. Genesis of freshwater, cave and deep –sea faunas. – M., 1985. – 247 P. (In Russian).

*Birshtein Ya.*A. Life in caves: Ecological and systematic essay. // Advances in modern biology, 1940. – Vol. 13, Issue 3. – pp. 385 – 402. (In Russian).

Vorobyova, L., Kulakova, I., Bondarenko, O., Portyanko, V., & Uzun, E. Meiofauna of the periphytal of the Odessa coast Ukraine. Journal of the Black Sea/Mediterranean Environment, – 2016, 22(1): – pp. 60–73.

Blum N.S., Taldenkova E.E. Analysis of marine microfauna. // Scientific publication. no. 3. Methods of paleogeographic reconstructions. – 2002. – pp. 213 – 247.

Boaden P., The interstitial Turbellaria Kalyptorhynchia from some North Wabes beaches. // Proc. ZooL Soc. London. – 1963. Vol. 141, N 1, S. – pp.173 – 205.

Boaden P. Tiobiotic facts and fancies (aspects of the distribution and evolution of anaerobic meiofauna) // The meiofauna species in time and space. – Microfauna Meeresbo – den. – 1977. – 61. – pp. 45 – 63.

Bogatova Yu.I., Bronfman A.M., Vinogradova L.A., Vorobyova L.V. et al. Current state and trends in ecosystem change // Practical ecology of marine regions. Black Sea. – Kyiv: Nauk. Dumka, – 1990. – pp. 192–200. (In Russian).

Bogatova Yu.I., Garkavaya G.P. Hydrochemical bases of biological productivity of the Azov Sea in summer // On the state of the ecosystem of the Azov Sea. – Odessa, – 1989. – pp. 13–39. – Dep. to VINITI 08.02.89, No. 859–B89.

Bogatova, V.N. Bolshakov, E.G. Volya, L.V. Vorobyova, G.P. Garkavaya, L.A. Garlitska. Small Adzhalyksky (Grigorievsky) estuary // The northwestern part of the Black Sea: biology and ecology // K.: Naukova Dumka, 2006. – Section III. Marginal ecosystems, Chapter 1. Estuaries of the Northwestern Black Sea region, 1.4. Hydrological, hydrochemical and biological features of functioning (1.4.2). – pp. 371–382. (In Russian).

Bolshakov V.S. Note on the structure of the Danube hydrofront // Oceanology. – 1962. – No. 2, issue. 4. – pp. 352–359. (In Russian).

Bolshakov V.S. Transformation of river waters into sea water. – Kyiv: Nauk. Dumka, – 1970. – 325 P. (In Russian).

Boltovskoy E. Foraminiferos v sur relations cin to medio // Vus. Argentine Cienc. Nat., Rev. Hidrobiol. 1. – 1963, – pp. 23–32. (In Russian).

Bondarenko A.S. Polychaetes of macro – and meiobenthos of the Odessa region of the Black Sea. // Environmental problems of the Black Sea: materials of the Scientific and Practical Conference, (June 30–31), 2008, Odessa). – pp. 40–44. (In Russian).

Bondarenko A.S. Species composition and distribution features of polychaetes in the western part of the Black Sea. // Ecology of the sea. issue – 2009 78.– pp. 22 – 27. (In Russian).

Bondarenko A.S. Polychaetes of the "coast –sea" ecotone. // Fundamental and applied research in biology. Materials of the 1st International Scientific Conference of Students, Postgraduate Students and Young Scientists. Volume 1. Donetsk. – 2009 – pp. 155–156 (In Russian).

Bondarenko O.S. Characteristics of the taxocene polychaetes of the Odessa marine region in the current period. // Scientific notes of Ternopil National Pedagogical University. University, series: Biology, – 2010, No. 3 (44). – pp. 22 – 25 (In Russian).

Bondarenko A. S. Taxocene of polychaetes in the estuary coastal zone of the Danube River. Marine Ecological Journal. Dept. issue, – 2011, no. 2. – pp. 11–16 (In Russian).

Bondarenko A.S. Seasonal dynamics of polychaetes in the northwestern part of the Black Sea. // Dynamics of biological Sea: science. Conf., 19–21 – 2012, Lugansk. – pp. 113–114. (In Russian).

Bondarenko O.S. Species diversity of polychaetes in the eumeiobenthon of the downstream part of the Black Sea. // Scientific notes of Ternopil National

Pedagogical University. University, series: Biology, Special issue: Hydroecology – 2015, No. 3–4 (64). – pp. 59–62. (In Russian).

Bondarenko A.S. Current state of the taxocene of polychaetes of coastal rocks and stones of the Odessa Sea region (Black Sea). // "Fauna of Ukraine between the 20th and 21st centuries. New concepts of zoological research." All –Ukrainian Zoological Conference. – 2017. – pp. 43–44. (In Russian).

Bondarenko A.S. Polychaeta. Odessa region of the Black Sea: hydrobiology of the pelagic and benthic. // Odessa. Astroprint – 2017 – pp. 149 –154 (in Russian).

Bondarenko O.S., Vorobyova L.V.. Influence the North –Western Part of the Black Sea Habitat Factors on the Meiobenthic Polychaetes (Turkish Journal of Fisheries and aquatic sciences, N 7 – 2023, – pp. 1 –18.

Bondarenko O., Vorobyova, L.V Ecological factors in the formation of the community of meiobenthic polychaetes in the north –western part of the Black Sea // J. Black Sea/Mediterranean Environment. – 2024: – pp. 43 –55 DOI:10.2478/v10009-007-0039-9.

Boon A.R. and G.C.A. Duineveld. 1998. Chlorophyll a as a marker for bioturbation and carbon flux in southern and central North Sea sediments. Marine Ecology Progress Series. 162. pp. 33 –43.

Bougis B. Methode pour l etude quantitative de la microfaune de fonde marine (meio –benthos) // Vie Milliu. – 1950. – 1, N 1. – pp. 23–38.

Brekhovskikh V.F., Vishnevskaya G.N., Dolgopolsky V.K. et al. The influence of benthos on the erosion of bottom sediments // Water resources. – 1988 – 3. – pp. 103 –108. (in Russian).

Bresler V.l., Yanko V. Acute toxicity of heavy metals for benthic epiphytic Foraminifera Pararotaria spinigera (Le Calvez) and influence of seaweed –derived doc. // Enviromental Toxicology and Chemistry — 1995, 14(10) – pp.1687 –1695.

Bronfman A.M, Vorobyova L.V., Garkavaya G.P. and all. Main feature and tendencies of antropogenic changes in the ecosystems of the North –Western Black Sea shelf // Black Sea symposium Ecological probl. and economic prospects, 16 – 18 Sept. Istambul, – 1991: pp. 59 –75.

Buchinsky P.I., A brief sketch of the Novorossiysk Territory estuaries fauna. //Novorossiysk.West Novorossiisk. Islands naturalists; – 1885: 9/10, no. 1/2, – pp. 1 –24. (In Russian).

Bush L.F., Characteristics of interstitial sand Turbellaria: the significance of boady elongation, muscular development and adhesive organs. Trans. // Amer. Microsc. Soc. – 1968: 87, N 2, – pp. 244 –251.

Carman K.R., Fleeger J.W., Pomarico S.M. Response of a benthic food web to hydrocarbon contamination // Lim. Oceanogr. – 1997: Vol. 42. – pp. 561 –571.

Chislenko L. L. On the existence of a ″size gap″ in the marine fauna of the littoral and sublittoral zones // Reports of the USSR Academy of Sciences. Nov. ser. 137, issue 2. – 1961: – 431–435. (In Russian).

Coull Bruce C., Bell Susan S. Ecological Processes in Coastal and Marine Systems // Respectives of Marine Meiofaunal Ecology – 1979, Publ. Springer US – pp. 189-216.
DOI 10.10007/978-1-4615-9146-7 10.

Coull B.C. Long –term variability of estuarine meiobenthos: an 11 year study. // Mar. Ecol. Prog. Ser. Bio. – 1985 – l/24: – pp.205–218. DOI: 10.3354/meps024205

Coull B.C. Role of meiofauna in estuarine soft –bottom habitats / B. C. Coull // Australian Journal of Ecology. – 1999. – Vol. 24, No 4. – pp. 327 –343. DOI: 10.1046/j.1442 –9993.1999.00979.x .

Coull B.C. Dudley B.W. Dynamics of meiobenthic copepod populations: a longterm study (1973 – 1983) // Mar. Ecol. Progr. Ser., – 1985. – Vol. 24. – pp. 219 –229.

De Troch M. Fiers F., Vincx M. Niche segregation and habitat specialization of harpacticoid copepods in a tropical seagrass bed // Marine Biology,Vol. – 2002. – 142(2). – pp. 345 –355.

Dinet A. Donnes quantitative sur le meiobenthos bathyal de la mer de Norvege // Geochimie Organique des Sediments Marins Profond. – 1977 – pp.13–14.

Dotsenko S.A., Ryasintseva N.I., Rozanova L.E., Savin P.T. Hydrobtological characteristics of shallow waters in the payone of the Argentine Islands // Jul.UATSY.– 1987.V.1: – pp.141–148. (In Russian).

Duka L.A. Trophic complexes of larvae and fry of fish in the coastal thicket zone of the Black Sea // Vopr. ichthyology. – 1978. 18, No. 1. – pp. 43–53. (In Russian).

Duka L.A. Nutrition of shelf fish in the seas of the Mediterranean basin. // Kyiv: Nauk. dumka, – 1988: 193 P. (In Russian).

Duka L.A., Gordina A.D. Species composition and nutrition of young fish of the Black Sea in Cystoseira thickets // Biology of the sea, Kyiv. – 1971. Issue. 23. – pp. 133 –159. (In Russian).

Ecosystem of the Grigorievsky (Maly Adzhalyk) Estuary / Scientific ed. Vinogradov A.K. – Odessa: Astroprint, 2008. – 263 P. (In Russian).

Environmental Monitoring and Assessment. – Gidrometizdat –1985– D. Reidel Publishing Comp., 1986. – 7. – pp. 31 – 38. (In Russian).

Faubel A., lnterstitielle Acoela (Turbellaria) aus dem Litoral der nordfriesischen Inseln Sylt und Amrum (Nordsee). Mitt. // Hamburg, zool. Mus. und Inst., – 1976: 73 – pp. 17–56.

Filip'ev I.N. Free -living marine nematodes of the Sevastopol environs // Proceedings of the Special Biol. Lab. and Biol. Art. Rus. Academy of Sciences, ser. 2. – 1918 –1922. 4, issue 2:14 pp. 68 –91. (In Russian).

Galemanski B., Interstitsialnata tekamebna fauna at pyaschniya Morskie supralittoral. // Abstract of thesis. Candidate. Biol.nauk. Sofia. – 1980. – p.45.

Galtsova V.V. Free -living nematodes as a component of the meiobenthos of the Chupa Bay of the White Sea // Nematodes and their role in the meiobenthos. – L.: Nauka, – 1976: – pp.165 –270. (In Russian).

Galtsova V.V., Role of marine nematodes in the energy balance of the ecosystem marine biology. // 1984. № 1: – pp. 54 –56 (In Russian).

Galtsova V.V. Meiobenthos of marine ecosystems on the example of free – living nematodes / Proceedings of the Zool. Inst. of the USSR Academy of Sciences. – 1991: – pp. 224. – 236. (In Russian)

Galtsova V.V., Gutnichenko V.G., Kamenskaya O.E., Detinova N.N. Study of the interaction of meio – and macrozoobenthos with an emphasis on large agglutinated protozoa // Benthos of the northern seas of Eurasia – 1997: – pp. 57 – 60. (In Russian).

Galtsova V.V., Vladimirov M.V. Meiobenthos of the south –eastern part of the Kandalash Gulf of the White Sea // Ecology of the benthos of the south –eastern part of the Kandalash Gulf and adjacent waters. – L.: ZIN AN SSSR, – 1988: – pp. 47 – 74. (In Russian).

Garkavaya G. P. Bogatova Yu. I., Berlinsky N. A. Features of the formation of hydrochemical conditions of the Ukrainian part of the Danube estuary region // Ecosystem of the coastal region of the Ukrainian Danube Delta. – Odessa: Astroprint, –m – 1998: pp. 21–62. (In Russian).

Garkavaya G.P., Bogatova Yu.I. Sources of eutrophication // North –western part of the Black Sea: biology and ecology. Kyiv, "Naukova Dumka". – 2006: pp. 59–60. (In Russian).

Garkavaya G.P., Bulanaia Z.T., Bogatova Yu.I. Biogenic substances and oxygen in the Danube waters of the Black Sea // 20th international. conf. on the study of the Danube. – Kiev: Nauk. dumka, – 1982: pp. 81–84. (In Russian).

Garlitska L.A. Seasonal dynamics of Harpacticoida (Crustacea, Copepoda) in Grigorievky lagoon, northwestern Black Sea // Application of Micro – and Meioorganisms to Environmental Problems: 2nd International Conference, 27 Aug – 1 Sept, Winnipeg, – 2000 – pp. 45–46.

Garlitska L.A. Seasonal Dynamics of Harpacticoida (Crustacea, Copepoda) of the Grigorievsky Estuary // Environmental Safety of the Coastal and Shelf Zones and Integrated Use of Shelf Resources. – Sevastopol, – 2000: pp. 406 –411. (In Russian).

