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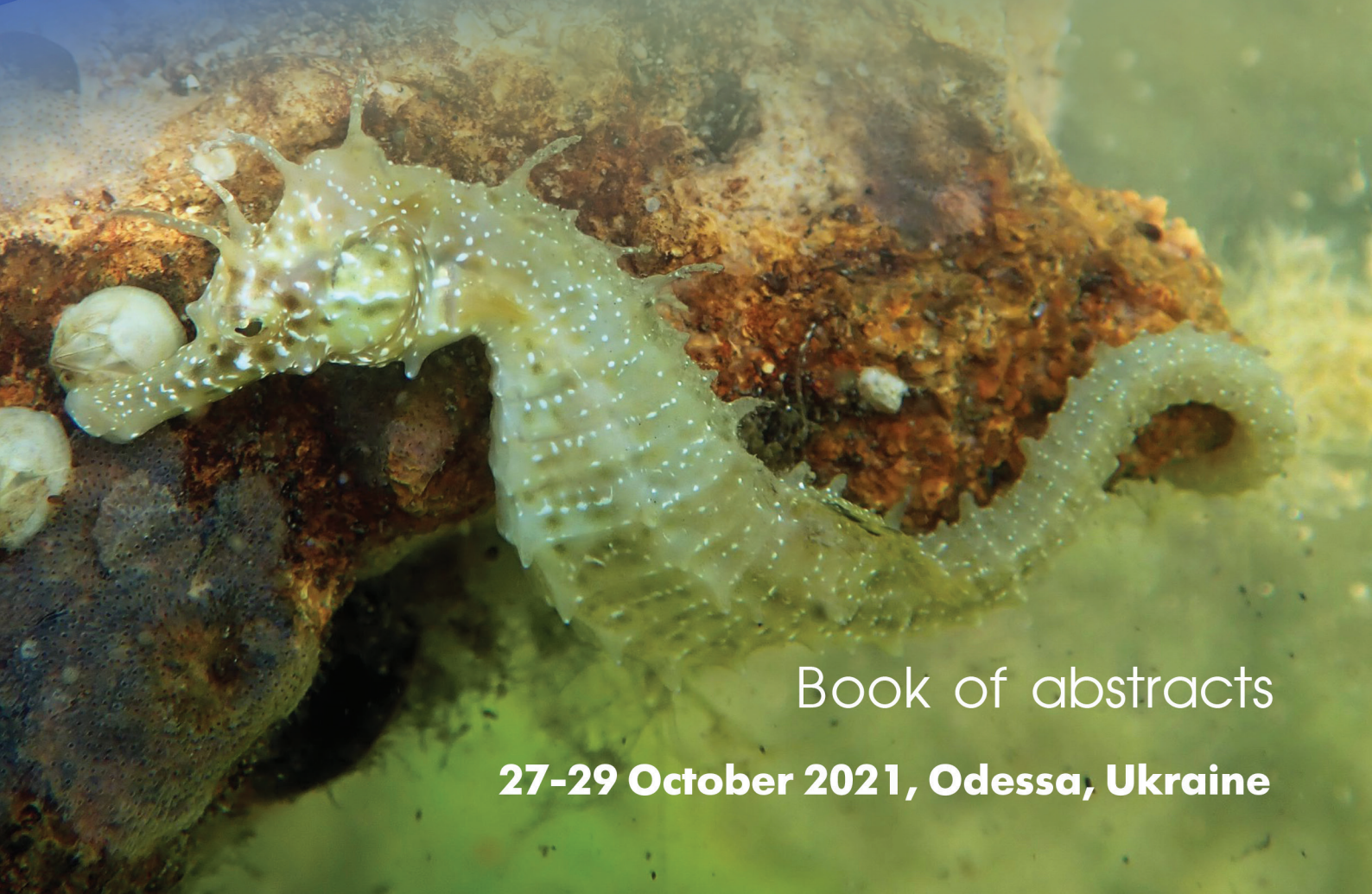
Marine ecosystems: research and innovations



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CONTENT

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RECENT TRENDS IN SIZE-FRACTIONATED PRIMARY PRODUCTION ALONG THE SOUTH-EASTERN BLACK SEA

In the present study, seasonal changes of size-fractioned primary production (picophytoplankton, <0.2-2µm; nanophytoplankton, 2-10 µm; microphytoplankton, >10 µm) were investigated along the south-eastern Black Sea from November 2014 to August 2015. Samplings were carried out seasonally from surface to 40 m depths with 10 m intervals at 12 stations. The rates of primary production (PP) were measured by a combination of 14C *in-situ* incubation experiments on natural phytoplankton assemblages.
C-14 experiments revealed that total PP ranged from 295 $mgCm^{-2}d^{-1}$ to 5931 $mgCm^{-2}d^{-1}$ along the stations. Size-fractionated PP ranged from 119 to 1848 $mgCm^{-2}d^{-1}$, from 96 to 3156 $mgCm^{-2}d^{-1}$ and from 73 to 3363 $mgCm^{-2}d^{-1}$ for pico-, nano- and microphytoplankton, respectively. In terms of season, the contribution of microphytoplankton and nanophytoplankton were prominent in spring. During summer and autumn, picophytoplankton and nanophytoplankton were characterised with high contribution of primary production. Overall, winter (4163 $mgCm^{-2}d^{-1}$) and spring (5931 $mgCm^{-2}d^{-1}$) were the most productive seasons, which coincided with high phytoplankton activity. In terms of stations, coastal stations had higher primary production rates.

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MICROPLASTICS IN THE COASTAL WATERS AND SEDIMENTS OF THE SOUTHERN BLACK SEA

Microplastic pollution is one of the fastest growing environmental problems in the Black Sea due to excessive river discharge of several industrialized countries into this semi-enclosed sea. In present study, microplastic pollution along the coastal waters of the Southern Black Sea was assessed during the research cruises of TUBITAK 118Y125 project between July 2019 and June 2020. Samples were collected at surface waters with a manta trawl, from several depths with Niskin bottles and from sediments with box core. Microplastic pollution was characterized using optical microscopy and FT-IR in terms of size, morphology and chemistry. Microplastic concentrations in surface waters were significantly higher in the river mouth stations. In surface waters, the primary shapes were fragments (46.8 %), followed by films (26.7 %), fibres (18.9 %), foams (7.4 %), beads (0.2 %) and pellets (0.01 %). Thirteen different colours of microplastics were detected in surface waters with the most common colour being transparent (32.3 %) followed by white (28.8 %), and blue (12.2 %). In the subsurface depths, the primary shapes were fibres (63.21%), followed by film (21 %), fragments (15.7 %), foam (0.13 %) and beads (0.05 %), no pellet was found. Microplastic concentrations at subsurface depths, reached up to 22 par.l^{-1}. An increasing MP concentration with depth was observed. The primary shapes in the sediment were fibers (51.5 %), followed by fragments (39.1 %), films (9.2 %) and beads (0.2%), no foam and pellet were found. Eleven different colours of microplastics were found in the sediment with blue being the most common colour (39.1 %) followed by red (17.9%) and transparent (15.6 %). Most microplastics were in the 1-2 mm size range in surface waters and 0.2-1 mm size range both in the subsurface depths and sediments, respectively. The FT-IR analysis confirmed that polyethylene and polypropylene were the most common polymers both at surface and sediment, and polyethylene terephthalate was the most common polymer in the subsurface depths. Results show that microplastics are present in all the matrices (surface, water column and sediment) of the Southern Black Sea, confirming that microplastic pollution is ubiquitous in the basin with potential adverse social, economic, ecological and health implications.

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RECREATIONAL AREA – A POTENTIAL SOURCE OF THE RESERVED WATER AREA POLLUTION

According to the zoning of the shelf of the Ukrainian sector of the north-western part of the Black Sea by hydrological and hydrochemical parameters (Northwestern part of the Black Sea: biology and ecology, 2006) the recreational zone of the village of Zaliznij Port of the Kherson region is located in the Central district and causes a significant anthropogenic influence on the state of the coastal and marine ecosystems of the district.
Recreational development of the village was carried out mainly in the period 1975-1990 without the development of projects for the development of its recreational area and had significant shortcomings. In the General Plan of the village of Zalizny Port (Rationale for the development of the recreational zone) in 2004, the total (maximum) capacity of the recreational zone was calculated at 28.0 thousand people staying per day. Even at that time, the existing treatment facilities could not cope with the significant volumes of domestic wastewater that needed treatment. According to the working project "Reconstruction of existing treatment facilities in the village of Zaliznij Port" (2007) estimated capacity of treatment facilities was 3500,0 $m^3 \cdot day^{-1}$.
Over the past 10 years, the recreational load has increased significantly, especially after the annexation of Crimea, when tourists who are accustomed to rest on the peninsula, chose the sea beaches of Kherson region. In May-August 2019, the coastal areas of the Kherson region visited by 1.7 million tourists (Sociology of Tourism. Who are our guests? 2019).
Today, according to the site http://gport.com.ua/ (date of the application 15.04.2021) there are 67 hotels, 190 boarding houses, 28 recreation centers, 31 apartments for vacationers, 108 recreation facilities in the private sector, 2 children's camps, 1 cottage for recreation exist in the territory of the Zaliznij Port along the Black Sea coast for almost 6.5 kilometers. There is no modern Master Plan, the treatment facilities are in unsatisfactory condition. Hundreds of thousands of people rest here every year. New recreation facilities are constantly being built, wild beaches are being expanded and unauthorized discharges of polluted water into the sea are taking place through primitive shallow ditches (own observations).
There is a tendency to increase the amount of household waste generated in the coastal zone. Significant amounts of municipal solid waste end up in the sea (especially in wild beaches). Protection zone of the Black Sea Biosphere Reserve near the village of Zaliznij Port 460 m wide in the season is completely filled with people and transport, in the off-season – mountains of garbage. Of course, both the protected area and the Tendra Spit feel the effects of pollution within the recreational area. Since 2000, on the protected coast from the Zaliznij Port to the border «Mors'kij» every year by the reserve staff, students, schoolchildren, volunteers, the traditional collection and removal of garbage carried by sea.
Most beaches are subject to engineering and improvement.
There is an urgent need to develop a regional strategy for waste management and extensive research in the coastal strip of the existing recreational area.

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TOWARDS THE IMPLEMENTATION OF EU'S REGULATION ON ALIEN INVASIVE SPECIES FROM THE BLACK SEA – THE BASELINE LIST AND INFORMATION ON MARINE ALIEN SPECIES FROM ROMANIA AND BULGARIA

The Black Sea is a unique and a fragile ecosystem characterised by low levels of biodiversity but by high values of biological productivity. Recent studies have shown that its biota is severely threatened by alien species. The Black Sea receives alien species from several donor regions and, due to its geographical position, the introduction and spread of alien species into the Black Sea is expected to be amplified because of climate changes. Accurate lists of alien species from EU countries that border the Black Sea are essential for implementing European policies, i.e., the EU Marine Strategy Framework Directive and the 1143/2014 Regulation on the prevention and management of the introduction and spread of invasive alien species. Although, alien species have been studied in the north-western part of the Black Sea, little is known about the alien species in its south-western part. Thus, there is a stringent need for comprehensive and validated lists of alien species from the Black Sea regions of Romania and Bulgaria. The aim of our study is to provide a comprehensive and validated list of alien species from the Romanian and Bulgarian marine waters. Furthermore, we propose to address the uncertainties associated with the identification, distribution, and introduction pathways of alien species into Bulgarian and Romanian marine waters. The validated list of alien species provided by our study comprise 34 species for the Romanian Black Sea region and 24 for the Bulgarian one. The best represented Phylum is Arthropoda (Crustacea) for both countries. Most of the alien species are established in both countries' marine regions, while the number of invasive species is higher in Romania (13 species) than in Bulgaria (8 species). The results indicated that over the last 50 years there was a steady increase in the number of introduced alien species in marine regions of both Romania and Bulgaria. In conclusion, this study provides supporting information for addressing marine alien species at national levels and for the implementation of EU's regulation towards an effective early warning, prevention and control of alien species in the western part of the Black Sea.

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DYNAMICS OF WATER SALINITY BY ALGAE BIOINDICATION AND STATISTICAL MAPPING IN THE LENA RIVER DELTA, LAPTEV SEA, RUSSIAN ARCTIC

The Lena River forms a vast delta, when it flows into the Laptev Sea, one of the largest in the world. The estuary area of the river with delta and the seaside section, is part of the Ust'-Lensky State Nature Reserve. The territory is located beyond the Arctic Circle in the zone of continuous permafrost. There are numerous channels of its delta. The river mouth area includes many small water bodies: lakes, streams, hollows, and swamps. The study of large river deltas ecosystems is of particular importance because of their role as natural "recorders" of global environmental changes. Special ecotonic communities of aquatic organisms are formed in this type of habitats that can play an essential role in maintaining these regions' biodiversity when large rivers flow into the sea in the mixing zone of the sea and fresh waters. The large-scale plans for the development of extractive industries have begun in recent years to be implemented in this Russian Arctic sector. In this regard, the study of biodiversity and the study of aquatic organisms' bioindication properties in the Lena River's estuary area is becoming more and more relevant. The use of bioindication methods for assessing the current state and trend of changes in the aquatic ecosystems of the delta in the light of the future development of oil production remains very important, since they give an integral idea of the change in the basic indicators of the environment. This cannot be done by chemical analysis of water, since the delta area remains inaccessible. One of the important aspects of the methods of bioindication and statistical mapping we use is the visualization of not only chemical, but also biological results. This will help oil producers and environmentalists understand each other more easily. This study aimed to identify the species composition of algae in lotic and lentic water bodies of the Lena River delta and use their indicators property about water salinity. It was trace indicator species distribution over the delta and their dynamics along the delta's main watercourses to assess the impact of river waters on coastal sea sections of the Laptev Sea. For this, all previously published materials on algae and the chemical composition of the region's waters were involved, and data obtained for the waters of the lower Lena reach in recent years. The available materials of field observations were analyzed using several statistical methods. The study results indicate that hydrological conditions are the main factor regulating the spatial structure of the species composition of algal communities in the Lena delta. The distribution of groups of salinity indicators across flowing water bodies reflects the effect of water salinity. It allows suggesting possible sources of this influence. The mechanism of tracking the distribution of indicators itself is a sensitive method that reveals even subtle changes in environmental indicators. Therefore, as an integral method, bioindication can be helpful for further monitoring together with statistical mapping as the visualization integrative instrument.

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THE SPATIO-TEMPORAL PATTERN OF THE MESOZOOPLANKTON COMMUNITY FROM THE ROMANIAN BLACK SEA WATERS

Mesozooplankton samples were collected from the Romanian Black Sea waters, in the warm season of 2018-2020, within the national monitoring network, network which covers all three marine reporting units according to the Marine Strategy Framework Directive (variable salinity, coastal and marine). In 2018 two expeditions were carried out, one in July and one in September, in 2019 one expedition was made in August and in 2020 one in June. The qualitative composition of the mesozooplankton population showed variations, the highest number of species being recorded in 2019 and 2020 and the lowest in September 2018. Copepods dominated as number of species over the entire analysed period, with the maximum value in 2019 and 2020, being followed by species of Cladocera and by the meroplanktonic component. The fodder component of the mesozooplankton community was dominant, *Noctiluca scintillans* which represents the nonfodder component recording lower density and biomass values. Within the fodder component, represented by Copepoda, Cladocera, meroplankton and other groups, Copepoda was best represented from the quantitative point of view. For the mesozooplankton community, three indicators were established in order to assess the marine environmental status, in accordance with MSFD: mesozooplankton biomass, copepods biomass and *Noctiluca scintillans* biomass. The evaluation for the ecological status was made taking into consideration the marine reporting units appropriate to MSFD, in warm season. In July 2018, the good ecological status was recorded for copepods and mesozooplankton biomass indicators, in all three marine reporting units. Exception was *Noctiluca scintillans* biomass in coastal waters, where the poor ecological status prevailed, the other two marine reporting units recording values for good ecological status. In September 2018 the good ecological status for the analyzed indicators prevailed, except for the copepod's biomass in marine waters. In 2019, copepods biomass and *Noctiluca scintillans* biomass reached good ecological status in all three marine units. Mesozooplankton biomas indicator reached good ecological status only in the coastal and marine waters, in waters with variable salinity recording values for Non-GES. In 2020, the indicators copepods biomass and mesozooplankton biomass recorded values for poor ecological status. *Noctiluca scintillans* biomass has reached good ecological status in waters with variable salinity and marine waters, coastal waters being characterized by a poor ecological status.

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AZOV SEA BASIN – PROBLEMS AND PROSPECTS

The Azov Sea is an exceptional object in several aspects at once. This sea is an almost isolated shelf sea surrounded by a fertile steppe. The Azov Sea belongs to the system of the Mediterranean Sea of the Atlantic Ocean, in the southern part, it connects with the Black Sea through the shallow Kerch Strait. The geographic border of the Azov Sea is located between the extreme points: 47 ° 17′ north latitude. and 39 ° 49'E. in the northeast at the top of the Taganrog Strait, 39 ° 18 'east longitude in the west (Arabat Bay) and in the south of the Kerch Strait (45 ° 17'N) between Cape Takil and Panagia. According to the latest research (Krylenko V.V., Krylenko M.V., Aleinikov A.A., 2019), the total length of the shores of the Azov Sea is 3,430 km, the total area is 40,570 km2. The length of the shores and the area of the Azov Sea excluding isolated objects (bays and estuaries) is 2,100 km, the area is 38,095 km^2. The average sea depth is 7.4 m, the maximum depth in the center of the sea is 14.4 m. The greatest length of the Azov Sea – the line the spit Arabatskaya Strelka - the Don Delta is 380 km, the greatest width along the meridian between the peaks of Temryuk and Belosaraisky bays is 200 km. The small size of the sea, shallow depths, a clearly expressed continentality of the climate with its characteristic uneven moisture, together provide rich biological productivity of the basin. Under the conditions of such a climate, the Azov Sea has a number of specific features: a large inflow of solar radiation, which provides a relatively high water temperature, the nature of the atmospheric circulation, which determines the intensive wind mixing of waters, a large inflow of river waters enriched with nutrients relative to the volume of the sea, which causes a positive fresh balance, about three times lower than in ocean waters, salinity and a high concentration of biogenic salts (Matishov G.G., Gargopa Yu.M., Berdnikov S.V., Jenyuk S.L., 2006).

At the same time, there are several problems in the Azov Sea basin. The first is overfishing and poaching. The second problem is pollution. On the shelf of the Azov Sea, the oil deposit "Novoe" is being developed in the southeastern part of the Azov Sea. Also, the state of the waters is affected by intensive shipping and the work of large ports on the territory of the Azov Sea. Many problems are caused by provides activities of metallurgical plants in Mariupol. The river flows of the Don and Kuban (the largest rivers flowing into the Azov Sea) have recently become more and more polluted and bring a large amount of nutrients into the sea along with smaller rivers. Intense recreational human activities add biogenic pollution. The third major problem is siltation with isthmuses to limans, bays, and estuaries of the Azov Sea, as well as erosion of the coastline.

Due to climate changes (an increase in air temperature and a decrease in precipitation), the hydrological conditions of the Azov Sea also change, with an increase in the need for irrigation of fields on the coast, the amount of river water inflow decreases, and with a decrease in precipitation and an increase in water evaporation, the sea level as whole decreases and increases gradually its salinity, which can globally affect the biodiversity of waters. In addition, an increase in water temperature leads to a decrease in the amount of dissolved oxygen in water, which also negatively affects the condition of its inhabitants. Another problem is the penetration of invasive species into the water area of the Azov Sea.

Thus, we see that when studying the prospects for the development of the Azov Sea, taking into account the whole complex of factors, it is necessary to draw conclusions that in the near future, if we are not do something to protect and restore the state of the waters a sharp loss of biodiversity, a decrease in productivity, a change in the state of waters and even a drastic decrease in surface area is possible.

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ALITTA SUCCINEA (LEUCKART, 1847) (ANNELIDA: POLYCHAETA) IN THE UKRAINIAN PART OF THE DANUBE NEARSHORE AREA

The Danube nearshore area is one of the most eutrophed regions of the northwestern part of the Black Sea. It embraces the influence of river runoff. The transformation of river waters into sea ones takes place in this area.

One of the most abundant representatives of benthic invertebrates in this area is the euryhaline polychaete *Alitta succinea* (Leucart, 1847). It lives in mussel drusen, on sandy-shell, silty-sandy and silty soils in the coastal part of bays, gulfs and estuaries (Kiseleva, 2004). At the Danube nearshore area, this polychaete is abundant both on soft bottom (Bondarenko, 2011) and on hard substrates, in the fouling community of hydraulic structures (Gillet et al., 2010).

The paper analyzes long-term data (2004–2019) collected in the depth range of 3.8–25.2 m on various types of soft bottoms. In the study area, silts are present at all depths, a sandy substrate is found at a shallow depth, a silted shell – mainly in the seaward part. To establish the significance of individual factors (type of substrate, salinity (S ‰) and temperature (t, ºC) of the near-bottom water layer) in changes in the abundance and biomass of *A. succinea*, multivariate analysis of variance (ANOVA) was used. The role of each factor was assessed while excluding the influence of other analyzed parameters.

A. succinea in the study area is presented in the structure of several benthic communities. It is also the leading species of *A. succinea* and *A. succinea+H. filiformis* communities, making the abundance and biomass in them respectively: 436·ind.·m^{-2} and 16.640 g·m^{-2}, 580 ind.·m^{-2} and 13.523 g·m^{-2}.

The distribution of *A. succinea* abundance over depth coincides with the zones that were differentiated according to the formation of bottom sediments and the quality of pore solutions. Their chemical composition reflects the processes of interaction between river and sea waters (Garkavaya, Bogatova, 2007). *A. succinea* developed maximally in the depth range of 10.1–15.0 m and 15.1–20 m (374 ind.·m^{-2}, 9.385 g·m^{-2} and 406 ind.·m^{-2}, 10.075 g·m^{-2}, respectively), reducing their abundance at greater depths.

Analysis of variance showed that the abundance of *A. succinea* was significantly influenced by the type of substrate ($F = 3.23$; $p = 0.0231$) and salinity ($F = 4.97$; $p = 0.0007$), and the biomass was influenced by the type of substrate ($F = 4.49$; $p = 0.0162$), salinity ($F = 2.56$; $p = 0.0278$) and temperature ($F = 4.41$; $p = 0.0018$).

The high values of abundance and biomass were recorded on silty substrates (silt – 223·m^{-2}, 6.874 g·m^{-2}; silted shell – 201 ind·m^{-2}, 3.236 g·m^{-2}), whereas these parameters were lower on sandy substrates (142 ind.·m^{-2}, 1.833 g·m^{-2}). The greatest fluctuations in the salinity were recorded in the bottom layer of water in the nearshore area of the river at a depth of up to 10 m. In different periods both fresh and sea waters were noted, with the salinity 16.8‰, at depths of more than 10 m – from 11.7 to 18.0‰. The highest average abundance of this polychaete (387 ind.·m^{-2}) is recorded in the salinity range of 10.0–12.0‰, the lowest – 16.0–18.0‰, the highest biomass (6.706 g·m^{-2}) is formed at salinity of 14.0–16.0‰. The temperature of the bottom water layer was statistically significant for the biomass of *A. succinea*. The highest average values of biomass were recorded at a temperature regime of 4.0–8.0ºC (7.794 g·m^{-2}). With an increase in temperature to 20.0ºC biomass slightly decreased to 5.268 g·m^{-2}. In the temperature range 20.1–24.0ºC the biomass of *A. succinea* decreased to 1.880 g·m^{-2} and it increased to 5.267 g·m^{-2} at temperatures above 24.0ºC.

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THE CURRENT STATE OF COMMERCIAL AQUATIC BIOLOGICAL RESOURCES AND FISHERIES IN THE NORTH-WESTERN PART OF THE BLACK SEA (NWBS)

In the second half of the twentieth century, the basis of the commercial catch of Ukraine in the Black Sea was made up of small pelagic fish species: anchovy, sprat, horse mackerel. They accounted for more than 50% of the total catch. The share of valuable fish species (mackerel, bonito, herring, sturgeon, turbot) was about 25%. In recent decades, the Black Sea ecosystem has undergone large-scale changes associated with increased anthropogenic impact and the introduction of a number of invasive species of living organisms. The introduction of the ctenophore *Mnemiopsis leidyi* and Rapa whelk had the greatest negative impact on the traditional commercial resources. Significant losses of fishing in Ukraine are also associated with the inability after 2014 to catch fish that migrate to the waters of the Crimea for the winter (anchovy, horse mackerel). Their catch outside the waters adjacent to the peninsula has never exceeded a few percent. Currently, Ukrainian fishermen fish only in the northwestern part of the Black Sea. After the massive reproduction of Rapa whelk in the NWBS, a further decrease in the stocks of the main commercial resources is observed. In these conditions, fishermen were forced to quickly switch to the catch of Rapa whelk. Its production in the NWBS over the past 5 years has grown more than 30 times, and now accounts for 70-80% of the total catch. At the same time, the share of small pelagic fish in the total catch decreased to 22%, and valuable fish species - to 1%.

The changes that have occurred under the influence of the Rapa whelk in the trophic webs of benthic biocenoses have practically not been studied. There is no doubt about the necessity of fishing for Rapa whelk as an aggressive predatory invader that negatively affects the ecosystem of the NWBS. However, the increase in the catch of Rapa whelk in recent years is due to the widespread use of dredges and beam trawls. These fishing gears pose a significant threat to benthic biocenoses. The issue of assessing the impact of the catch of Rapa whelk with dredges and beam trawls on the bottom communities in the NWBS requires an urgent comprehensive study for effective regulation of the fishery.

The main features of the fishing of aquatic biological resources in the NWBS in recent years.

1. The volumes of catch of traditional mass species of pelagic fish (sprat, anchovy, horse mackerel) are steadily decreasing. The catch of other fish species is carried out at an insignificant level.
2. The growth of landing in recent years has been achieved due to an increase in the catch of invertebrates, mainly Rapa whelk.
3. Fishing for Rapa whelk with dredges and beam trawls has a significant negative impact on bottom biocenoses.
4. A sign of negative ecological transformation in the NWBS ecosystem is the massive development of filamentous algae. The water is saturated with *Mnemiopsis leidyi* mucus and decaying organic matter. At the same time, the processes of self-purification of the sea are significantly inhibited due to the destruction of seston-feeding mollusks by Rapa whelk.

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EU INSTRUMENTS FOR THE BLACK SEA REGIONS

Policy regarding maritime borders, exclusive economic zones and marine shelves are an important element of the EU's strategy. The European Commission has identified 7 maritime regions near its borders: the Adriatic and the Ionian Sea, the Atlantic Ocean, the Arctic Ocean, the Baltic Sea, the Mediterranean, the North Sea, and the Black Sea.

The Black Sea accumulates many political tensions. In contrast with other regions, only in the Black Sea basin not all coastal countries were involved in the maritime spatial planning program. This example clearly shows that at the stage of implementation of any EU initiatives the successful ones are only in Bulgaria and Romania. In addition, the Black Sea is a politically unstable region.

