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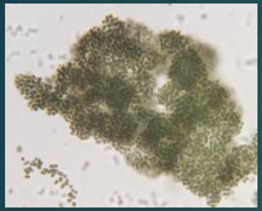
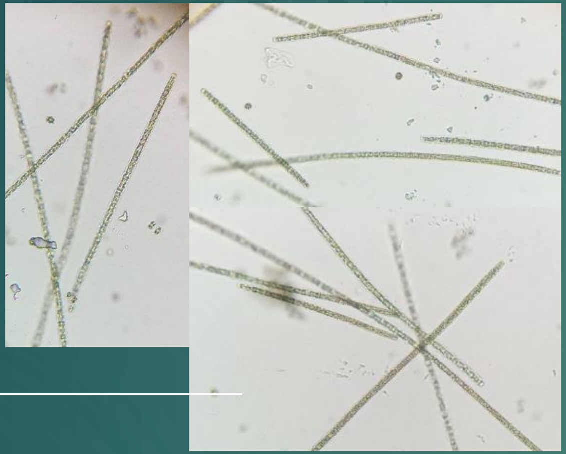
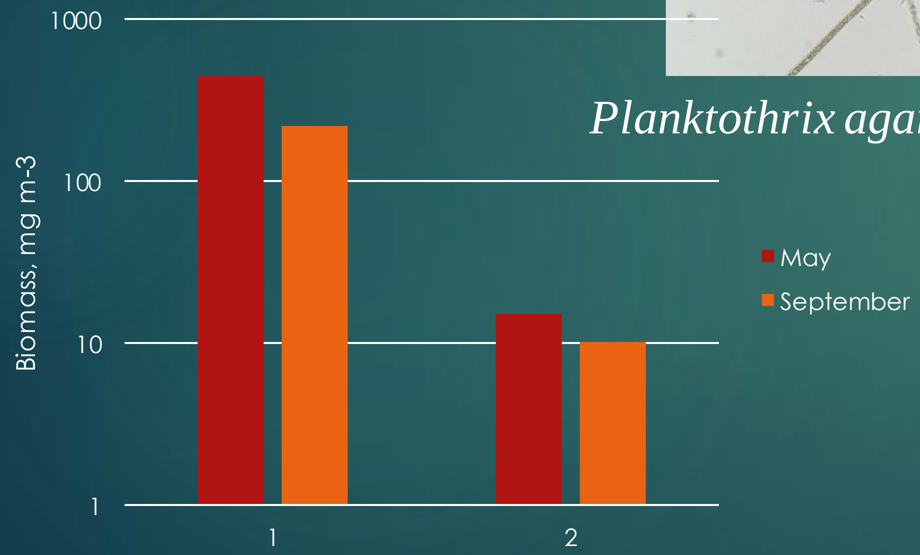
Features of the phytoplankton in the Khadjibei Estuary (northern coast of the Black Sea) in the modern period (2016 – 2021)



Microcystis aeruginosa



Planktothrix agardhii



Biomass of *Planktothrix agardhii* in 2019 (1) and 2021 (2)

According to the research in the summer of 2016, in the phytoplankton of the Khadjibei Estuary, an average of 73.98% of abundance and 71.38% of biomass were cyanoprokaryotes. Throughout the estuary, the water "bloom" is noted due to the significant growing of *Microcystis aeruginosa (Kutz.) Kutz* with a maximum abundance of 244 · 10 ^{3} colonies in liter and biomass 173 g·m^{-3}.

As know, *Microcystis aeruginosa* is a species-agent of water "bloom". It toxicity is due to endotoxin (Ryabushko, 2003). In the Khadjibei Estuary this species called the water "bloom" with the abundance up to 24 · 10 ^{6} cells · l^{-1} (Nesterova et al., 2006). In the North-Western Black Sea, the maximum abundance of species reached in summer up to 15 · 10 ^{6} cells · l^{-1} (Nesterova, 2001).

However, in May and September 2019 – 2021 in the Khadjibei Estuary registered water "bloom" caused by another – cyanoprokaryotic alga *Planktothrix agardhii* (Gomont) Anagnostidis α Komarek 1988 (basonium *Oscillatoria agardhii* Gomont). The maximum biomass of which was 452 g · m^{-3} with the abundance of 360 · 10 ^{6} cells · l $^{-1}$. *Planktothrix agardhii* is a toxic microalga that produces hepatotoxin (Aune, Berg, 1986; Eriksson et al., 1988). While *M. aeruginosa* was registered at only a few stations in small quantities with a maximum biomass of 0.016 g · m^{-3}. Probably, the species *P. agardhii* displaces *M. aeruginosa*.