Garlitska L.A. Species composition of harpacticoid copepods in Grigorievsky Liman (Black Sea) // TWIMCO (12th International Meiofauna Conference), 11–16 July 2004. – Ravenna, 2004: – pp.128.

Garlitska L.A. Species diversity and type of harpacticoid copepod distribution in water areas with high anthropogenic influence // The International Workshop on Black Sea Benthos / – Istanbul: Turkish Marine Research Foundation, – 2004: – pp. 181 –189.

Garlitska L.A. Harpacticoida (Crustacea, Copepoda) of the Grigorievsky estuary under modern conditions / L. Garlitskaya // Biodiversity. Ecology. Evolution. Adaptation: 2nd int. conf., March 28 – April 1, 2005: abstracts of the report. – Odessa, 2005: – p. 80. (In Russian).

Garlitska L.A. Garpaktikoidy // Ekosistema Grigor'yevskogo (Malogo Adzhalykskogo) limana / [red. A.K. Vinogradov]. – Odessa: Astroprint, – 2008: pp. 156–172. (In Russian).

Garlitska L.A. Species Composition and Diversity of Benthic Harpacticoids of the Northwestern Black Sea – Comparative Analysis / L. A. Garlitska // Environmental Safety of the Coastal and Shelf Zones and Integrated Use of Shelf Resources. – Sevastopol, – 2009: pp. 301–309(In Russian).

Garlitska L.A. Ecology of Harpacticoida (Crustacea, Copepoda) of the northwestern part of the Black Sea. // Candidate's thesis of Biological Sciences (Ph.D. (Biology)) by 03.00.17. – Hydrobiology. Sevastopol, – 2010: – 21 P. (In Russian).

Garlitska L.A., Vorobyova L. V. Garkavaya G. P. et al. // Northwestern Black Sea: biology and ecology, Section III. Marginal ecosystems, Chapter 1. Estuaries of the Northwestern Black Sea region, 1.4. Hydrological, hydrochemical and biological features of functioning (1.4.2).]. – K.: Naukova Dumka, – 2006: – pp. 371–382. (In Russian).

Gelmboldt M.V. Comparison Characteristic of Halacaridae Fauna from the Black and Mediterranean Seas // Proc. International Conf. Biodiversity of Coastal Marine Ecosystems – Corinth (Greece), – 2001: – pp. 37 –38.

Gelmboldt M.V. Meiofauna as Monitoring Tool in Protection of the Coastal Environment // Proc. Fifth International Conference on the Mediterranean Coastal Environment, MEDCOAST – Hamammet (Tunisia), – 2001 – pp. 94 –95.

Gelmboldt M.V. Fauna of sea mites (Halacaridae: Acari) of coastal waters of Zmeiny Island // // Abstract of reports of the Conf. of young scientists "Pont Euxinus – II Problems of ecology of the Azov –Black Sea basin: current state and forecast. Sevastopol, – 2001. – pp. 64 –65. (In Russian).

Gelmboldt M.V. Modern state of marine mites (Halacaridae: Acari) species biodiversity in the Black Sea // Proc. 11th International Meiofaunal Conference (ELIMCO). – Boston (USA), – 2001: – p.76.

Gelmboldt M.V. Species composition and distribution of sea mites (Halacaridae: Acari) interstitial of the Odessa coast // Collection of scientific papers. Ecological safety of coastal and shelf zones and integrated use of shelf resources. – 2001. Issue 2. Sevastopol. – pp. 316 –321. (In Russian).

Gelmboldt M.V. Species diversity of marine mites (Halacaridae: Acari) of some estuaries of the northern Black Sea region // Scientific notes of Ternopil State. ped. University im. V. Gnatyuk. – series: Biology. – 2001. 4 (15): pp.122 –123. (In Russian).

Gelmboldt M.V. Species composition and abundance of sea mites (Halacaridae: Acari) of the Odessa Gulf // Hydrobiological journal. – 2001, Vol. 37, No. 1. – pp. 22 –26. (In Russian).

Gelmboldt M.V. Species diversity of sea mites (Halacaridae: Acari) of the Ukrainian Black Sea coast // Bulletin of Odessa University. – 2001. Vol. 6, Issue 1. – pp. 125 –130. (In Russian).

Gelmboldt M.V. Changers in composition of interstitial meiofauna as an example of the anthropogenic influence on the coastal zone // Proc. 3rd International Congress "Environmental Micropaleontology, Microbiology and Meiobenthology" – Vienna (Austria), – 2002: – pp. 81 –82.

Gelmboldt M.V. Fauna of marine mites (Halacaridae) of Odessa Port (Survey UNDP IMO GEF Globallast Program) // «Marine biodiversity in the Mediterranean and the Black Sea" – 2003 – pp.7 –20.

Gelmboldt M.V. Sea mites of the northwestern part of the Black Sea: species diversity and ecology // Ph.D. dissertation abstract, Sevastopol, – 2003: – 18 P. (In Russian).

Gelmboldt M. Fauna of marine mites (Halacaridae) of Odessa port (survey UNDP IMO GEF Globallast Program) // Proc. 12th International meiofauna conference Ravenna (Italy), – 2004 – p. 141.

Gelmboldt M. Fauna of marine mites (Halacaridae: Acari) of the Black Sea // 4th International congress "Environmental micropaleontology, microbiology and meiobenthology" – Isparta, Turkey, – 2004 – p.78.

Gelmboldt M.V. Fauna of sea mites / Basic biological studies of the Odessa sea port (August –December 2001). Final report // Monograph series of the Odessa demonstration center of the GloBallast program. – issue 7. – 2005. Odessa. – pp. 69 –71. (In Russian).

Gelmboldt M.V. Meiobenthos. Marine mites // In the book "Northwestern part of the Black Sea: biology and ecology (1967 – 2003)" K.: Naukova Dumka, — 2006. – pp. 260 –267. (In Russian).

Gelmboldt M.V. Marine mites (Halacaridae: Acari) – a component of fouling of hydraulic structures of the Odessa coast" // Proceedings of the conference "Periphyton and fouling: theory and practice, St. Petersburg (October 22 –24, 2008) – St. Petersburg: ZIN RAS, 2008. – pp. 32 –34. (In Russian).

Gelmboldt M.V. Species diversity of sea mites (Halacaridae: Acari) of the Ukrainian Black Sea coast // Bulletin of the Odessa National University. – 2016. – 6(1). – pp. 125 –130. (In Russian).

Gelmboldt M.V., Dovgal I.V. New find of suctoria (Celiophora, Suctorea) on ticks (Acari, Halacaridae) from the Ukrainian coast of the Black Sea // Abstract of the report of the Scientific and Practical Conference of the Ukrainian Scientific Society of Parasitologists, // Bulletin of Zoology. – 2005. issue 19., part 1 – pp. 85 –86. (In Russian).

Gerlach, S.A. Die biozönotische Gliederung der Nematodenfauna an den deutschen Küsten. // Z. Morph. u. Ökol. Tiere, , – 1953: 41, 5–6 – pp. 411–512.

Gerlach, S.A. Die Nematoden fauna der sublitoralen Region in der Kieler Bucht. // Kieler Meeresforch, – 1958: 14, – pp. 64–92.

Gerlach S.A. Food-chain relationships in subtidal syltysand marine sediments and the role of meiofauna in stimulating bactirial productivity // Oecologia (Berl.). – 1978: 33. –pp.55–70.

Giere O. Meiobenthology: the microscopic motile fauna of aquatic sediments // Heidelberg: Springer –Verlag. – 2009: – 527 P.

Gomoiu M. –T. Problemes concernant l`eutrophisation marine // Reserches marine, Constanta. V. 18. 1985: – pp. 59–95.

Gomoiu M. –T. Quelques problems concernant le syndrome d`eutrophisation marine au niveau du benthos de la partie nord –oust de la mer Noire // Rev. Roum. Biol. Ser. Biol. Anim., Bucharest. –. 1987: V. 32(2). pp.157–162.

Gomoiu M. –T., Sekrieru D., Paraschiv G., Opreanu P., Puschiaza D. Some remarks on the ecological state of benthic populations recorded during the IAEA 98 Black Sea cruise of "Prof. Vodyanitskiy" R/V 2003–2004 // Modern and Ancient Fluvial, Deltaic and Marine Environments and Processes. Geo –Eco Marina. – 2005: pp. 10–19.

Gooday, A.J., Bernhard, J.M., Levin, L.A., Suhr, S.B. Foraminifera in the Arabian Sea oxygen minimum zone and other oxygen –deficient settings: taxonomic composition, diversity, and relation to metazoan faunas. // Deep – Sea Research – 2000, 47: – pp. 25 –54.

Graff L., Turbellaria. 2. Rhabdocoelidida. // Das Tierreich. – 1913, 35. pp. 1 – 484.

Gray I., Ryeger R.M. Quantetative study of the meiofauna of an exposed sandy beach of Robin Hood, s Bay, Yorkshire // Mar. Biol. Ass. U.R. – 1977: pp. 1 –19.

Harmelin J. G. Les grottcs sous –marines obscures: un milieu extreme et un remarquable biotope refuge / J. G. Harmelin, J. Vaceler, P. Vasseur // Téthys. 11. – 1985: – pp. 214–229.

Higgins R.P. Kinorhyncha // Introduction to the Study of Meiofauna. – Wachington, DC: Smithsonian Institut Press. – 1988: – pp. 328–331.

Higgins P., Adrianov A., Kinorhyncha from the Black Sea/ 1. Redescription of Kinorhynchus paraneapolitanus // Trass. Am. Microsc. Soc., – 1991:110(4). – pp. 328 – 336.

Ivanov A.I. Plankton algae as indicators of salinization and eutrophication of brackish waters (using the example of estuarine areas of the northwestern part of the Black Sea) // Proceedings of the Soviet –English seminar ″Scientific foundations of quality control of surface waters by hydrobiological indicators″. L. Gidrometeoizdat, – 1977: – pp. 221–229. (In Russian).

Izrael Yu.L., Gasshina N.K., Abakumov V.N., Tsyban A.V. Hydrobiological service for observations and control of the aquatic environment // Scientific foundations for monitoring water quality using hydrobiological indicators. Proceedings of the All –Union Conf. (November 1 –3, 1978). M: – pp. 7 – 9. (In Russian).

Karnaukhov V.N. The role of mollusks with a high content of carotenoids in protecting the aquatic environment from pollution. – Pushchino: ONTI NTsBI AN USSR, 1979: 74 p. (In Russian).

Karnaukhov V. G. Thermomechanical behavior of viscoelastic bodies under harmonic loading / V. G. Karnaukhov, I. K. Senchenkov, B. P. Gumenyuk. – K.: Science. Dumka, 1985. – 288 P. (In Russian).

Kiseleva M.I. Food spectra of some bottom invertebrates of the Black Sea // Zool. journal. – 1975. – 54, issue. 11. – pp. 1595 – 1601. (In Russian).

Kiseleva M.I. Qualitative composition and quantitative distribution of meiobenthos off the western coast of Crimea // Benthos. Kyiv: Nauk. Dumka – 1965: – pp. 48–61. (In Russian).

Kiseleva G.A. Effect of substrate on the sedimentation and metamorphosis of benthic animal larvae // Bottom biocenoses and biology of benthic –eating organisms of the Black Sea. – Kyiv: Naukova Dumka, – 1967: 71 –84. (In Russian).

Kiseleva M.I. Zoobnthos // Fundamentals of biological productivity of the Black Sea. – Kyiv: Nauk. Dumka – 1979: – pp. 221 –222. (In Russian).

Kiseleva M.I. Changes in the composition and distribution of polychaete worms in the Sea of Azov // Zool. Zh. 23, issue. 2. – 1987: – pp. 40–46. (In Russian).

Kitseleva M.I. Changes in the composition and distribution of polychaete worms in the Azov Sea // Hydrobiological journal. – 1987: – pp. 40 –45. (In Russian).

Kiseleva, M. I. Polychaetes (Polychaeta) of the Asov and Black Sea. // Science Centre, Murmansk Marine Biological Institute – 2004: – 412 P. (In Russian).

Kiseleva M.I., Makkaveeva E.B. Study of zoobenthos // Problems of marine biology. – Kyiv: Nauk. Dumka – 1971: – pp. 71–77. (In Russian).

Klimchuk A.B., Amelichev G.N., Lukyanenko E.A..Cadastre of caves: status and tasks // – Simferopol, – 2007: 24.P. (In Russian).

Konnerth –Ionescu A.. Contribution a l'etude des Halacarides du littiral roumain. // Trav. Mus. hist, natur. "Gr. Antipa". 8. – 1968: – pp. 365 –369.

Konnerth –Ionescu A., Nouvelles donnies sur les Halacarides de la mer Noire. // Trav. Mus. hist, natur. "Gr. Antipa". Ibid. 10. – 1970: – pp. 19 –23. Konnerth – Ionescu A., Les Halacarides de la Mer Noire (secteur Roumain) – 1973: – pp.83 – 88.

Konstantinov, AS., General Hydrobiology. M.: High. Sk. – 1972: – 310p. (In Russian).

Konsulova Ts., Turbellaria (Turbellaria) of Bulgaria shelf of Black Sea. // Proc. Institute of Fisheries Varna. Варна, 16, Vol. 11. – 1978: – pp. 87 –101.