In 2019 EU start Common maritime agenda for the Black Sea (CMA) which can offer successful answers to some of the specific problems in this basin. The CMA cover all Black Sea states: Russia, Bulgaria, Georgia, Moldova, Romania, Turkey and Ukraine.

CMA includes the full range of issues related to Black Sea activities (infrastructure, transport, ecology, tourism, aquaculture, fisheries, digitalization, etc.), except political and security issues. Exception of the policy matters is one of the reasons of mechanism' success. In addition, the European Commission has decided to separate the scientific component – SRIA.

Ukraine jointed this instrument in early 2019 but till the summer of 2020 Ukrainian steps were non-systematic. Only in the end of 2020 Ukraine defined the nationals' coordinators (Ministry of foreign affairs of Ukraine and Ministry of education and science of Ukraine), formed national team and the Ukrainian national hub under Black Sea Assistance Mechanism started its activity. For the first step Ukrainian stakeholders need to raise awareness on the opportunities presented by the blue economy in the Black Sea region for the upcoming EU funding possibilities for Ukraine to support their engagement in the CMA implementation at national level and regional level.

Talking about the EU financial instruments within CMA instrument we can figure out eight:

1. Neighbour development and international cooperation instrument (target on special priorities of cooperation during 2021-2027).
2. Interreg next Black Sea program 2021- 2027.
3. Horizon Europe.
4. Interregional innovation investment.
5. LIFE Program.
6. European Maritime and Fisheries Fund.
7. ERASMUS +.
8. TAIEX (Technical Assistance Information Exchange).

Some of these programs are not new for Ukrainian stakeholders, but common window for Black Sea related projects is in any case a big advantage.

The implementation of CMA and SRIA as an integrative tool to improve maritime governance could be noted positively, stressing the relation between marine activity in Black Sea and Blue Growth. Weaknesses CMA for Ukraine is in a lack of private risk funding for innovative maritime technologies, which is still hampering maritime innovation to get to the market in one hand and from another hand in lack of state support.

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MOLECULAR GENETIC STUDIES OF MUSSELS FOR USE IN AQUACULTURE

Mariculture of mussels (*Mytilus galloprovincialis* Lamarck, 1819) is an important branch of aquaculture for Black Sea region of Ukraine. The mussels are an important source of protein and farmed commercially in many countries (FAO, 2016; Ferreira & Bricker, 2016). It is necessary to identify species of mussels produced by aquaculture for labeling, traceability, food security and marketing purposes (Larraín et al., 2012, 2014). Molecular markers are often used for variety identification in aquaculture studies and could be applied at the individual or population level to solve taxonomic uncertainties and conservation of the genetic biodiversity.

We used molecular markers - microsatellites (MS) and *Me 15/16* primers, which amplify part of the unique region of the gene of adhesive protein, for analysis of mussels that were gathered from different locations with the aim to investigate genetic polymorphism between the samples.

Mussels were collected in the North part of the Black Sea: in the Gulf of Odesa (location A coordinates – N: 46°26'28" / E: 30°46'20"; location B – N: 30°43'44,9904" / E: 46°22'2,3376"; location D – N: 46,3393903 / E: 30,6606115; location E – N: 46,3763172 / E: 30,7519035) and near Snake Island - location C – N: 45°15'18" / E: 30°12'15".

Purification of genomic DNA was performed using CTAB method (Saghai-Maroof et al., 1984) and columns (CONGEN Biotechnologie GmbH, Germany). We used primers *Me 15/16* (Inoue et al., 1995) and primers for MS-loci: *Mch 5*, *Mch 8* (Ouagajjou et al., 2011) and *MT 203*, *MT 282* (Gardeström et al., 2007). The amplification fragments were fractionated by electrophoresis in polyacrylamide gels (7 %) and stained with $AgNO_3$, according to Promega, (1999). The size of the amplification fragments was defined using the program GelAnalyzer (http://gelanalyzer.com/index.html) according to the marker *pUC 19 / Msp I*.

The MS loci – *Mch 5*, *Mch 8*, *MT 203*, *MT 282* were analysed for mussels from the locations A, B, C. These markers turned out polymorphic and we revealed 48 alleles. The number of alleles per locus ranged from 8 (*Mch 5*) to 16 (*MT 203*). 45 mussels were analyzed at the *Mch 5* locus and 8 alleles were detected (PIC = 0.77). The MS locus *Mch 8* was characterized by a high level of polymorphism (PIC = 0.85), we detected 13 alleles among 53 studied mussels. At the *MT 203* locus 16 alleles were detected among 45 studied mussels (PIC = 0.81). At the *MT 282* locus 31 mussels were analyzed and 11 alleles were detected (PIC = 0.75). According to the results of MS-analysis the calculation of the PIC index showed that all the studied groups of mussels are highly polymorphic. Samples from locations A, B, C differed from each other in a number of alleles, which have mostly low frequency (0.02-0.1). The alleles that met with a high frequency (0.14-0.61) were common for samples from the A, B, C locations.

Inoue et al. (1995) have shown that combination of *Me 15/16* primers could be used for clear distinction of three species of mussels according to the lengths of amplification fragment: *M. edulis* (180 bp), *M. galloprovincialis* (126 bp) and *M. trossulus* (168 bp). In our work 96 mussels from A, B, C, D, E locations were analyzed by using *Me 15/16* and only the 126 bp allele was detected, therefore we revealed exclusively individuals of *M. galloprovincialis*.

Allelic characteristics at microsatellite loci provide an opportunity to characterize the selected genotypes with the highest adaptive potential that can be bred in aquaculture in some parts of the Black Sea.

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THE ROLE OF COASTAL UPWELLING IN THE BALTIC SEA ECOSYSTEM: FIRST INSIGHTS ON ITS EFFECT ON THE FISH ASSEMBLAGES AT THE SE BALTIC SEA COAST

Coastal upwelling, i.e., a phenomenon, when surface coastal waters are being pushed away from the coast and replaced by waters uplifted from the deeper layers to the surface, is influencing the entire environment from the biological processes to socio-economic activities. Upwelling induced changes in sea surface temperature (SST), salinity and nutrient concentrations are very closely linked to the functioning of the marine coastal ecosystem, and, in turn, can have a significant impact on primary production intensity and affect the entire food chain from zooplankton to fish, birds and marine mammals.

In the Baltic Sea, upwelling can be observed all along the coasts with a sustained wind in almost any direction. Under the presence of northerly winds, it is rather frequently observed at the South-Eastern (SE) Baltic coast. Bearing in mind that Baltic coastal waters are intensively used for regionally important commercial fishery, possible impacts of upwelling events might affect the fish community and, at the same time, can potentially impact fishing efficiency and commercial catches during certain upwelling periods.

Our aim here, therefore, is to better understand the importance of coastal upwelling on biological processes, and how it may affect fishing stocks, gillnet fishery and the reliability of fish community indices-based environmental monitoring. For this, coastal fishing efficiency due to short-term upwelling events was analysed coupling long-term (2000-2019) satellite SST data and scientific gill-net fish catch data from the Lithuanian Baltic coastal waters. Preliminary results indicate that upwelling might influence the diversity of the fish community, as during its events 1-2 main species are predominant, while before upwelling the fish community is more diverse. In addition, our results suggest that upwelling can influence the assessment of the ecological status of coastal waters. In 25-30 % of analysed cases, fish-based Good Environmental Status indicators established under Marine Strategy Framework Directive (MSFD 2008/56/EC) were influenced by the presence of upwelling and the environmental status has changed from what was observed before the upwelling event. This implies that if the fish community surveys are performed under monitoring programmes with temporally limited sampling and the evaluation of environmental status coincide with upwelling-impacted fish community, it may potentially lead to misinterpretation of environmental status of coastal waters.

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CHARACTERISTICS OF ANTHROPOGENIC TRANSFORMATION OF FISH COMMUNITIES IN THE SEA OF AZOV

The Sea of Azov, together with its rivers, estuaries and bays, is extremely valuable for the conservation and reproduction of many fish species. The system of lower riverbeds, river estuaries, lagoons, and coastal marine waterbodies has promoted the development of a unique fish community. The prosperity of ichthyocenoses was provided with the diversity of habitats that facilitated efficient spawning, fattening, and wintering. According to the estimates, the Sea of Azov and its adjacent waters support over 150 fish species, including such rare and endangered as beluga, Russian and starry sturgeons, sterlet, tub gurnard, etc. A significant number of species in the regional water bodies are endemic (Azov shemaya, stellate tadpole-goby, Azov percarina, etc.).

Fish populations, their number and distribution are determined by many factors, especially the availability of habitats for reproduction, fattening and wintering. Since the mid-20th century, Ukrainian river ecosystems, river estuaries, lagoons and sea bays have experienced significant anthropogenic transformations. The major anthropogenic factors that influenced the status of the fish populations are as follows:

1. *Hydraulic engineering in river basins.* Hydraulic engineering and intensive irrigation has led to dramatic transformation of most river basins in the region. This resulted in significant changes in the abundance of anadromous fish, which migration and reproduction were hampered by the construction of dams. Primarily, it affected the populations of sturgeons, sichel, vimba bream, freshwater bream, shemaya, roach, pike-perch, etc.
2. *Transformation of lagoons and sea bays*. Under the conditions of complex transformation of ecosystems for the "benefit" of the national economy, a significant number of estuaries and coastal sea bays that served as fattening and spawning areas for marine and anadromous species have been converted.
3. *Intense pollution of water areas*. The industrial development and growth in municipal wastewater, observed since the mid-20th century, have brought significant amounts of pollutants to natural water bodies, affecting water quality and deteriorating habitats of both freshwater and marine fish species.
4. *Intentional and accidental introduction of non-native species.* A significant number of non-native fish species (silver carp, grass carp, so-iuy mullet, Prussian carp, etc.) were introduced to increase the productivity of new water bodies (reservoirs, ponds, isolated marine bodies of water). Conversely, under the conditions of disturbed hydroecosystems, free ecological niches were filling with non-native species that accidentally penetrated the water bodies of the region (pumpkinseed, stone moroko, Chinese sleeper, etc.).
5. *Overexploitation of aquatic bioresources*. The use of aquatic bioresources and especially fish is a traditional form of nature management in the region. Unfortunately, between years, the overexploitation of commercial fish has led to significant overfishing and undermined the population of fish species (sturgeons, gobies, turbot, so-iuy mullet, pike-perch, etc.).

Thus, in the last 70 years, the Sea of Azov has experienced noticeable changes in the structure of fish communities, namely a significant reduction in the abundance of anadromous and semi-anadromous fish species (sturgeons, sichel, vimba bream, freshwater bream, shemaya, roach, pike-perch, etc.). Fattening and reproduction conditions for many marine fish species dramatically deteriorated, thereby affecting their number in water bodies of the region.

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DISTRIBUTION OF SALT WEDGE IN THE DNIEPER LOWER REACHES – RETROSPECTIVE AND CURRENT STATE

The inflow of salt water to the Dnieper mouth was observed even before the creation of the Dnieper reservoirs. This phenomenon occurred several times a year and lasted 5-15 days. Salt water penetrated mainly along the Rvach branch. For example, before the construction of the Kakhovka Reservoir the mineralization in the bottom layer of water near Kizomys village reached 15540 mg/dm^3. The concentration of chloride ions increased to 3000 and 4600 mg/dm^3 respectively in the water of the bottom layer near Kherson City and Kizomys village during the filling of the Kakhovka Reservoir and up to 4000–5000 mg/dm^3 near Kherson during the filling of the Kremenchuk Reservoir, when discharge was 300 m^3/s. Their concentration in the water near Kherson and Kizomys during 1968–1985 fluctuated in the range of 25.6–164.6 and 13.6–1600 mg/dm^3 respectively. Thus, salt water in this period did not reach Kherson City.

The range of saline water penetration into the Dnieper mouth after the construction of the Kakhovka Reservoir began to depend not only on the wind surges, but also on the releases of the Kakhovka hydroelectric power plant (HPP). According to the current Rules of the Dnieper Reservoirs Operation the sanitary release is 500 m^3/s. It should prevent salinization of the lower reaches of the Dnieper River, but does not have sufficient scientific substantiation.

The model (nomogram) (Timchenko V.M., 2006) to determine the length of the salt wedge in the main riverbed depending on the initial salinity of water in the Dnieper-Bug estuary and discharges of the Dnieper was developed taking into account the data of long-term field observations and existing theoretical methods of calculation. According to this nomogram the probability of salt water penetration into the Dnieper by 10–30 km is insignificant under the guaranteed sanitary release (500 m^3/s) and normal hydrometeorological conditions.

To verify this model the field studies were conducted on the Dnieper River below Kherson City in the second half of June and early September 2018. According to the data of the Kakhovka HPP, the average discharge in both observation periods was about 500 m^3/s.

During the first and second expeditions the inflow of salt water to the lower reaches of the Dnieper was established. In the first case it did not reach Kherson City, and in the second – penetrated into the water column near the Kherson City, but only for a few hours and it was displaced by fresh water masses during the release of the Kakhovka HPP. The upper border of the salt wedge in June was at a depth of 5.5 and 7.5 m respectively in Kizomys village and Dniprovske village. The maximum values of water mineralization were observed in the bottom layer and were about 4550 and 4280 mg/dm^3 respectively. In the period preceding this measurement the south-western wind prevailed, which contributed to the spread of the wind surge from the estuary. During the second expedition, the water mineralization in the bottom layer near the Kherson City reached 3560 mg/dm^3, but a few hours after the start of the release on Kakhovka HPP it decreased to 1100 mg/dm^3. The upper border of the salt wedge in September in the Rvach and Bakay arms was at a depth of 0.5 m, near Dniprovske village and Kherson City – at a depths of 4.0 and 6.5 m respectively. The maximum value of water mineralization in the Rvach arm was 7020 mg/dm^3 during our studies.

Thus we can conclude that now the probability and scale of the salt wedge penetration in the lower reaches of the Dnieper River has increased significantly compared to the 60-80s of last century, and existing models need to be refined on the basis of empirical data taking into account specific hydrometeorological conditions.

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PRELIMINARY ASSESSMENT OF CONTAMINANTS FROM KILIA BRANCH OF THE DANUBE TO THE BLACK SEA

The Danube River accounts for more than 60% of the river's inflow into the Black Sea, and more than 35% of the inflow of all freshwater into it, including precipitation (Levashova et al., 2004).
On average, the Danube River annually brings about 200 km^3 of water to the sea. The Kilia Branch is separated from the Danube in the Reni area. In 1990, 70% of the Danube water entered the Kilia Branch, in 1957 – 62.5%, in 1985 – 58.7%, and in 1999 – only 55.6%. Thus, the trend determines a sensitive decrease in runoff by an average of 0.173% per year during the 20th century (Lihosha, 2004). Calculations for 2005, 2010 and 2015 show the share of the runoff of the Kiliya Branch, equal to 51.2%, 49.8% and 48.3% of the total flow of the Danube respectively (Morozov, Mikhailov, 2004).
If the current trend in the redistribution of water flow between the Kilia and Tulcea branches of the Danube River continues, the following formula can be used (Morozov, Mikhailov, 2004):

$Q_{k,\%} = 8 \cdot 10^{-6}(t - 1850)^3 - 0{,}004(t - 1850)^2 + 0{,}3625(t - 1850) + 60$, where

$Q_{k,\%}$ – percentage of the total flow of the Danube to the Kilia Branch; t – is the number of the year.

With a decrease in the amount of water that passes through the Kiliya Branch of the Danube River, the concentration of pollutants increases, because the number of pollution sources located in the catchment area remains the same.
Long-term monitoring of the Danube seaside showed that annually from the Kilia Branch to the Black Sea on average come the following amounts of dissolved forms of heavy metals: 289.06 kg of copper, 692.39 kg of zinc, 142.03 kg of nickel and 26.68 kg of cadmium, and in suspended form 780.13 kg of copper, 2306.15 kg of zinc, 526.18 kg of nickel and 37.44 kg of cadmium.
The total amount of pollutants entering the sea every year was as follows: 1,059.18 kg of copper, 2998.57 kg of zinc, 668.40 kg of nickel, 63.10 kg of cadmium, 8.64 tons of oil products and 5.74 tons of suspended matter.
According to the Environmental Monitoring and Evaluation Program (2001), soils in many European countries are contaminated with mercury. The largest area of soils contaminated with this extremely dangerous metal in the Danube basin is observed in Romania and Slovakia. The main source of soil pollution with mercury is the activity of gold mining facilities. Thus, in 2000, cyanides and heavy metals were dumped into the Danube from one of these facilities (Kilia part…, 2001).
Research carried out by the Institute of Marine Biology of the NAS of Ukraine showed that mercury was present in bottom sediments at all monitoring stations of the Danube - Black Sea ship channal, in quantities that exceed the EU Target value (TV) for bottom sediments.
At the seaside of the Kiliya Branch of the Danube, the average mercury content was 3.10 ± 0.01 $\mu g \cdot g^{-1}$ dw, the range is 0.05–9.92 $\mu g \cdot g^{-1}$ dw. Two peaks of the mercury content occurred at the exit from the Novostambulskiy Branch of the Danube (8.85 $\mu g \cdot g^{-1}$ dw, exceeding TV 29.5 times) and at the exit from the Starostambulskiy Branch (9.92 $\mu g \cdot g^{-1}$ dw, exceeding TV 33 times).
Due to its high water content, the Danube has a noticeable impact on the entire northwestern part of the Black Sea. In the Odessa region of the Black Sea, mercury was found at 70% of the stations. The average mercury content here was 2.20 ± 0.05 $\mu g \cdot g^{-1}$ dw, the range was 0.00–0.69 $\mu g \cdot g^{-1}$ dw. Since the total discharge of mercury from local sources (treatment facilities in Odessa, Chornomorsk and Pivdenyi, as well as drainage water in Odessa) is only 31.6 g per year, it is obvious that mercury was brought to the Odessa region of the Black Sea from the Danube.

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LONG-TERM POLLUTION OF THE REUT RIVER BASIN WITH HISTORIC-USE PESTICIDES DDT, DDT-METABOLITES (DDE, DDD) AND HCHS.

Historic-use pesticides found at the sites of former warehouses and the territories adjacent to them can be considered as an object of management (Preda, 2019). Information on the detection of historic-use pesticides in various territories, such as fields or gardens, comes regularly from different states. The authorities of the Singerei district provided two sites of the former warehouses of the villages of Bilicenii Vechi and Belicenii Noi and the adjacent territories for testing within the framework of a Technology Transfer project (Sidorenko, 2018–2019). The Singerei district, in particular, the villages of Bilicenii Vechi and Bilicenii Noi, is localized in a territory with a network of lakes and rivers, such as the Big, Middle, and Small Chuluk Rivers, which are feeders of the Reut River.

Studies on the spread of pollutants to a distance of 10–50 m from the borders of the former warehouses in Bilicenii Vechi showed the presence of the following pesticides. The first zone is directly the territory of the warehouse; the 1st contour of 5 m: the sum of the present pesticides: 0.147–12.608 mg/kg of DDT metabolites (DDT, DDE, DDD) and 0.026–0.463 mg/kg of HCH isomers (α-, β-, and γ-HCH); the 2nd contour of 50 m: the sum of the present pesticides: 0.124–4.357 mg/kg of DDT metabolites (DDT, DDE, DDD) and 0.054–0.780 mg/kg of HCH isomers (α-, β-, and γ-HCH).

This work is a continuation of studies on the distribution of pollutants on an area of 150 m, in particular, the bottom sediments of the Big Chuluk River (Bilicenii Vechi). Contaminated soil from two sites was sampled in accordance with ISO standard 15009-2-2018 and ISO standard 23909-2-2008. All analytical determinations of the persistent organic pollutant (POP) content in soil were conducted by gas chromatography using an Agilent Technologies 6890N gas chromatograph coupled to an Agilent Technologies 5973 mass-spectrometer equipped with an Agilent Technologies 1530N split/splitless autoinjector, a 30 m × 0.25 mm × 0.25 μm HP-5MS capillary column, and ECD (microelectron-capture detector). In this paper, DDTs refer to the sum of concentrations of all DDT metabolites (DDT, DDE, DDD) and HCHs refer to the sum of concentrations of HCH isomers (α-, β-, and γ-HCH). The studies showed the presence of the following pesticides: the 3rd contour of 150 m: the sum of the present pesticides: 0.353–2.321 mg/kg of DDT metabolites (DDT, DDE, DDD) and 0.053–0.866 mg/kg of HCH isomers (α-, β-, and γ-HCH); the 4th contour: the sum of the present pesticides: 0.001–0.003 mg/kg of DDT metabolites (DDT, DDE, DDD).

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OXIDATIVE STRESS BIOMARKERS IN FISH AS BIOLOGICAL RESPONSES TO MARINE POLLUTION AND MICROPLASTICS

Modern life results in continuous impact of different pollutants to aquatic ecosystems, of which marine plastic is considered as global environmental problem. According to United Nations, 30% of marine fish contained microplastics in their tissues, which consequently can lead to gut blockages, reduced energy budgets or starvation and toxic effects (Rochman et al., 2019). Our research was conducted in Croatia, in the Southern Adriatic Sea near the Port of Ploče and Neretva River mouth, known by the pollution impact of harbor activities, agricultural runoff and tourism. Three fish species, *Mullus barbatus* Linnaeus, 1758, *Merluccius merluccius* Linnaeus, 1758, *Pagellus erythrinus* Linnaeus, 1758, were used as bioindicators of contaminant exposure by measurement of oxidative stress biomarkers in muscle tissue, comparing fish from nearshore and offshore area. Oxidative stress is a commonly observed response to microplastic impact, but also to metal and organic exposure (Qiao et al., 2019). Our goal was to compare different biomarkers in native fish as indication of oxidative stress (malondialdehyde, MDA and glutathione, GSH), organic and metal exposure (acetylcholinesterase, AChE) and general stress (total proteins, TP). Results showed that 10% of the total trawl catch contained waste, mostly plastic. Isolation of microplastics from the fish gut content confirmed its presence in almost all selected individuals. Although Adriatic Sea was reported as the third location in Europe by plastic waste abundance (Zeri et al., 2018), our results pointed that fish species still don't show significant differences in biological responses to oxidative stress or metal and organic exposure between nearshore and offshore area. But presence of microplastics in the gut content of sampled fish highlights the importance of continuous biomonitoring and assessment of plastic accumulation in marine environment and organisms.

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PHYTOPLANKTON'S CONTEMPORARY STATE OF THE KUIALNYTSKY ESTUARY IN CONDITIONS OF CONNECTION WITH THE BLACK SEA

Studies were conducted within the framework of project "The impact of the launch of sea water from the Odessa Bay to the Kuialnytsky Estuary on the state of its living natural resources according to hydrochemical and hydrobiological indicators (2015 - 2020)". On December 24, 2014, the launch of seawater into the estuary began, which was carried out by gravity through a pipe with a diameter of 1 m, length 2 km, laid through the embankment and released into the sea to a depth of 5 m. Before the start of seawater launch, salinity in the estuary was about 300 ppt. In 2018, the salinity of the Kuialnytsky estuary fluctuated in the range of 140 - 290 ppt and about 380 ppt in 2020. The purpose of this work was to investigate the contemporary state of phytoplankton of the Kuialnytsky Estuary in the conditions of launching sea water from the Odessa Bay.

As a result of phytoplankton research in the Kuialnytsky estuary in 2015, *Dunaliella salina* (Dunal) Teodoresco "bloomed" throughout the period of sea water supply. At the same time, its abundance was only twice less than its maximum possible concentration - $40 \cdot 10^6$ cells $\cdot$ l^{-1} (Masyuk, 1973).

In 2016, during the sea water launch into the estuary due to the decrease in salinity, the green alga *D. salina* died with a decrease in its part of total phytoplankton biomass from 91.9 to 1.6 %. Quantitative indicators of phytoplankton in the central and northern part of the estuary were approximately in the same range of fluctuations of values as before the opening of the channel.

In January 2017 (the channel was functioning) in the area of seawater launch, the basis of phytoplankton biomass (97%) was formed by the dinophyte alga *Alexandrium ostenfeldii* (Paulsen) Balech & Tangen, which is known to be toxic (produces sansitoxin, spirolides, goniatoxins) (Jensen and Moestrup, 1997). In February, the largest biomass of microalgae (3752.77 mg $\cdot$ m^{-3}) was observed in the area of seawater launch. At this station there was a "bloom" of water ($1.34 \cdot 10^6$ cells $\cdot$ 1^{-1}) caused by diatom alga *Skeletonema costatum* (Greville) Cleve, and was intensive growthing of diatom algae *Melosira moniliformis* (O.F. Muller) C.Agardh, which is known to growth significantly in waters with high rates of organic pollution (Proshkina-Lavrenko, 1954; Kuzminova, Rudneva, 2005). The values of the abundance and biomass of these species of microalgae were in the estuary such as in the sea (*Alexandrium ostenfeldii*) and several times higher (*Skeletonema costatum*, *Melosira moniliformis*).

Thus, based on studies from 2015 to 2020, it was found that the launch of seawater into the Kuialnytsky Estuary has an ambiguous impact on the quantitative indicators of *Dunaliella salina*: the maximum biomass was in 2017, and the minimum – in 2018. In the average biomass of *D. salina* in 2018 (45.02 mg $\cdot$ m^{-3}) was 25 times less than in 2017 (1132.61 mg $\cdot$ m^{-3}), 4 times than in 2016 (176.96 mg $\cdot$ m^{-3}) and 11 times than in 2015 (485.48 mg $\cdot$ m^{-3}). It should be noted that in December 2020 the biomass of phytoplankton did not differ from 2018. In 2017, in the area of seawater launch, there was an intensive growth of marine phytoplankton species with the level of "water blooming" (*Skeletonema costatum*), such as toxic microalgae (*Alexandrium ostenfeldii*) and microalgae indicators of organic pollution (*Melosira moniliformis*). Therefore, further monitoring of the phytoplankton's state of the Kuyalnytsky estuary is necessary in the conditions of seawater launch.

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MAPPING OF FLOODED AREAS IN THE NEMUNAS RIVER DELTA USING REMOTE SENSING METHODS

Flooded areas in Nemunas River delta are dynamic and ever-changing environments, depending on weather, hydrology, and other conditions, such as river flow, precipitation, topography, soil, and land cover. Areas that are flooded for a long time can affect vegetation communities and types. Flooded areas can cause significant changes in physical processes, such as water flow and water evaporation in a river basin. In extreme situations, emission of methane gas (CH4) can occur from flooded areas. Due to these environmental traits, it is important to determine hotspots of flooded areas to assess the problem and find the solution for improvement of ecology in these type of areas.