First observation of the Peacock blenny, *Salaria pavo* (Actinopterygii: Blenniidae), in the Sukhyi Lyman, Black Sea, Ukraine

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The Sukhyi Lyman is an estuarine system of two small steppe rivers, Akkarzhanka and Dalnyk, which has unique hydrochemical conditions (Starushenko, Bushuyev, 2001). The north-western part is artificially separated by dam from the other part of the estuary and its hydrochemical regime is formed under the freshwater flow of the Dalnyk River and used for aquaculture. The central and south-eastern parts of the estuary are under the influence of the Port of Chronomorsk, almost lost the fishery importance because of intensive antropogenic pressing. The hydrochemical regime of the Sukhyi Lyman is under the strong influence of the neighbored sites of the sea, therefore has typical for the North-Western Black Sea salinity, with exception of the desalinated north-western part of the estuary.

In September 2021, during a snorkeling observations of the bottom dwelling fauna, an individual of the peacock blenny was picoted at the depth 0.4 at coordinates 46.332944N, 30.661555E (Fig. 1). The fish could be easily identified by the presence of a high leather crest on top of head, which extends from beginning of eyes to beginning of dorsal fin (Fig. 2). The individual was identified as a male. It was observed at the mussel bed on the rocky bottoms.

Fig. 1. The view of the Sukhyi Lyman in the place of the fish finding

There are 9 species of blennids (Actinopterygii: Blenniidae) known in the Ukrainian Black Sea waters (Movchan 2011). The peacock blenny, Salaria pavo (Risso, 1810), is a rare fish in the North-Western Black Sea, where it is registered only near the Cape Tarkhankut and near the Snake Island (Boltachev & Karpova 2017; Snigirov et al. 2020). The Sukhyi Lyman is a brackish water bay south of the City of Odessa. The fish fauna of this water body consists of up to 58, including of four bleniids: *Aidablennius sphynx, Parablennius sanguinolentus, Parablennius tentacularis* and *Parablennius zvonimiri* (Khutornoi 2021).

This finding could be recorded as the prolongation of the expansion of the Atlanto-Mediterranean blennid to the North-Western Black Sea. First cases of the expansion were recorded in 1998, when two new blenniid species were registered in the Gulf of Odessa: *Aidablennius sphynx* and *Parablennius zvonimiri* (Khutornoi 1998). Later, in 2019, *Coryphoblennius galerita* was found in the same region (Khutornoy & Kvach 2019).

A

B

C

Fig. 2 (A-C). Photographs of the peacock blenny (*Salaria pavo*) from the Sukhyi Lyman (author: M. Son)

First information on the phenology of the Black Sea population of invasive Asian date mussel *Arcuatula senhousia*