Korovchinsky, N.M., and Sergeeva, N.G., A new family of the order Ctenopoda (Crustacea:Cladocera) from the depths of the Black Sea. // Zootaxa – 2008: – 57–66.

Kosheleva E.A., Nematoda Desmoscolecida of the deep –sea Dnieper Canyon (Black Sea). – Marine Ecol. Journ. (Sevastopol, Ukraine), 2012, 9 (3) – pp.57 –62. (In Russian, English summary).

Kovtun O. A. (O. A. Alexander Ereskovsky, Oleg K Kovtun, Konstantin K Pronin). Marine cave biota of the Tarkhankut Peninsula (Black Sea, Crimea), with emphasis on sponge taxonomic composition, spatial distribution and ecological particularities. *Journal of the Marine Biological Association of the United Kingdom*, 2016, Proceedings of the 9th World Sponge Conference held in Fremantle Australia in 2013: New Frontiers in Sponge Science), 96 (02), pp.391-406. ⟨10.1017/S0025315415001071⟩. ⟨hal-01456337⟩.

Kovtun O.A. New and rare species of marine invertebrates from underwater caves of the Tarkhankut Peninsula (Black Sea, Western Crimea) // "Speleology and speleostology: development and interaction of sciences". – Proc. int. scientific – practical. conf. (November 16 –20, 2010, Naberezhnye Chelny). – 2010: – pp. 311 –314. (In Russian).

Krantz G. W., Arenicolous Halacaridae from the interstitial zone of Schooer –Greek Oreon (Acari, Prostigmata). Acarologia. 18. N 2. – 1976: – 241 –258.

Kristensen R.M, Higgins R.P. Kinorhyncha // Microscopic Anatomi of Invertebra – tes. 4. – 1991: – pp. 377–404.

Kristensen, E. 2000. Organic matter diagenesis at the oxic/anoxic interface in coastal marine sediments, with emphasis on the role of burrowing animals. Hydrobiologia. – 2000. 426: – pp. 1 –24.

Kulakova I.I. Free –living nematodes in the western part of the Black Sea // Institute of Biology South. seas to them A.O. Kovalevsky Academy of Sciences of the Ukrainian SSR. Odessa department – Odessa, – 1987: 35 P. – Dep. in VINITI 02/06/87, No. 879–B87.

Kulakova, I.I. Free –living nematodes of the western shelf of the Black Sea. // Ecologya morja, 3, – 1989: – pp. 42–46 (In Russian).

Kulakova I.I. Free-living nematodes from the Grigorievsky liman (North-Western part of the Black Sea) // Proc. the 10th Inter. Meiofauna Conference (XIMCO): (27-31 july 1998, Plymouth). – 1998. – P. 74.

Kulakova I.I. The response of free –living nematodes to pollution on the Ukrainian north –western Black Sea shelf // Proc. the second International Conference ‘‘Application of Micro –and Meioorganisms to Environmental Problems’’. August, 27 – September 1, 2000, Winnipeg, Canada. – 2000: – pp. 66 – 67.

Kulakova I.I Free –living nematodes in the marine part of the Danube estuary // Proc. the 11th International Meiofauna Conference (ELIMCO), (July, 2001). Boston, USA. 2001: p.83.

Kulakova I.I. Current state of the fauna of free –living nematodes in the northwestern part of the Black Sea under anthropogenic impact // Environmental safety of coastal and shelf zones and integrated use of shelf resources. – Sevastopol: MGI. – 2001: – pp. 295 –300. (In Russian).

Kulakova I.I. Current state of the fauna of free –living nematodes in the Odessa region (northwestern part of the Black Sea) // Science of the Ternopil Pedagogical University. Series Biology. Hydroecology. v.3 – 2001: pp. 136 –137. (In Russian).

Kulakova, I.I. Features of the distribution of free –living nematodes in the northwestern part of the Black Sea. // Extended abstract of candidate’s thesis. Sevastopol – 2002: 18 P. (In Russian).

Kulakova I.I. (2006). "Free –living nematodes of the northwestern Black Sea" / Northwestern Black Sea: biology and ecology (1967 –2003). Responsible. Eds. Zaitsev Yu.P., Aleksandrov B.G., Minicheva G.G. – K.: Naukova Dumka – Section 2, Ch. 6.2. – 2006. – pp.. 254 –260; Section 3, Ch. 1.4. – pp. 358 –422. (In Russian).

Kulakova I.I. Nematodes of the Grigorievsky estuary // In the book. "The Northwestern Black Sea: Biology and Ecology (1967 –2003)" – K.: Naukova Dumka, – 2006: – pp. 206 –210. (In Russian).

Kulakova I. Comparative analysis of the structure of the nematode taxocene in the marine part of the Ukrainian Danube Delta. // EMMM 2007 Fifth International Conference, University of Erlangen, Germany, August 24 – September 1, – 2007: – pp. 68

Kulakova I.I. The Contemporary State of Development of Free –living Nematodes of the Northwestern Black Sea // AGU Joint Assembly (22 –25 May 2007 Acapulco, Mexico) – 2007: – p.71.

Kulakova I.I. Free –living nematodes // Ecosystem of the Grigorievsky (Maly Adzhalyk) Estuary, Odtssa, Astroprint – 2008 – pp.147 –156(In Russian).

I. I. Kulakova I. Current state of the interstitial meiofauna of sandy beaches of the Odessa coast // ONU Bulletin. Biology. – 2012. Vol. 17, 1-2, – pp. 26-27 (In Russian).

Kulakova I.I. Free –living nematodes of the periphyton of artificial substrates of the Odessa Gulf of the Black Sea // Ecosystems, their optimization and protection. Simferopol, – 2014 – Issue 11. – pp. 229 –234. http://ekosystems.cfuv.ru/wp –content/uploads/2016/11/eko_11_30.pdf.

Kulakova I.I. Comparative assessment of the taxonomic diversity of free –living nematodes in the estuarine coastal zone of the Ukrainian part of the Danube Delta // Nauk. zap. Ternop. nat. ped. univ. ser. Biol., No. 3 –4. – 2015: – pp. (64). (In Russian). Russian).http://dspace.tnpu.edu.ua/bitstream/123456789/5843/1

Kulakova I. I. Fauna of freeliving nematodes in the ukrainian part of the danube river mouth area in Danube in the modern period // Visnyk of ONU. Biology, 2020. – Vol. 25, issue. 2 (47). – pp.97 –108. (In Ukrainian)

Kulakova I. Assessment of the ecological state of the Danube delta coastal area (northwestern part of the Black Sea) based on meiobenthos and nematode assemblages. // Geo –Eco –Marina, 28, – 2022: – pp. 21–39. https://doi.org/10.5281/zenodo.7491434.

Kulakova I.I. Torgonskaya O.A. Nematodes of the Grigorievsky estuary and some of their functional characteristics // Environmental safety of the coastal and shelf zones and integrated use of shelf resources – Sevastopol. – 2006: – pp. 412 – 418. (In Russian).

Kulakova I.I., Vorobyova L.V. Free –living marine nematodes of the coastal zone area near the Snake Island of the Ukrainian shelf of the Black Sea. // Scientific notes of Volodymyr Hnatiuk Ternopil National Pedagogical University. Series: Biolog 1(75), – 2019: – pp. 13–20. DOI: https://doi.org/10.25128/2078 –2357.19.1.2. (In Russian).

Kulakova I.I., Vorobyova L. Meiobenthos and taxocene of Nematodes under changes in ecological conditions in the coastal zone of the NorthWestern part of the Black Seaë // Geo –Eco –Marina 30, 2024 – pp. 21 –41 (DOI: 10.5281/zenodo.14229131).

Kadurin V., Kravchuk A., Kondariuk T., Kulakova I., Dikol O., Kadurin S. (2024). Influence of methane and other hydrocarbon gases on foraminifera and nematodes in the Northwestern part of the Black Sea. // Marine Environmental Research,– 2023: – 193 P. 106285 https://doi.org/10.1016/j.marenvres.2023.106285

Laubier L., Adaptations cher les annelidespolychetes interstitielles. / Ann. Biol. 6, N 1/2. // 1967: –l –16.

Leates G.W., Nematode breeding and activity: the importance of development stager.Biol. Tert. Soils. 3, N 1/2. – 1987: – pp.143 –146.

Lee W.Y., Zhang X.K., Van Baalen C., Arnold C.R. Feeding and reproductive performance of the harpacticoid Tisbe carolinensis (Copepoda, Crustacea) // Marine Ecology Progress Series. Vol. 24. – 1985: – 273 –279.

Losovskaya G.V., Rytikova L.Yu. State of bottom communities of the northwestern part of the Black Sea under conditions of changing river runoff // Ecology of the sea. – – Issue 26. – 1987: – pp. 37 –43. (In Russian).

Losovskaya, G. V. Long –term changes in the composition and distribution of polychaetes of the North –Western Black Sea. // Hydrobiologycal Journal, 24(4) – 1988: 21 –25. (In Russian).

Lysitsyn A. P. Biogeochemistry of the ocean B., Nuka – 1983: – 368 P. (In Russian).

Mack –Fira V., Donnees nouvelles sur la fauna de Turbellaries du littoral roumain (mer Noire). Bucuresti, (Rapp. Comm. Int. Mer. Medit; Vol. 22, N4) – 1973: – p.79.

Makkaveeva E.B. On the ecology and quantitative distribution of arachnids in the north –eastern part of the Black Sea // Hydrobiological journal. 2, No. 5. – 1965: – 30–38. (In Russian).

Makkaveeva E.B. The role of macrophytes and ecological factors in the formation of the species composition of overgrown communities // Bottom biocenoses and biology of benthic organisms of the Black Sea. – Kyiv: Nauk. dumka, – 1967: – pp. 52–61. (In Russian).

Mamkaev Y.V., Materials on the interstitial fauna of the Barents Sea. // News. Leningrad. University. Biol. factor. 9, N2. – 1962: – 82 –92. (In Russian).

Mare M.F., A study of marine benthic community wich special reference to the microorganisms. // J.Mar. Biol. Ass. U.K. 25, N 3. – 1942: – pp. 571 – 574.

Marinov T. Verkh microzoobenthos fauna on the Black Sea // Izv. Institute for fisheries and fish farming. 4. – 1964: – 61 –71.

Marinov T., Characteristics of meiobenthos in sandy mediolittoral and groundwater. // Proc. Institute of Fisheries Varna. 14. – 1975: – pp.103 –135.

Marinov T. Qualitative composition and quantitative distribution of meiobenthos from the Bulgarian fish water area on the Black Sea // Ibid. 16. – 1978: – 35–49.

Marinov T. Zoobenthos from the Bulgarian sector on the Black Sea. // Sofia: Publishing House BAN – 1990: – 195 P.

Mastepanova E. A. Interstitial polychaetes of the Russian seas // Invertebrate zoology. – 2004. – pp. 59 – 64 (In Russian).

McIntyre A.D., Ecology of marine meiobenthos. Biol. Revs. Cambridge Philos. Soc 44, N 2. – 1969: – pp. 245 –290.

McIntyre A.D. Observations on the status of sublidal meiofauna research // Smiths Contr. Zool. – 1971. – 76. – pp. 149–154.

McIntyreA.D., Murison D. J. The meiofauna flatfish nursery ground // Mar. Biol/ Ass. U. K.. – 1973, 53.– pp. 93 –118.

Mclntyre A.D., Munro A.L.S., Steele J.H. // Energy flown a sand ecosystem. Marine food chains. // Ed. J. H. Steele. Edinburgh: Oliver and Boyd, Vol. 17 – 1969.– pp.1 –47.

Mikhailova T.V., Sergeeva N.G. Position of the lower boundary of habitat of various groups of macrozoobenthos in the Black Sea // Abstract of the report of the III Congress of Soviet oceanologists, section ″Ocean Biology″. Part 2. – L., – 1987: pp. 147–148. (In Russian).

Mileikovsky S. N. Larvae of marine benthic invertebrates and their role in marine biology. – Moscow – 1985: – 117 P. (In Russian).

Mironov A.N. Moskalov L.I Mironov A.N. Sea caves and their inhabitants // Nature, No. 2, – 2003: – 50 –55.

Modig H. Olafsson E. Responses of Baltic bentic invertebrates to hypoxic events // J. Exp. Mar.Biol. Ecol. 229 – 1998: – pp. 133 –148.

Mokievsky V.O., Ecology of marine meiobenthos. //Com. of Scientific Publications. M. – 2009: – 280 P. (In Russian).

Monchenko B.I., New data on harpaktikoid Black Sea (Crustacea, Copepoda). // Reports. Akad. № 5. – 1967. pp. 461 – 465. (In Russian).

Monchenko V. I. On harpacticoids (Crustacea, Harpacticoida) of the Soviet section of the lower reaches of the Danube and its delta / V. I. Monchenko, V. Polischuk // Bulletin of Zoology. 6. – 1969: – pp. 58 – 64. (In Russian).

Monchenko V.I., New data on the distribution of rare harpaktikoid at nord – west coast of the Black Sea. // Gidrobiol. Journal. 10, № 5. – 1974: – pp. 41 – 49. (In Russian).

Monchenko V. I. New data on the distribution of rare harpacticoids along the northwestern coast of the Black Sea // Hydrobiological journal. – Vol. 10, No. 5. – 1974: – pp. 98 –101. (In Russian).