In this study 3 drone flights were completed in two areas in Nemunas River delta (near Kintai village and Sakūčiai forest) during the period between 2019-2021. Images taken from drones were mosaicked using photogrammetry and used for the validation of flooded areas retrieval results from Synthetic Aperture Radar (SAR) images and supervised classification training. Flooded areas in the Nemunas River delta in Lithuania and Russia were investigated using SAR Sentinel-1. SAR image preparation and classification was done using Google Earth Engine. For flooded areas, the mapping was done using two different methods: Random Forest Classification and Change detection. With the Random Forest Classification method, it was possible to detect land, open water, and temporally flooded vegetation, while with the change detection method only open water could be separated from the land. Eventually, using change detection method, hotspots were compared with soil type, land cover, and topographical wetness index (TWI) data.

Hotspots analysis showed that most often flooded areas were found on the right bank of Nemunas River, which is part of Lithuania. The most common flooded areas were spotted around Sakūčiai forest, around Žalgiriai forest, and around Bundalai forest. The longest-lasting hotspots on soil were found on various sandy loams and clay loams, while the least lasting hotspots were found on gravely sand surfaces. The longest-lasting hotspots on land cover type were found in swamps in the Nemunas River delta while the least lasting hotspots were found on natural grasslands.

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BIOETHICAL ASPECTS OF HYDROBIONT RESEARCH

One of the foundations for the stability of aquatic ecosystems is the significant biodiversity of hydrobionts and the existence of multiple biotic relationships between them. Experimental methods are increasingly being adopted among the wide range of methods used to study these organisms. Experimental methods investigations usages are needed to receive results for the following, in particular: the passing in aquatic animals of physiological and biochemical processes, including those associated with the adaptation of organisms to environmental factors; the modeling the relationships between hydrobionts in ecosystems; development of biotesting with hydrobionts etc. This allows the use for scientific purposes of aquatic animals removed from their natural habitat. At the same time, it is particularly important to respect the world's generally accepted bioethical standards (Directive 2010/63/EU of the European Parliament and of the Council, 2010). The latter include, among other things, the search for alternatives to research with vertebrate animals, the reduction of experimental animal numbers, improvement of research protocols to minimize pain and suffering in experimental animals (European convention for the protection of vertebrate animals used for experimental and other scientific purposes, 1999; Russell, Burch, 1992). These provisions also apply to the taxon Cyclostomata representatives and the taxon Cephalopoda representatives, which correspond to a significant development of their cognitive functions (Directive 2010/63/EU of the European Parliament and of the Council, 2010). One of the ways to reduce the impact of a set of factors that cause stress in the body is to use in experiments instead of aquatic animals extracted directly from the natural environment, namely those aquatic animals that are purposefully grown in specialized nurseries. In selecting invertebrates for experimental studies, it is worth drawing attention to the results of studies of the taxon Decapoda representatives indicating their responses to factors, known to cause pain; for which reason the question of certain features in the scientific use of that animals become actual (Passantino A. et al., 2021). According to bioethics principles, research planning and implementation should focus especially on procedures that involve temporary immobilization, anesthesia or euthanasia of hydrobionts. The respective procedures should be planned, resourced and organized in such a way as to prevent stress in experimental animals, to minimize, and better to eliminate, pain, ensure the rapid and effective immobilization of these organisms, which should be preceded by their loss of "state of consciousness" (Close, 1997). In addition, because of the difficulty of monitoring the said state on the basis of data on the cognitive reactions of an animal, it is considered "conscious" to be the state in which the animal is able to perceive and respond adequately to external stimuli, and it is considered "unconsciousness» to be the state in which the animal is loses sensitivity to the corresponding stimuli. In order to provide medicinal anesthesia to aquatic animals, it is recommended to use techniques involving immersion of animals in aquatic environment with appropriate pharmacological agents (VMA Guidelines for the Euthanasia of Animals, 2013). If such anesthesia terminates, the "state of consciousness" can potentially be restored in animals. In view of the latter, respective studies should include procedures to ensure that animals are reactivated and returned to the nursery after the experiment is completed.

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THE RESULTS OF FIELD RESEARCH ON THE PLASTIC WASTE DISTRIBUTION WITHIN THE SURF ZONE OF THE BEACH IN THE CITY OF YUZHNE

The last half century has been marked by a number of significant negative changes in the environment state, among which one of the most dynamic and noticeable was the continuous accumulation of large amounts of waste from synthetic materials both on land and in water areas. Today, plastic waste and microplastics are recorded in different amounts in all major components of the world's oceans – water column, bottom sediments and many biological objects. At the same time, the receipts, composition and distribution dynamics of waste have significant regional differences, both globally and locally. This is due to the geographical characteristics of the waters and the surrounding land, the location and intensity of pollution sources.

The ecological condition of the Ukrainian sector of the Azov-Black Sea basin is sufficiently studied; however, data on the contamination degree with plastic waste is quite limited, which requires the formulation and conduct of appropriate research.

Literature data on the plastic waste and microplastics distribution in the waters show that beach areas can be considered one of the most indicative objects for determining the degree of pollution. This is determined by the factor of intensive separation and accumulation in the surf zone of substances that are in the thickness or on the surface of the water layer; and the social status of beach areas as active recreation areas, allows us to consider them as a primary source of plastic emissions into the environment.

The main research areas of the SSI "MariGeoEcoCenter NAS of Ukraine" are the study of various aspects of the marine environment pollution with plastic waste in Ukraine, the creation of an information base, primary systematization and determination of current research areas on this issue. During 2020, the Center's scientists developed an information base on this issue, mainly on the foreign literature sources basis, and conducted field research, which was limited to certain parts of the Black Sea coast of Ukraine.

In particular, field works were performed within the surf zone of the city beach of Yuzhne during the last summer period. The main purpose was to study the distribution peculiarities of microplastics in modern sand deposits and sea suspension of active recreation areas. Along with the process of natural material sampling, a visual assessment of the qualitative and quantitative plastic characteristics within the beach area of Yuzhne was carried out. The visual assessment results showed a small number of plastic fragments and the absence of large objects (large bottles, bags, fishing tackle, etc.). Approximate calculations show that in terms of the beach studied area, the plastic objects presence was one object per 50-70 m2 of territory. The qualitative composition of certain fragments mainly included synthetic fibers, bottle caps, plastic jewelry particles, food wrappers, and pieces of polyethylene.

Comparison of our data with the results of similar studies presented in the available literature sources indicates a low level of pollution of the Yuzhne beach area compared to some parts of the coast within the Mediterranean, North Atlantic and even the Bulgarian Black Sea sector. Electron microscopic analysis of the obtained samples also showed the absence of clearly identified fragments of microplastics in the composition of both the suspended matter in the surf zone and in the sand deposits of the beach.

Despite the fact that such research is still unsystematic and local, they allowed to gain practical experience, determine a certain arsenal of field research methods and get a preliminary idea of the contamination degree and quality of plastic waste in one of the most popular recreation areas within the coastal cities of Ukraine.

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MAIN CHARACTERISTICS OF THE BLACK SEA BOTTOM DEPOSITS IN VIEW OF THE NECESSITY FOR ASSESSMENT OF THE SUSTAINABILITY OF ITS GEO-ECOLOGICAL SYSTEM

Under the stability of the marine geological and ecological system (MGES) (Emelyanov, 2020) we understand the ability to maintain for a certain time and within a certain space the structure, properties and functions, which inherent in it and its subsystems, under active dynamic natural and anthropogenic influences. These influences, which cause various changes in the MGES, are mainly related to complex global processes occurring in the geoecological system of our planet under the influence of both its internal events and external, space events (Emelyanov, 2003). As a result of the synergy of these processes in time and space of the World Ocean and, in particular, the Black Sea, different levels of geological and other phenomena are observed. At the same time there are cyclic and rhythmic (mostly) changes in MGES, adjacent aquatic ecosystem (MAQES) and their subsystems, which depend, inter alia, on sea level fluctuations, cyclonic and upwelling circulation of MAQES aquatic environment, its structure, biogeochemical, hydrochemical, hydrophysical and other processes occurring in it.
The longterm research have confirmed that the natural endo- and exogeodynamic processes play a decisive role in the natural impact on MGES, because they are mainly associated with changes in sedimentation conditions and the existence of the biogenic component of MGES, its geochemical and diagenetic transformations, peculiarities of the morphology of the boundaries between the MGES and the adjacent MAQES, its changes, etc.
The authors propose a set of characteristics of the bottom sediments of the Black Sea, the knowledge of which allows to assess the stability of the MGES as a subsystem of the geoecosystem of the Black Sea by its zoning.

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ECOHYDROLOGICAL FEATURES OF THE ZHEBRIYANSKAYA BAY

Zhebriyanskaya Bay is a bay of the North-Western part of the Black Sea and borders on the Danube Delta. In the early 1980s, the port of Ust-Dunaisk was created in the corner of the bay and a connecting channel «Prorva-Zhebriyanskaya bay» was dug, the flow of which was three times higher than the natural inflow of Danube water into the bay along the Belogorodsky arm (Vorobyova, 1995). Until the mid-1990s, navigation in the river delta was carried out using this channel. After that, he became shallow and ceased to perform the function of the ship's passage. Now the Danube-Black Sea navigational route operates in the Bystroe arm and has a lesser impact on the state of the bay's ecosystem.

Among the ecohydrological factors, the dynamics of the Danube water inflow, fluctuations in the water level, hydrodynamic processes, hydrophysical and hydrochemical indicators, as well as the nature of the formation of bottom sediments are important for the functioning of the ecosystem of the bay and adjacent water bodies. All of them are interconnected to some extent. It should also be noted that the ecohydrological features of the bay affect the state of the ecosystem of the bays in the coastal part of the delta, and until the 1980-s, also on the Sasyk estuary-lake. It was the inflow of seawater through periodically formed gaps and penetrations that was the determining factor in the functioning of the ecosystem of this reservoir.

Long-term changes in water level are important for water exchange in the bays and Sasyk estuary-lake before its transformation into a reservoir, as well as for aquatic organisms living in shallow waters. The average level of the bay for a long-term measurement period (1951-2014, h/post «Primorskoe») was -0.19 m BS. At the same time, the minimum average annual value of -0.42 m BS was in 1954, and the maximum 0.17 m BS in 2010. In the same year, the maximum average water level for the month was 0.26 m BS. Average annual amplitudes of level fluctuations in the bay are 11-46 cm. They were maximum indicator in 1953, 1970 and 2011, minimum in 1987. Short-term changes in the water level affect the reshaping of the bottom topography, changes in the landscape features of sandy shores (barrows), the nature of bottom sediments and sedimentation processes, as well as the distribution of hydrophysical, hydrochemical indicators and hydrobionts, for example, phytoplankton, over the water area. So, according to the data of urgent measurements per day in the bay, the amplitude of the level could be 152 cm. Such significant fluctuations are the result of waves caused by the wind with a speed of more than 10 m/s. Such hydrodynamic activity, even once a year, can provoke the reshaping of the coast along its entire length.

Simultaneously, the long-term action of the southerly and southeasterly winds with a speed of up to 5 m/s can cause a surge of the Danube water in the bay. At the same time, due to insufficient turbulent mixing, river waters mix little with sea waters, which contributes to the formation of separate areas that differ in hydrophysical and hydrochemical indicators. During the summer period, the penetration of untransformed river waters, which reaches the end of the bay, can be observed several times. In turn, under the action of the east wind, sea waters can penetrate along the branches of the delta.

In addition to natural ecohydrological factors in the formation of the state of the Zhebriyanskaya Bay, the nature of the anthropogenic load is also important. These are, for example, an artificial redistribution of runoff along the Danube branches, pollution of river water, an increasing recreational load due to the lack of treatment facilities in the developing resort area of the v. Primorskoe. But in general, the most important remain the variability of meteorological and hydrological conditions for the functioning of the ecosystem of the bay.

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CONTACT INDICATORS FOR PROGNOSTIC CALCULATIONS OF REBUILDING OF THE MORPHOFUNCTIONAL ORGANIZATION OF THE BASIPHYTE-EPIPHYTE ALGOSYSTEM

The basiphyte-epiphyte algosystem is a new biological element for assessing and monitoring the ecological status of marine coastal ecosystems. The increased sensitivity of the algosystem to changes in the ecological state of water bodies is determined by the presence of components with alternative ecological activity – macro- and microepiphytes. The algosystem is characterized by high information content and representativeness, meets the requirements of the European Water Directives (WFD, 2000/60/EC, MSFD, 2008/56/EC) and is used in the quantitative assessment of anthropogenic impact on water bodies, which makes it possible to determine their ecological state. The current ecological status class of water bodies in the northwestern part of the Black Sea was determined and their ranking was carried out on the basis of the developed indicators of the algosystem – the coverage of the basiphyte with epiphytes ($P_{(b/e)}$, %) and the ratio of the surface of the basiphyte and the epiphyte (SI_b/SI_e, units) (Kalashnik, 2019).

The next step should be to predict the restructuring of the basiphyte-epiphyte algosystem depending on changes in environmental conditions (anthropogenic load, climatic anomalies), which affects the change in the rate of the autotrophic process. For the forecast, it is proposed to use contact indicators that reflect the state of the components of the algosystem under certain conditions. The restructuring of the components of the basiphyte-epiphyte algosystem is primarily manifested in a change in the ratio of components with alternative ecological activity, which is reflected in the average values of the specific surface area of the algosystem as a whole. It was found that with an increase in trophicity in the reservoir, finely branched and filamentous macrophytes with a high specific surface area begin to dominate (Minicheva, 1996), and the epiphytic component reacts with intensive quantitative development (Shcherbak, Semenyuk, 2011). Together with an increase in the specific surface area of basiphytes and the number of epiphytes, the values of their surface indices (SI) also increase. This morphofunctional indicator integrally reflects the state of different-sized components of the basiphyte-epiphyte algosystem under different environmental conditions. Since an increase in the trophicity of a water body leads to the predominance of a microcomponent, it is proposed to use *contribution of the epiphytic component* (C_e, %) as a contact indicator – the contribution to the surface of the algosystem of the epiphytic component, expressed as a percentage. The proposed indicator is calculated using the formula: $C_e = (SI_e/(SI_b+SI_e))\times 100\%$).

As a result of the research, it was found that in waters with increased trophicity (natural or anthropogenic), the contribution of the epiphytic highly functional component in the surface of the algosystem is from 50 to 95%.

Studies of the indicator basiphyte-epiphyte algosystem – the *contribution of the epiphytic component* (C_e, %) in water bodies with different anthropogenic load, as well as in different seasons of the year, have determined the possibility of using it as a contact indicator. It is expedient to use it to predict the restructuring of the components of the algosystem under the influence of anthropogenic (eutrophication) or natural (climatic anomalies) factors that accelerate or slow down the primary production process.

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STRUCTURAL-FUNCTIONAL ORGANIZATION OF CHAROPHYTES ASSOCIATED ZOOCENOSIS IN BAYS OF NORTH-WESTERN PART OF THE BLACK SEA

The Charophytes biocenosis is one of the key elements of benthos in shallow semi-enclosed mesogaline Black Sea bays (Korolesova, 2015). Zooperiphyton and macrophytes associated invertebrates are very important components of natural-aquatic complexes and widely used as bioindicators (Pligin et al., 2019; Goridchenko, 1981; Talskih, 1980). Taxonomical and ecological structure of macrophytes biocenosis in Northwestern Part of Black Sea is well studied, but traditionally heterotrophic and autotrophic components were considered separately (Makkaveeva, 1979; Makarov, Viter, 2018; Minicheva, 1993). In this work, we attempt to provide a comprehensive study of zoo- and phytocen.

Lamprothamnium papulosum and *Chara aculeolata* play role of the edificators in investigated biocenosis. Charophytes are macrophytes with a relatively low functional activity (values of the Specific Surface of the Population (S/Wp): 16 and 12 $m^{2}\cdot kg^{-1}$, respectively) (Minicheva, 1990) and complex thallus. The first species forms almost monospecific meadows on wide shallow waters (up to 1 m), the second grows in deeper water (up to 2 m) and dominates in complex multilevel phytocenoses.

For current investigation, macroinvertebrates of Charophytes biocenosis were collected in Tendrivska and Yagorlytska bays Black Sea Biosphere Reserve NASU during 2010-2016. It was identified 69 species of invertebrates, 2 – Actinaria, 1 – Polycladida, 9 – Bivalvia, 14 – Gastropoda, 1 – Anisopoda, 10 – Amphipoda, 2 – Cumacea, 3 – Isopoda, 1 – Cirripedia, 1 – Mysidacea, 1 – Decapoda, 20 – Polychaeta, 2 – Ascidia, 1 – Porifera, 1 – Chironomida. The zoocene is characterized by a high level of species diversity and low dominance (Shannon's index=4.44, Simpson's index=0.08).

Representatives of bottom epifauna and infauna predominate in the composition of invertebrates; less than half of species are topically associated with thalli of macrophytes. The zooperiphyton is dominated by crustaceans, bottom epifauna – by mollusks, infauna – by polychaetes. The dominant is *Mytilaster lineatus*. The average biomass of invertebrates in the zoocene is 88.67±14.60 $g\cdot m^{-2}$ (significantly lower than average for all aquatory), the number – 3811.08±520.38 $ind\cdot m^{-2}$ (not significantly differs from the average for all aquatory).

Analysis of the trophic structure with the population index for groups showed that the core of the zoocene is formed by filter feeders and herbivorous microphages. The value of the trophic structure homogeneity index (Nesis, 1965) – 0.36, indicating the absence of a clearly expressed dominance and the complexity of the trophic structure.

The P/B ratio, which characterizes the biomass turnover rate for studied zoocene (42.98), is significantly higher than the general one for macrozoobenthos of the bay (27.65). In the frame of Charophytes biocenosis, the zooperiphyton has higher biomass turnover rate than the bottom fauna.

Thus, it is shown that the zoocene of the Charophytes biocenosis has complex and diverse trophic structure and a high rate of biomass turnover due to the predominance of short-cycle species with relatively low values of individual weights. Such structural-functional organization of the zocene is a consequence of phytocenosis features, which cause the formation of a wide variety of microhabitats and ecological niches within its framework.

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HEAVY METALS IN BIOTA, WATER AND BOTTOM SEDIMENTS OF THE CONTACT WAVE-BREAK ZONE OF THE KHADZHIBEY ESTUARY (NORTHWESTERN PART OF THE BLACK SEA)

Contour biotopes are critical zones of the hydrosphere, which are the first to encounter anthropogenic impact; therefore, they can be used as biological indicators for integrated monitoring of the aquatic environment (Zaitsev, 1986).
Chronic contamination of contour biotopes with heavy metals leads to negative environmental consequences due to their high toxicity, constant presence, ability to accumulate in marine organisms and subsequent migration along food chains (Khristoforova, 1989).
The boundary surface of the «estuary – sandy shore» contour biotope (psammocontour) is characterized by intensive ecological activity of the components and is very vulnerable to technogenic load.
The aim of the study is to analyze heavy metals in the component of the aquatic environment (water and bottom sediments) of the psammocontour of the Khadzhibey Estuary, as well as to determine the accumulation of heavy metals in the mass form of invertebrates in the contact wave-break zone *Pontogammarus maeoticus* (Sowinsky, 1894).
The catch of crustaceans, water sample, bottom sediments were taken in calm weather in the surf zone of the central and southern parts of the estuary. The analysis of the total content of heavy metals in organisms and environmental components was carried out by the atomic absorption method.
The average concentrations of heavy metals in the components of the aquatic environment of the wave-break zone of the Khadzhibey Estuary are the following decreasing series: Zn>Cu>Cr>Ni>Cd> Hg (water); Cr>Zn>Cu>Ni>Cd>Hg (bottom sediments).
The highest values of the accumulation coefficient were found for copper, and the lowest for mercury. The indicators of the accumulation coefficient of *P. maeoticus* were distributed according to the degree of decreasing values: Cu>Zn>Cr>Cd>Ni>Hg.
The water area of the impact of wastewater discharge from the station of biological wastewater treatment «Severnaya» is the most polluted with heavy metals and in comparison with surface water. Bottom sediments and specific biota were revealed as concentrators of heavy metals.
The use of *P. maeoticus* as a biomonitor informatively corresponds to the degree of heavy metal pollution of continental brackish water bodies and allows one to assess their real environmental hazard in the area of greatest concentration.
The established patterns make it possible to consider *P. maeoticus* to be an effective concentrator of heavy metals, capable of reflecting the status of pollution and its dynamics in the «estuary - sandy shore» contour biotope. The results obtained confirm the importance of using hydrobionts of contour communities as ecological sentinels in assessing the quality of the aquatic environment of marine and coastal water bodies (Alexandrov, Zaitsev, 2016).
The quality of the aquatic environment in the wave-break zone of the Khadzhibey Estuary indicates a significant technogenic load. In bottom sediments and biota of the psammocontour there is an increased content of the gross content of heavy metals with respect to the aquatic environment.

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NEW AND RARE PROBOSCIS TURBELLARIAN SPECIES (PLATYHELMINTHES, KALYPTORHYNCHIA) FOR THE UKRAINIAN COAST OF THE BLACK SEA

In this study we are dealing with the suborder Kalyptorhynchia. This taxon was erected by L. von Graff in 1905 to combine flatworms with a proboscis, a unique, very specific frontal muscular organ that peculiar only to this group of free living turbellarians. We are using the term Turbellaria (or turbellarians) without the implication that it is a formal taxon.

The first record of Black Sea Kalyptorhynchia is from W. Uljanin (Uljanin, 1870), who described 5 species which were collected on algae in the Sevastopol bays. Following this description, accounts on turbellarians with a proboscis from the Black Sea are rather scarce. V. Czerniavsky (Czerniavsky, 1881) noted one species previously mentioned by W. Uljanin. S. Pereyaslawzewa (Pereyaslawzewa, 1992) recorded 5 species – three of them were new ones. L. von Graff in his marvelous work (Graff, 1905) described 4 new species and totally recorded 9 species of proboscis turbellarians from the coast of Sevastopol. Finally, W. N. Beklemischev (Beklemischev, 1927) described 4 species of Kalyptorhynchia from the Odessa Bay.

Thus, to date, 16 species of proboscis turbellarians have been recorded in the literature for the Ukrainian coast of the Black Sea. This list contains nine valid species: *Gyratrix hermaphroditus* Ehrenberg, 1831, *Itaipusa sophiae* (Graff, 1905), *Paulodora dolichocephala* (Pereyaslawzewa, 1892), *Polycystis naegelii* Kölliker, 1845, *Progyrator mamertinus* (Graff, 1874), *Rogneda minuta* Uljanin, 1870, *R. tripalmata* (Beklemischev, 1927), *Schizorhynchus tataricus* Graff, 1905, *Utelga spinosa* (Beklemischev, 1927), – and seven species have uncertain taxonomic position and waiting for future investigators to clear up this issue. These are the following species: *Acrorhynchides graciosus* (Uljanin, 1870), *A. reprobatus* (Pereyaslawsewa, 1892), *Acrorhynchus spiralis* (Pereyaslawzewa, 1892), *Leuconoplana ovata* (Uljanin, 1870), *Macrorhynchus bivittatus* (Uljanin, 1870), *Polycystis georgii* Graff, 1905, *P. intubata* Graff, 1905.

In 1987-1989 we carried out a study of acoelan turbellarians on the northwestern coast of the Black Sea. During this investigation, we studied other groups of Turbellaria (including Kalyptorhynchia) as accompanying species. Sketches were made on the basis of living material; permanent slides with Faure–Berlese's mounting medium were prepared. However, we did not prepare serial sections for accompanying species. Since no studies of proboscis turbellarians on the Ukrainian Black Sea coast have been carried out since 1927, we decided to analyze the available material, which, in our opinion, has a certain scientific value and will increase the knowledge about Kalyptorhynchia species of this region. Besides that, in June 2018, additional material was collected from the coast of the Odessa Bay.

As a result, we were able to recognize 17 species of proboscis turbellarians. Among them there are seven already known species: *G. hermaphroditus*, *I. sophiae*, *P. naegelii*, *P. intubata*, *P. mamertinus*, *R. minuta*, *R. tripalmata*, and *U. spinosa*. Five species are new for Ukraine. These are: *Cheliplana orthocirra* Ax, 1959, *C. vestibularis* de Beauchamp, 1927, *Cicerina eucentrota* Ax, 1959, *Proschizorhynchus gullmarensis* Karling, 1950 and *Baltoplana magna* Karling, 1949. With the exception of *C. eucentrota*, these species are also new for the Black Sea as a whole. We have not yet been able to identify five more species. Perhaps these species are new to science.

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LONG-TERM CHANGES OF BACTERIOPLANKTON IN THE NORTH-WESTERN PART OF THE BLACK SEA

Data of bacterioplankton studies in the north-western Black Sea (NWBS) for the 42 years' period (1979-2020) have been generalized. Extensive studies of bacterioplankton in the NWBS were performed in the 80th and early 90th of the past Century when eutrophication processes were reaching maximal intensity (Kovalova, Serman, 1994; Kovalova, 2003). Using of those data in the comparison with the results of current studies performed regularly since 2003 by the staff of the Regional Centre for Integrated Environmental Monitoring and Ecological Studies (Odesa National I.I. Mechnikov University) in the framework of integrated environmental monitoring programme of marine coastal waters of the Zmiinyi Island (Kovalova, 2008; Kovalova & Medinets, 2010; Konareva et al, 2015) helps us reveal the changes in the NWBS bacterioplankton that happen in this Century. Under the current conditions (2003-2020) average annual values of bacterial number varied from $1.2 \cdot 10^6$ to $2.0 \cdot 10^6$ cells·ml$^-$ and were 1.6 times lower than in the end of the past Century ($2.0 \cdot 10^6$ – $3.3 \cdot 10^6$ cells·ml$^-$, 1986-1995) when the highest level of eutrophication was observed in the NWBS. For the majority of years (83 %) positive correlation relationship (r=0.32-0.71) was established between the bacterial number and the chlorophyll *a* concentration, which indicated high influence of autochthonous vegetable organic matter (OM) on the quantitative changes in bacterioplankton. The closest negative relationship (from r= −0.45 to r= −0.91) was established between bacterioplankton and water salinity, which reflects the distribution in the sea of OM brought by rivers. According to the obtained empirical regression equation, the number of bacterioplankton within salinity values of 7.70-19.70 ‰ changed more than in 5 times. The number of bacteria, which corresponded to mesotrophic status of water $(0.78\text{-}1.88) \cdot 10^6$ cells·ml$^-$, was established at the salinity values of 14.25-19.39 ‰, while the highest bacterial number typical of eutrophic marine waters $(2.18\text{-}4.19) \cdot 10^6$ cells·ml$^-$ was registered at salinity of 13.72-7.86 ‰. The tendency of 40% decrease of the relative number of surface water samples, which corresponded to eutrophic waters in terms of bacterial number was established in 2003-2020 compared with 1990-1995. Under the current conditions (2003-2020) the most of the studied waters in the NWBS (80 %) corresponds to mesotrophic status.

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REGARDING COMPLEX METHODS OF ASSESSING THE STATE OF THE MARINE ENVIRONMENT

A universal method for assessing the level of trophicity of marine waters and generally accepted manuals for practical assessment do not exist to date. For each study on this problem, a subjective authors` approach prevails, that usually determines the choice of indicators and their number when calculating various environmental indices. Usually, the proposed assessment methods are limited with the number of measured hydrochemical and biological parameters and indicators of the marine environment. The most frequently recommended for scientific research and use in monitoring programs for the state of the natural marine environment is the calculated E-TRIX index and BEAST, which has been widely used in recent years.