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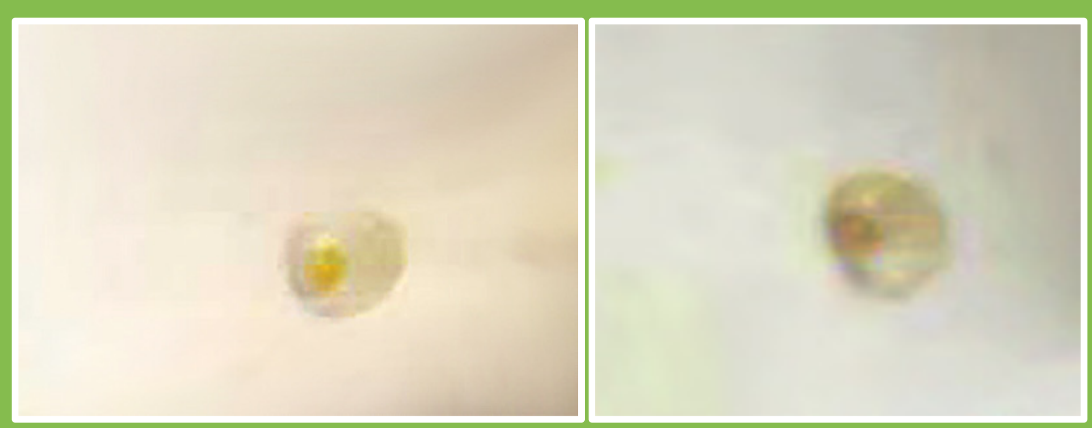
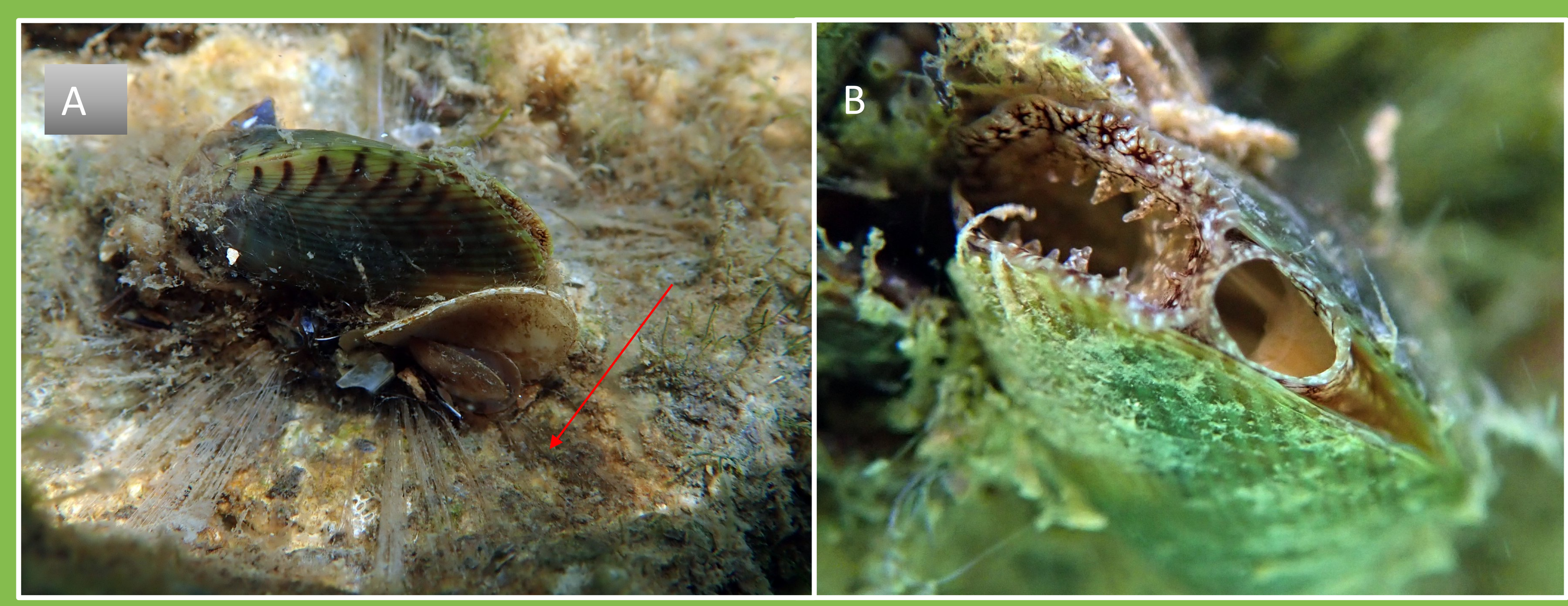
Findings of mussels in Sukhyi Liman

The population of non-indigenous A. senhousia in the Black Sea estuaries (Sukhyi Liman and Small Adzhalyk Liman) in 2020-2022 was monitored. It included both benthic and planktonic samples.