Monchenko V.I., Polischuk V.V. On harpacticoids (Crustacea, Harpacticoida) of the Soviet section of the lower reaches of the Danube and its delta. // Vestnik Zoologiya, No. 6. – 1969: – pp. 58 –64. (In Russian).

Moodley L, Hess C. Tolerance of in Faunal Benthic Foraminifera for Low and High Oxygen Concentrations // Biol. Bull. 1992 Aug;183(1):94-98. doi: 10.2307/1542410.

Moodley L at all. Differential response of benthos meiofauna to anoxia with special reference to Foraminifera (Protista, Sarcodina). // Marine Ecology progress series. Vol. 158 – 1997 – pp. 151-163.

Moreno, M., Semprucc I, F., Vezzulli, L., Balsamo, M., Fabiano, M., Albertelli, G. The use of nematodes in assessing ecological quality status in the Mediterranean coastal ecosystems. // Ecological Indicators, 11 – 2011: – pp. 328 – 336, http://dx.doi.org/10.1016/j.

Muresan, M., Teaca, A. Muresan, M., Teaca, A. The free –living nematode community structure within the Romainan circalittotal habitats. // Geo –Eco – Marina, 25 – 2019: – pp. 7 –13.

Murrell M.S, and Fleeger J.W. Meiofauna abundance in the Gulf in Mexico continental Shelf affected by hypoxia // Cont. Self pres. 9 – 1998: – pp. 1049 –1062.

Muss B.J. A new quantitative sampler for meiobenthos. // Ophelia. 1. – 1964: – pp. 209 –216.

Nastenko E.V. Zooplankton as an indicator of the pontification of the Azov Sea under conditions of progressive withdrawal of river runoff // On the state of the ecosystem of the Azov Sea. – Odessa, – 1989: – pp. 66 –84. – Dep. in VINITI 08.02.89, No. 859 –B89. (In Russian).

Neel J.K., A limnological investigation of the psammon in Douglas // Lake. Michigan, with especial reference to shoal and shoreline dynamics. Trans. Amer. Microsc. Soc. 67 – 1948: – pp. 1 –53.

Nesterova D.A. General characteristics of phytoplankton. // Odessa region of the Black Sea of pelagic and benthic area. – Odessa. Ástroprint" – 2017: pp. 11 –22 (In Russian).

Nesterova D. Terenko L. Phytoplankton of the Odessa region under modern conditions // Environmental safety of coastal and shelf zones. Sevastopol – 2000 – 3 – pp.83 –390.

Nichols A.G., A new quantitative samples for the meiobenthos. // Ophelia. 1. – 1935: – pp. 209 –216.

Nichols A.G., Copepoda from the interstitial fauna a study beach. // Mar. Biol.Ass. U.K. 20. № 1 – 1935: – pp. 379 –406.

Odum Yu.R. Ecology. // M.: Mir, T. 1. – 1986: – 328 P.

Pennak R.W., Ecology of the microscopic metazoa inhabiting the sand beaches of some Wisconsia. // Ecol. Monogr. 10. – 1940: – pp. 537 –615.

Pereyaslavtseva S.M.,. Addition to the fauna of the Black Sea. Proc. Kharkiv. obschestva naturalists. 25, N 1. – 1891: – pp. 21 –26. (In Russian).

Petrova A., Sur la pre'sence d'Halacaridens subterraneus Schuls, 1933 et Halacarellus phreoticus n.sp. // Acarologia. 12, N 2. 1972: – pp. 367 –373.

Petrova A., Sur quelques Halacaridens trouves dans la littoral de la mer Noire. Ibid. 14, N 4. – 1973: – pp. 570 –590.

Petrova A., Une nouvelle espece d'Aquaopsis (Prostigmata, Halacaridae) du littoral de la Mer – Noire. // Hidrobiologia. 4. – 1976: – pp.67 –70.

Petrova A. Pontarachna valkanovi sp. n. (Acari, Pontarachnidae) du littoral de la Mer Noire. // Acta zooL bulg. 10. 1978: – pp. 60 –63.

Phleger F.B., & Press J.H. Ecology and Distribution of Recent Foraminifera. // Baltimore: Md. – 1960: – 180 P.

Portianko V. V. Harpacticoida (Crustacea, Copepoda) of mussel beds and macroalgae on the rocky substrates in the north –western Black Sea. // Vestnik zoologii. 51(5) – 2017: – pp.407 –412, DOI 10.1515/vzoo –2017 –0048 Scopus Web of Science). (In Russian).

Portyanko V. V. The role of Harpacticoida (Crustacea, Copepoda) in the formation of quantitative indicators of the meiobenthos of the upper sublittoral of the Odessa Gulf. // Abstracts of the VIII scientific and practical conference of young scientists Pontus Euxinus. Sevastopol, – 2013: – pp. 113–115. (In Russian).

Portyanko V. V. Harpacticoida (Crustacea, Copepoda) of the coastal waters of Zmeiny Island (Black Sea). // Proceedings of the scientific and practical youth conference “Environmental problems of the Azov –Black Sea region and integrated coastal zone management” (September 29 – October 5, 2014), Sevastopol, – 2014: – pp. 140–143. (In Russian).

Portyanko V. V. Harpacticoida (Crustacea, Copepoda) fouling of hard substrates of Zmeiny Island. // Proceedings of the Third International Scientific and Practical Conference "Biodiversity and Sustainable Development" (September 15 – 19, 2014) to the 100th anniversary of the Karadag Biological Station – Karadag. Simferopol. – 2014: – pp. 282 –284. (In Russian).

Portyanko V. V. Harpacticoida (Crustacea, Copepoda) pelocontour of the Odessa Marine Region (Black Sea). // Scientific Notes of the Ternopil National Pedagogical University named after Volodymyr Hnatyuk. Series: Biology. Special issue: Hydroecology. No. 3–4 (64). – 2015: – pp. 535–539. (In Russian).

Portyanko V.V. Harpacticoida (Crustcea, Copepoda) of the upper sublittoral of the Odessa marine region. // Scientific notes of the Ternopil National Pedagogical University named after Volodymyr Hnatyuk. Ser.: Biology. No. 3 (70). – 2017: – pp. 169–173. (In Russian).

Portyanko V. V. Harpacticoid copepods of contact zones of the peninsular – western part of the Black Sea. – 2021 – pp. 1-18 (In Russian).

Preston H.,. Halacaridae (Acari) von Gereilenstranden Nordnorwegen. // Mainz. (Abh. Akad. Wiss. und Lit. Math. – naturwiss. KL Mikrofauna M e – eresbodens; Bd. 70). – 1978: 20 S.

Pronin K.K. Sea grottoes of the northern section of Tarkhankut // K.K. Pronin // Speleology and karstology, No. 6. – 2011: – pp. 12 –24

Raffaelli D.G. Monitoring with meiofauna a reply to Coull, Hicks and Wells and additional data // Var. Pollut. Bull. – 1981.Vol. 12, № 11. – pp. 381 –382.

Raffaelli D.G. Mason C.F., Pollution monitoring with meiofauna, using the ratio of nematodes to copepods // Mar. Pollut. Bull. 12. – 1981 – pp. 158 –163.

Remane A. Die Besiedlung des Sandbodens im Meer und die Bedeutung Lebensformtypen fur die Oecologie. // Zool. Anz. 21. – 1952: – pp. 327 –359.

Ricardo Cardoso Neves, Nuria Sanchez, Roberto Sandulli, et al.. Characteristics of meiofauna in extreme marine ecosystems: a review // Marine Biodiversity, № 1, – 2017: – pp. 35 –71.

Risgaard –Petersen ti al., Evidence for complete denitrificacion in benthic foraminifer. // Nature. V.443. 2006: – pp. 93 –96.

Saidova X.M. Distribution of foraminifera in bottom sediments of the Sea of Okhotsk // Trudi Instituta okeanologii. T.32. – 1960: – pp. 207 –209. (In Russian).

Scheltema R. The relationship of salinity to larval sarvival and development in Nas –sarius obsoletus (Gastropoda) // Biol. Bull. 129, N 2. – 1965: – pp. 340–354.

Schmidt P., Zonierung und jahreszeitliche Fluctuationen der interstitiallen Fauna in Sandstranden des Gablets von Tromso (Norwegen). Mainz. // Abh. Akad. Wiss. und Lit. Math. –naturwiss. Kl. Mikrofauna Meeresbodens; Bd. 12. – 1972: – pp. 81 –89.

Schmidt P., Interstitielle Fauna von Galapagos 4. Gastrotricha. Mainz, 76S. // Abh. Akad. Wiss. und Lit. Math. –naturwiss. KL Mikrofauna Meeresbodens; Bd.26. – 1974: – pp. 215 –237.

Schmidt P., Sopott E., Interstitielle Fauna von Galapagos. 15. Macrostomum n. sp. (Turbellaria, Makrostomida). Mainz, 45S. –// Abh. Akad. Wiss. und Lit. Math. –naturwiss. Kl. Mikrofauna Meeresbodens; Bd. 57. – 1976: pp. 453 –469.

Schmidt P., Interstitielle Fauna von Galapagos 21. Lebensraum, Umweltfaktoren. Gesamtfauna. Mainz, // Abh. Akad. Wiss und Lit. Math. – naturwiss. KL Mikrofauna Meeresbodens; Bd. 68. – 1978: – pp. 573 –622.

Schornikov E.M., The fauna of the Black Sea and azovski ostracods in environmental aspects and zoogeograficheskom. // Bottom biocenoses and benthic biology of the Black Sea. Kiev: Naukova Dumka. – 1967: – pp. 122 –142. (In Russian).

Schornikov E., Zenina M., Ivanova E. Ostracods as indicators of the aquatic environmental conditions on the northeastern Black Sea shelf over the Past 70 Years. Russian Journal of Marine Biology. – 2015. № 40. – pp. 455–464. DOI: 10.1134/S1063074014060200.

Semprucc i, F., Balsamo, M., Frontalini, F. et al. The nematode assemblage of a coastal lagoon (Lake Varano, southern Italy): ecology and biodiversity patterns. // Scientia Marina, 78: – 2014: – pp. 579 –588, Doi:10.3989/scimar. 04018.02A

Semprucci, F., Colantoni, P., Sbrocc a, C., Baldelli, G., & Balsamo, M. Spatial patterns of distribution of meiofaunal and nematode assemblages in the Huvadhoo lagoon (Maldives, Indian Ocean). // Journal of Marine Biological Association of the United Kingdom, 94. 2014: 1377 –1385.

Sergeeva N.G. On the presence of invertebrate animals of the benthos at great depths in the Black Sea // Abstract of the report of the 3rd All –Union Conf. on Marine Biology. – Kyiv, Part 1. 1988: – pp. 246–247. (In Russian)

Sergeeva N.G. Morphological variability of Terschellingia longicaudata de Man, 1907 (Nematoda, Monhysterida) in the Black Sea // Fauna, morphology and systematics of lower worms. // Proc. Inst. Biol. Int. Water. 64 –(67). – 1991: — pp. 117 –129 (In Russian).

Sergeeva, N.G. New data on life in deep –sea hydrogen sulfide zone of the Black Sea, in Globalnaya sistema nablyudenii Chernogo morya fundamentalnye i prikladnye aspekty // Black Sea Global Observing System: Fundamental and Applied Aspects, Sevastopol: MGI–EKOSI, – 2000: – pp. 138–146. (In Russian).

Sergeeva, N.G. Meiobenthos of the Black Sea anaerobic zone. In Alexandrov, B.A., Kats, B.M., and Safranov, T.A., eds., Collected Papers "The Black Sea Ecological Problems. Black Sea Strategic Action Plan Implementations (1996–2000). Odessa, SCSEO, – 2000. – pp. 258–262. (In Russian)

Sergeeva N.G. Morphological anomalies of free –living nematodes as an indicator of the state of the environment // Current state of biodiversity of coastal waters of Crimea (Black Sea sector). – 2003: – pp. 302 –310 (In Russian).

Sergeeva N.G. Meiobenthos of deep –water anoxic hydrogen sulfide zone of the black sea, in Oceanography of the Eastern Mediterranean and Black Sea. Similarities and Differences of Two Interconnected Basins // Proc. II Int. Conf., Ankara, 2002), Aysen Yilmaz, Ed., Ankara: Tübitak Publ., – 2003: – pp. 880–887.

Sergeeva, N.G., Gooday, A.J., Mazlumyan, S.A., Kolesnikova, E.A, Lichtschlag, A., Kosheleva, T.N., Anikeeva, O.V. Meiobenthos of the oxic/anoxic

interface in the Southwestern region of the Black Sea: abundance and taxonomic composition. In: Anoxia: Paleontological Strategies and Evidence for Eukaryotes Survival, (eds., A.V. Altenbach, J.M. Bernhard, J. Seckbach), Springer – 2012–, pp. 369-401.

Sergeeva N., V. Zaika et al. Vertical structure of the chemical properties of western Black Sea. // Indian J. Marine Sci. 32 (4) – 2003: – pp. 314 –322

Sergeeva N, Zaika V. The Black Sea Meiobenthos in Permanently Hypoxic habitat // Acta zool. bulg., 65 (2), — 2013: – 139 –150.).

Sergeeva N.G. Kolesnikova E.A. Results of the study of the meiobenthos of the Black Sea // Ecology of the sea. – Kyiv, Issue 45. – 1996: pp. 54–62. (In Russian).