E-TRIX is an integral indicator related to the characteristics of the primary production of phytoplankton and nutritional factors. In the calculation formula of the index E-TRIX is composed of the following indicators of ecosystem: the concentration of chlorophyll-a – analog, which replaces the index of phytoplankton autotrophic biomass; the deviation of oxygen saturation from 100% – an indicator of the primary production intensity of the system, which covers the phase of active photosynthesis and the phase of respiration predominance; the concentration of total phosphorus and mineral nitrogen-indicators of the nutrients presence.

The eutrophication assessment methodology (BEAST) was developed specifically for the Black Sea and is a modification of the eutrophication assessment methodology (HEAT) previously developed by the Helsinki Commission (HELCOM), essentially BEAST is identical to the HEAT 3.0 assessment methodology. Dimensionless water quality index (EQR) in this method characterizes the assessment of water quality relative to their trophicity and is determined by the ratio of the actual values of the observed parameters (denoted in the method as AcStat) to target values (Target), which are determined by background values that were previously before eutrophication period (denoted in the method as RefCon and correspond to GES) taking into account the permissible deviations from the background.

Within the framework of international projects Emblas I, Emblas II, Emblas-Plus, Anemone BSB165 and national monitoring, the trophicity of the Black Sea waters in the economic zone of Ukraine and open sea waters was assessed using the E-TRIX and BEAST methods, and the results were compared. In the period 2000-2019, the numerical values of the E-TRIX index showed a tendency to reduce the trophic level of coastal marine bodies and amounted to -0.51 per year. According to the BEAST quality indicator, as a result of the performed baseline assessment, the overall spatial structure of waters within the exclusive economic zone of Ukraine mostly corresponds to low and poor status.

In most regions, the results of the E-TRIX and BEAST assessments were the same, in some they differed significantly. The BEAST method includes more parameters in the assessment set and is more complete, it makes it possible to assess the entire water column. However, the assessment itself largely depends on the value of the reference values that the expert sets for each sea area and this significantly affects the final result of the assessment.

When conducting monitoring, it is advisable to continue using several complex methods, not excluding E-TRIX, since the results of the assessment by this method depend only on the quality of the measurements.

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BIOASSAY OF THE BLACK SEA WATER QUALITY ON MUSSELS` LARVAE OF EARLY STAGES OF DEVELOPMENT

In the water bodies of the north-western part of the Black Sea (NWBS), different in level and nature of anthropogenic load, in 2020 the state of environment was assessed by bioassay methods using Black Sea mussels (*Mytilus galloprovincialis* Lamarck) of different stages of development.
The morphogenesis of mussel larvae (in the early stages of development) in clean or contaminated (to varying degrees) water was a much more sensitive indicator for assessing the state of marine environment than the physiological and morphological parameters of these adult Mytilids.
The use of mussel larvae for bioassay of the marine environment quality at the stages of trochophores and prodissoconchs allowed to establishing the presence of even insignificant changes in the ecological characteristics of the NWBS surface coastal waters condition.
In the summer of 2020, the ecological characteristics of the studied waters significantly improved compared to last year (in all tested waters were formed normal larvae 6.0-6.6 times more).
The best, in the ecological sense, among the tested sea waters in the summer were the environment of the Arcadia beach and the water area near the Cape Malyi Fountain (CW5) (in the waters of which 52.7% of test-objects of normal morphology were formed). They corresponded to the ecological class of waters "good", and the environment of other researched areas of the sea – class "moderate".
In autumn, during the bioassay of surface water quality on mussel larvae, a significant improvement of the aquatic environmental quality was detected along the coastal zone of the NWBS from Odessa port (CW6) to the beach "Albatros" in the village of Zatoka (CW4).
These surface waters were inherent by good ecological status (GES), which was characterized by the formation in them of larvae of a larger (on 0.7-7.3%) number of morphologically normal larvae of mussels stage prodissokonch, than in the better by ecological properties (for these test-objects) water sample taken from the mainland slope of the NWBS in 2016.
Namely, it was found that of the best ecological condition (in indicator of the percentage of formed mussels larvae of normal morphology in water testing) were characterized the environments of a row of areas of water bodies:
– CW5 (Kovalevsky's Dacha – 67.2%, the coastal zone of Cape Malyi Fountain – 65.2%, beaches "Dolphin" and "Arcadia" – 64.3% and 61.6%, respectively);
– CW4 ("Albatros" recreation center beach in Zatoka – 60.6%);
– CW6 (Odessa port – 51.6%).
For the first time in 20 years of monitoring researches of the Black Sea environment by the method of water quality bioassay on mussel larvae of early stages of development, the above environments of water bodies corresponded to the ecological class of water "good", and all other studied coastal zones of sea – to class "moderate".
The results of the bioassay of the environment quality of the Dniester and Dnipro-Bug districts of the NWBS conducted during 2020 showed that the best ecological properties for the development of aquatic organisms on the coastal zone of Odessa were inherent in the environments of beach "Arcadia" (in summer) and of marine aquatories located nearby Dacha Kovalevsky's (in autumn) and Cape Malyi Fountain (in summer and autumn).

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BIODIVERSITY, SPECIES COMPOSITION AND CURRENT TRENDS OF THE BENTHIC INVERTEBRATE COMMUNITY OF THE ROCKY INFRALITTORAL HABITATS OF THE GEORGIAN BLACK SEA COAST

The tendency of global climate changes shows a growing interest on environmental status of coastal areas with reference to changes in marine community structure. One of the main factors for evaluating the current trends is study of biodiversity and species composition of the benthic community. Research implemented during the last decade on the rocky infralittoral zone of the Georgian Black Sea coast demonstrates some structural variations of benthic community. Surveys were conducted seasonally at three stations (Sarpi-Kvariati, Green Cape, Tsikhisdziri) being good illustrators of biodiversity of rocky habitats. Surveys lead in 2016-2019 at the same stations around floristic composition and morphofunctional activity of macrophytobenthos testify to the good ecological condition of these waters (Filimon et al., 2016). Many algae characteristic of rocky habitats are common here, including the brown multicellular algae *Treptacantha barbata* (*Cystoseira barbata*) being an important biocenosys for a large variety of benthic invertebrates. Additionally, vertebrate fauna associated to this particular habitat type raises interest for future research, as *T. barbata* thickets are foraging and shelter areas for many fish species (Filimon et al., 2016).

Regarding invertebrates of the rocky infralittoral habitats, they were mainly presented by three taxonomic groups: Mollusca, Arthropoda and Annelida. Species composition of Mollusca has practically not been changed during the surveys being presented by 8-9 species. However, it's been noticed that since 2010 the species composition of Arthropoda and Annelida has significantly enriched. Almost 4 times growing has been obvious for the Annelida species composition and number of species Arthropoda has almost doubled. Consequently, composition of rocky habitats' benthal has been increased from 28 to 40 species.

As for abundance of surveyed benthic invertebrates, the prevailing taxa was Mollusca, that consisted 97% of the total abundance in previous samples, whereas current results showed 81% of the samples surveyed during recent years. The dominant specie at all stations was bivalvia *Mytilaster lineatus* (Gmelin, 1791). The tendency of the stable domination of *M. lineatus* has been prolonging up to now. It should be taken into consideration that the significant raise of percentage portion of abundance of Annelida (Polychaeta) and Arthropoda is noticeable. If in previous samples abundance of mentioned groups was 1%, recent results have shown 14% and 5% expansion subsequently.

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ALIEN FISH SPECIES IN THE NORTH-WESTERN PART OF THE BLACK SEA WITHIN THE TERRITORY OF UKRAINE

Since the 1970s, 9 alien fish species have been recorded in this region belonging to 9 genera of 6 families. Of them, 1 species occurs regularly (11.1 %), 3 sporadically (33.3 %), and 5 occasionally (55.6 %).

Soiuy mullet *Planiliza haematocheila* is the single alien species that occurs **regularly** in the NW Black Sea. It was intentionally introduced in the Azov-Black Sea Basin in the 1970s and it has fully acclimatised and has become a species of economic value. Currently, this species occurs along the entire coastline of Ukraine, including the NW Black Sea (Tkachenko, 1999; Vinogradov, Khutornoy, 2013 and others).

The following species occur **sporadically**. Greater pipefish *Syngnathus acus*. It has been recorded relatively recently off Turkey. In 2006, a male and a female were caught in the Chorna river's estuary in Sevastopol Bay and another female a year later at the same location (Boltachev et al., 2009). In the NW Black Sea, several specimens were caught near Snake **(Zmiinyi)** Island (Snigirov et al., 2020). The vector of introduction of the species is unknown; it could be mediterranization or transfer with ballast waters. Salema porgy *Sarpa salpa*. It was first recorded in waters of Ukraine in 1999 off Crimea in Balaklava Bay (Boltachev, Yurakhno, 2002). In the NW Black Sea, the species has been recorded regularly since 1995 in Tendra and Yahorlyk Bays as well as in the coastal zone of Kinburn Spit and Tendra Island (Tkachenko, 2012). Natural vector of introduction (mediterranization). Gilthead seabream *Sparus aurata*. It was first recorded in waters of Ukraine in 1999 near Balaklava Bay (Boltachev, Yurakhno, 2002). To ten and more specimens of the species have been regularly recorded in the NW Black Sea since 2004, particularly near Kinburn Spit, in Tendra and Yahorlyk Bays, and in the Dnipro-Bug Estuary; a single record is also known off the Danube Delta (Tkachenko, 2005, 2012; Manilo, Redinov, 2019). Natural vector of introduction (mediterranization). It is possible that the species' abundance increases due to escape from marine aquaculture, in which the species is cultivated near the Black Sea coast of Turkey.

Occasional species. European pilchard *Sardina pilchardus.* Since the 2000s, the species has been occasionally found in catches of fishing trawlers near the southern coast of Crimea. In the NW Black Sea, the species was recorded earlier, in 1958, in catches from Cape Burnas to Sychavka (Vinogradov, 1960). In 1970–1990, the European pilchard was noted by Zambriborshch et al. (1995) and Chernikova and Zamorov (2011) as an uncommon species in Odessa Bay. Later records of the species are unknown. Natural vector of introduction (mediterranization). Flying gurnard *Dactylopterus volitans.* In the Black Sea, two documented records of the species are known: from Odessa Bay in September 1979 (Movchan, 2011) and an immature 40 mm long specimen nearby to Sevastopol (Liubymivka) (Boltachev, Karpova, 2014). Natural vector of introduction (mediterranization) or with ballast waters of vessels. Pilot fish *Naucrates ductor.* In the 1870s, a single specimen of the species was recorded in the roadstead of Odessa (Svetovidov, 1964). Natural vector of introduction (mediterranization). Greater amberjack *Seriola dumerili.* It is known in the Black Sea for a record off the Caucasus (Luzhniak et al. 2020). The species was first mentioned for the NW Black Sea (Odessa Bay) by Snigirov et al. (2020). Natural vector of introduction (mediterranization). White seabream *Diplodus sargus.* It is known in the Black Sea by single records off Turkey and Bulgaria. A specimen was also caught off Sevastopol in 1950 (Svetovidov, 1964). In the NW Black Sea, the species was first recorded among stranded macrophytes on the southern coast of Yahorlyk Bay in 2008 (Tkachenko, 2013). Another specimen of the species was caught in 2019 in the Dnipro-Bug Estuary (Tkachenko, 2020). Natural vector of introduction (mediterranization).

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THE REAPPEARANCE OF TWO LONG TIME CONSIDERED DISAPPEARED RED ALGAE ALONG THE ROMANIAN BLACK SEA COAST

In the past decades, along the Romanian Black Sea coast, a phytobenthic qualitative decline was noticed, as a consequence of unfavorable natural (freezing of the sea surface, heavy storms) and anthropogenic factors (eutrophication, pollution). This paper refers to two red algae – *Dasya baillouviana* (S.G. Gmelin) Montagne, 1841 and *Spermothamnion strictum* (C.Agardh) Ardissone, 1883 – who become endangered over decades along the Romanian coast, reaching the point of being considered extinct. Although nowadays their distribution area is extremely reduced, their reoccurrence is particularly important for the state of Romanian Black Sea biodiversity phytobenthic state.

D. baillouviana was reported for the first time in many years near Constanta city, during summer season 2019, around the newly built dikes, in a monospecific association. Following the annual qualitative monitoring of these newly built constructions, the development of a red algae, totally different from the typical summer season macroalgal components, was observed. The qualitative analysis of the fresh biological material led to the identification of the species *D. baillouviana.* The association was formed by large specimens, highly branched, similar to those observed in the past decades herbaria. *Dasya* has a reddish filamentous thallus, with a feathery appearance. The species was sampled during the full reproductive period, so all the reproductive elements were clearly observed: the antheridia (with fully developed male cells), placed towards the apical part of the branches and pedunculated cystocarps, towards the basal part of the thallus.

The species reoccurence is particularly important, since it has not been reported along the Romanian coast since the 70s (Bavaru, 1977; Vasiliu, 1984). *D. baillouviana* is currently included along the Romanian Black Sea coast in the Red List of endangered marine species, in the basis of Order no. 488/2020 published in the Official Gazette of Romania, as being a Critically Endangered species, due to its reduced distribution and low population recovery capacity. Known to normally develop at greater depths, the species probably never disappeared from the Romanian coast, but retreated to deeper horizons, where its identification was more difficult. Along with the newly built dikes, part of the thallus with well-formed reproductive elements were brought to surface, where favorable conditions and available rocky substrate were encountered, hence the species proper development.

S. strictum is a species whose presence is known to be closely related to the *Phyllophora* fields. The species was identified also during summer season 2019, in the northern part of the Romanian Black Sea coast (Sf. Gheorghe area), in association with *P. crispa*, at 30-35 m depths. So far, this species has not been reported elsewhere. The species presented reduced dimensions, a highly branched thallus, with secondary branches arranged at an angle of less than 45˚. For the Romanian part, the last report of this species (and the only one by the way) dates from 1935 (Celan, 1936). The species decline is directly proportional to *Phyllophora* decline, *S. strictum* being a species mainly identified in *Phyllophora* fields. The slow restoration of *Phyllophora* fields may lead over time to the identification of other characteristic species of this important habitat.

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STATISTICAL PROCESSING OF LONG-TERM DATA SERIES ON AVERAGE ANNUAL WATER RUNOFF OF THE DANUBE RIVER

Statistical processing of runoff data is an important step in any further study and use of runoff data series. The purpose of this work is the statistical processing of average annual data on water discharge over a multi-year period, determining the homogeneity of the data series and the study of cyclicity of runoff.

The first stage of the work was to determine the homogeneity of the data series. Statistically homogeneous series are series of random variables that belong to one general population. To test the hypothesis of statistical homogeneity of two series of data, which are subject to the normal distribution, the parametric criteria of Student and Fischer-Snedekor and the nonparametric criteria of Wilcoxon are used. It is advisable to perform an analysis of statistical homogeneity of one data series, in which the series is divided into two samples of equal length.

The results of the assessment of the homogeneity of the time series of the runoff in the Danube by the criteria of Fisher, Student and Wilcoxon at the level of significance $\alpha = 5\%$ showed that according to Fisher's criterion, the series are homogeneous ($F = 1.07$; $Fa = 2.74$), the series are also homogeneous according to Student's criterion ($t = 0.02$; $ta = 2.04$), the series are also homogeneous according to Wilcoxon's criterion ($U = 202$ at $U1 = 135$; $U2 = 285$), therefore, the samples belong to one general population, such data can be used in further calculations.

The next step was to study the cyclicity of the runoff. It is not advisable to study the cyclicity of runoff using only chronological graphs of runoff fluctuations. Thus, some years of high or low water content can greatly interfere with determining the patterns of fluctuations in annual runoff. To prevent this, filtration or smoothing methods are used. Quite often in calculations residual curves are used. Thus, the period for which the section of the residual curve has an upward slope relative to the abscissa axis with a predominance of positive deviations from the mean, corresponds to the multi-phase phase of runoff fluctuations. The low-water phase of runoff corresponds to the area that has a downward slope with a predominance of negative values.

During the analysis of the residual curves of the average annual water runoff of the Danube, it is possible to clearly distinguish the phases of water content. Thus, from the 1980 to 1982 there is a high-water phase, from 1983 to 1994 – low-water, from 1995 to 2010 – high-water phase, from 2011 to 2020 – also low-water.

Determining the numerical characteristics of random variables is an important step in statistical analysis, and hence further research.

In the course of the work, statistical processing of time series of average annual runoff for the period from 1980 to 2020 was performed. Statistical parameters of runoff characteristics for the Danube River were calculated, namely: number of years of observations (n, years), average long-term values of runoff (W, km^3), variation (Cv), skewness (Cs) and Cv/Cs ratio.

Statistical parameters of the characteristics of runoff are calculated by two methods: the method of moments and the maximum likelihood estimation.

According to the method of moments, we obtained that $Cv = 0.18$, $Cs = 0.48$, $Cs / Cv = 2.7$. By the maximum likelihood estimation $Cv = 0.18$, $Cs = 0.52$, $Cs / Cv = 2.9$.

Thus, as a result of the study it was determined that the series of runoff data is homogeneous by three criteria, the runoff cyclicity was studied and the water phases were determined, as well as the statistical parameters of runoff values were calculated, which differ slightly by two methods.

The obtained results can be used for further calculations of the runoff of the Danube River.

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STUDIES WITHIN THE EU-FUNDED PROJECT COPERNICUS ASSISTED ENVIRONMENTAL MONITORING ACROSS THE BLACK SEA BASIN (PONTOS)

Background and aims. Within the Black Sea Basin (BSB) program priority 'to promote coordination of environmental protection and join reduction of marine litter in the Black Sea Basin' by improving joint environmental monitoring the 30-month project 'Copernicus assisted environmental monitoring across the Black Sea Basin – PONTOS' was launched on July 1, 2020. The overall goal is to make information and knowledge available to scientists, policy makers, citizens and other relevant stakeholders and provide a full picture of the state and temporal evolution of Black Sea region environment. This is based on three main pillars (i) **technology transfer among the Black Sea nations** by developing the technological and knowledge infrastructure for the setup of online services, (ii) **use of the Copernicus program for environmental monitoring** by coupling Copernicus derived information with local knowledge, (iii) **engagement of local and regional actors at multiple levels** as co-designers and receptors of the benefits accrued by PONTOS. Moreover, 4 representative pilot areas were selected in all partner countries to perform the specific assessments to address the main environmental issues identified for the region.
Studies in the Ukrainian Pilot. The Ukrainian pilot area consists from 2 subareas: (i) coastal zone with the most popular beaches and recreational areas in the south of Ukraine from Odesa city to the Danube river delta, (ii) the Dniester river delta area with adjacent estuary. We have been assessing the **dynamics of coastline changes** with identification of the main factors triggering those alterations for the period of 1983 – 2020 by coupling historical in-situ data and processing satellite images (using different manual, semi-automatic and automatic approaches). The ability to monitor chlorophyll concentration with satellite images allows to remotely estimate nutrient pollution in both in-land and coastal surface waters, while the validation with region-specific in-situ data can significantly increase the accuracy of this method, thus enhance its applicability. This has been undertaking during the comprehensively designed regular field campaigns within the **Integrated assessment on chlorophyll concentration and eutrophication dynamics** in the Dniester estuary and Bile lake. In addition, **the Assessment on changes in wetland and floating vegetation cover** over the last decade has been started. The PONTOS intends to develop the automatic approach (tuned and validated with in-situ data) to effectively distinguish the main water vegetation types and quantify their cover areas online. Within the **Assessment on agricultural water balance, water productivity and water stress indices**, we aim at integrating in-situ measurements, satellite data and numerical models to estimate the current situation and suggest the better management options how to increase water use efficiency and crop yield for the most popular crops in region (sunflower and wheat).

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NITROGEN POLLUTION SOURCES AFFECTING COASTAL AREAS IN THE NORTH-WESTERN BLACK SEA

Background. Coastal areas known as a valuable resource of ecosystem services are very susceptible to anthropogenic interactions. In the north-western part of the Black Sea (NWBS) riverine input to the sea is formed by the Danube and the Dniester rivers, which are subjected to numerous ecological concerns in their catchments mainly related to nutrient loads from intensive agriculture, outdated/ absent wastewater treatment facilities, poorly developed sewage system and atmospheric deposition (Medinets et al., 2020a,b). At the same time, various recreational and touristic facilities (hotels, restaurants, camps etc.) located in the vicinity to the coastline are land-based hotspots of pollution directly affecting coastal ecosystem and hardly can be quantified in terms of nutrient input (HBS, 2020). In addition to that, atmospheric deposition contributes to nutrient loads in these areas (Medinets, 2014, Medinets et al., 2020b).

The aim of this work to quantify the fluvial and atmospheric Nitrogen (N) input to the coastal areas as well as identify main sources forming them.

Fluvial N input. Based on published data of own research as well as international reports we have assessed the N loads from the Dniester and the Danube to the Black sea. Medinets et al. (2020a) reported that 25.7 Gg N yr^{-1} was run-off to the Dniester Estuary from the Dniester river over 2010-2019. They found that the share of organic N in water mass varied from 27% (2014) to 75% (2018). It was estimated that around 23.1 Gg N yr^{-1} was entered to the Black Sea from the Dniester over 2010-2019. On average annual riverine TN load from the Danube to the Black Sea was reported to be ca. 401 Gg N yr^{-1} during 2010-2017 (ICPDR, 2020). Nevertheless, we assume that the ICPDR data might be overestimated by 10-20% if the ramified structure and large area of the Danube Delta is taken into account. Finally, the cumulative mean fluvial TN load from the Danube and the Dniester to the Black Sea varied in a range of 384-424 Gg N yr^{-1} in 2010-2017 affecting the water quality, biodiversity and ecosystem services in the NWBS.

Atmospheric N input. Increased emissions of reactive N from the anthropogenic activities and altered natural ecosystems have a strong impact on climate and air quality leading to higher rate of N atmospheric deposition affecting human health and ecosystems. Medinets et al. (2020b) demonstrated that the rates of N deposited to the natural wetland (10 kg N ha^{-1}) were 2-fold less than to cropland (20 kg N ha^{-1}). On average, total organic N contributed from 72% (cropland) to 66% (wetland). However, the rate of total N scavenged from the atmosphere to the water surface (Medinets, 2014) was 23% higher than the mean rate deposited to croplands.

Coastal land-based hotspots are the most understudied. The great progress was made within BSB Black Sea Hotspots project to identify the large hotspots. However, a number/ contribution of potential small/ medium hotspots (hotels, restaurants, café etc.) is unknown.

It is essential than the facilities for N pollution control and N management system across river basins and coastal zone should be established by the Black Sea country authorities asap. An urgent need is to establish a viable network of coupled coastal and atmospheric deposition monitoring stations within the NWBS with real-time interactive visualization for operational decision making.

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LIBRARY OF THE SEA BED VISUAL FEATURES BASED ON UNDERWATER IMAGERY SURVEY IN SVALBARD, ARCTIC

Visual underwater sampling technique popularity increased over the years. Usage of underwater videos and photographs in combination with other traditional sampling techniques (dredge and grabs) is becoming more frequent. After extensive laboratory work of sorting and identification of individuals in collected samples the features visible in underwater imagery can be confirmed, however, work in the laboratory is not always feasible to conduct due to time constraints of the specialists or limited sampling time in the field. Identification at the lowest taxonomic level is certainly always preferred, but coarser taxonomical identification or the use of morphospecies and functional groups of benthic animals is proven to be sufficient for large natural and anthropogenic-induced changes.

This work demonstrates the earliest stages in developing of a shared Arctic visual library of megabenthic fauna in the upper sublittoral (2-66 m) of Hornsund and Isfjord areas (western Svalbard). At present, we identified more than 60 biological and physical features, that were confirmed by specialists in taxonomy of Arctic macrobiota. Biological features in our Arctic database are classified by the highest taxonomical ranks (phylum), such as Annelida, Ascidiacea, Arthropoda, Bryozoa, etc. A separate group combines all features belonging to macrophytes. The physical features are grouped into the following categories: burrows, trails, substrate, and others. Each feature in the database is assigned to a photographic image in its natural environment, location, date, and approximate depth at which it was found.

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PLASTIC POLLUTION AT CHERNOMORETZ BEACH, BULGARIAN BLACK SEA COAST

Various studies about different seas and their microplastic contamination are available. However, the data for the Black sea coast, especially the Bulgarian (Western) part is still rather scarce. Therefore, it is essential to evaluate the microplastic contamination.
This study is based on two campaigns for the collection and identification of microlitter (2019) and macrolitter (2020) occurrence at Chernomoretz beach (near Varna), a sample site with relatively low anthropogenic pressure. Microplastic abundance, type, size, colour and distribution were recorded.
For large microplastics abundance ranges from 144 to 979 items, 32.92 to 208.46 number of particles per kg d.w. or 576 to 3915.77 number of particles per m². Fibers were the most abundant microplastic type and occurred at all stations with 94 to 98% and 12 colours. The predominant colours are transparent (37%, 6-17mm long), blue (16%, 1-5mm long) and grey (15%, 1-8mm long) followed by black, red, brown, green, pink, yellow, orange, white and purple.
For small microplastics abundance ranges from 61 to 102 items or 204.19 to 372.21 number of particles per kg d.w. Types of microplastics found in the study were dominantly fibers with 83 to 98% and 9 colours. The predominant colours are transparent (31%), grey (27%) and blue (22%), followed by black, pink, green, brown, red and white.
For macrolitter artificial polymer materials are the most dominant type of debris - 83%. Plastic construction waste, plastic pieces 2.5 cm to 50cm, foam sponge, polystyrene pieces 2.5 cm to 50cm and crisps packets/sweets wrappers were with the highest abundance. Polystyrene pieces 0 - 2.5 cm and plastic pieces 0 - 2.5 cm accounted for about 20% of all artificial polymers.
Litter density was estimated at 0.43 items/m² in abundance and at 0.002 kg/m² in mass. The Clean Coast Index (Alkalay et al., 2007) classified the state of the Chernomoretz Beach as a Moderate beach (CCI = 8.49).

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DIFFERENCES IN METAL ACCUMULATION AND CONDITION OF MARINE FISH SPECIES POTENTIALLY IMPACTED BY THE PORT OF PLOČE IN THE EASTERN ADRIATIC SEA

Marine ecosystems are threatened by variety of anthropogenic activities and pollutants, of which metals present serious threat due to their persistence, toxicity and potential to bioaccumulate. Metal concentrations in water may not reflect the chronic pollution load so bioindicator organisms such as native fish species are used to get an overall measure of contaminant exposure in the aquatic environments (Kraemer et al., 2006). Our goal was to estimate metal exposure in the area impacted by harbor activities, agriculture and tourism near the Port of Ploče and Neretva River mouth in the Southern Adriatic Sea in Croatia, using 30 individuals of three fish species (*Mullus barbatus* Linnaeus, 1758, *Merluccius merluccius* Linnaeus, 1758, *Pagellus erythrinus* Linnaus, 1758) as bioindicators. Biometric characteristics revealed the highest total length and masses of *M. merluccius* compared to other two species. Fulton condition index, as a measure of fish feeding and health, pointed to better condition of *M. merluccius* and *M. barbatus* compared to *P. erythrinus*. Metal exposure was assessed by determination of metal concentrations in water and fish muscle, as well as biomarker responses of metal exposure (metallothioneins), oxidative (malondialdehyde) and general stress (total proteins) in fish muscle. Accumulation of the most elements showed considerable species-specific differences except for Al, Fe, K and Mg, which concentrations were comparable in all species. The most elements showed significantly higher metal accumulation in *M. barbatus* (As, Co, Cu, Mn, Pb, Rb) and the lowest in *M. merluccius* (Co, Cu, Pb, Sr and Zn) when compared with other two species. Species-specific differences were also observed in biomarker responses, possibly as an adaptive response to the present ecological disturbances. Due to the complexity of anthropogenic releases of contaminants and their potential toxic effects, it is crucial to analyze larger set of relevant chemical and toxicological variables including metals and biomarkers, which can be preferably assessed in combination to provide information on marine ecosystem health. Such comprehensive research can provide adequate monitoring strategies in order to preserve the nature and living organisms, but also to provide marine ecosystems goods and services to human population.

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ADVANTAGES OF MORPHOFUNCTIONAL INDICATORS OF PHYTOBENTOS FOR ASSESSMENT OF THE ECOLOGICAL STATUS OF MARINE ECOSYSTEMS

In recent period all six Black Sea countries have made significant progress in implementing the Water Framework Directive (WFD, 2000/60/EC) and Marine Strategy (MSFD, 2008/56/EC) standards for the Black Sea ecosystem. This progress has been made thanks to the efforts of the project ANEMONE (2017-2019) funding of the European Union and the Black Sea Crossborder Cooperation Program, and the project EMBLAS I, II, PLUS (2014-2021) funding of the European Union and UNDP.

Descriptor №1 – «Biodiversity», in accordance with the MSFD, is a key tool for assessing the Ecological Status Class (ESC) of marine ecosystems based on the state of pelagic and benthic communities. Macroalgae and Angiosperms, which are representatives of phytobenthos communities – are recognize as Biological Quality Elements, based on which the ESC of transitional, coastal and shelf ecosystems can be assess. Among other Biological Quality Elements of marine ecosystems, the phytobenthos has a number of advantages for monitoring the ecological state of water bodies: 1. Structural-functional organization to reflect the first stage of ecological process – primary production; 2. Attached object provides to assessment of the studied water area; 3. Presented by large dominant species, which form an indicatory community – *Cystoseira, Zostera, Phyllophora*; 4. Sensitive structural-functional organization well reflects the variability of the nature conditions and anthropogenic loading; 5. Long life cycle to present an integrated response on the environmental status.

According to the proposals of European experts, when assessing the ESC of marine ecosystems based on the organization of bottom vegetation, it is necessary to use the Ecological Evaluation Indexes (EEI), which reflect the indicative properties of macrophytes (Orfanidis, Panayotidis, Stamatis, 2001, 2003; Orfanidis, Panayitidis, Ugland, 2011). Strict requirements must be imposed for the phytoindicators to be use as EEI: – reflection of the basic ecological function of Biological Quality Elements; – sensitiveness to the anthropogenic load; – comfortable for monitoring. The complex of morphofunctional indicators based on the active surfaces of aquatic vegetation, developed by Ukrainian experts, best satisfy these requirements (Minicheva, 1998). The proposed the four morphofunctional indicators for EEI quantification have differences in possibilities for spatial and temporal assessment of ESC for marine ecosystems (Minicheva, 2013). "Black Sea monitoring guidelines. Macrophytobenthos." was prepared with the aim of application of morphofunctional indicators of phytobenthos for assessing the ESC under national monitoring in the Black Sea countries (Minicheva, Afanasyev, Kurakin, 2015).

The practice of using morphofunctional phytoindicators to assess the ESC of the Ukrainian, Georgian, Bulgarian and Russian coasts, has shown that the most sensitive to changes in the ecological state of coastal ecosystems, as well as very easy to use, is the indicator – "Percentage the sensitive species" in floristic composition of macrophytobenthos community – S_{sp},%. This indicator is basic on an assessment of the ratio in the floristic composition of phytobenthos of the sensitive and tolerant species, the specific surface of the populations (S/W_p) of which is, respectively: S/W_p = 5-25 $m^2 \cdot kg^{-1}$ (*k*-species) and $S/W_p \geq 25$ $m^2 \cdot kg^{-1}$ (*r*-species).

Assessment of the ESC using morphofunctional indicators of phytobenthos of the coastal and shelf zones in the Ukrainian sector of the Black Sea shows that in recent decades there has been an improvement in its ecological situation. In the coastal ecosystems of the Danube-Dniester interfluve, the ESC category increased from "Moderate" to "Good". In the central part of the Zernov's Phyllophora Field from category "Poor" to "Moderate".

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RESEARCH OF MODERN ECOLOGICAL PROBLEMS OF THE UKRAINIAN SECTOR OF THE BLACK AND AZOV SEA: DIRECTIONS, ACHIEVEMENTS, PROSPECTS

The modern scientific directions of the marine ecosystem`s research, which are the theoretical basis for effective solution of the problems of sustainable use of the marine environment in Ukraine, are considered.

The main, fundamental direction of marine research in Ukraine is aimed at studying the ***mechanisms of communities` functioning in different types of Black and Azov Sea ecosystems (coastal, shelf, open, transition, delta, estuary).*** This direction solves a number of important scientific problems, namely: - anthropogenic transformation of the coastal zone; - impact to river waters (eutrophication, persistent organic pollutants, etc.); - waste waters pollution (toxicity); -assessment of the scale of transformation of marine assemblages; - spreading of alien species; - outbreak of short-cycle species; - speed-up of ecological processes, etc. In the future, in the frame of the scientific achievements in this area (North West Black Sea: biology and ecology, 2006) the approaches to diagnose the priority problems of water bodies and selecting the optimal measures to achieve their Good Ecological Status (GES) could be improved.

An important area that enables to control of the state of marine ecosystems and decision-making on the national level is the ***development of scientific approaches for state marine monitoring in accordance with the standards of the Water Framework Directive and the EU Marine Strategy***. Today, thanks to the national fundamental developments and support of the EU and UNDP technical assistance project EMBLAS, the approaches and tools for assessing the ecological status class of marine ecosystems in Ukraine based on integrated biological indicators have been identified. The control over the 11 descriptors should be applied to the Marine Strategy of Ukraine, which provides the development of national marine action plans to achieve and support the GES of the Black and Azov Seas for the period of 2022-2027 and 2028-2034.

Modern planetary climate features update the direction of research related to the ***assessment and prediction of the marine biological component functioning in the context of climate change***. The ratio of the reaction of the biological component in the abnormal and post-abnormal periods open the possibility to predict the environmental consequences of hydrometeorological anomalies (Adobovsky et al., 2012). Assessing the adaptive capacity of marine aquatic organisms to climate change can be the basis for developing measures to minimize the negative consequences for the entire Black and Azov Sea region.

The direction of ***assessment and prediction of the state of biological resources of the Black and Azov Sea ecosystems*** is an applied aspect of the theory of productivity of aquatic ecosystems and is a scientific basis for solving the problem of sustainable use of marine biological resources. The achievements of this area should be used for the preparation of national and regional programs aimed at the restoration of biological resources of the Black and Azov Seas (fish, molluscs, algae).

The direction of ***ecological management of the Black and Azov Sea regional ecosystems*** offers the theoretical scheme of Integrative Ecological Management, which includes three sequenced parts: – *Basic Diagnostic; – Decision Making; – Target Result* (Minicheva, Demchenko, Sokolov, 2021). Their implementation allows us to quickly achieve GES, sustainable development and socio-economics benefits for the artificial, recreational or marine protected areas.

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SPECIES COMPOSITION OF MOLLUSKS FROM THE COASTAL DECOMPOSITION OF THE DZHARYLHACH BAY

The state of the Black Sea ecosystem today is fully dependent on anthropogenic impact. Infrastructure development trends, construction of natural complexes by industrial facilities – harm the aquatic environment and its inhabitants. In this way, studying the literature, with climate change, eutrophication and pollution, there is a gradual modification, replenishment, or disappearance of marine organisms. In particular, the type of mollusk inhabiting the Black Sea littoral has transformed, which is reflected in its species composition.

The material was harvested in August-September 2020 on the north-eastern coast of the Black Sea in the Dzharylhach Bay. Mollusk shells were selected by the route method. Eleven mollusk species of two classes of bivalves and gastropods were identified. A total of 124 specimens were sampled.

Shells of bivalve mollusks of 8 species were sampled from sandy-shell sediments in the course of the study on the coastal decomposition of the Dzharylhach Bay. Most of the represented species are regularly found in the research. *Loripes lucinalis* (Lamarck, 1818) was the most abundant species at 31.1%, *Spisula subtruncata* (O. G. Costa, 1829) at 4% as the least abundant species in the sample except for single specimens. *Cerastoderma lamarcki* (Reeve, 1845) accounted for 24.1%, with the largest shell sizes, averaging 25.6 mm shell length, *Cerastoderma glaucum* (Poiret, 1789) – 13.7% with an average shell length of 21.9 mm, *Chamelea gallina* (Linnaeus, 1758) – 5.5%, *Mytilus galloprovincialis* (Lamarck, 1819) – 8.4% and *Lentidium mediterraneum* (OG Costa, 1829) – 10%. All six species are representatives of the Mediterranean zoogeographic complex, having entered the Black Sea in the Holocene. *Mya arenaria* (Linnaeus, 1758) is a rather young invasive species that has colonized completely the Black Sea-Azov basin. In our sampling, it is registered in a single specimen. In addition, three species of gastropod mollusks were observed in the collected material. *Cerithium vulgatum* (Bruguiere, 1792), *Bittium reticulatum* (EM Da Costa, 1778), and *Tritia reticulate* (Linnaeus, 1758) were in single specimens. Rather monotonous species diversity of mollusks relates to natural conditions (salinization of the bay, silted soil, etc.). Morphometric parameters of shells, including shell thickness, are evidence of a high level of salinity in the bay. In the example of *C. lamarcki* species, it was – 0.88 mm, in contrast to the moderate level of water salinity with a shell thickness of 1.1 mm, suitable for the existence of most mollusks. From the ecological point of view, all mollusks that made up the sample have different living conditions. The mollusks are divided into different groups according to their relation to the ground. Soft, muddy soils are suitable for *S. subtruncata* (sometimes found on muddy gray soils) and *Ch. gallina*. Sandy soils for *M. arenaria*, *B. reticulatum*. Hard soils for *M. galloprovincialis*, *T. reticulate*, *C. vulgatum*. Dominance or substitution in species of *C. lamarcki*, *M. galloprovincialis*, and *Ch. gallina* unites them in a common biotope of existence. The obtained low values of the species composition are explained by the location of the Dzharylhach Bay, which is located between the coastline and the open sea. Because of the flow direction from the Dnieper-Bug Estuary, the bay is a "sediment trap". This "trap" is filled with pollutants of natural and anthropogenic origin, resulting in the siltation, and blooming of water. This results in the death and decline of the hydrobiont populations.

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CHARACTERISTICS OF THE ESTABLISHED POPULATION OF THE NEW INVADER *ARCUATULA SENHOUSIA* (BIVALVIA: MYTILIDAE) IN SUKHYI LIMAN

This research is aimed to study samples of the Asian date mussel, *Arcuatula senhousia* (Benson, 1842), an invasive mollusk new to the Black Sea basin, to estimate an establishment success and a phenotypic diversity of the introduced into Sukhyi Liman population in the initial phase of its dispersal.

Arcuatula senhousia was first recorded in the Black Sea in 2002 in Romania (Micu, 2004) (single finding of a live animal, no further reports there); in 2015 in the Strait of Kerch (Kovalev et al., 2017) (two live specimens); in 2017 in Bulgaria (Chartosia et al., 2018) (one juvenile specimen). During the 2018 field survey in the Sukhyi Liman, we collected mollusks that were identified as *A. senhousia* according to morphological features. Its identity was also confirmed by means of DNA barcoding to avoid the misidentification with the native *Modiolus adriaticus* Lamarck, 1819 (Zhulidov et al., 2020). Later in 2020, we collected more field material from various localities in Sukhyi Liman, revealing the successful establishment of the population. The sediment types the samples were retrieved from is characterized by mud, shell gravel, pebbles, and marine litter. The species is mainly found among seagrasses, filamentous algae and in reed roots along salinity from 14 to 16; it was previously shown that *A. senhousia* avoids shallows with substantial freshwater input (Zhulidov et al. 2020). In different locations, the density of the species ranged from 4 to 1000 specimens per square meter (sometimes predominantly juveniles). Obviously, the settling process in the reservoir is ongoing.

The further conchological analysis of mollusks revealed notable variability in the shell color, as well as in the pigmentation (composed of transversal and longitudinal elements, like zigzag stripes), and in the presence of light and dark radial areas on the shell, indicating the high phenotypic plasticity of the species. The phenotypic pattern in Bivalves (e.g. *Dreissena polymorpha*) are associated with the environmental condition (Protasov et al., 2011), in particular with light (Shlekhtin, Sidorova, 1990), a thermal regime (Protasov, 2002); the age-related variability is also revealed by Pavlova (2014). There are data on the complex genetic determination of the pattern in Bivalves (Newkirk, 1980; Vendrami et al., 2017) and the shell color (Stolbova et al., 1996). Therefore, variation in intraspecific shell characteristics can result from genetic adaptation with selection acting on the standing of population phenotypic plasticity (Estoup et al., 2016; Thorson et al., 2017; Clark et al. 2020). Given the thermal-related features reflected in the *A. senhousia* genetic structure (see Asif & Krug 2012), it can be assumed that phenotypic diversity in the Sukhyi Liman may be environment-related, and epigenetic processes are occurring in the population. The detailed comparison of *A. senhousia* from different habitats is required to evaluate the correlation between phenotypic heterogeneity and environmental abiotic factors.

To sum up, the previous records and new field material from the 2020 year (Sukhyi Liman) indicate the species's ecological stability and consolidation in the local animal community. *Arcuatula senhousia* reported for the Black Sea occupy a poorly populated by native byssus-attached shallows and seems to find a specific free niche (Zhulidov et al., 2020). We assume the hypothetical distribution of *A. senhousia* in the northern Azov-Black Sea basin in the future, because 3-week larval period in estuarine molluscs may allow them a long-distance dispersal by alongshore currents (Ellingson & Krug, 2006). The transport of adult mussels by rafting on floating substrates, or transport by small boats also may serve as vectors for its dispersal within a region (Asif & Krug, 2012).

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THE FREE-LIVING NEMATODE COMMUNITY STRUCTURE WITHIN THE SOUTH LOBE OF ZERNOV'S PHYLLOPHORA FIELD OF THE ROMANIAN BLACK SEA SHELF

The paper deals with the analysis of nematode community structure, diversity and dynamics performed in May 2018 and June 2020 within the habitats of the Romanian circalittoral zone.The differences in nematodes distribution as a result of Danube's influence are highlighted. The nematode trophic structure and the Maturity index (MI), were used to assess the ecological quality status of benthic habitats covering over 70% of the two Natura 2000 protected areas: the ROSCI 0066 – Delta Dunării – Marine Zone and the ROSCI 0413 - The South Lobe of Phyllophora Field of Zernov. Similar to other studies, our results showed a slightly increase in the number of species, genera and trait groups generally with increasing of water depth and sediment heterogeneity of coarse mixed habitat of *Phyllophora*. The efficiency of MI and the proportion of sensitive and generally opportunistic genera for detection of stress induced by the river discharge is discussed. The thresholds used to classify the indices values into the ecological classes proposed by different authors were used in the present paper, since these have been validated in similar conditions elsewhere. The results show that, within the scope of the present work, the applied indices and thresholds succesfully reflected the specific conditions of the Romanian circalittoral under the Danube's discharge influence.

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HETEROTROPHIC FLAGELLATE DIVERSITY AND COMMUNITY STRUCTURE FROM THE NORTHWEST COAST OF THE BLACK SEA

Heterotrophic flagellate (HF) are ubiquitous, but they are a poorly studied group of organisms in many aquatic ecosystems. Special studies of the species composition and spatial distribution of HF are still rare. In the Black Sea extensive research of HF has been carried out in the last years give species composition insight (Prokina et al., 2017; 2019), however, community of benthic HF from the northwest coast of the Black Sea has not previously been studied.

The northwestern part of the Black Sea is a shallow, biologically highly productive area influenced by the river runoff of large rivers (Danube, Dnieper, and Dniester). Benthic HF sampling (the upper 3 cm layer of sand sediment) from coastal zones of northwest part of the Black Sea was completed between April 2017 and October 2020. The study was conducted in three locations at the water edge and on the sublittoral zones (depth of 3 m). The first (site I) is the *beach* near the Cape Adzhiyask (under the greatest influence of the river flow of the Dnieper-Bug Estuary), the second (site II) is the intermediate beach near the Maly Adzhalyksky (*Grigorievsky*) *Estuary* and the third (site III) is the *beach* near the Cape Malyi Fontan (most distant from the mouth of the estuary). Water salinity fluctuations were noted in site I (4.1-16.8 ppt), in other areas the salinity was higher and more stable (13.1-17.2 and 14.5-17.7, respectively). Detection of species composition, abundance, biomass, size fractionation of HF communities were carried out by live counting procedure. The Margalef diversity index, the Berger-Parker dominance index, the Whittaker β-diversity index were calculated. The similarity between different sites was assessed using the Sørensen index.

A total of 102 HF species and 28 unidentified taxa were found. Euglenids (42 species) and dinoflagellates (17 species) dominated in species richness. The most common species (found in all sites) were *Colpodella perforans* Patterson & Zöllfel, 1991, *Bodomorpha reniformis* Zhukov, 1978, *Protaspa tegere* Larsen and Patterson, 1990, *Caecitellus parvulus* Patterson et al., 1993, *Anisonema acinus* Dujardin, 1841 and *Petalomonas pusilla* Skuja, 1948.

In total, 58 taxa were found in I site, 44 taxa in II site, the largest number of taxa (75) was recorded in III site. The species composition of the HF was richer in the sublittoral zone (109 taxa) compared to the water's edge (65 taxa). The abundance of HF was also 1.7 – 2.2 times higher at a depth of 3 m, and the biomass exceeded 2.4 – 7.4 times due to the greater abundance and presence of large-cell species in the HF community (the average cell volume was 2.9 times larger). The maximum values of the abundance and biomass of flagellates were noted on the sublittoral of the III site in October 2020 – 7740 cells per cm^3 of sand and $2800 \cdot 10^{-6}$ $mg \cdot cm^{-3}$ respectively. The Margalef index in different sites at the water edge was from 0.48 to 0.58, in the sublittoral it is higher (0.72 – 0.86), and only in the II site it was lower (0.42). Within the same site at the water edge and in the sublittoral, the values of the Berger-Parker index are close, but differ significantly in different sites (in the sublittoral from 0.54 in the II site to 0.40 in the III site), which indicates a lower diversity of the HF community in II site. The Sørensen index showed some similarity between the HF communities at the water edge of I and II sites– 0.52, it indicates the possible influence of fresh river waters. In the sublittoral, the similarity between the sites was weak (the Sørensen index 0.26–0.36).

High species diversity indicates a highly complex community because a greater variety of species allows for more variety of species interactions.

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"GREEN SHIPPING": REDUCING THE RISK OF INTRODUCING INVASIVE SPECIES BY MARITIME TRANSPORT, LESSONS LEARNED FROM THE REGIONAL INTERREG PROJECT COMPLETE

The major involvement of shipping in uncontrolled introduction of invasive species, i.e. potential harmful aquatic organisms and pathogens (HAOP) is a serious problem, which may have consequences on environment, economies and human health. To address this problem, the International Maritime Organization (IMO) adopted the International Convention for the Control and Management of Ship's Ballast Water and Sediments (BWMC 2004) and, more recently, the Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (2011). At the regional level, the HELCOM Baltic Sea Action Plan (2007) has set the ecological objective "*No introductions of alien species from ships*". The management of both ballast water and biofouling of ships is a complex task. The BWMC entered into force in September 2017 and its implementation requires numerous decisions to be taken by port state administration and ship owners. The implementation of the IMO Biofouling Guidelines will help to achieve a "*win-win*" solution, where the absence of biofouling reduces the risk of potential HAOP introductions, at the same time preventing chemical pollution by antifouling paints and increasing the ships' performance due to decreased fuel consumption and emissions.

In October 2017, an INTERREG Baltic Sea Region Programme project COMPLETE, uniting 12 partners, including environmental agencies, universities, research institutes, NGO and the intergovernmental organization HELCOM, was launched with the aim to address two major sources of potential HAOP introduction by shipping: ballast water and ship hulls. The project tackled several gaps in current knowledge and management: rights and obligations of involved stakeholders such as ship owners and port authorities; approaches for non-indigenous species monitoring and surveillance for the EU Marine Strategy Framework Directive (MSFD) and the BWMC; risk assessment based exemptions from ballast water management requirements; legal aspects; regional cooperation and information exchange. The technical aspects of that complex problem include yet limited knowledge on antifouling practices and procedures (and resulting level of biofouling); the lack of common cleaning procedures and facilities and their cost-efficiency analysis; quantities of biofouling waste and its handling procedures; and the role of leisure boats and their trailers in primary introductions and secondary spread of invasive species. The project ended in 2020 and is currently undergoing the extension stage (COMPLETE PLUS) to ensure that the COMPLETE results and tools are operational and sustainable in the future, after the completion of the project.

The outcomes of the project are presented in details at www.balticcomplete.com/publications/project-reports. Here are just a few products that were created by the project, discussed with numerous stakeholders and accepted for use: "Recommendation on hull cleaning practice to reduce discharge of substances from antifouling paint", "eDNA sampling protocol for hull biofouling and ballast water monitoring, and guidelines for the monitoring of target non-indigenous species using molecular methods", "The Early Warning System on HAOP in the Baltic Sea and its implementation in the AquaNIS information system", "Guide on best practices of biofouling management in the Baltic Sea", "Proposal for a Regional Baltic Biofouling Management Roadmap", "The manual on non-indigenous species monitoring for HELCOM Contracting Parties", "HELCOM and OSPAR's joint online tool for facilitating decisions on granting exemptions on ballast water management".

It is important, that the principles of cooperation and the results obtained in the COMPLETE project are applicable to other regional seas of Europe, primarily to the Black Sea, which is closest to the Baltic in its geographic and physicochemical characteristics. Moreover, it is well known that the Black and Caspian Sea (Ponto-Caspian) region is one of the main suppliers of invasive species to the Baltic Sea, although the reverse process (transfer of species from north to south) is less known. A joint (Ponto-Caspian – Baltic Sea) project aimed at reducing the risk of the transfer of invasive species by water transport would be mutually beneficial and would allow solving the problems of harmonious inter-regional implementation of not only the BWMC and the IMO Biofouling recommendations, but also the problems associated with the European Framework Directive in part of Descriptor 2 "Non-indigenous species".

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MONITORING OF THE MARINE ENVIRONMENT IN THE BALTIC AND BLACK SEAS: TOWARDS UNIFICATION OF THE ASSESSMENT APPROACHES

The Baltic and the Black Sea exhibit many striking similarities as geologically young post-glacial brackish water bodies, semi-isolated from the ocean. Both seas are exposed to similar anthropogenic pressures, and in both seas, increasing attention is being paid to the search for scientifically based solutions to improve the state of the marine environment. Harmonization of marine monitoring methods and agreement on the correct interpretation of the results is critical to a common understanding of marine environmental issues and ways to improve the health of the marine ecosystem. This is not an easy task, as all European countries have their own traditions in the field of marine sciences and environmental impact studies, moreover, some of these methods are included in national environmental legislation. In this article, we present the results of a joint Lithuanian-Ukrainian project aimed at unifying the existing and developing new methods for assessing the state of the marine environment of the Black and Baltic Seas. Two Descriptors of Good Environmental Status of the Marine Strategy Framework Directive (MSFD, 2008/56/EC), D2 "Non-indigenous species" and D5 "Eutrophication", were chosen for the study.

In relation to D2, we postulate that the gradient of environmental degradation with respect to invasive alien species causing biological pollution (*sensu* Olenin et al. 2010) is a function of their relative abundance and distribution ranges, which can range from low abundance with no measurable adverse impacts to occurring in large numbers in many locations with huge impacts on local communities and habitats and ecosystem functioning (Olenin et al. 2010, 2011). Our task is to timely detect NIS arrivals to new environment (Olenin et al. 2016) using the latest identification methods (Zaiko et al., 2019) and to learn how to quantify the extent of their impact on biodiversity, habitats and ecosystem functioning (Olenin et al. 2007; Zaiko et al. 2011).

For D5 "Eutrophication", a novel approach, based on the morphofunctional ecology of aquatic vegetation, namely the specific surface area of macrophyte populations (S/Wp), offers a number of new indicators for assessing the level and consequences of eutrophication (Minicheva 1998, 2013). For example, in the Baltic Sea, eutrophication causes replacement of the bladder wreck species *Fucus*, which S/Wp ranges within 2-5 (m^2 kg^{-1}) by epiphytic green algae (S/Wp range 60-120) (HELCOM 2006). Similar processes take place in the Black Sea, where ecologically sensitive species *Cystoseira* (S/Wp range 10-12) are replaced by *Ceramium* (S/Wp range 30-40) (Minicheva 1990), and *Phyllophora* (S/Wp range 7-9) are substituted by a complex of red filamentous algae with S/Wp up to 80-120 (Minicheva 2007; Minicheva et al. 2009). It is important that the difference in the floristic composition of geographically distant ecosystems does not complicate a comparative assessment using the S/Wp indicator, making possible comparative analysis of the Baltic and Black Seas.

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CRYOBANKING OF MARINE FISH GAMETES IN UKRAINE

Cryopreservation is considered to be the most effective and preferable way of long-term storage of animal genetic resources (Kopeika, 2019). Sperm conservation methods have been extensively studied for fish species over the last 60 years (Magnotti, 2018). Despite the simplicity and affordability, the preservation of genetic material of marine fish *in vitro*, by cryopreservation is almost not used in Ukraine.

Marine fish gametes possess greater resistance than freshwater species to variations in external osmolality and it is one of the factors of higher cryoresistance. Cryopreservation of sperm from most marine fish species is not as developed as for freshwater species, and most of the work conducted in the recent years has been done on freshwater species (Martínez-Páramo, 2017).