Sergeeva N.G. Gilbert, A.S., and Yanko –Hombach, V., eds., The modern faunal anoxic zone of the Black Sea as a remnant of the ancient anoxic biosphere. // In Proceedings of the Third Plenary Conference of IGCP 610 "From the Caspian to Mediterranean: Environmental change and Human Response during the Quaternary" (September 22–30, 2015; Astrakhan, Russia), Moscow State University, Moscow, – 2015. – pp.109 –111.

Shannon C., Weaver W. The mathematical theory of communication // Urbana: Univ. Illinois press, – 1963: – 117 P.

Shchedrina Z.G. Fauna of foraminifera of the eastern sector of Antarctica // Inf. Bull. SAE – L. Sea transport –No. 3 – 1958: – pp. 51 –55. (In Russian).

Sheremetevsky A.M. Black Sea Kinorhyncha // Zool. Zh – 53, issue 7 – 1974: – pp. 974 –987. (In Russian).

Sheremetevsky A. M. Meiobenthos of the Laptev Sea and New Siberian Islands // Hydrobiological journal. – 13, No. 1. – 1977: – pp. 63–70. (In Russian).

Sheremetevsky A.M. The role of meiobenthos in biocenoses of the shelf of southern Sakhalin, eastern Kamchatka and the Novosibirsk shallow waters. – L.: Nauka, – 1987. – 135 P. (In Russian).

Sheremetevsky A.M., Meiobenthos of the Laptev Sea and New Siberian Islands // Hydrobiol. Zh. 13, No. 1. – 1977: – pp. 63 –70. (In Russian).

Shornikov E. I. Experience in identifying Caspian elements of the ostracod fauna in the Azov –Black Sea basin // Zool. Zhurn. 43, issue 9. – 1964. –pp. 1276–1293. (In Russian).

Shornikov E.I. To the study of Ostracoda of the Azov and Black Seas // Benthos. – Kyiv: Nauk. Dumka, – 1965: 103–121. (In Russian)

Shornikov E.I. Leptocythere (Crustacea, Ostracoda) of the Azov –Black Sea basin // Zool. Zhurn. – 45, issue 1. – 1966: – pp. 32–49. (In Russian).

Shornikov E.I. Fauna of the Black Sea –Azov ostracods in ecological and zoological aspects // Bottom biocenoses and biology of benthic organisms of the

Black Sea. – Kyiv: Nauk. Dumka, – 1967: – pp. 122–143, 97 –111. (In Ukrainian). https://doi.org/10.18524/2077 –1746.2020.2(47).204214.

Shornikov E. I. Subclass of ostracods, or shell –shaped crayfish, Ostracoda // Key to the fauna of the Black and Azov Seas. K.: Nauk. dumka, 1969. 2. – pp. 163 –260. (In Russian).

Shornikov E. I. Ecology of Azov –Black Sea ostracods // Ecological studies of benthic organisms. K.: Nauk. dumka, 1972. – pp. 53 –88. (In Russian).

Shornikov E.I. Ostracods are bioindicators of aquatic ecosystems // Ecological problems of wildlife conservation / Abstract of the All –Union Conf. Part 3. Moscow, 1990. pp. 235 –236. (In Russian).

Shornikov E.I. Ostracods as indicators of the dynamics of aquatic ecosystems // Vestn. FEB RAS. No. 5. – 1996: – pp. 36 –42. (In Russian).

Shornikov E.I., Sokolenko D.A. Ostracods as indicators of bottom water masses in the southern part of Peter the Great Bay, Sea of Japan // Biology of the Sea. Vol. 25, No. 2. – 1999: – pp. 1– 80 –183.). (In Russian).

Shornikov V.I., Zenina M.A. Ostracods as an indicator of the state and dynamics of ecosystems (on the example of Peter the Great Bay, Sea of Japan) // Vladivostok. Dalnauka – 2014: – 334 P. (In Russian).

Sinegub I.A. Distribution of biocenoses of some areas of the North –Western part of the Black Sea // Recommendations for the creation of modular sections of artificial media plants. scientific report. Odessa, –No. State reg. 0290I 044598. – 1989: – pp. 43 –55. (In Russian).

Sinegub I.A. Macrozoobenthos of the littoral and sublittoral zone of the Ukrainian Antarctic station Academician Vernadsky" // Bull. UFC – 1998, 2: – pp. 206 –217. (In Russian).

Sinegub I.A., Vorobyova L.V. Zoobenthos of some biocenoses of the Odessa marine region of the Black Sea. Conference: Biodiversity and Sustainable Development. – 2014 – pp. 327 –328. (In Russian).

Sokolov I.I., Arachnids // Fauna of the USSR – M. Nauka – 1952 – issue 5 – 198 P. (In Russian).

Sokolov I.I., Yankovskaja N.I., Squad of ticks // Definator of the fauna of the Black and Azov Seas. Kyiv, Naukova Dumka. – 1972: – pp. 8 –42. (In Russian).

Sokolova M.N., Zezina O.M., Kamenskaya O.E., Meiobenthos – the subject and the research problem. // Proc. The Institute of Oceanology of the USSR. 117. – 1982: – pp. 19 –29. (In Russian).

Sovinsky A.M. Insight into the study of the fauna of the Ponto –Caspian –Aral Sea basin // Zap. Kiev. Society of Naturalists –3, issue 1 – 1902: – 216 P. (In Russian).

Steyaert et al.. Biomass spectra as descriptors of functional changes tu human and natural impact // Marine Ecology press 249 – 1999 – pp 157-170. DOI 10 3354/meps 24 9157.

Sveshnikov V. A. Morphology of mytilid larvae. Commercial bivalve mollusks mussels and their role in ecosystems. // Leningrad: Publishing House of the Zoological Institute of the USSR Academy of Sciences, – 1979: – pp. 103 –104. (In Russian).

Swedmark B., The interstitial fauna of marine sand. BioL Rev. 39, N 1. – 1964:– pp. 2 –17.

Synegub I.A. Distribution of biocenoses of some areas of the North –Western part of the Black Sea // Recommendations for the creation of modular sections of artificial media plants. scientific report. Odessa, –No. State reg. 0290I 044598. – 1989: –pp. 43 –55. (In Russian).

Tereshchenko N.N., Polikarpov G.G., Kovalenko T.P. Monitoring studies of the phaseolina settlement zone in the Kalamitsky Gulf region of the Black Sea // Hydrobiological journal. – – 28, No. 4. – 1992: 23–30. (In Russian).

Tereshchenko N.N., Polikarpov G.G., Timoshchuk V.I., Kovalenko T.P. Molismological monitoring of the ″Phaseolite patrol″ // Molismology of the Black Sea. – Kyiv: Nauk. Dumka, – 1992. – pp. 143–154. (In Russian).

Thiel H. Haufigkeit und Verteilung der Meiofauna im Bereich des Island – Faroer –Ruckens // Bereichte der Deutschen Wissenscht. Kommission fur Meeresforschung. 22. – 1971: – pp.99–128.

Thorson G. Reproductive and larval in the Sound // Medd.Komm. Dan. 1950, Vol. 25, No. 1. – 1950: – pp. 3 –123.

Thorson G. Parallel level –bottom communities, their temperature adaptation, and their «balance» between predators and food animals // Perspectives in marine biology. Berkeley; Los Angeles: Univ. Cal. press, – 1958. – pp. 67 –86.

Thorson G. Light as an ecological factor in the dispersal and settlement of larvae of marine bottom invertebrates // Ophelia. 1. – 1964: 167–208.

Thorson G. Some factors influencing the recruitment and establishment of marine benthic communities. // Netherl. J. Sea Res. 3, N 2. – 1966: – pp. 267 –293.

Ulyanin J.N., Turbellaria (Turbellaria) of Sevastopol Bay. // Proc. 2th of Congress Russian. Naturalists. M. T. 4. – 1879: – pp. 1 –96. (In Russian).

Ushakov N.V. Benthic works of the Soviet Antarctic expedition on the diesel –electric ship "Ob" (1956 –1958) // Inf. Bulletin SAE. –L. V.3. – 1958: – pp. 39 – 43. (In Russian).

Uzun, E.E. Quantitative characteristics of seed shrimps (Crustacea, Ostracoda) in the Odesa coastal region (Black Sea). // Scientific notes of Ternopil National Pedagogical University, 3 –4 (64) – 2015: – pp. 672–675 (In Russian).

Uzun E. E. Ostracods (Crustacea, Ostracoda) of fouling of natural and artificial substrates of the Odessa Gulf // Proceedings of the Third International Scientific and Practical Conference "Biodiversity and Sustainable Development" (September 15-19, 2014), Simferopol, Republic of Crimea. 2014, pp. 371-372.

Uzun E. E. Ostracods (Crustacea, Ostracoda) of the upper sublittoral of Zmeiny Island (Black Sea) // Proceedings of the scientific and practical youth conference "Environmental problems of the Azov-Black Sea region and integrated management of the coastal zone" (September 29 – October 5, 2014) – Republic of Crimea, Sevastopol, 2014, pp. 202–204.

Uzun O. Ye. First revision on ostracods (Crustacea, Ostracoda) of plastic substrate in Odessa marine region // International scientific conference, dedicated to 95th Anniversary of Academician of the NAS of Ukraine Yuvenaly Zaitsev «Achievements in studies of marginal effect in water ecosystems and their practical significance»: Book of abstracts (June 13-14, 2019, Odessa, Ukraine) / Aleksandrov B.G., Snigirova A.A. (eds.) - Odessa-Istanbul, 2019. – p. 65.

Uzun E.E. Evmeobentos crustaceans on a plastic garbage in the coastal part of the small fountain (Odesa Gulf, Black Sea)] Marine Ecological Journal, no. 2. – 2021: – pp. 83 –92. (In Ukraine).

Uzun O. Meiobenthos on hard substrates in the nearshore of the Odessa marine region (Black Sea) (O. Uzun, L. Vorobyova, I. Kulakova, V. Portianko) // ForBio and MEDUSA course: Evolution and Diversity of Meiobenthos (13–16 September 2021, White Sea Biological Station (MSU) / University Museum of Bergen (UiB), virtual symposium): Abstracts of student presentations – p.8.

Uzun, O. Ostracodes (Crustacea, Ostracoda) in the Rocky Nearshore Water Area of Snake Island (Black Sea). Zoodiversity, 56 (3), – 2022: – pp. 171–180. https://doi.org/10.15407/zoo2022.03.171 (In Ukraine).

Uzun E. E., Portyanko V. V. Shell crayfish (Crustacea, ostracoda) and harpacticoids (Crustacea, copepoda) in the waters of Cape Bolshoi Fountain in the Gulf of Odessa. Materials of the XI All –Ukrainian scientific and practical conference "Biological research – 2020" (21–23 February 2020), Zhytomyr. (In Russian).

Uzun, E.E., & Portianko, V.V. Evmeobentos crustaceans on a plastic garbage in the coastal part of the small fountain (Odesa Gulf, Black Sea)]. // Marine Ecological Journal, 2, – 2021: – pp. 83–92 (In Ukraine). https://doi.org/10.47143/1684 –1557/2021.2.08.

Uzunov J. Two new interstitial species from Bulgarian Black Sea littoral. // ZooL Inst, and Mus. Bulg. Acad. Sci. – 27, N 6. – 1974: – pp. 843 –845.

Uzunov J. Distribution of interstitial nematodes in the capillary horizon of some Bulgarian Black Sea beaches. // Hydrobiologia. – 15. 1977: 183 –191

Uzunov J. New data on interstitial nematodes from Bulgarian BL S. coastal with description of Camacolaimus pontolittoralis sp.n. // Acta zool. Bulg. 8. – 1978. – pp. 32 –37.

Vernadsky V.I. Biosphere – M.: Mill. – 1968: – 374 P. (In Russian).

Villora-Moreno S. Environmental heterogeneity and the biodiversity of interstitial polychaeta // Bull. marine sci. Vol. 60, No. 2. – 1997: – pp. 494–501.

Vinberg G.G. Advances in limnology and hydrobiological methods of monitoring the quality of inland waters// Scientific foundations for monitoring water quality using hydrobiological indicators. Proceedings of the All –Conscious Conf. (November 1 –3, 1978). M. – 1981. – pp. 16 –25.

Vincx M., Heip C. The use of meiobenthos in pollution monitoring studies. A revive// ICES CZ. /M. – – E/33. – 1987: pp.1 –18.

Vinogradov K.A. Issues of studying the "contact" zones of the sea. // Abstracts of reports, Interuniversity zoogeographical conf., September 26 –30, 1966, Odessa. – 1966: – pp.43 –45 (In Russian).

Vinogradov K.A. Biology of the northwestern part of the Black Sea. // Kyiv, Naukova dumka, – 1967: – 265 P. (In Russian).

Vinogradov K.A. Contact zones of the southern seas and some aspects of their ecological –geographical study // Questions of biooceanography, 2nd Int.oceanographic. congress. (Moscow, May 30 –June 7, 1966.– 1967: – pp. 159 – 160. (In Russian).

Vinogradov K.A. Contact zones of the southern seas// Biological problems of oceanogravi of the southern seas. Kyiv, Naukova dumka – 1968: – pp.45–49. (In Russian).