Cryopreservation techniques can be divided into two types: slow cooling rates and ultrarapid rates (vitrification). Cryopreservation protocols must be carefully designed for each species and each type of cells (Martínez-Páramo, 2017). Fundamental studies of fish gametes cryoresistance will help to optimize the technology of their cryopreservation (Kopeika, 2014). In this case, the gametes of Antarctic fish, organisms that live in extreme conditions and have specific adaptations, are a good object that needs careful research.

Cryobanking plays an important role in genetic selection programs, biodiversity preservation and assisted reproduction. Gene banks of cryopreserved semen can be used to maintain genetic diversity of fish populations that are endangered and protect against inbreeding (Suquet, 2000). These collections can be important resources for the restoration and reintroduction of many species. Storage of cryopreserved materials for the creation of cryobanks or in population recovery programs has a great environmental potential, only partially implemented in world practice.

However, the approach and implementation of a program for the conservation of rare and endangered species by banking genetic material requires fundamental and practical scientific developments. The selection of objects and the development of cryobiological methods are a complex interdisciplinary problem, as they require the joint efforts of specialists in cryobiology, zoology, genetics, reproductive physiology, nature protection. Careful planning and cooperation among various parties involved in a given conservation program is a key factor for the successful use of sperm cryopreservation (Martínez-Páramo 2017).

In our opinion, Ukraine needs to create cryobanks of fish genetic resources and develop methods for using cryopreserved materials to maintain biological diversity and join international programs for the conservation of rare species.

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BIOINDICATION OF THE BLACK SEA ENVIRONMENT QUALITY BY THE STATE OF MICROPHYTOBENTHOS

During 2020, in UkrSCES an assessment of coastal zone environment quality of the north-western part of the Black Sea (NWBS) was carried out on the method of bioindication by systematic, quantitative, morphological, halobiont and saprobiological indicators of microphytobenthos, samples of which were taken from hard and soft grounds in water areas with different anthropogenic load.
There 158 species of microalgae have been registered in the water bodies of NWBS. Diatoms predominated (67.1 %), cyanoprokaryotes (14.6 %) were common. The content of planktonic Dinophyta has increased almost 2 times compared to 2019 and reached 10.8 %.
Abnormal diatom cells were singly. There bent *Tabularia gaillonii* cells were found on mussel shells near Cape Malyi Fountain (CW5) and in Odessa port (CW6) waters, curved valves of *T. fasciculata* were observed on mussels from the water area adjacent to Cape Malyi Fountain, and on the concrete near Dacha Kovalevsky's (CW5) – similarly deformed cells of *Nitzschia lanceolata* var. *minor*.
The microphytobenthos species composition on all substrates was dominated by poly- and mesogalobic, β-mesosaprobic diatoms. There were more halophiles and indifferent in the zones of influence of desalinated estuarine and drainage waters, particularly on the beaches of Yuzhne city and of the Kobleve (CW7), "Dolphin" (CW5) and coast of Zatoka (CW4). In the water area near Cape Maly Fontain, saprobionts were the least in microphytobenthos, and α-mesosaprobes were absent. In anthropogenic marine areas – the coast of Chkalov's name sanatorium (CW5) and Kobleve, on the beach "Dolphin" and in the Odessa port there were more α-mesosaprobes.
In summer, the number of algae species found in the CW5 water body was 16-47, their abundance ranged from 284.78 to 2 876.17·10^6 cells/·m^{-2}, biomass – from 77.36 to 1 579.42 mg·m^{-2}. In autumn, the number of species in CW4 varied from 20 to 27, the abundance – from 1 643.80 to 10 057.22·10^6 cells·m^{-2}, and biomass was 244.54-1 497.10 mg·m^{-2}. There 14-58 species were found in the waters of CW5, their abundance was 812.08-22 740.59 · 10^6 cells·m^{-2}, biomass – 27.40-3 617.51 mg·m^{-2}. In CW6 were from 26 to 65 species of microalgae, their abundance varied from 555.57 to 4 822.81 · 10^6 cells·m^{-2}, biomass – 43.83-1 467.89 mg·m^{-2}. In CW7, the species quantity ranged from 20 to 58, the abundance ranged from 1 277.60 to 7 584.24 · 10^6 cells·m^{-2} and the biomass was 519.22-4 482.35 mg·m^{-2}.
The most numerous were cyanoprokaryotes *Gloeocapsopsis crepidium*, *Leptolyngbya fragilis*, *Lyngbya confervoides*, *Calothrix scopulorum* and diatoms *Achnanthes brevipes*, *Licmophora gracilis*, *Navicula ramosissima* and *T. fasciculata*. By biomass large-cell diatoms were dominated: *T. fasciculata*, *Melosira moniliformis* and species of the genera *Amphora*, *Gyrosigma*, *Pleurosigma*. In autumn, the dinophyte alga *Lingulodinium polyedra* vegetated in masse in most waters. Microalgae, mainly, developed more intensively on hard grounds.
In the CW4, CW5 and CW6 water bodies, the state of the aquatic environment significantly improved in autumn and, for the first time in all years of observations, corresponded to the ecological class of water "good" at most coastal monitoring stations and "moderate" at the rest of the researched waters.

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TETRAPODS OF THE SEA: ASSESSING THE ROLE IN MARINE ECOSYSTEMS

As you know, the sea is inhabited by many species for which the marine environment is evolutionarily secondary; these species are amphibiotic and «true» secondary aquatic marine forms both. These 2 groups include many species of vertebrate tetrapods: reptiles, birds and mammals (not only marine, but true amphibiotic semi-marine forms of amphibians do not exist).

Considering the situation of habitation of these species in the sea we come to the conclusion that, first of all, the following question is relevant: what is the contribution of some species to the functioning of ecosystems of the environment, which is secondary for this species (in this case, the sea)? In this case, the contribution to ecosystems (or a role in ecosystems) should be understood as the impact of the organisms on ecosystems, in this case, on marine ecosystems. It is obvious that the sought indicator is a combination of various components. We will accept the following designations (Roman, 2021).

Rol is the role in marine ecosystems, the sought complex indicator; Nut – nutrition, indicator of consumption of feed – biological resources of the sea; Res – respiration: $ResO_2$ – oxygen uptake, $ResCO_2$ – carbon dioxide evolution; D – defecation of excrement into the marine environment; E – excretion, release of products of nitrogen metabolism; M – the mass of body (or part of this mass) which falls into the water after its death; N – the number of specimens of this species.

Regarding the units it is necessary to take specific indicators as a basis – the numerical indicators of the masses of substances (absorbed, released, introduced); in this case, units are not used. Next, it is necessary to introduce coefficients that would help reflect the real contribution of each indicator. Thus, it is necessary to take into account the fact that the introduction of nitrogen-containing compounds is very important for marine ecosystems but, in this time, the respiration of tetrapods affects the gas regime of the sea indirectly and, in general, very insignificantly; it is also necessary to take into account what type of feed this species feeds on. Then k_{Nut}, k_{ResO2}, k_{ResCO2}, k_D, k_E – respectively, coefficients for nutrition, respiration, oxygen absorption, carbon dioxide evolution, defecation, and evolution of nitrogen metabolism products; k_M is the coefficient (proportion) of body weight, which (averaged for an individual of a given species) enters to the marine environment after the death of the organism.

Then the role of the species in marine ecosystems can be represented as follows:

$Rol = N (k_{Nut} Nut + k_{ResO2}ResO_2 + k_{ResCO2}ResCO_2 + k_D D + k_E E + k_M M)$.

A similar approach is also applicable in the definition of the so-called inclusion of the species in secondary (for this species) marine ecosystems.

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CRITICAL TAXONOMIC REVISION OF THE BROWN ALGAE OF THE GENUS *CYSTOSEIRA* S.L. IN THE NORTHERN BLACK SEA

In the Black Sea, the most diverse and productive marine ecosystems are represented by marine forests, formed by brown algae of the genus *Cystoseira* C. Agardh sensu lato (Kalugina-Gutnik, 1975). Recent studies have shown the polyphyletic nature of Atlantic-Mediterranean *Cystoseira* s.l. (Draisma et al., 2010; Bruno de Sousa et al., 2019). Later, according to the results of molecular phylogenetic analysis, as well as on the basis of morphological and anatomical features, the genus was divided into three separate genera: *Cystoseira* sensu stricto, *Gongolaria* Boehmer and *Ericaria* Stackhouse (Orellana et al., 2019; Molinari, Guiry, 2020).

In our work (Sadogurska et al., 2021) we analyzed three mitochondrial markers (COI, 23S rDNA and mt-spacer) and conducted morphological analyses of *Cystoseira* s.l. specimens from 17 localities along the Black Sea coasts and compared them with Mediterranean samples of *Gongolaria barbata* (Stackhouse) Kuntze, *Ericaria crinita* (Duby) Molinari & Guiry, and *Ericaria barbatula* (Kützing) Molinari & Guiry.

The results of molecular phylogenetic analysis showed, that the genus *Cystoseira* s.l. in the Black Sea is represented by taxa that belong to genera *Ericaria* and *Gongolaria*.

The analysis of Black Sea specimens, identified as *Cystoseira barbata* (Stackhouse) C.Agardh, confirmed its belonging to the genus *Gongolaria*. It is shown, that the recognition of the separate intraspecific taxa in attached *Gongolaria barbata* is unreasonable because the morphological variability of this taxon results from seasonal changes and ecological plasticity (Sadogurska et al., 2021). However, unattached thalli, collected in the Dzharylhach Bay in the seagrass meadows of *Zostera marina* L., have morphological differences. Therefore, a nomenclature combination was proposed: *Gongolaria barbata* f. *repens* (A.D. Zinova & Kalugina) S.S. Sadogurska (Sadogurska, 2021). In addition, it is shown that the unattached *Gongolaria barbata* f. *repens* is not synonymous with the species *Cystoseira aurantia* Kützing sensu Orellana et al. (2019) (previously rearranged by them to the genus *Cystoseira* s.s.).

The molecular analysis of the Black Sea endemic *Cystoseira bosphorica* Sauvageau showed its affiliation to the genus *Ericaria* and conspecificity with the Mediterranean species *Ericaria crinita* and *Ericaria barbatula*. Given the unique morphological features and geographical isolation, its endemicity was confirmed, and a combination *Ericaria crinita* f. *bosphorica* (Sauvageau) S.S. Sadogurska, J. Neiva et A. Israel was proposed (Sadogurska et al., 2021). In addition, it is shown that the original description of the *Cystoseira barbata* var. *flaccida* and *Cystoseira barbata* f. *hoppei* × *flaccida*, proposed by Woronichin (1908), correspond to the later description of the *Cystoseira bosphorica*. Therefore, we proposed to consider these names as synonyms for *Ericaria crinita* f. *bosphorica*.

Thus, it is shown that in the northern part of the Black Sea only three *Cystoseira* s.l. taxa occur: *Ericaria crinita* f. *bosphorica* (Sauvageau) S.S.Sadogurska, J.Neiva et A.Israel, *Gongolaria barbata* (Stackhouse) Kuntze f. *barbata*, and *Gongolaria barbata* f. *repens* (A.D.Zinova & Kalugina) S.S.Sadogurska comb. nov.

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FEATURES OF BIODESTRUCTION OF POLYETHYLENE TEREPHTHALATE IN THE MARINE ENVIRONMENT

Polyethylene terephthalate (PET) is one of the most advanced materials which can be used for packaging of different types of food and drinks. It is due to chemical resistance, inertness, and ability to process this polymer well. However, the greatest part of plastic that accumulates in the ecosystem consists of PET. This is especially true for marine ecosystems, as they are the ones that get the most debris. That is why it is important for us to see the changes in the structure and properties of PET through the sea organisms of the Black Sea.
We studied samples of transparent and dark PET, which were put in the marine environment near Odessa to a depth of 3 m for a month (in October 2020). The surface of some of the samples was made rough, which could affect the intensity of the microalgae fouling.
According to optical microscopy, the degree of fouling of the samples was compared with a smooth and rough surface. More microalgae were found on the surface of PET samples with a rough surface. The X-ray diffraction analysis of samples structure showed that the structure of PET after the action of microalgae remains amorphous, which can be explained by the short-lived experiment.
The nature of the thermodestruction, during thermal gravimetric analysis, the DTG after algae fouling and without are typical for PET. At the first stage of thermal destruction (370 - 450°C) in the presence of oxygen in the air, mainly intramolecular rupture of ester bonds presents, which leads to the formation of acidic fragments of phthalic acid and a set of hydrocarbons of different chemical nature. Another stage of thermal destruction (450 - 630ºC) arouse the main interest, destruction is carried out by a radical mechanism.
It was found that the displacement of the beginning and end of the stages towards lower temperatures and increase in weight loss compared to the control is the characteristic of transparent smooth and rough plastic. So, for samples of transparent rough plastic, the effect of the experiment with microalgae fouling in comparison with the control is manifested in the shift of the beginning of the first stage towards lower temperatures by 5°C and the end of this stage by 10°C towards lower temperatures. The temperature of the end of the second stage for the samples after fouling is shifted by 20°C towards lower temperatures. This may indicate a weakening of the bonds between the polymer units due to the influence of the experimental conditions. It is on these samples with the help of optical microscopy recorded the densest fouling. Minimal weight loss was found for dark smooth plastic samples that were less susceptible to fouling.
Therefore, as a result of the study it can be concluded that microalgae biofouling, even in case of short-term experiment, can affect the properties of PET in the marine environment. It can be assumed that if the experiment is longer, the influence of algae in combination with other environmental factors may contribute to PET biodegradation.

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EXPLORING THE POSSIBILITIES OF APPLYING INTERNATIONAL EXPERIENCE IN CREATING THE FIRST BLUE PARK IN UKRAINE

Blue Parks are the Blue Park Award winning Marine Protected Areas (MPA) benchmark for sustainable management and maximum conservation of wildlife (https://marine-conservation.org/blueparks/). The Blue Park Initiative supports international progress towards Aichi Goal 11 of the Convention on Biodiversity and UN Sustainable Development Goal 14 and the long-term goal of protecting 30 % of the ocean by 2030. Ukraine should have ambitions to create such benchmark MPAs. It has the largest among the Azov-Black Sea basin (the length of the sea coast is 2 759.2 km and more than 72 000 km^2 of the exclusive sea economic zone), and a significant part of the national gross domestic product is formed by 5 coastal regions of Ukraine. The intensive development of industrial and agricultural production, the construction of cities, infrastructure, etc., influenced the ecological balance, species and quantitative composition of the flora and fauna of the Azov-Black Sea region. In this regard, according to the Maritime Doctrine of Ukraine for the period up to 2035 (Resolution of the Cabinet of Ministers of Ukraine 07.10.2009 No. 1307 https://zakon.rada.gov.ua/laws/show/1307-2009-%D0%BF#Text), MPA development is promising in the development and protection of the marine environment. According to the results of accounting data as of 01.01.20 in the Azov-Black Sea region, there are 1,045 territories and objects with an area of 16,703,000 ha, including 402,500 ha in the Black Sea. The ratio of the protected area to the total area of the regions – the "reserve indicator" is on average 6.19 %, and in Ukraine as a whole – 6.77 %, while the European requirements are at least 10 % of the protected areas. Unfortunately, in fact, the rationing and regulation of nature management occurs in protected areas that have administrations at the national level, where clear prohibitions and restrictions on economic activities are established. The rest of the protected categories at the national level, in particular zakazniks, function and are protected at the expense of landowners and land users, which negatively affects their condition. In connection with the jurisdiction of the North-Western Black Sea shelf, the issue of transferring the "Zernov's Phyllophora field" under protection has not yet been resolved. Taking this into account, the prospects for optimization of protected areas were considered by creating the first in Ukraine marine national park "Black Sea North-Western Shelf", which will unite the already existing national reserves "Zmeiniy Island" (232 ha), "Small Phyllophora field in Karkinitsky Bay" (38,500 ha) "Zernov's Phyllophora field" (402,500 ha). The total area of the reserves is 4412.32 km^2, i.e., the park is Large-scale MPA (LSMPA) (greater than 150,000 km^2). The advantages of LSMPA are as follows: encompass entire marine ecosystems and ecological processes; encompass areas large enough to protect critical habitats of many migratory species; exemplify a precautionary approach in the face of major climatic uncertainties; act as living laboratories and provide scientific baselines that can increase our understanding of the differences between local and global stressor; protect extensive cultural spaces, such as traditional voyage routes (Lewis et al., 2017). The creation of a national park will ensure the protection and state control over nature management; organize monitoring of shelf areas, streamline the collection and analysis of scientific research data; sustainable development of territories, aquaculture, rational use of natural resources, to strengthen ecological educational and others. According to Article 21 of the Law of Ukraine "On the Natural Reserve Fund of Ukraine"(https://zakon.rada.gov.ua/laws/show/2456-12#Text), a reserved zone, zones of regulated and stationary recreation, an economic zone will be allocated, but such zoning is more suitable for a land national park. In world practice, zoning is used in marine parks to regulate fishing, shipping and other activities, and these additions must be made to Article 21 of the law.

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THE IMPACT OF THE BLUE SPACE ON THE HEALTH OF THE POPULATION

The phenomenon of health is the most valuable human capital and is viewed as a profitable investment in the future. The World Health Organization defines health not as the absence of illness or disease but as a state of complete physical, spiritual, and social well-being. Most of the Earth's surface is covered by water, and most of the human body is composed of water – two facts illustrating critical links between water, health, and ecosystems (WHO, 2017). Humans are an integral part of a balanced ecosystem that develops under the influence of the natural environment, and the quality of life depends on the quality of the environment. One of the global ecosystem compotents is the blue resource, which provides resources for everyday life, trade, food, and other goods and services. Therefore, traditional research and concern have been focused on the pollution and exploitation of marine resources under the influence of human activities.

Blue space refers to all visible, outdoor, natural surface waters with potential for the promotion of human health and well-being. This excludes outdoor swimming pools, garden ponds and fountains; however, it can include modified and artificially constructed spaces that still contain natural surface water such as canals, dammed lakes or urban streams/rivers (Haeffner et al., 2017).

The blue space covers more than 70% of the Earth's surface, and over half the world's population lives in coastal zones. Billions of people depend on marine ecosystems for their livelihoods, with seafood providing a key source of protein and micronutrients that form the basis of a healthy diet. Numerous novel medications have been extracted from marine organisms, including anti-cancer agents from sponges and algae.

Unfortunately, the already degraded marine ecosystems are under a persistent and growing risk of further damage from microbiological and chemical pollution, overexploitation, and climate change. Rising CO_2 emissions threaten the entire marine ecosystem with acidification, while whole coastal communities are at risk of increasing floodings from storms and rising sea levels, with implications for critical public health infrastructure (e.g., fresh water and sewage systems). Changing environmental conditions also encourage the spread of toxic algal blooms. Chemical threats to health range from the well-documented dangers of methylmercury poisoning during fetal development to toxicity from the complex cocktail of chemicals in the environment, including endocrine-disrupting phthalates and perfluoroalkyl substances, whose diverse autoimmune effects are especially important for elderly people and those with compromised immune systems (Fleming, Laws, 2006).

In summary, it's important to highlight the necessity of priority measures which include objective identification of ecosystem services available nowadays both at a local and a global scale, as well as the exploration of future scenarios that might affect OHH in different ways. It's necessary to know today's baseline and future projections in order to define adaptive and mitigation strategies that will guarantee good ocean and human health. Problems should always be well described by collecting information, assessing risks and impacts.

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APPLICATION OF SMART REPRESENTATIVE FRAME SELECTION FOR EFFECTIVE UNDERWATER IMAGERY ANALYSIS AND ANNOTATION

The need for reliable, accurate and effective methods for exploration and mapping of the seabed stems from the requirements of the European Union Legal Acts, such as the EU Marine Strategy Framework and Maritime Spatial Planning Directives. Maritime space is needed for renewable energy installations, oil and gas exploitation, maritime shipping and fishing, ecosystem and biodiversity conservation, aquaculture production and many other purposes. The demand for maritime space requires an integrated planning and management approach, which, in turn, should be based on solid scientific knowledge and reliable mapping of the seabed. One of the widely used seabed mapping methods is underwater imagery. The main advantage of this method is its simplicity allowing rapid collection of a large amount of data, and, hence, cost-effectiveness. The analysis of video data could be simply reviewing raw videos and roughly estimating visual features such as the coverage of underwater vegetation, number of megafaunal species, sediment composition, etc. Raw data analysis could be challenging, i.e., the movement of the camera makes it hard to track features, you cannot see the entire video sample, the estimation of features is not precise. To overcome these challenges 2D video mosaics (a video converted into a still image) can be used (Šaškov et al., 2015). On the other hand, underwater video mosaics requires manual labor and can struggle with fast moving objects such as mobile megafauna, also the color and brightness on the edges of mosaic images can be different what makes annotation of visual features difficult (Šiaulys et al., 2021).
In this study, instead of traditional computation-intensive mosaicking, we use automatic frame extraction algorithms to select the representative frames from raw videos and investigate whether the selected frames can well represent the entire video or 2D mosaic. Two methods of extracting several video frames for annotation were evaluated: soft (using a smart selection of representative frames) and hard (selecting strictly equally-spaced frames). The soft selection was made by calculating EfficientNet-based embedding for each video frame and iteratively running sparse modeling representative selection (SMRS) algorithm on the resulting dataset until selected frames cover approximately the whole video. The hard selection was done by simply selecting frames within a specific distance (i.e. every 200th frame). The analysis were performed on tree types of visual features: mobile brittle stars from the Borebukta bay (Isfjorden, Svalbard archipelago) measured in number of individuals, red algae *Furcellaria lumbricalis* and substrate composition in Lithuanian coastal area (Baltic Sea) estimated as coverage percentage. The preliminary results have shown that soft selection algorithm of representative frames can be a time-effective alternative of video mosaicking and could be a solid option for both annotation and analysis of large amounts of video data.

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TRAJECTORY OF DEVELOPING EDUCATORS' ECOLOGICAL THINKING: CONSERVATION OF AQUATIC ECOSYSTEMS IN SCHOOLS

The need to form the ecological thinking of students in the field of conservation of marine ecosystems arose in connection with the danger of destruction of the unique natural complexes of the Black Sea. The sea suffers from plastic, marine life and fauna are proof of this, as in many photos living creatures are packed in plastic. Man is overwhelmed by irrational consumption and lack of knowledge and skills of sorting and processing materials. Therefore, it is extremely important to start environmental education activities in preschool and, to continue, in secondary schools.

Modern individual educational trajectory of students requires creative and non-traditional technologies and methods for the realization of creative and intellectual potential personality *(Skakun N., 2019).* At the same time, it is important for teachers of the new generation to skillfully combine environmental education at the level with the formation of key competencies of students of the New Ukrainian School. To do this, the teacher must have information and communication skills and skills of organizing educational activities and skillfully combine work with material visualization and narrative technologies. We offer to get acquainted with our own experience in the direction of ecological trajectory of development and formation of skills of ecological thinking and rational ecological actions in students of secondary school *(Skakun N., 2020).*

1. *Actions to preserve the environment*, in particular waterways – rivers and the heart of Ukraine – the Black Sea. The teacher should actively search for various environmental education events, promotions, challenges and flash mobs and, critically evaluating them, participate. The simplest in the organization and the most effective - is the organization of a corner for the collection of secondary raw materials with the subsequent disposal of plastic, Tetra-pack and more.
2. *Interactive puzzles made of recycled materials,* which are made of plastic collected by us with markings 2. The use of such game content is a clear confirmation of how conscious environmental behavior differs from littered roadsides, overflowing garbage cans, use of artificial packaging / various containers or other. After all, synthetic materials such as polyethylene, propylene, plastics, synthetic fibers, vinyl chloride, sterols and many others will remain unchanged on the planet and in the water of ecosystems.
3. *Responsible consumption training*, where students perform a variety of didactic exercises using demonstration visual materials, thus realizing how to arrange family life for a comfortable ecological existence.
4. *Commemoration of memorable eco-dates*. Applicants should be accustomed to holidays that have an educational, environmental and universal meaning. Important dates in this context are International Black Sea Day (October 31), World Water Day (March 22), World Wetlands Day (February 2) and other important calendar days. By *brainstorming, by means of heuristic conversation* in the educational process, you can generate a number of ideas for organizing thematic events and greetings. Realize the ideas will be original use of *holiday infographics, interactive video, posters or STEAM project.*

«Humanity will not die from a nuclear nightmare, it will suffocate in its own waste», *were the sad words of Niels Bohr, a prominent nuclear physicist, but we can stop the predicted prospects for an environmental catastrophe.*

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OVERVIEW OF BARNACLE SPECIES FROM THE ROMANIAN BLACK SEA COAST - HISTORICAL RECORDS AND RECENT CHANGES

First information on barnacles from the Romanian Black Sea waters date back to the first half of the last century. First mention of presence of *Amphibalanus improvisus* (Darwin, 1854) and *Chthamalus stellatus* (Poli, 1791) on the Romanian littoral was done by Borcea (1926) who lately, (1931) evinced the spreading of the former across the entire NW Black Sea shelf. Also, Borcea (1934) identified *A. eburneus* in paramarine lagoon Razelm and Golovita.
Since its introduction into the Black Sea in 1844, *A. improvisus* has become a common species in the Pontic basin. In the monography on the ecology and bionomy of the Romanian Black Sea, (Bacescu et al. 1971) identified five barnacle species, among which the common *A. improvisus*, the rarely encountered *A. eburneus* (Gould, 1841) and *Chthamalus stellatus*, which apparently has disappeared from the Romanian littoral after the harsh winter in 1954. Two additional species, *A. amphitrite* (Darwin, 1854) and *Verruca spengleri* Darwin, 1854 have been found only once, the former on coarse shelly bottoms with *Lithophyllum* nearby the Snake Island and the latter, only as larvae.
A. improvisus is a ubiquitous epibenthic species forming diverse associations on hard natural or artificial (biofouling) substrate in mid-, infra- and circalittoral. In 1960s, the *Mytilaster – Mytilus – Amphibalanus* association represented a distinct and diverse community in the midlittoral zone of Mangalia – 2 Mai area, represented by several assemblages, such as: the calcareous algae *Lithophyllum* – nudibranch *Limapontia capitata*, the rocky epibenthic association *Embletonia pulchra, Steromphala divaricata, Patella ulyssiponensis, Monophorus perversus*. In 2006, extensive investigation of the coastal benthic habitats in the National Marine Protected Area "Vama Veche – 2 Mai" provided detailed qualitative and quantitative distributional data on the epibenthic rocky community, among which *Mytilaster - Mytilus - Amphiblanus* association along with *Corallina officinalis*. After 2007, with the designation of the Natura 2000 ROSCI0269 and mapping of the benthic habitats within the area, the Habitats 1170–6 and 1170–7 were identified, which represent the midlittoral rocky habitat slightly covered by seawater and midlittoral rocky habitat permanent covered by seawater.
Currently, a significant improvement of the status of these habitats were noted. The investigations performed in 2020 - 2021 revealed the existence of a new habitat represented by the association *Microeuraphia depressa – Steromphala divaricata - Diadumene lineata* and *Lepidochitona cinerea*, the first two species rarely found at the Romanian littoral before. The new habitat occupies the belt of rocks situated in the lower splash zone exposed to strong hydrodynamic action. The habitat has a high conservative value due to presence of encrusting or articulate red algae (*Lithophyllum incrustans, Corallina officinalis*) and surprising expansion of *Steromphala divaricata*.