Vinogradov K.A. On the development of research in contact zones southern seas. // Biooceanographic studies of the southern seas. Proceedings of the jubilee session dedicated to the 50th anniversary of the October Social Revolution. Kyiv: Nakova Dumka, – 1969: – pp. 22 –31. (In Russian).

Vinogradov K.A. Contact zones of the southern seas of the USSR and related problems of use, reproduction and protection of biological resources. // Protection of fish stocks and increasing the productivity of water bodies in the southern zone of the USSR. Tater. Interuniversity meeting, Chisinau – 1969. – Chisinau, – 1970: – pp. 8 –9. (In Russian).

Vinogradov A.K., Bogatova Yu.I., Nesterova D.A. et al. The most important abiotic and biotic features of the Grigorievsky Estuary ecosystem // Ecosystem of the Grigorievsky (Maly Adzhalyk) Estuary // Scientific ed. Vinogradov A.K. – Odessa: Astroprint, – 2008: – pp.14 –18. (In Russian).

Vinogradov A.K., Bogatova Yu.I., Sinegub I.A. Ecosystems of the water areas of seaports of the Black Sea –Azov basin (Introduction to the ecology of seaports). – Odessa: Astroprint, – 2012 – 528 P. (In Russian).

Vorobyova L.V. The study of interstitial meiofauna. // Biologya moray. Issue 43, – Kiev, – 1977: – pp. 64 –67 (In Russian).

Vorobyova L. V. Quantitative characteristics of the meiobenthos of the northwestern part of the Black Sea in the spring / A. O. Kovalevsky Institute of Biology of the Southern Seas, Academy of Sciences of the Ukrainian SSR. Odessa. branch. – Odessa, – 1985: 33 P. – Dep. in VINITI 14.06.85, № 4214–85. (In Russian).

Vorobyova L.V. Meiobenthos of the Ukrainian Shelf of the Black and Azov Seas. – Kyiv: Nauk. Dumka, – 1999: – 300 P. (In Russian).

Vorobyova L.V. Meiobenthos as an object of biological monitoring of marine ecosystems // Global system of observations of the Black Sea: fundamental aspects. Sevastopol, – 2000: – pp. 360 –366. (In Russian)

Vorobyova L.V. Meiobenthos of the Black Sea (an essay on the history of study) // Hydrobiological Journal. No. 3. – 2002. – pp. 99 –111. (In Russian)

Vorobyova L.V. Ecosystem of Grigorievsky (Small Adzhalyk) Estuary – Odessa – 2008 –264 P.

Vorobyova L.V. Features of the spatial distribution of meiobenthos in the contact zone "river – sea" (Danube River, Black Sea) // Proc. 3rd Int. Conf. "Problems of studying the marginal structures of biocenoses", October 2 –4, Saratov, – 2012: – pp. 39 –42. (In Russian).

Vorobyova L.V. Foraminifera. // Odessa region of the Black Sea: hydrobiology of the pelagial and benthal], Odessa, “Astropint”, – 2017: – pp. 108 – 117. (In Russian).

Vorobyova L.V. The role of environmental factors in the formation of temporary meiofauna in the Odessa Sea Region of the Black Sea] // Scientific notes of Ternopil National Pedagogical University Ser. Biol. no.81 (1–2). – 2021: – pp. 39 –46. (In Russian).

Vorobyova L.V. Influence of abiotic factors on the abundance of Foraminifera in the Odessa Sea Region (Black Sea) // J. Black Sea/Mediterranean Environment, no. 27(1) – 2021 – pp. 66 –77.

Vorobyova L.V. Meiofauna of various biotopes of the upper sublittoral of the Odessa Bay. // Marine Ecological Journal. 1 –2 – 2022: – pp.108 –115.

Vorobyova L.V., Bolshakov V. N. Meiobenthos of the black sea under anomalous climatic conditions // Marine Ecological Journal, № 1–2. – 2023: – pp.23 –32. (DOI 10.47143/1684 –1557/2023.1 –2.3)

Vorobyova L.V., Bondarenko A.S. Polychaetes as a component of meiobenthos (Black Sea, northwestern part) // Ecological safety of coastal and shelf zones and integrated use of shelf resources. – Sevastopol, – Issue. 15. – 2007: – pp. 473 –481 (In Russian).

Vorobyova L.V., Bondarenko O. S. Meiobenthic bristle worms (Polychaeta) of the western Black Sea shelf // Journal of the Black Sea/Mediterranean Environment, Volume 15. Number 2/3, – 2009: – pp.109 – 121.

Vorobyova L.V., Bondarenko O.S., Oksana S., Izaak O. Meiobenthos polychaetes in the northwestern Black Sea // Oceanological and Hydrobiological Studies. – Vol. XXXVII, No.1. – 2008: – pp. 1 –13. (In Russian).

Vorobyova L.V., Garkavaya G.P., Nesterova D.A. et al. Zhebryanskaya Bay as a model of environmental processes in impact zones of the northwestern part of the Black Sea // Studies of the shelf zone of the Azov –Black Sea basin. Sevastopol: MGI NAS of Ukraine, – 1995: – pp. 44 –54. (In Russian).

Vorobyova L.V., Izaak O.S. Characteristics of the meiobenthos of the northwestern part of the Black Sea in winter // "Ecol. safety of coastal and shelf zones". – 2007. Issue 15. – pp. 465 –473. (In Russian*).*

Vorobyova L.V., Kovtun O.A., Kulakova I.I., Garlitskaya L.A., Bondarenko A.S., Rybalko A.A. Marine invertebrates of underwater caves and coastal grottoes of the Tarkhankut Peninsula (Western Crimea) // Bulletin of the Odessa National University. Series. Biolog.Vol. 17, issue. 1/2. – 2012: – pp.

Vorobyova L.V., Kulakova, I.I. On Some Distribution Patterns of Interstitial Meiofauna // Hydrobiological Research in Ukraine in the 11th Five –Year Plan. Abstracts of the Ukrainian Branch of the VSBO, Kyiv, – 1987 – pp. 23 –25. (In Russian).

Vorobyova L.V., Kulakova I.I. On Some Distribution Patterns of Interstitial Meiofauna in the Area of Coastal Protection Structures on the Odessa Coast // Abstracts of the Conference "Geographical and Economic Problems of Development of the Southern Seas of the USSR", May, Rostov –on –Don. – 1987 – pp. 129 –130. (In Russian).

Vorobyova L.V., Kulakova I.I. Sandy Sea beaches – the contact zone of the soil and the marine fauna // soil fauna and soil fertility: Sat. Materials of the 9th Int. colloquium on soil zoology (Moscow, 15 –17 August. 1985. – Moscow: Nauka. – 1987: – pp. 519 –520. (In Russian).

Vorobyova L.V., Kulakova I.I. Spatial distribution of Acarina in the interstitial of sandy beaches // In –t biol. of the southern seas im. A.O. Kovalevsky of the Academy of Sciences of the Ukrainian SSR. Odessa branch. Odessa, – 1988: – 24 Dep. in VINITI 06.09.88, No. 6865 –B88. (In Russian).

Vorobyova L.V., Kulakova I.I. Spatial distribution of the meiobenthos of the Azov Sea // On the state of the ecosystem of the Azov Sea. – Odessa, – 1989: – pp.100 –130. Dep. to VINITI 08.02.89, No. 859 –B89. (In Russian).

Vorobyova L.V., Kulakova I.I. Composition and spatial distribution of Nematoda and Copepoda (Harpacticoida) in the Sea of Azov // Hydrobiol. journal. Vol. 26, No. 2. – 1990.– pp. 11 –16. (In Russian).

Vorobyova L.V., Kulakova I.I. Quantitative characteristics of the meiobenthos of the northwestern part of the Black Sea – Odessa; Mayak. – 1991: 62 P. (In Russian).

Vorobyova L.V., I.I. Kulakova. Spate –temporal variability of the meiobenthos of the Zhebriyanskaya Bay // Ecosystem of the coastal area of the Ukrainian Danube Delta. – Odessa: Astroprint, – 1998: – pp. 238–249. (In Russian).

Vorobyova L.V., Kulakova I.I. Spatio –temporal variability of the meiobenthos of Zhebriyanskaya Bay // Ecosystem of the coastal region of the Ukrainian Danube Delta – Odessa, – 1998 – pp. 245 –262. (In Russian).

Vorobyova L.V., Kulakova I.I. Current state of meiobenthos in the western part of the Black Sea // Scientific notes of Ternopil ped. un. –tu. Series: Biology. Specialist. issue "Hydrobiology". No. 4(27). – 2005: – pp. 36 –38. (In Russian).

Vorobyova L.V, Kulakova I.I. Contemporary state of the meiobenthos in the western Black Sea, Odessa: Astroprint. – 2009. – 126 P. (In Russian).

Vorobyova L.V., Kulakova I.I. Free living marine nematodes of the coastal zone area ntar the snake island jf the Ukrainian shelf of the Black Sea // Scientific Issue Ternopil Volodymyr Hnatiuk National Pedagogical University. Series: Biology, Vol 75, No 1 – 2019 – pp.1 –17. (In Russian).

Vorobyova L.V., Kulakova I.I., Bondarenko A.S., Portyanko V.V. Contact zones of the Black Sea: Meiofauna of the lithocontour of the northwestern shelf. Odessa. «Astroprint». – 2017: 194 P.

Vorobyova L.V., Kulakova I.I., Bondarenko A. S., Portyanko V. V. Contact zones of the Black Sea: meiofauna of the lithocontour of the northwestern shelf [monograph]. Odessa: "Feniks", – 2019: – 196 P. (In Russian).

Vorobyova L.V., Kulakova I.I., Bondarenko A.S., Portyanko V.V. Polychaeta. // Contact zones of the Black Sea: meiofauna of the lithocontour of the northwestern part of the Black Sea. Odessa. Astroprint. – 2019: – pp. 160 –165). (In Russian).

Vorobyova L.V., Kulakova I.I., Bondarenko A.S., Portyanko V.V. Meiofauna of the periphyton of a natural rocky substrate (Odessa Bay, Black Sea) // Marine Ecological Journal, – 2020: – pp. 14 –21. (In Russian).

Vorobyova L.V., Kulakova I.I., Bondarenko A. S., Portyanko V.V., Uzun E.E. Meiofauna of the periphytal of the Odessa coast // J. Black Sea Mediterranean Environment, Vol. 22, no. 1. – 2016: – pp. 60–73. (In Russian).

Vorobyova L.V., Kulakova, I.I., Garlitska L.A. The current state of meiobenthos in front of the mouth of the Danube in the conditions of construction of the navigable canal // Proceedings of the Congress of the Hydroecological Society of Ukraine (September 7 –10, 2010, Zhytomyr) Scientific notes of Ternopil National University. Pedagogical University. Series: Biology. Special issue: Hydroecology, № 2, – 2010: – pp. 68 –71. (In Russian).

Vorobyova L.V., Kulakova I.I., Garlitska L.A. Meiobenthos of the Ukrainian part of the Danube coast under the conditions of construction of a shipping canal // Marine Ecological Journal. Vol. 11, No. 3, – 2012. – pp. 33 –40. (In Russian).

Vorobyova L.V., Kulakova I.I., Portyanko V.V. Meiobenthos as a food source for young fish of the bottom and benthic complexes of the flood –water part of the Black Sea // Materials of the VII International Conference "Modern fishery and environmental problems of the Azov –Black Sea region" June 20 –23, Kerch, – 2012 – pp. 126 –132. (In Russian).

Vorobyova L.V., Kulakova I.I., Sinegub I.A. et al. Odessa region of the Black Sea: hydrobiology of the pelagial and benthal] Odessa, "Astropint", – 2017) – pp.108 –117. (In Russian).

Vorobyova L.V., Kulakova I.I., Sinyogub I.O. et al. Meiobenthos of the area of the Ukrainian Antarctic station "Akademik Vernadsky" // Bulletin of the Ukrainian Antarctic Center. Kiev: Ukr. Ant. Center, – 1998. – pp. 191 –197. (In Russian).

Vorobyova L.V., Kulakova I.I., Sinegub I.A., Bondarenko O.S., Kudrenko S.A., Ribalko O.O. (2024). Current status of meiofauna and macrofauna in the periphyton of coastal hydrotechnical spores of the Odessa coast of the Black Sea // Marine Ecological Journal No. 1 –2. 2024. – pp. 15 –25. DOI: 10.47143/1684 –1557/2024.1 –2.2.

Vorobyova L.V., Kulakova I.I., Uzun E. Meiofauna of the periphytal of the Odessa coast, Ukraine. // Journal Black Sea/Mediterranean Environment. V.22, 1., – 2016 – pp. 60 –73

Vorobyova L.V., Kulakova I.I., Yaroshenko N.A. Mites of the interstitial zone and biotopes of the upper sublittoral of the northwestern Black Sea // Abstracts of the III All –Union Conference on Theoretical and Applied Acarology, October 4 – 6, Tashkent, – 1976, – pp. 69 –70. (In Russian).

Vorobyova L.V., Polishchuk L.N., Nesterova D.A., Sinegub I.A., Kulakova I.I., Bondarenko A.S., Portyanko V.V., Kudrenko S.A., Rybalko A.A., Migas R.V., Snigireva A.A., Uzun E.E. Odessa region of the Black Sea: hydrobiology of the pelagic and bentali [monograph]. Odessa: Astroprint, – 2017: – 328 P. (In Russian).