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A CONCEPTUAL FRAMEWORK FOR PHYTOPLANKTON BLOOMS MONITORING

Biodiversity of phytoplankton as key primary producers is of uttermost importance for the functioning of marine ecosystem, while extremely sensitive to environmental pressures such as anthropogenic eutrophication and global climatic changes, that result in dramatic communities perturbations and harmful algal species outbreaks. Therefore, phytoplankton traits are used as relevant indicators of water quality under various policy directives. Phytoplankton monitoring is a critical element of marine ecosystem health assessment and high quality monitoring data are vital for tracking changes in the phytoplankton community structure and activity. The new generation flow cytometers with integrated imaging in flow cameras (IFCM) combine capabilities of the microscope and traditional flow cytometry in a single instrument allowing compensation of disadvantages of the specific methods. The aim of this study is to demonstrate the potential of the automated system CytoScence (IFCM) for monitoring phytoplankton communities in the Black Sea. For discrimination of different phytoplankton taxa bio-optical features (light scattering and fluorescence) and morphological traits were measured on natural phytoplankton samples. Phytoplankton groups with similar spectral properties and size were clearly distinguished, clustered and quantified. The preliminary results suggest that CytoSence system could be instrumental for express monitoring of phytoplankton natural communities and the implementation of an early warning system for harmful algal blooms in Bulgarian coastal waters.

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THE NOWADAYS FISH FAUNA OF THE GULF OF ODESA, DNIESTER MOUTH FOREFRONT NEAR-SHORES AND COASTAL WATERS OF THE SNAKE (ZMIINYI) ISLAND

The sea ecosystem research and investigations of its individual components, in particular, coastal ichthyocenoses, remain relevant. It is very important for the development and implementation of measures for the conservation and rational use of fish resources of the whole Black Sea. The aim of this work is to study ichthyofauna of the coastal areas in the northwestern part of the Black Sea. Standard ichthyological methods were used. Material was collected in the Gulf of Odessa in 1993-2020, on the Dniester mouth forefront near-shores in 2017-2020, in the coastal waters near Snake (Zmiinyi) Island in 2003-2020.

The inventory of the fish fauna species composition in the Gulf of Odessa, Dniester mouth forefront near-shores and the Snake Island coastal waters (North-Western Black Sea) is provided. In total 98 species were identified (from 79 genera, 42 families, 28 orders) of marine, brackish-water, anadromous and freshwater fish (Snigirov et al., 2020). The number of fish species may increase in the case of the penetration and dispersal of new invading species, or transit of the freshwater fish into the coastal sea areas. In the result of the long-term ichthyological studies we recorded: 80 fish species (from 63 genera, 37 families, 27 orders) in the Gulf of Odessa, 64 species (from 56 genera, 35 families, 27 orders) in the Dniester mouth forefront near-shores, and 76 species (from 63 genera, 40 families, 27 orders) in the Snake Island coastal waters.

The basis of ichthyofauna in all three regions is formed by Ponto-Caspian, Atlantic-Boreal and Mediterranean fish species. Other groups are presented by lower number of species. The sea fish species and brackish-water species are dominated. Most of species are bottom-dwelling and near bottom, pelagophyles and protecting eggs species. On feeding habits, equally dominate predatory and benthos-eating species, comprising one-half of all the species found in the area. The share of the rest of species is much smaller.

It is believed that this structure species distribution of the coastal waters ichthyocenoses is natural in the north-western part of the Black Sea (Vinogradov et al., 2017).

There is a certain similarity in the living conditions of fish in the Gulf of Odessa, Dniester mouth forefront near-shores and the Snake Island coastal waters. This largely determines faunal similarity of this three regions of the north-western part of the Black Sea.

The values of similarity on species level of the ichthyofauna of the Odessa Bay and the Dniester mouth forefront is 80.6%, of the Dniester coastal area and the coastal waters of the Snake Island – 77.1%, of the Odessa Bay and coastal waters of the Snake Island – 76.9%.

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PRELIMINARY DATA ON MICROPLASTIC IN SURFACE WATERS IN UKRAINIAN PART OF THE NORTH-WESTERN BLACK SEA

The north-western part of the Black Sea (NWBS) is highly affected by river discharge. This results in increased concentrations of various types of contamination, including microplastics. The studies of its distribution of microplastics are very rare (Aytan et al., 2016; Mukhanov et al., 2019; Pojar, Stock, 2019). There is a list of publications that describes microplastic in the sediments (Cincinelli et al., 2020; Diatlov et al., 2020; Pojar et al., 2021) and there is no information on this type of stressor in surface marine waters of Ukraine.
The studies were conducted in the coastal area of Odessa (August, 2020 and July, 2021) and in open waters of the NWBS (October, 2020 and June, 2021). The samples were collected with neustonic net (100 mkm mesh size) from the surface layers (0–5 cm and 5–20 cm below the water surface). The microplastic particles were analyzed under a stereomicroscope in the size range 0.1-10.0 mm.
The most common types of microplastic were fibres. The concentration of microplastics in 0-5 cm layer is several times higher than in 5-20 cm layer. The quantity of particles was 10 and 4 times higher in coastal area than in open waters in 0-5 cm and 5-20 cm layers. The average amount of microplastic in 0-5 cm layer made 673 par. m^{-3} in August 2020 and 60 par. m^{-3} in July 2021; the 5-10 cm layer – 66 part. m^{-3} and 7 par. m^{-3}, respectively. In open waters of the NWBS, the average quantity of microplastic was 5 and 2 par. m^{-3} in 0-5 cm and 5-20 cm layer in October 2020, and 23 par. m^{-3} and 4 par. m^{-3} in June 2021, respectively. We noted the higher amount of black and blue fibers both in coastal and opened waters of NWBS.

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BIOFOULING ON THE POLYMER SUBSTRATES AS A NEW RESEARCH FOCUS OF THE INSTITUTE OF MARINE BIOLOGY OF THE NAS OF UKRAINE

The study of biofouling on plastic substrates were begun in 2018 within the framework of a young project funded by the Ukrainian Foundation for Basic Research (№ Ф83 / 88-2018). The main idea of this work was to conduct the inventory of marine litter at the bottom in the Gulf of Odesa and to give the description of the biofouling of two types of polymers (polyethylene, PE and polyethylene terephthalate, PET) with emphasis on microalgae and meiobenthic communities.

These studies provided the adaptation of methods for studying the formation of fouling on plastic materials by benthic organisms. For the first time in the region it was shown that 59 species of aquatic organisms take part in the formation of biofouling: 40 species of microalgae (29 diatoms, 8 cyanobacteria, 2 dinophytes, 1 green) and 19 species of harpacticoids. A total of 900 m^2 of seabed was analysed, on which 29 units of marine litter were recorded. The most common debris was polyethylene (plastic bags). In the autumn, three times more litter was recorded than in the summer. In summer, more fouling was observed on bottles, and in autumn – on bags. Quantitative indices of fouling on plastic varied within the limits known for other substrates in the Gulf of Odesa. The results of these studies demonstrated the adaptation of aquatic organisms to life on relatively new types of substrates in the Black Sea and have been published in a number of works (Snigirova, Kurakin, 2019; Snigirova et al., 2019, 2020).

In the course of the study on associations of aquatic organisms on the litter collected in the marine environment, it became clear that for a deeper understanding of the processes occurring on the surface of the plastic substrate, experimental studies are needed. Subsequent studies have raised questions regarding the detection of stages of biofouling formation, the identification of the first plastic colonizers, the rate of population and the formation of stable fouling by aquatic organisms.

As a result of the project of the National Academy of Sciences of Ukraine for young scientists (№ 87-11 / 10-2020) the experimental studies of biofouling on plastic substrates were started. 3 types of experimental constructions were developed and for the first time in the North-Western Black Sea region a series of mesocosm experiments with different duration in natural conditions were conducted. The laboratory microcosm experiments demonstrated a competitive relationship between microalgae and ciliates for LDPE substrate, and in 2 weeks the number of microalgae decreased significantly. It was shown that in a week on the natural environment on polyethylene terephthalate (PET) a diverse community was formed mainly by diatoms (28 species) with a small presence of cyanobacteria, as well as prothallus of algae-macrophytes of the genus *Ulvella*.

The presence of 13 taxa of meiobenthos was showed. Moreover, we revealed 7 species of harpacticoid copepods, which were found on all experimental plates and can be considered as indicator species of plastic. It is determined that stable groups of meiobenthos are formed due to eumeiobenthic taxa (mainly harpacticoids and nematodes) (Snigirova et al., 2021).

An important aspect of the initiated research is their contribution to the development and implementation of Marine Strategy approaches, as marine litter is the tenth descriptor. The obtained results and further development of these ideas will help to estimate the duration of litter in the natural environment based on the analysis of the fouling formed on it. The introduction of the study of the impact of plastic as a new type of pollution should become one of the elements of environmental monitoring and contribute to the formation and understanding of the so-called "good environmental status" of the sea.

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SPATIAL ASSESSMENT OF HYDROECOLOGICAL CONDITIONS OF THE BLACK SEA NORTHWESTERN PART REGARDING THE LOCATION OF ARTIFICIAL REEFS

Spatial processing of the international databases «The Copernicus Marine Environment Monitoring Service» (CMEMS) and EMODnet Seabed Habitats by GIS enabled the long-term distribution of hydrologic indicators of the North-West Black Sea (NWBS) with a year-on-year trend. The abiotic and production conditions of the NWBS are characterized by spatial heterogeneity, which is due to the enormous influence of river run-off and the branched shape of the relief represented by the network of paleovalleys. High heterogeneity is confirmed by standard deviation values, which in many cases exceed the average.

The analysed substrate distribution and mosaic also reflect the morphological features of the relief phages and the effects of the river flow dissipation zone, where marine and terrigen processes are mixed.

Using a geo-information analysis based on the vertical and latitudinal distribution of the ecofactors, NWBS was zoned with the following distinction: Paleo-river catchments; Macroforms of relief (lowlands and uplands), ecological zones of the seabed (infraralitoral, upper circolitoral, lower circolitoral, elitoral), phototrophic zones (euphotic, dysphatic, aphoric); anomalies in concentrations of chlorophyll a; Area with the highest risk of hypoxia and nutrient effects. In particular, the topographic analysis of the morphostructure of the relief according to calculation of the «Index of Bathymetric Position» made it possible to distinguish uplands, banks and basins, on which obtained areas of meso and microrelief with the greatest potential of the habitat.

The data obtained can be added to the implementation of the Marine Water Framework (MSFD, 2008/56/EU) and Habitats (Directive 92/43/EU) Directives into national legislation and regional monitoring programs, concerning: typology and classification of water masses and sediments; definition of reference conditions and ecological status of classes; location of artificial reefs, etc.

On the basis of geomorphological, hydrochemical, production and phototrophic analysis, it has been established that the most basic conditions are found in the areas of Yahorlytska, Tendrivska and Kartynytska bays, which are characterized by good illumination, the absence of a vertical thermo-galine structure and low risk of hypoxic conditions. The high ecological status of these bays is confirmed by the international Convention on Biological Diversity, which places them in the register of high biological and ecological values (CBD/EBSA/WS/2017/1/4 September May 2018).

Also promising as high-performance zones of artificial reefs are areas of uplands (Budakska, Dnistrovska, Chornomorska and Tendrovska) and cans are defined on the basis of the BPI index. In the area of Budakska and Dnistrovska Uplands there is the Big Phillophora Field of Zernov, which is also in the register of marine areas with high biological and ecological value (CBD/EBSA/WS/2017/1/4 September May 2018).

With regard to improve the ecological status of the seabed habitats, it is recommended to create artificial reefs with sanitary mariculture in the areas of greatest influence (dissipation) of the river run-off and to reduce dissolved oxygen in the bottom horizons. These are primarily the following areas: Danube Avandelta; Odessa gutter (depths 25-30 m); Dnieper gutter (located submeridionally south of the Odessa gutter).

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CURRENT TRENDS IN AQUATIC INVASIONS IN THE ESTUARINE ECOSYSTEMS OF THE BLACK SEA

Because of the unprecedented variety of hydrological conditions in the estuaries of the region, they are colonized by marine, freshwater, brackish and halophilic species.
The mouths of brackish estuaries, transformed during the construction of canals, drastically change hydrological conditions and become areas with increased biopollution. Under conditions of artificial fragmentation, various invasive communities can form within the estuary.
Small streams associated with estuaries, as well as estuaries of small streams flowing into the sea become separate hotspots for biopollution.
Estuaries become the gateway to the colonization of large river basins by euryhaline species of marine origin.
There is an exchange of relict fauna between the estuaries of the Ponto-Caspian basin, which leads to intra-guild competition.

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CHALLENGES OF THE BALLAST WATER MANAGEMENT CONVENTION: INCREASING OR DECREASING PROBLEM ISSUES?

Shipping facilitates the transportation of over 90 % of the world's commodities and eventually transfers ~10 billion tons of ballast water (Ghosh and Rubly, 2017; Khandeparker and Anil, 2017). The diversity of organisms in the ballast tanks varies from bacteria to fish, especially at larval stages (Olenin et al. 2002; Gollasch et al. 2002; Wu et al. 2017; Cabrini et al. 2018). Based on the analysis of data stored in the information system on aquatic non-indigenous and cryptogenic species AquaNIS (2021) 29 out of 60 (48%) of non-indigenous species (NIS) introduced to the Baltic Sea in the 21st century, were likely transported by ships' ballast water and sediments; with a decreasing trend in recent years.
Recently the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWMC) (IMO, 2007) came into force, which aimed at reducing the spread of harmful aquatic organisms and pathogens (HAOPs) with ships' ballast water. The monitoring of ballast water is crucial part to understand the diversity of organisms, including pathogens present in vessel ballast tanks, e. g.: which species are present, how many propagules there are, and what is their capacity to establish upon release (Darling and Frederick, 2018). Still, there is a lack of studies and risk and impact management plans of such pathogens, starting from sampling protocols, methods of analysis, action plans after detection, the viability of organisms after ballast water treatment (Gollasch et al. 2012). Despite increasing attention and awareness about harmful aquatic organisms and pathogens (HAOP), the fundamental knowledge on HAOP after ballast water management system (BWMS) treatment is needed (Brockerhoff et al. 2006), in order to apply adequate control and prevention strategies to improve biosecurity (Whittle et al. 2013). A set of new best practices, guidelines, and protocols must be established to protect the environment from the negative effects of shipping processes. In this study the first attempts of monitoring ballast water results and guidelines will be presented. After detection of HAOP, the crucial step in ballast water management is a warning signal service (Early et al. 2016). One of the solution could be a combination of rapid detection methods and mobilized data using an open approach. The specific goals of the early warning are firstly to warn vessels to prevent loading of ballast water when critical biological conditions occur in ports and surrounding areas i.e. outbreaks of HAOP. Secondly, to warn a port, environmental and health authorities when NIS or pathogens are present in ports or surrounding areas to enable management activities (Magaletti et al. 2017). Early warning system with risk assessment tools can be integrated into online systems, such as AquaNIS (AquaNIS, 2021), for timely communication of findings of HAOPs to all relevant authorities in countries and international shipping companies to ensure that there is sufficient time for the response measures and the roles of all actors are clearly defined. The aim of the Early Warning System (EWS) is to give an opportunity to send warning signal about the presence of HAOP in ports and adjacent areas. Development of communication mechanism integrating rapid ballast water sample analysis and online data platform is crucial for the prevention and management of the spread of HAOP. Still the fundamental questions remain regarding the overall risk posed by ballast water transport and the degree to which recent changes in management policy have reduced that risk.

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THE RESTORATION OF THE TEMPERATURE'S VERTICAL PROFILE BY THE SATELLITE DATA ON THE EXAMPLE OF THE BLACK SEA

The current stage of studying the Black Sea basin, from the mid-1990s to the present, is characterized by a sharp decrease in the number of systematic expeditions to the open sea. The remote methods of sea observation have been further developed - data from satellites and buoys are regular means of monitoring the state and dynamics of the open sea, allowing to set and solve new tasks of operational service for interested users. The modern possibilities of identification of data of remote observations allow to speak about monitoring of the processes proceeding on scales from hundreds of meters till the first hundred kilometers with the periods from hours and days. The ability to involve satellite observations and acoustic sounding data requires substantial detailing for their reference to real conditions, and the selection of an appropriate simulation model to assess changes in the state of the marine environment.

To investigate the appropriate response of the sea to climate change and anthropogenic impact requires constant monitoring of the state of the sea surface, the variability of the upper mixed layer, the vertical structure, and dynamics of water in the active water layer, processes in the shelf zone, etc. Synchronous application of various remote methods - satellite and acoustic expands the possibilities of monitoring large sea areas, as it provides continuous operational data on the state of the environment both on the surface and in the water column. The strategy of integrated use of remote sensing should provide long-term and continuous collection and systematic integration of data obtained by various methods using modern technical means, which will be based on them in simulation.

The estimate of the connection between satellite observations and contact measurements of water temperature was carried out based on statistical methods of analysis by establishing correlation and regression dependences.

The calculations of water temperature's vertical profile based on satellite data of surface water temperature on the example of the Black Sea using the developed method in the State Institution "Hydroacoustic Branch of Institute of Geophysics by S.I. Subbotin name of NAS of Ukraine" (Sryberko, 2019; Sryberko, 2021) statistically significant results for the period of spring - autumn showed. Thus, the effectiveness of the method and its convenience in terms of availability of source information determines its economic benefits.

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MONITORING AND STATE ASSESSMENT OF PELAGIC HABITATS IN RELATION TO BIODIVERSITY (D1) AND EUTROPHICATION (D5) DESCRIPTORS (MSFD) IN THE BULGARIAN BLACK SEA

The Marine Strategy Framework Directive (MSFD) (Directive 2008/56/EC) was adopted by the European Union (EU) in 2008, requiring EU Member States to maintain or achieve Good Environmental Status (GES) in their seas by 2020.The suite of 11 MSFD descriptors aims to deliver a holistic management approach, representative of the state and functioning of the whole marine ecosystem, through the establishment of environmental thresholds and monitoring of associated indicators to determine GES. Marine monitoring is an essential element of reporting and assessment of the marine environment and provides insight into coastal and ocean processes. Marine biodiversity monitoring is essential for the management of anthropogenic activities that affect the state of marine ecosystems, to support the understanding of complex marine systems, to determine GES, and to evaluate the effectiveness of the established measures. Eutrophication (D5) is a process driven by the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, leading to: increased growth, primary production and biomass of algae; changes in the balance of organisms; and water quality degradation. The consequences of eutrophication are undesirable if they appreciably degrade ecosystem health and biodiversity and/or the sustainable provision of goods and services.
Plankton is employed in ecosystem-based monitoring programmes to assess environmental status of regional waters and changes resulting from anthropogenic and climate pressures and are mandated by the MSFD in the indicative list of characteristics to be considered.
We used data and results from the second reporting cycle assessment in regards of MSFD requirements, covering the years 2012–2019. The overall aim was to evaluate the D1 and D5 monitoring system employed for the pelagic broad habitat types assessment.

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LONG-TERM ECOLOGICAL RESEARCH (LTER) AND MONITORING OF MARINE ECOSYSTEM COMPONENTS AT BLACK SEA - MACROSITE

Long-Term Ecosystem Research (LTER) is an essential component of world-wide efforts to better understand ecosystems structure, functions, and long-term response to environmental, societal and economic drivers, contributing to the knowledge base informing policy and to the development of management options. The LTER allows to follow the evolution of the ecosystems over decadal scales to understand the driving processes behind their temporal variability in relation to local and global stressors (Zingone et. al., 2019).

The Bulgarian LTER (LTER – BG) is long-duration research and monitoring of ecosystems or components of ecosystems. An essential quality of an LTER site is the availability of long term data. The most obvious way to analyze the data is by looking for trends and this can be achieved with high frequency monitoring. LTER-Bulgaria is currently composed of 7 sites and cover the major biogeographical regions. They widely represent the main ecosystems in Bulgaria – Forest sites – 2 (Petrohan – mainly beech and mixed forests and Yundola – coniferous forests); Wetland – 1 (Srebarna lake); Marine macro-site – 1 (Black sea); Coastal zone – 1 (Sozopol Bay); Freshwater body – 1 (Mesta river).

Black sea macro-site includes three areas: cape Kaliakra (northern Bulgarian Black Sea Coast), cape Galata and Varna Bay (northern Bulgarian Black Sea Coast), and Koketrays Sand bank (only for macrozoobenthos) –southern Bulgarian Black Sea Coast. The aim is to study plankton and benthic biodiversity and taxonomic structure, successions, ecology of mass species, blooms, molecular taxonomy and ecology, distribution of potential toxic species, ecological indicators for assessment of marine ecosystem, invasive species, spatial and temporal distribution, trophic conditions and interactions, climate change, changes in ecosystem services due to human pressures. The main topics are marine biology and ecology study in coastal and shelf areas, long-term monitoring, development of indicators and classification systems for the ecosystem state assessment in respect to European Directives (WFD, MSFD, HD) concepts

The study aim is to highlight: i) the fundamental contribution of time series to the development of plankton knowledge that can be of general interest much beyond the local scale and ii) the role of ecological observations to address the challenges posed by climate change and evolving human needs and stressors within the coastal zone.

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THE STRUCTURE OF MACROZOOBETHOS BIOCENOSIS *MELINNA PALMATA* IN THE DANUBE REGION OF THE BLACK SEA

The leading species of the biocenosis – the polychaete of Atlantic-Mediterranean origin Grube, 1870 – belongs to the widespread marine species. In the Black Sea, it is found on loose silty soils along all shores to a depth of 162 m (Vinogradov, Losovskaya, 1968). The length of the melinna in the Black Sea is up to 60 mm (Dragoli, 1960). From the particles of silt polychaete builds a rubber tube, most of which is immersed into the sludge, whereas the upper part protrudes above its surface.

In contrast to the typical for the silty soils of the Black Sea the biocenoses of mussel and phaseolin silt, which are distributed along all shores (Losovskaya, 1977), the biocenosis of melinna occupies some areas at a depth of 12-30 m. It is located mainly in areas of river removal by organic detritus, which is determined by the nutrition of the melinna as a form that collects detritus from the soil surface. The largest areas occupied by the biocenosis of melinna in the north-western part of the Black Sea are observed in the Dnieper-Dniester interfluve (Vinogradov, 1960), in the western – near the coast of Bulgaria (Kaneva-Abadzhieva, Marinov, 1960), in the east – near the confluence of the Rioni and Inguri (Losovskaya, 1977).

In 2004–2020, in the Danube region of the sea, the biocenosis of melinna was isolated at 58 stations, mainly on silt at a depth of 9.5–25.0 m, in the water salinity range of 13.7–18.0 ‰. 52 taxa of macrozoobenthos were registered: worms – 17, mollusks – 20, crustaceans – 12, representatives of other groups – 3. The average number of benthos was 2694 ± 360 specimens · m-2, biomass – 175,486 ± 27,129 g · m-2, leading species - 1823 ± 313 specimens · m-2 and 30,244 ± 5,200 g · m-2, respectively. The highest single density of *M. palmata* was 12140 specimens · m-2, biomass - 160,000 g · m-2.

The fauna of the biocenosis was represented exclusively by the marine complex, euryhaline forms predominated in number (91.4%) and biomass (90.8%). The basis of the number (67.7%) of benthos was formed by M. palmata, biomass (59.9%) - the invasive species Anadara kagoshimensis (Tokunaga, 1906) and Mya arenaria Linnaeus, 1758. In the structure of the biocenosis six stenohaline species registered – Acanthocardia tuberculata, Linnaeus 1758), Pitar rudis (Poli, 1795), Polititapes aureus (Gmelin, 1791), Spisula subtruncata (da Costa, 1778), Abra nitida milachewichi Nevesskaja, 1963, and Medicorophium runcicorne (Della Valle, 1893), the total density of which 233 ± 57 specimens · m-2 was, biomass – 16.07 ± 5.43 g · m-2. According to the frequency of occurrence, the number of constants (P ≥ 50%) included 6 species – M. palmata, Nephtys hombergii Savigny in Lamarck, 1818, Polydora cornuta Bosc, 1802, A. kagoshimensis, A. nitida milachewichi; their share was 86.8% density and 62.0% benthos biomass.

Among the taxonomic groups, worms predominated (82.1%) and mollusks predominated in biomass (76.6%). Among the four trophic groups, detritophages dominated in the number of taxa (21) and density (83.1%), and sestonophages in biomass (72.1%). The index of uniformity of food structure was 0.43. The average biomass of the forage part of benthos was 66.924 g · m-2; it was dominated by worms (57.6%) and mollusks (40.7%). By the number of taxa (36), abundance (97.1%) and biomass (92.8%) the representatives of the infauna dominated. Seven alien species – Diadumene lineata (Verrill, 1869), P. cornuta, Dipolydora quadrilobata (Jacobi, 1883), Rapana venosa (Valenciennes, 1846), A. kagoshimensis, Amphibalanus improvisus (Darwin, 1854) – accounted for 3.8% of the density and 61.7% of benthos biomass.

The composition and structure of the biocenosis of M. palmata in the Danube region of the sea in 2004–2020 were similar to those of the biocenosis in the Odessa marine region (Sinegub and Vorobieva, 2017) and off the coast of Bulgaria (Kaneva-Abadzhieva and Marinov, 1960).

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THE DISTRIBUTION OF TINTINNIDS ALONG THE ROMANIAN BLACK SEA IN THE SUMMER SEASON

Species composition, abundance and distribution were studied along the Romanian Black Sea in 2019 and 2020 summer season. Following the analysis of a number of 78 samples, a higher diversity was identified in 2019 (22 species) compared to 2020 (15 species).
The species belonging to the genus *Tintinnopsis*, *Stenosemella*, *Metacylis*, *Favella*, *Eutintinnus* and *Tintinnidium* was a constant presence in both summer period while the species belonging to *Codonella*, *Rhizodomus*, *Amphorellopsis*, *Leprotintinnus* and *Salpingella* genus varied from one year to another.
It is also highlights variations of the dominant species, depending on the type of water (coastal, marine or with variable salinity) and the analised period. The waters with variable salinity were represented by the species *Leprotintinnus pellucidus* and *Favella ehrenbergii*, respectively. The coastal waters were represented by the species *Favella ehrenbergii* and *Tintinnopsis campanula* while the marine waters by *Tintinnopsis minuta* and *Metacylis mediterranea.*
The general trend for all analised period is a growing trend in densities and biomasses of tintinid populations from the south to the north of the Romanian waters.

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RED LIST OF MARINE INVERTEBRATES OF ROMANIA – THE PREMISES, ACTUAL IUCN STATUS AND PERSPECTIVES

The protection of endangered species is a constant feature of today's society. Worldwide, the assessment of the conservation status of species and their inclusion in the so-called "red lists" has become widespread. The publication of Red Data Books for various countries or regions of the globe is a very important step in raising awareness among the public and policy makers of the need to protect plant and animal species. In the Black Sea area, in terms of wildlife, such initiatives have existed, with Red Books being published for Bulgaria, Ukraine, Moldova, and Crimea and for the Black Sea (Black Sea Red Data Book). Some of these Red Books include only species, others also include habitats that are considered as being endangered at the regional level.
Taking into account the IUCN criteria for determining the degree of conservation, a total of 51 species of marine and brackish water invertebrates have been proposed to be included in the Red Book of Invertebrates of Romania: Porifera (sponges) – 2 species, Cnidaria (jellyfishes) – 1 species, Nemertea (ribbon worms) – 1 species, Bryozoa (bryozoans) – 1 species, Platyhelminthes (flatworms) – 1 species, Annelida Polychaeta (bristleworms) – 5 species, Crustacea (crustaceans) – 19 species, Bivalvia, Gastropoda and Polyplacophora (mollusks) – 21 species.
After analyzing the literature data and direct observations in recent years, we propose their classification according to the IUCN categories as follows: CR – 12 species, EN – 22 species, VU – 15 species, NT – 2 species.

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BROAD-SCALE CIRCALITTORAL SOFT-BOTTOM BENTHIC HABITATS AT THE ROMANIAN BLACK SEA COAST

Marine habitats play an important role in some of the key ecosystem processes (i.e., primary production, food webs, recycling, etc), but they are subject to many human pressures which put in risk their functionality. The modern approach of marine habitats has been developed within the context of European policies, such as the 2008/56/EC Directive. In this context, the Black Sea broad-scale benthic habitats map created within the EuSeaMap project are presented. The wave energy, substrate, temperature, density and break of the slope were identified as key variables for the classification of the Black Sea region into biological zones. The broadscale habitats is the result of the spatial combination of biological zones and benthic communities' distribution. Particular for the Danube's plume area, identification of the infralittoral/circalittoral boundary based on the estimated percentage of light reaching the sea bottom did not work as appropriately due to combined fine sediment and fresh water apposition interfering with the standard substrate and benthic zonation pattern observed in coastal areas. 32 broad scale habitats have been agreed for the Romanian Black Sea, of which 19 coastal, 12 soft bottom circalittoral habitats, and one within the bathyal and abysal zone.
Our study has contributed to the improvement and updating of knowledge concerning the area in terms of biodiversity and habitat distribution. Over the last 10 years, GeoEcoMar has considerably intensified the research effort managing to obtain information from more than 300 stations used also to delineate the actual habitats according to EUNIS classification and MSFD. According to recent researches, both the benthic and pelagic ecosystems have witnessed a period of improvement, exemplified by the reappearance of some species, which used to be abundant in the period of ecological stability. The results showed an increased macrobenthic diversity comparative with the period of the '90s.

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PLANKTOTHRIX AGARDHII (CYANOPROKARYOTA) TOXIC BLOOMS IN KHADZHIBEY ESTUARY (UKRAINE)

The first identification of *Planktothrix agardhii* (Gomont) Anagnostidis & Komárek 1988 (Cyanoprokaryota) was performed during an early bloom in the Khadzhibey Estuary in April 2019. This estuary is one of the largest estuaries at the northwestern part of the Black Sea region. Prior to our finding, this species was not observed in the estuary, and it is not included into the list of phytoplankton for this area (Nesterova et al., 2006).
P. agardhii is a new cyanobacterial species for the Black Sea as well. It was found in an autumn phytoplankton at the Odessa Bay (Terenko and Hushchyna, in press).
P. agardhii is a filamentous planktonic species usually found in eutrophic and hypereutrophic shallow waterbodies. This species commonly creates blooms in fresh/brackish waterbodies of the temperate zone. *P. agardhii* is a potentially toxic species. It produces microcystins which are hepatotoxins. Therefore, it has a toxic effect on a liver by an inhibition of a protein phosphatase and causing a cellular apoptosis later. The researchers from Europe confirm that blooms of this species in inland waters mostly contain microcystin (Chorus and Welker, 2021).
The massive bloom was registered on 17th June 2020 when the water temperature and salinity were 24.6°C and 4.5 ‰ respectively. The abundance of *P. agardhii* was 7.8 million trichomes·l^{-}. The biomass was 23.4 g·m^{-3}. The average width of the trichome was 4.34 µm and the average length was 260.62 µm. The water in the estuary had olive-green colour with an earthy smell of geosmin.
We found that this species was present in the phytoplankton community all year around with a high biomass accumulation in spring, summer, and late autumn.
The mass mortality of biota, mostly fish and shrimps, was registered during summer blooms of *P. agardhii*.
The water from a spring bloom of *P. agardhii* with the abundance of 29.4 million trichomes·l^{-} and biomass of 38.8 g·m^{-3} was analyzed on the presence of toxins. ELISA was used to detect the total microcystin concentration in MC-LR equivalent. Results showed that this population was toxic with a total microcystin concentration 15.6 µg·l^{-} as MC-LR equivalent. This concentration is lower than a proposed by WHO guideline value for a recreational use which is 24 µg·l^{-} (Chorus and Welker, 2021). However, analyses of toxins were done from the bloom developed at 4°C and concentration of them might be higher during summer months. The additional research aiming to learn and understand a variation of toxins' concentrations and the congeners in the estuary during blooms of *P. agardhii* in different seasons is planned.

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ASSESSMENT OF TENDENCIES IN THE DEVELOPMENT OF MESOZOOPLANKTON ON THE NORTH-WESTERN COAST OF THE SEA OF AZOV

The northwestern coast of the Sea of Azov is subject of anthropogenic pressures. This is due to intense recreational activity in the area of the Fedotova and Stepanivska spits, and serious technogenic pressure in the area of the Berdyansk spit, where, in addition to recreation, navigation is developed. Invertebrates are the most sensitive group in the coastal sea zone. They react with high speed both to anthropogenic impacts and global climatic changes (Vorobyova, 2019). Meso-zooplankton (MZP) is one of the most reactive communities of invertebrates. Monitoring of MZP communities condition allows us to follow the state of coastal ecosystems.
The purpose of this work is to receive information of the trends occurring to the MZP communities of the northwestern coast of the Sea of Azov.
The material for the work was the MZP samples collected from May to August in 2016-2020 in the northwestern coast of the Sea of Azov. The work was carried out under the monitoring program of the Priazovsky NP according to the generally accepted methods. When processing samples, organisms without signs of mechanical damage and decomposition were taken into account, biodiversity, quantitative characteristics and the ratio of components in the samples were assessed. The data of salinity, chlorophyll-a content and water surface temperature were also analyzed. The last two parameters are open-source data (oceancolor.gsfc.nasa.gov).
Evaluating changes in these indicators during the study period, we can observe some tendencies. Upward trends of the water surface temperature and total dissolved solids are found. The meanings of their slope coefficients (SC) trend lines are for TDS is 0.384 ‰ and 0.08°C for temperature. There is also a tendency of decreasing in the concentration of chlorophyll-a in the coastal zone. Slope coefficients for its trend line was 0.18859 mg.·dm^{-3}.
In view of such changes, we see decreasing in the seasonal abundance of holoplankton. For the area of the Fedotova and Stepanivska spits, the SC was 601.83 org.m^{-3}, for the area of the Berdyansk spit 1590.3 org.m^{-3}. This may be due to both the feeding conditions and increasing of jellyfish *Rhizostoma pulmo* press since 2019. During the study period, we recorded the mass death of MZP only during the periods of phytoplankton and cyanobacteria blooms, which usually occurred in early to mid-July. In addition to a decrease of abundance, we observe decreasing of biodiversity and changes in the structure of MZP communities. The occurrence of Cladocera in samples decreased, as well as the diversity of Calanoida species. All received data indicates negative processes which take place in the study region. Such changes in biotic and abiotic parameters can be effects associated with global warming.

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BIOLOGICAL INTERACTION BETWEEN ICHTHYOPLANKTON AND MACROZOOPLANKTON IN THE BLACK SEA

The main objective of the paper is to demonstrate the biological interaction between the two planktonic components in the studied area as well as to reveal their qualitative and quantitative analysis. Ichthyoplankton and macrozooplankton assemblages were studied from samples collected from the Romanian, Bulgarian and Turkish Black Sea water column.

Fish species reproduction and their larvae development are closely related to the environmental conditions, the breeder's stock state, the trophic base, but also to the relation between prey-predator. The changes recorded in the marine biotic complex in the last years have led to a tendency of quantitative decrease regarding ichthyofauna, the main cause being the excessive fishing but also the high abundance of the macrozooplankton.

Macrozooplankton is considered harmful to fish populations due to competition for food and by direct predation on fish eggs and larvae (Brodeur, 2008).

The qualitative structure of ichthyoplankton in October 2019 included eggs and larvae of *Merlangius merlangus*, eggs and larvae of *Mullus barbatus ponticus* and a low number of *Sprattus sprattus* eggs, the dominant species being the whiting.

The identified macrozooplankton species were scyphozoa *Aurelia aurita* and ctenophores *Pleurobrachia pileus, Mnemiopsis leidyi, Beroe ovata*.

Following the quantitative analyzes of the collected samples, it was found that in the areas where the macrozooplankton recorded high densities values, the ichthyoplankton density was low. The distribution of *P. pileus* species was represented by high density values in all three analyzed areas.

This leads to a high consumption of zooplankton organisms, necessary for fish larvae development, *P. pileus* species becoming the main competitor for the fish larvae food resources (Grishin, 2007).

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EVALUATION OF THE AMATEUR ANGLING IMPACT ON LOWER DNIESTER FISH RESOURCES AS AN EXAMPLE OF THE TRANSBOUNDARY SCIENTIFIC COOPERATION

The joint evaluation of amateur fishery on fish resources of the Lower Dniester (the Dniester River basin from the Dubasari Hydropower Dam to the river mouth excluding the Dniester Liman) was realized during one year period in 2019 and 2020 by three groups of researchers, representing right-bank Moldova, left-bank Moldova and the Ukrainian Lower Dniester area.
The evaluation was realized by monitoring of individual catches by each group with the numbering of the fishermen by the river segments in each season.
It was determined that the total amateur catch corresponds to 547 tones of fish per year. The figure demonstrates that the fishing pressure on fish resources is enough significant and comparative with the industrial fishery in the Dniester Liman (about 2000 tones). About 2/3 of all fish is caught in Ukraine and 1/3 – in Moldova, including Transdniester region.
Despite the provisions of Annex V of the Dniester 2012 treaty, the cooperation between riparian states Moldova and Ukraine on Dniester biologic resources is very low. In fact, both countries have no coordination of the protection measures and activities. When in Moldova, including Transdniester region, the industrial fishery in the Dniester River is stopped from 2016, in Ukraine it is ongoing both in the river and in its estuary. The widely developed poaching has also a serious impact on fish resources. The close cooperation of the riparian states in this field is necessary, to prevent fish resources and water biodiversity degradation. The current research represent the example of such joint transboundary study realised by experts from all important regions of the river basin. Further similar research could be initiated by the Dniester River Commission established in accordance with the Dniester 2012 basin treaty.

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INFLUENCE OF THE LEVEL OF WATER EXCHANGE WITH OPEN SEA IN THE WATER AREAS OF COASTAL PROTECTION STRUCTURES OF THE ODESSA BAY (BLACK SEA) ON THE SIZE STRUCTURE OF ISOPOD *IDOTEA BALTHICA*

The nature of the size structure of the population of *Idotea balthica* (Pallas, 1772) was studied within the three water areas of the coastal protection structures of the Odessa Bay of the Black Sea, the first of which was with free water exchange with open sea (flow velocities are 30–35 $cm \cdot s^{-1}$), the second with limited (10–12 $cm \cdot s^{-1}$) and the third – with difficulty (3–5 $cm \cdot s^{-1}$).

It is known that sexual dimorphism in these crustaceans is expressed, including in the size of their body (Khmeleva, 1973). As shown, males of *I. balthica* living in the Odessa Bay of the Black Sea are much larger than females, but smaller by at least 30% of the limit sizes for this species specified in other areas of the Black Sea (Varigin, 2014).

As a result of the conducted researches it was found out that the average length of a body of males of *I. balthica* increased at consecutive transition from water area with a free water exchange (12,4 ± 1,1 mm), limited (13,2 ± 0,6 mm) and difficult (14,2 ± 0,5 mm). The difference between the average body length of crustaceans for water areas with free and difficult water exchange is statistically significant (p = 0.0149) at the level of 95%. At the same level, the difference between the average body length of crustaceans living within the waters with limited and difficult water exchange is statistically significant (p = 0.0336). The analysis showed that the average body length of *I. balthica* females also increased with a 95% confidence in the transition from the water area with free water exchange (9,1 ± 0,6 mm) to the water area, within which water exchange was difficult (9,7 ± 0,2 mm).

The described differences were also found in the analysis of the size-frequency distribution of the studied crustaceans within these three water areas. Thus, in the water area with free water exchange, the body length of most males of *I. balthica* was in the range from 10 to 14 mm. Large males larger than 16 mm are rare. Analysis of the size-frequency distribution of male crustaceans living within the water area with limited water exchange showed a marked shift in their size characteristics towards the largest individuals. Within the water area with difficult water exchange, the predominance of large males becomes obvious.

Females have a different size-frequency distribution within the studied water areas. Here the difference is manifested between individuals of crustaceans living in waters with limited and difficult water exchange. In the semi-enclosed water area with difficult water exchange, the dimensional characteristics of crustacean females are shifted towards larger individuals.

Thus, the semi-enclosed water area with difficult water exchange with open sea is characterized by conditions favorable for the development of *I. balthica*. Within these water areas, reliably protected from the action of large waves, live individuals of these crustaceans of the largest size. It is known that the size of the female *I. balthica* depends on its absolute fertility (Khmeleva, 1973). Therefore, larger females can give more offspring, which will contribute to the prosperity of the population of this species within the coastal zone of the sea.

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ANTIMICROBIAL ACTIVITY OF BACTERIA OF *LACTOBACILLUS* GENUS ISOLATED FROM BLACK SEA SPONGES

Recently, the search for new producers of active substances, with a wide range of actions, is increasingly being conducted in the marine environment. Among the microorganisms of primary interest are lactic acid bacteria, which are not typical representatives of the marine microbiocenosis. There are few publications about lactic acid bacteria isolated from marine hydrobionts (Kathiresan et al., 2008). Representatives of this group of microorganisms are isolated from fish, corals, algae, but not from sponges. Isolated and studied strains according to all morphological, physiological, biochemical, and cultural characteristics belonged to the *Lactobacillus* genus (Valérie et al., 2003).
Species identification of strains was carried out according to the composition of cellular lipids fatty acids. Determination of antagonistic properties was carried out in vitro by a hole-diffuse method (Chetan et al., 2017; Presti et al., 2015) in relation to such indicator test strains: *Escherichia coli, Proteus vulgaris, Klebsiella pneumoniae, Salmonella enterica, Pseudomonas aeruginosa, Bacillus subtilis, Micrococcus luteus, Enterococcus faecalis, Staphylococcus aureus*.
The result of identification showed that 9.1% of isolates were identified as *Lactobacillus vaccinostercus*, 52.7% of isolates as *Lactobacillus parabuchneri* and 38.2% as *Lactobacillus bifermentans*. Studies have shown that lactobacilli isolated from *Haliclona sp.* sponges, selected in the north-western part of the Black Sea, have antagonistic activity against both gram-positive and gram-negative microorganisms from the studied list of indicator microorganisms. Most strains (85.45%) had a strong antagonistic effect on *Micrococcus luteus*. An average level of antimicrobial activity was shown against *Escherichia coli* (72.73%), *Enterococcus faecalis* (56, 36%), *Pseudomonas aeruginosa* (56.36%) and *Staphylococcus aureus* (50.91%) strains. Approximately 55% of the studied *Lactobacillus* strains exhibited no antimicrobial activity in relation to *Salmonella enterica*. 38.18 % of the studied *Lactobacillus* strains demonstrated the high levels of antagonistic activity of lactobacilli against *Bacillus subtilis.*
Thus, our studies have shown that investigated lactobacilli have antagonistic activity against both gram-positive and gram-negative microorganisms. The indicator strains of *E. coli*, *E. faecalis* and *P. aeruginosa* were mostly sensitive to the effects of lactobacillus. Also, our strains obtained high antagonistic activity against *B. subtilis* and *P. vulgaris*. Obtained results indicate that *Lactobacillus* strains that have been isolated from the Black Sea sponges can subsequently be investigated for their potential use as a microbial feed adjuvant in marine aquaculture. On the other hand the presence of lactic acid bacteria in the marine environment and especially in the sponges serves as a negative signal indicating a significant change in the microbiocenosis of the Black Sea.

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PSEUDOMEIOBENTHOS OF THE NORTHWESTERN PART OF THE BLACK SEA. SPATIAL DISTRIBUTION

In the meiobenthic community of organisms, it is customary to distinguish the permanent and temporary components of the meiofauna (Mokievsky, 2009) or in the terminology of L.L. Chislenko (1961) – eumeiobenthos and pseudomeiobenthos. Unfortunately for the Black Sea there are few special studies that would show the features of the formation of the temporary component of meiobenthos. Among representatives of the temporary component, the densest clusters are characteristic of juvenile individuals of polychaetes and bivalve mollusks. 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. Active subsidence of larvae and successfully completed (finishing) of metamorphosis makes it possible to replenish and restore bottom communities.

The maximum indicators of the average abundance of pseudomeiobenthos refer to depths of 10-15 m. In depth (10-15 m), a silty substrate, silted shell, silted sand was prevailed. The total number of pseudomeiobenthos was 20826.3±5010.4 ind.m^{-2} – 7.0% of the total number of meiobenthos. Juveniles of bivalve mollusks dominated (average 9515.5±3787.0 ind.m^{-2}), accounting up to 46% of the total pseudomeiobenthos. Polychaetes (37%) were the subdominant group with an average density (7789.4±1430.2 ind.m^{-2}). The average number of gastropods was (309.3±137.8 ind.m^{-2}), its share in the total index decreased from 6% to 1%.

An analysis of long-term studies has made it possible to characterize the formation density of pseudomeiobenthos (temporary meiofauna) settlements depending on the substrate, depth, and seasons of the year in the Odessa Sea region of the northwestern Black Sea by the example of oligochaetes, polychaetes and juvenile mollusks. Their largest accumulations (the total density of settlements was 30865.8±5384.3 ind.m^{-2}) are characteristic of the ground sand/shell: the total indices density of pseudomeiobenthos organisms was formed by polychaetes and mitilides – 15815.4±9574.6 ind.m^{-2}. The proportion of polychaetes reached 56.7% of the total abundance of pseudomeiobenthos (7646.15±8574.2 ind.m^{-2}). The smallest – for silty substrate (averaged 11705.5±1337.8 ind.m^{-2}). The maximum indices of the total number of temporary meiofauna were recorded on depth of 10-15 m (20826.3±5010.4 ind.m^{-2}). As shown by long-term studies, the average indicators of the total number of meiobenthos are the highest in the winter period. The same applies to the density of the temporary component.

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FEEDING OF *PONTICOLA CEPHALARGOIDES* (PINCHUK, 1976) IN ODESSA BAY IN 2020

Pinchuk's goby *Ponticola cephalargoides* (Pinchuk, 1976), first described as a broad–lipped form of the ratan goby *P. ratan* (Nordman, 1840), and later acquired the status of a species. It has a broken range represented by populations in the northwestern Black Sea and Azov region (Kerch Strait and the adjacent part of the Black Sea). This species is most numerous in the northwestern part of the Black Sea. However, despite this, information about its biology and, in particular, about nutrition is very small. Therefore, the aim of our research was to study the nutrition of Pinchuk's goby in the current state of benthic biocenoses of the coastal zone of Odessa Bay.

From June to November 2020 fishes were caught with a net at the distance of 150–250 meters from the shore in Odessa Bay (Small Fountain area). In the course of research, the intestinal contents of fish caught in summer (20 males and 4 females) and autumn (8 males and 8 females) were analyzed. First of all were restored their linear dimensions and then the mass. It was done by using preserved fragments of the bodies of organisms, and by comparison whith the collection material. To do this, we used the calculated average values of the mass of individual size groups of the studying species of benthos. In the summer, in the intestines of Pinchuk's goby were found food items belonging to 22 different taxonomic groups. The largest number of species in the diet were crustaceans: *Carcinus aestuarii, Idotea baltica basteri, Sphaeroma pulchellum, Amphithoe vaillanti, Corophium bonelli, Microprotopus minutus, Jassa ocia, Marinogammarus olivii, Melita palmata, Dexamine spinosa, Palaemon elegans.*

The fish also fed on oligochaetes and mollusks: *Hydrobia acuta, Mohrensternia lineolata, Setia valvatoides, Bittium reticulatum, Tritia reticulata, Mytilaster lineatus, Mytilus galoprovincialis, Lentidium mediterraneum*, and in addition some fish remains were found in the stomach. By the number and frequency of occurrence of foraging objects in the diet anelides was dominated (Sabellidae and Oligochaeta), and by weight – crustaceans (Amphipoda).

According to the value of the index of relative importance (IRI), the main food objects of Pinchuk's goby males in summer were crustaceans (*Carcinus aestuarii* – 5680 ‰) and annelides (*Fabricia sabella* – 3409 ‰), and in autumn also bivalve mollusks *Mytilus haloprovincialis* – 2592 ‰. The main food for females in summer were amphipods (*Amphithoe vaillanti* – 13182 ‰), annelides (*Fabricia sabella* – 6818 ‰), gammarids (*Marinogammarus olivii* – 6786 ‰) and isopods (*Idotea baltica basteri* – 5643 ‰. In autumn, the remains of fish (14726 ‰) and crustaceans (*Carcinus aestuarii* – 9659 ‰ took the first place in females by the size of IRI.

In summer, the nutritional spectra of individuals of different sexes differed significantly (species similarity index (SSI) – 42%), the index of food similarity (IFS) of males and females was about 14,5%. In autumn, the feeding spectrum of the Pinchuk's goby became much narrower (13 taxes). As before, the species composition was dominated by crustaceans and mollusks – 5 and 4 species, respectively. Compared with the summer months, two more species of crustaceans were noted in the diet of bulls: in males – *Dexamine spinosa*, and in females – *C. aestuarii* and oligochaetes.

In autumn, the number and weight of foraging objects in the diet of males were dominated by crustaceans (*C. aestuarii*), the frequency of occurrence was the highest in *C. aestuarii* and *A. vaillanti*, in the diet of females by the number of foraging objects dominated by oligochaetes, by weight of foraging – crustaceans (*C. aestuarii*) and fish remains. The most important food of Pinchuk's goby remained crustaceans – for males *C. aestuarii* (IRI – 13723 ‰), for females – *A. vaillanti* (IRI – 13182 ‰. In autumn, only the females of Pinchuk's goby were found fish remains in the stomach.

In autumn, the qualitative composition of the diet of individuals of different sexes became less similar (SSI – 37%), compared with the summer season. However, the intensity of consumption of the same food objects by males and females significantly increased (IFS – 70,5%).

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THE VARIABILITY OF COASTAL PHYTOPLANKTON OF THE NORTH-WESTERN BLACK SEA REGION

Material for analysis of phytoplankton of the coastal waters of the North-Western Black Sea region (NWBS) was collected during the EMBLAS project at the coastal monitoring stations 2016 and 2017, as well as in cruises NPMS UA 2017 and NPMS UA 2019.

The highest average biomass values for the NWBS in 2016 (8876 and 7745 mg/m^3) were found for *Pseudopedinella sp.* (Dictyochophyceae) and *Woloszynskia pascheri* (Dinophyceae). In 2017, Bacillariophyceae *Pseudosolenia calcar-avis* and *Dactyliosolen fragilissimus* have dominated. In 2019, the largest biomass was formed by *Ceratium tripos* (Dinophyceae) and *Nodularia spumigena* (Cyanophyceae). The average biomass of *C. tripo*s in 2019 (1039 mg/m^3) was for an order of magnitude lower than the biomass of *P. calcar-avis* in 2017 (16626 mg/m^3).

The inter-annual changes in the relative contributions of taxonomic classes to phytoplankton biomass of the NWBS were associated with redistribution of Bacillariophyceae (average contribution 62%) and Dinophyceae (average contribution 26%). The exception was 2019, when the contribution of Cyanophyceae has increased. The contribution of Dinophyceae to biomass has decreased to the minimum values in 2017. The contribution of Bacillariophyceae has increased proportionally. In 2019, the contribution of Dinophyceae has increased again.

The average phytoplankton biomass of the NWBS during the study period was 3012.4 mg/m^3 and varied from 26.3 to 43555.6 mg/m^3. The average biomass values of the phytoplankton communities of the NWBS in 2016 and 2017 do not statistically differ. The average biomass of 2019 was significantly lower than these indicators in 2016 and 2017. The annual average diversity indices and phytoplankton biomass of the NWBS varied in the opposite way. The average values of the Shannon index varied from 1.96 (2017) to 2.38 (2019). Thus, a decrease in biomass in 2019 was accompanied by an increase in the values of diversity indices.

A peculiarity of the development of phytoplankton of the NWBS is an increase in biomass in late winter (or early spring) and late summer (or early autumn). From November to January, the biomass decreases (Krivenko, Parkhomenko, 2010; Zaitsev et al, 2006). This determines the impact of different monitoring periods of 2016, 2017 and 2019 on data comparability. However, a good knowledge of the NWBS allows us to trace the long-term dynamics of biomass. Between 1973-1980, biomass has increased from 0.7 to 18 g/m^3 (Zaitsev et al, 2006). Since 1981, the phytoplankton biomass began to gradually decrease to 15 g/m^3 (1980-1990) and 5 g/m^3 (1990-1993). In 1999, the autumn biomass of phytoplankton of the Odessa Gulf was close to 3 g/m^3 (Zaitsev et al, 2006). This corresponds to the values obtained in 2016, 2017 and 2019. An analysis of 1477 samples obtained by IMB NASU in the NWBS allows to track changes in biomass in the warm period 2000-2012. They had a wavy character and varied from 440.7 mg/m^3 in 2001 to 5915.1 mg/m^3 in 2010, when climatic factors caused the development of *Nodularia spumigena*. The average biomass for 2000-2012 (2195.6 mg/m^3) is close to the average values during the study period. Wave-like changes are also typical for distribution of the biomass of Dinophyceae and Bacillariophyceae. Both the largest (91%, 2017) and the smallest (33%, 2019) contributions of Bacillariophyceae were identified during the study period. The average contribution of Bacillariophyceae was 60% (in 2000-2012) and 62% (in 2016-2019).

Thus, an analysis of the biomass and taxonomic structure of the NWBS phytoplankton in 2016, 2017, and 2019 did not reveal significant changes compared to the period 2000-2012, and in 2019 the biomass significantly decreased. This confirms the current trend in the recovery of NWBS ecosystem that occur after the eutrophication of the 70-80s.

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