Vorobyova L.V., Portyanko V.V. Harpacticoida (Crustacea, Copepoda) as a component of the meiobenthos of contour biotopes of the Odessa marine region. //

Proceedings of the Third International Scientific and Practical Conference "Biodiversity and Sustainable Development" (September 15–19, 2014) Simferopol, – 2014: – pp. 65–66. (In Russian).

Vorobyova L.V., Portyanko V.V. Harpacticoida (Crustacea, Copepoda) as a component of the meiobenthos of contour biotopes of the Odessa marine region. // Ecosystems, their optimization and protection. Simferopol, Issue 11(30). – 2014. – pp. 179–186. (In Russian).

Vorobyova L.V., Sinegub I.A. Macro – and meiobenthos of biocenoses of desalinated areas of the northwestern Black Sea // Odessa, – 1989: – 23 P, Dep. to VINITI 09.02.90, № 739 –B90. (In Russian).

Vorobyova L.V., Sinegub I.A. Anthropogenic biocenoses of hydraulic coastal protection structures and their impact on the coastal ecosystem // Abstracts of the first meeting of the Hydroecological Partnership of Ukraine, Kiev, – 1994: – p. 50. (In Russian).

Vorobyova L.V., Sinegub I.A. Structure and quantitative indicators of zoobenthos fouling of coastal protection structures off the coast of Odessa // Global Observing System of the Black Sea: Fundamental Aspects. Sevastopol, – 2000: – pp.132 –138. (In Russian).

Vorobyova L.V., Sinegub I.A., Kulakova I.I. Current state of macro – and meiobenthos of the Sukhoi Liman of the northern Black Sea region under anthropogenic impact // Odessa, – 1994: – 18 P. Dep. in VINITI 08.12.1994, № 2840–B94. (In Russian).

Vorobyova L.V., Sinegub I.A., Kulakova I.I., Garlitska L.A. Current state of zoobenthos of the Odessa Gulf / In –t of Biol. of the Southern Seas of the NAS of Ukraine, Odessa branch. – Odessa, – 1996: 57 – P. Dep. in VINITI 03/13/1996, No. 786–B96. (In Russian).

Vorobyova L.V., Sinegub I.A., Shurova N.M. Development and research of zoobenthos of the northwestern part of the Black Sea over a half –century period (1950 – 2000). Ecology of the sea. Issue 63 – 2003. – pp. 23 –29. (In Russian).

Vorobyova L.V., Torgonskaia, O.A. Energy characteristics of the meiobenthos of the Zhebriyan Bay. // Ecology of the seaside of the Ukrainian Danube delta. Odessa: Astroprint. – 1998. – pp. 275–289). (In Russian).

Vorobyova L.V., Yanko V.V. On the distribution of modern foraminifera in the northwestern Black Sea // Zool. Zh. Vol. 65, No. 8. – 1986. – pp. 1250 –1254. 1986. (In Russian).

Vorobyova L.V., Yanko V.V. Modern Foraminifera of the Azov Sea and the Kerch Strait // Ecology of the Sea, Issue 35. – 1990. – pp. 29 –34. (In Russian).

Vorobyova L.V., Yanko V.V. Foraminifera of the Bosphorus region of the Black Sea // Ecology of the Sea. Issue 39. – 1991. – pp. 47 –51. (In Russian).

Vorobyova L.V., Yaroshenko N.A. Marine mites (Halacaridae) of the northwestern part of the Black Sea // Hydrobiological journal. Vol. 15, issue 6. – 1979: – pp. 29 –33. (In Russian).

Vorobyova L.V., Yaroshenko N.N. Quantitative composition of Halacaridae of the Odessa Gulf and the Black Sea estuaries // Ibid. 18, No. 3. – 1982: – pp. 40 –43. (In Russian).

Vorobyova L.V., Zaitsev Yu.P., Kulakova I.I. Interstitial meiofauna sandy beaches of the Black Sea. Kyiv, Naukova dumka – 1992: – 192 P. (In Russian)

Warwick R.M. The influenct of temperature and salititi on energy partitioning in the marine nematoda Diplolaimelloides bruciei // Oecologia (Berl.) 51. – 1981: – pp. 318–325.

Warwick R.M. The nematode/copepodratio and its use in pollitionecology // Mar. Pollut/ Dull.,Vol. 12. – 1981: – pp. 329 –333.

Warwick R.M. A new method for detecting pollution effects on marine macrobenthic communities // Mar. Biol. V. 92. № 4. – 1986: – pp. 557–562.

Williams D. D. The brackish water hyporheic zone: invertebrate community structure across a novel ecotone. // Hydrobiologia. 51. – 2003: – pp. 153 –173.

Wilson C. The copepods of the Woods Hole region, Massachusets. // Bull. U.S. Nat. Mus. 2. 158. – 1932: – pp. 1 –635.

Wilson W. Herbert. Competition and predation in marine soft-sediment communities. Annual Review of Ecology and Systematics, 1990, – 221-241.

Yanko V.V., Troitskaya T.S. Late Quaternary Foraminifera of the Black Sea. / Moscow: Nauka, – 1987 – 111 P. (In Russian).

Yanko V.V., Vorobyova L.V. Modern Foraminifera of the Azov Sea and the Kerch Strait // Ecology of the Sea. – Issue 35. – 1990: – pp. 29 –34. (In Russian).

Yanko V.V. Vorobyova L.V. Foraminifera of the Bosphorus region of the Black Sea // Ecology of the sea, Issue 39. – 1991.– pp. 47 –51. (In Russian).

Yanko, V., Anmand M., Kaminski M. (1998) Morphological deformities of benthic Foraminiferal test in response to polution by heavy metals: implications for pollution monitoring. // Journal of Foraminiferal Research. – 28(3) – 1998: – pp. 177 –200.

*Yasuhara M., Yamazaki. and al..*Temporal changes jf jstracjde assemblsdges during the last 100 years/ // In sediment cores from Cjhirishima Bay. Japan. Yolozene , 13 – 2003 – pp. 527 –536.

Yasuhara M., Yamazaki. and al., The effect of long –term spatiotemporal variations in urbanization –induces eutrophication jn a dtnthic ecosystem/ Jdessa Bay/ // Limnoljgy and octanography, 52 – 2007 – pp. 1633 –1654/

Yingst J. Y. Patterns of microfaunal and meiofaunal abundance in marine sediments measured with adenosine triphosphate assay. // Mar. Boil. 47, N 1. – 1978: – pp. 41–54.

Zagorodnyuk I. Fauna of the caves of Ukraine // Ed.. – Kiev, – 2004: – 248 P. (In Russian).

Zagorovsky N.A., Rubinstein D. Materials for the system of biocenoses of the Odessa Gulf // Zap. o –va sel. khoz –va sout. Rossii. Issue 1. – 1916: – pp. 203–244. (In Russian).

Zaika V.E. Mechanisms of anthropogenic impact on the structure and functions of benthic ecosystems // Long –term changes in the zoobenthos of the Black Sea. – Kyiv: Nauk. dumka, – 1992: – pp. 226–233. (In Russian).

Zaika B.E., Zagorodnaya Yu.A., Kolesnikova E.A., Machkevsky V.K. et al. Marine diversity // Biodiversity of Crimea: assessment and conservation needs. Int. working seminar. November 1977. – Georgia, 1977. – pp. 62–66. (In Russian).

Zaitsev Yu. P. On the sustenance of the neuston biocenosis in the marine pelagic // Science. App. Department of Biol.st. – Odessa – 1960: – pp. 37-42. (In Russian).

Zaitsev Yu.P. Spawning specimens of anchovy and horse mackerel of the northwestern part of the Black Sea, identified using a new technique // Nauk. zap. Odessa biological station of the Academy of Sciences of the Ukrainian SSR. – Issue. 3. – 1961: – pp. 45–59. (In Russian).

Zaitsev Yu. P. Hyponeision // Biology of the north –western part of the Black Sea – Kyiv: Scientific opinion – 1967: – pp. 117 –125. (In Russian).

Zaitsev Yu. P. Marine Neustonology. – Kyiv – 1970 – 264 P. (In Russian)

Zaitsev Yu.P. The northwestern part of the Black Sea as an object of modern hydrobiological research // Biology of the sea, Kiev. – Issue. 43. – 1977: – pp. 3–6. (In Russian).

Zaitsev Yu. P. Current state and expected changes in the biology of the northwestern part of the Black Sea in connection with the protection and development of its resources // Study of biological resources and their protection in the southern seas. – Kyiv: Nauk. dumka, – 1977: – pp. 48 – 51. (In Russian).

Zaitsev Yu. P. Contour communities of seas and oceans. Fauna and hydrobiology of shelf zones of the Pacific Ocean // Proc. 14th Pacific Ocean Scientific Conference. Khabarovsk 1979, Vladivostok. Issue 4, – 1982 – pp. 51 –54 (In Russian).

Zaitsev Yu. P. Contourobionts in Ocean Monitoring. // Conturobionti in ocean monitoring) // Tr. Intl. Symposium – L., Gidrometizdat – 1985: – pp. 76 –83. (In Russian).

Zaitsev Yu. P. Marginal ecotones in ocean monitoring // Integrated global monitoring of the biosphere: Proc. of the 3rd Int. symposium, Tashkent, October 13 –20, L.: Gidrometeoizdat, – Vol. 3. – 1986: – pp. 33 –44. (In Russian).

Zaitsev Yu. P. Edge effect and its significance for marine ecosystems // Proc. report 5th Congress of the VSBO. – Kuibyshev, T. 1. – 1986: – pp. 80–81. (In Russian).

Zaitsev Yu. P. Konturobionty – the main "environmental target" in the marine ecosystem. // Proc. Reports. 3rd. Congress of the owls. oceanographers. L.: Gidrometeodates. – 1987: – pp. 11 – 13. (In Russian).

Zaitsev Yu. P. Ecological state of the shelf zone of the Black Sea off the coast of Ukraine // Hydrobiological journal. – 28, No. 4. – 1992: – pp. 3–14. (In Russian).

Zaitsev, Yu. P. The most blue in the world. – New York – 1998: – 142 P. (In Russian).

Zaitsev Yu. P. Littoral concentration of life in the Black Sea area and coastal management requirements // J. Black Sea/Mediterranean Environment. Vol.12. – 2006: – pp. 113 – 128.

Zaitsev Yu .. Introduction to the ecology of the Black Sea. — Odessa: Even, – 2006: – 224 P. (In Russian).

Zaitsev Yu. Black Sea shores of Ukraine. – K.: Akademperiodika, – 2008: – 242 P. (In Russian).

Zaitsev, Yu.P. Microorganisms community of marine sandy beaches pore waters. Data and hypotheses. Microbiology and Biotechnology 2 – 2008 – pp. 8-19 (in Russian)

Zaitsev Yu. P. Regional effect in marine ecosystems // Scientific notes of the Ternopil National Pedagogical University named after Volodymyr Hnatyuk. Series: Biology. Special issue: Hydroecology – No. 3 (44). – 2010: – pp. 94 – 97. (In Russian).

Zaitsev Yu. A key role of sandy beaches in the marine environment. J. Black Sea/Mediter. Environ. 18(2). – 2012 – pp. 114–127.

Zaitsev Yu. P. On the contour structure of the hydrosphere // Hydrobiological journal, 1 Vol. 51, – 2015: – pp. 2 –28. (In Russian).

Zaitsev Yu.P. Aleksandrov B.G., Bogatova Yu.I. et al. Snake Island // In the book. "Northwestern part of the Black Sea: biology and ecology (1967 – 2003)" – K.: Naukova Dumka, – 2006: – 442 P. (In Russian).

Zaitsev Yu.P. Antsupova L.V., Vorobyova L.V. et al. Nematodes in the deep –water zone of the Black Sea // Dop. AN URSR, Ser. B. – No. 11. – 1987: – pp. 77 –79. (In Russian).

Zaitsev Yu.P. Garkavaya G.P., Nesterova D.A., Polischuk L.N. The Danube as the main source of eutrophication of the Black Sea // Hydrobiological journal. – 25, No. 4. – 1989: – pp. 21 – 23. (In Russian).

Zaitsev Yu.P., Polikarpov G.G. Ecological processes in critical zones of the Black Sea (synthesis of the results of two research areas from the mid –20th to the early 21st century // Marine ecol. journal. – 2002: – pp. 33—55. (In Russian).

Zelinka C. Demonstration der Tafeln der Echinoderes // Monographie Verh. Dt. Zool. Ges., 6 – 1896: – pp. 197 – 199.

Zelinka, C. Monographie der Echinodera. // WilhelmEngelmann. Lepzig – 1928: – 396 P.

Zenina M.I. Ostracodes as indicators of the state and dynamics of ecosystem waters (on the example of the northern part of Amur Bay and the waters of the port of Vladivostok) // abstract of Cand. Diss. – 2009: – 31 P. (In Russian).

Zenkevich L.A. Biology of the seas of the USSR. //M.: Publishing house of the USSR Academy of Sciences, – 1963: – 738 P. (In Russian).

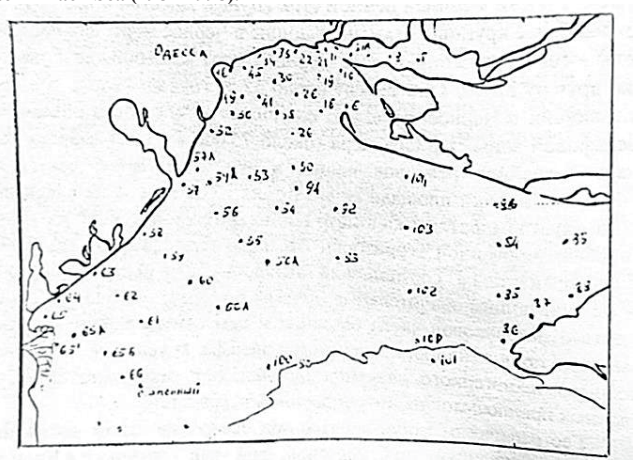
Zenkevich L.A., Filatov Z.A., Belyaev G.M., et al. Quantitative distribution of zoobenthos in the world ocean // Bulletin of the Moscow Islands of Naturalists. Separate Biol. 76, issue 3. – 1971 – pp. 186–187. (In Russian).

Zeppilli, D., Sarrazin, J., Leduc, D. et al. Is the meiofauna a good indicator for climate change and anthropogenic impacts // Mar Biodiv. 45. – 2015 – p.505. doi:10.1007/s12526 – 015 – 0359 –z

Zinn D.I. A brief consideration of the current terminology and sampling procedures used by investigators of marine interstitial fauna. // Trans. Amer. Mikrosc. Soc. 87. N2. – 1968: – pp. 219 – 226.

Maps of the main regular scientific expeditions for collecting meiobenthos samples.

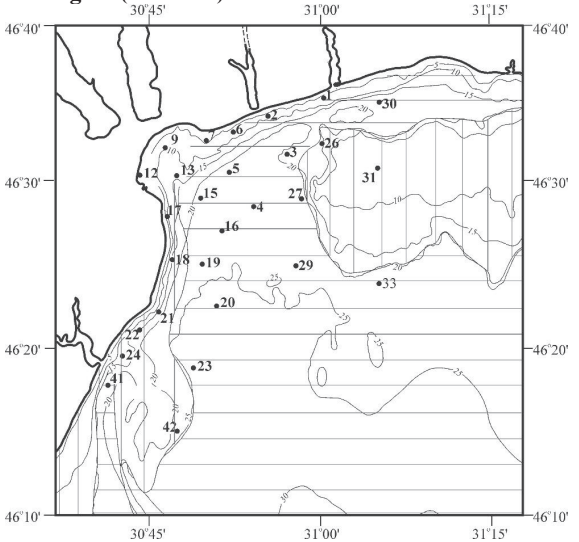
Northwestern Black Sea (1982-1998).



Sampling stations (station number)

No.	Latitude	Longitude	WD	Name of areas	No.	Latitude	Longitude	WD	Name of areas
2	N46°31’24”	E30°47’36”	9 m	Odessa area	44	N45°43’54”	E31°40’48”	28 m	Phyllophora Field
4	N46°33’30”	E31°00’00”	17 m	Odessa area	54	N45°34’54”	E31°33’54”	42 m	Phyllophora Field
5	N46°32’36”	E31°25’06”	6 m	Odessa area	40	N45°39’18”	E30°15’12”	18 m	Near Danube area
7	N46°30’42”	E30°45’18”	10 m	Odessa area	48	N45°29’18”	E29°52’06”	18 m	Near Danube area
10	N46°25’00”	E31°01’12”	18 m	Odessa area	49	N45°31’36”	E29°58’54”	21 m	Near Danube area
11	N46°23’30”	E31°00’00”	25 m	Odessa area	55	N45°20’06”	E29°50’00”	20 m	Near Danube area
12	N46°21’36”	E30°45’18”	18 m	Odessa area	62	N45°12’12”	E29°49’06”	20 m	Near Danube area
15	N46°20’00”	E31°14’54”	25 m	Odessa area	203	N45°20’30”	E30°11’06”	28 m	Zmeiniy Island
18	N46°17’48”	E30°41’24”	15 m	Odessa area	208	N45°15’18”	E30°07’06”	28 m	Zmeiniy Island
19	N46°12’06”	E30°48’42”	27 m	Odessa area	209	N45°15’54”	E30°11’06”	31 m	Zmeiniy Island
27	N45°55’27”	E30°50’18”	20 m	Phyllophora Field	210	N45°16’18”	E30°11’54”	31 m	Zmeiniy Island
28	N46°00’00”	E31°15’06”	27 m	Phyllophora Field	211	N45°15’54”	E30°14’06”	33 m	Zmeiniy Island
29	N46°00’00”	E30°30’00”	15 m	Phyllophora Field	212	N45°14’18”	E30°12’54”	35 m	Zmeiniy Island
36	N45°49’54”	E31°00’12”	24 m	Phyllophora Field	213	N45°15’06”	E30°15’00”	35 m	Zmeiniy Island
37	N45°50’00”	E31°29’00”	25 m	Phyllophora Field	214	N45°15’42”	E30°25’42”	38 m	Zmeiniy Island
43	N45°40’00”	E31°00’00”	27 m	Phyllophora Field	217	N45°10’06”	E30°11’30”	38 m	Zmeiniy Island

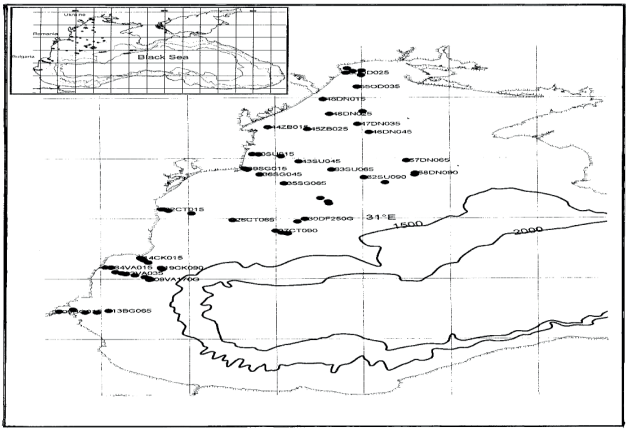
Odessa marine Region (1994-2018).



Coordinates of standard sampling stations in the Odessa maritime region from the vessel "Sprut".

№ станции	Координаты		Глубина, м
	N	E	
1	46° 34,80	31° 00,30	7
2	46° 33,70	30° 55,05	10-13
3	46° 32,10	30° 57,00	19-21
4	46° 28,60	30° 54,20	21-23
5	46° 30,90	30° 52,20	20-21
6	46° 32,80	30° 52,60	10-12
7	46° 32,20	30° 49,60	6-7
9	46° 31,85	30° 46,35	9
12	46° 30,30	30° 45,20	8-9
13	46° 30,90	30° 47,40	12-14
15	46° 29,10	30° 49,40	20-21
16	46° 27,30	30° 49,30	23
17	46° 28,10	30° 46,70	10
18	46° 25,80	30° 46,80	10-12
19	46° 25,00	30° 49,30	22-23
20	46° 22,60	30° 50,80	23-24
21	46° 22,30	30° 45,80	13-15
22	46° 21,80	30° 45,00	16
23	46° 18,90	30° 48,70	23-24
24	46° 19,50	30° 42,00	10-11
26	46° 32,64	31° 00,00	16-17
27	46° 29,10	30° 58,40	20
29	46° 25,00	30° 57,60	23-24
30	46° 35,00	31° 05,00	16-17
31	46° 30,80	31° 05,00	8-10
33	46° 24,00	31° 05,00	23-24
41	46° 17,80	30° 40,60	12
42	46° 15,00	30° 47,30	21

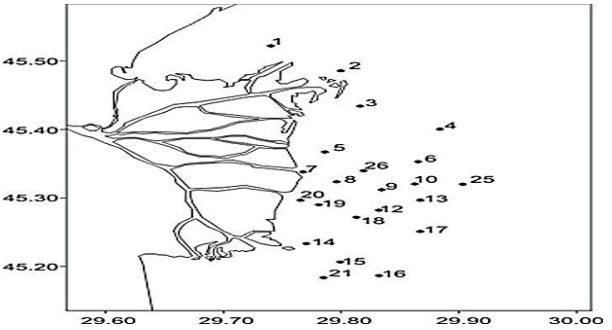
Western shelf of the Black Sea.



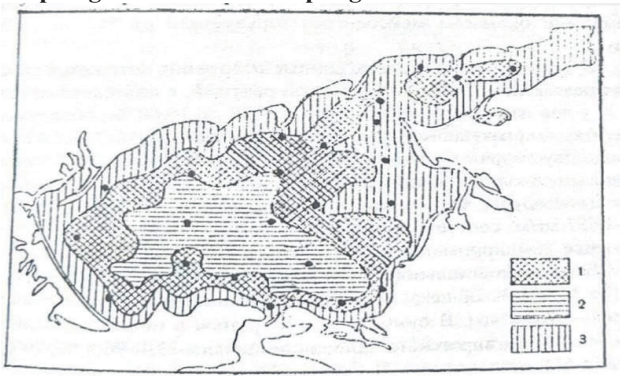
Sampling stations (station number, coordinates) in the western Black Sea

Station number	Coordinates		Station number	Coordinates	
	Latitude, N	Longitude,E		Latitude, N	Longitude,E
Varna Transect (VA)			35SG065	44°35'06"	30°05'81"
01VA015	43°12'24"	27°58'54"	34SG090	44°20'17"	30°30'85"
64VA020	43°11'58"	28°07'03"	33SG110	44°16'61"	30°36'15"
02VA025	43°07'06"	28°10'00"	32SG125	44°47'60"	30°36'75"
03VA035	43°05'88"	28°14'28"	Constantza Transect (CT)		
04VA045	43°05'03"	28°16'98"	22CT015	44°09'09"	28°41'68"
05VA065	43°03'81"	28°23'28"	23CT025	44°09'09"	28°47'78"
06VA090	43°02'00"	28°16'97"	24CT035	44°07'83"	28°46'23"
07VA110A	43°00'88"	28°32'64"	25CT045	44°05'07"	29°02'01"
08VA125	43°00'63"	28°33'11"	26CT065	43°58'22"	29°30'10"
Burgas Transect (BG)			27CT090	43°47'74"	29°59'78"
09BG015	42°27'93"	27°31'13"	28CT110	43°45'87"	30°03'98"
10BG025	42°27'90"	27°40'70"	29CT125	43°45'28"	30°07'38"
11BG035	42°26'98"	27°49'00"	Odessa Transect (OD)		
12BG045	42°27'00"	27°57'05"	50OD025	46°24'95"	30°49'19"
13BG065	42°28'60"	28°05'09"	54OD25	46°22'56"	30°59'61"
Cap Kaliakra Transect (CK)			55OD035	46°10'94"	30°56'32"
14CK015	43°20'96"	28°26'94"	Dnieper Transect (NE)		
15CK025	43°20'93"	28°27'60"	53NE015	46°27'25"	30°56'95"
16CK035	43°19'97"	28°27'91"	51NE025	46°29'58"	30°49'96"
17CK045	43°18'87"	28°29'15"	52NE025	46°26'61"	30°39'65"
18CK065	43°16'51"	28°32'35"	Zhebrian Bay Transect (ZB)		
19CK090	43°11'00"	28°41'00"	44ZB015	45°31'02"	29°54'90"
20CK110	43°09'80"	28°41'86"	45ZB025	45°29'10"	30°22'23"
Sulina Transect (SU)			Phyllophora field Transect (PH)		
40SU015	45°04'25"	29°44'05"	56PH025	45°47'77"	31°00'47"
41SU025	45°04'00"	29°48'31"	Dniester Transect (DN)		
42SU035	45°02'19"	30°03'81"	49DN015	45°58'71"	30°33'15"
43SU045	44°57'06"	30°16'05"	48DN025	45°44'26"	30°31'64"
63SU065	44°48'75"	30°38'59"	47DN035	45°34'07"	30°56'84"
62SU090	44°41'07"	31°00'82"	46DN045	45°25'99"	31°04'62"
Sf. Gheorghe Transect (SG)			57DN065	44°57'82"	31°30'02"
39SG015	44°49'82"	29°38'85"	58DN090	44°45'24"	31°35'93"
38SG025	44°49'41"	29°39'52"	59DN110	44°43'59"	31°35'49"
37SG035	44° 48'82"	29°40'40"	60DN125	44°42'74"	31°36'18"
36SG045	44°44'05"	29°49'01"			

Map of general area of sampling station in the Mouth of the Danube.



Map of general area of sampling station in the Azov Sea.



До 1973 року на північно-західному шельфі Чорного моря інформація про мейобентос як окрему категорію бентосних організмів була відсутня. Вперше для українського шельфу Чорного моря наведено списки видів основних груп мейобентосу (форамініфери, нематоди, гарпактикоїди, остракоди, кіноринхи, галакариди, поліхети). Описано особливості формування загальної чисельності та біомаси постійних і тимчасових компонентів мейобентосу на різних типах донного субстрату, вплив температури та кисневого режиму, описано довгострокову динаміку цих показників. У монографії вперше для Чорного моря представлено результати досліджень особливостей біорізноманіття та формування кількісних показників мейофауни в контурних біотопах контактних зон Чорного моря. Наведено приклади використання показників мейобентосу в моніторингу якості морського середовища різних акваторій українського шельфу.

Книга може бути корисною для гідробіологів, екологів, викладачів та студентів біологічних факультетів закладів вищої освіти.

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