Veliger of *Arcuatula senhousia*

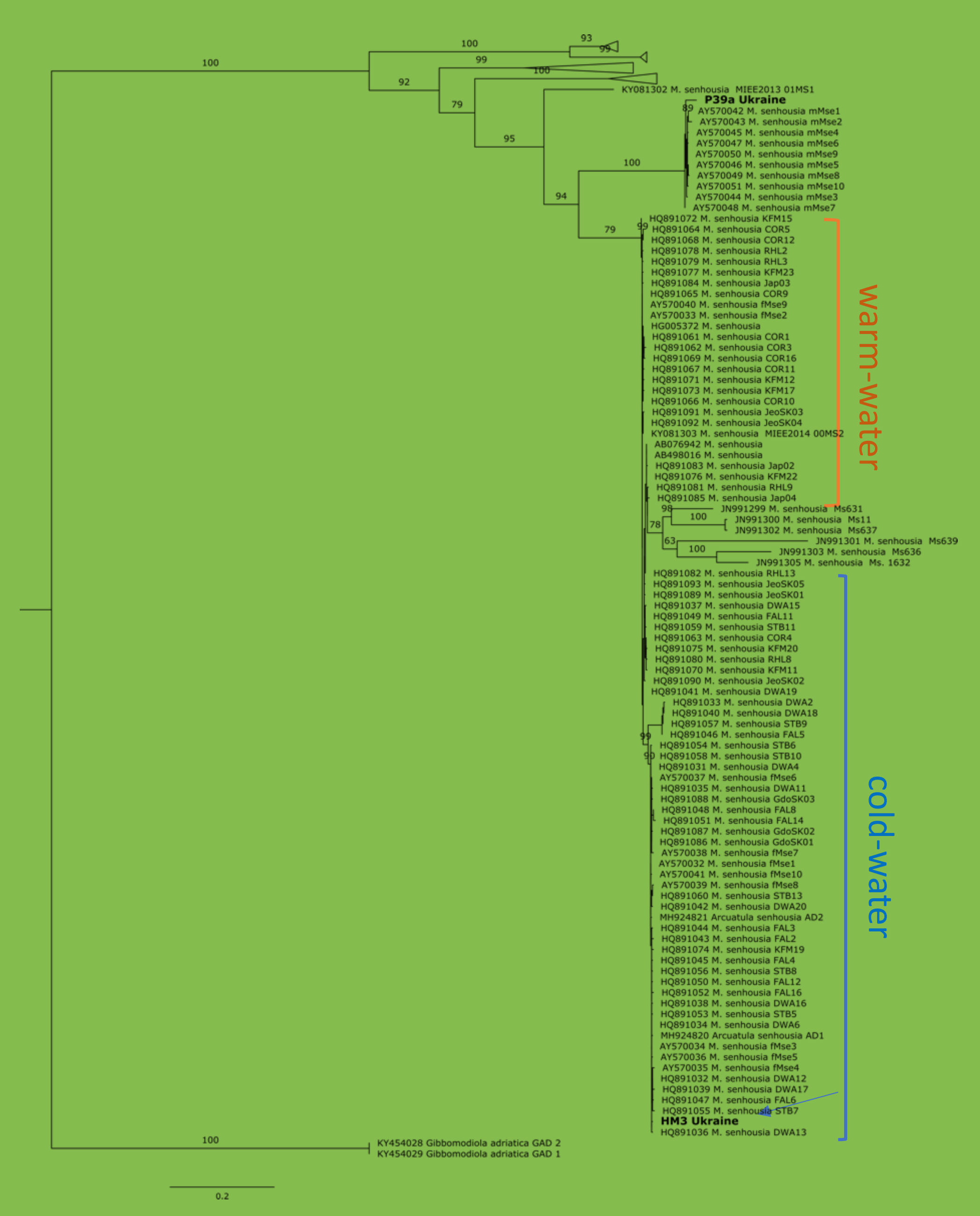


Arcuatula senhousia in nature attached with bissus filament to limestone gravel (A) and in the process of filtration (B)

Results:

- the population has density 4–1000 ind. m^2 , and occur in habitats with water salinity 14-16 ‰ and temperature up to 27^o C;
- spawning and larval development began when water temperatures dropped to 5-10 °C in late October and November;
- in the winter we observed a mass mortality of adults;
- in early spring the population of mollusks was represented mainly by young specimens up to 5 mm in size and very few large specimens of the last year's cohort;
- Biopollution Level Index (BPL) is 2 (Moderate). Counted by: class of occurrence (= C), influence on the native species and communities (C2 Moderate), habitat alteration (H0 None), influence on the ecosystem functions (E1 Weak).


Phenotypes of *Arcuatula senhousia* from Sukhyi Liman



Phylogenetic tree of *Arcuatula senhousia* based on COI. Lineages *sensu* Asif & Krug 2012

Discussion

The mortality may occur due to both the extreme water temperatures in the region, which have included episodes of coastal freezing, and the food deficits in the winter. Such phenological strategy differs sharply from the life strategies of Mytilidae of native species, as well as from populations of *A. senhousia* known from some other regions around the world with summer gametogenesis and spawning at higher water temperatures in early fall (Srgo et al. 2002; Watson et al. 2021). The phylogenetic analysis of Ukrainian population based on *cox1* gene region revealed that specimens joined the “cold”-water clade revealed by Asif & Krug (2012), thus confirming the distribution of this particular lineage in Europe. The presence of two clades (cold- and warm-water) is attributed to the mollusks’ temperature preadaptation (Asif & Krug 2012), and it is believed the water temperature restrains expansion, limiting the distribution along the coast.

FREE-LIVING HETEROTROPHIC FLAGELLATES FROM COASTAL SANDY SEDIMENTS OF NORTHWEST BLACK SEA

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Introduction

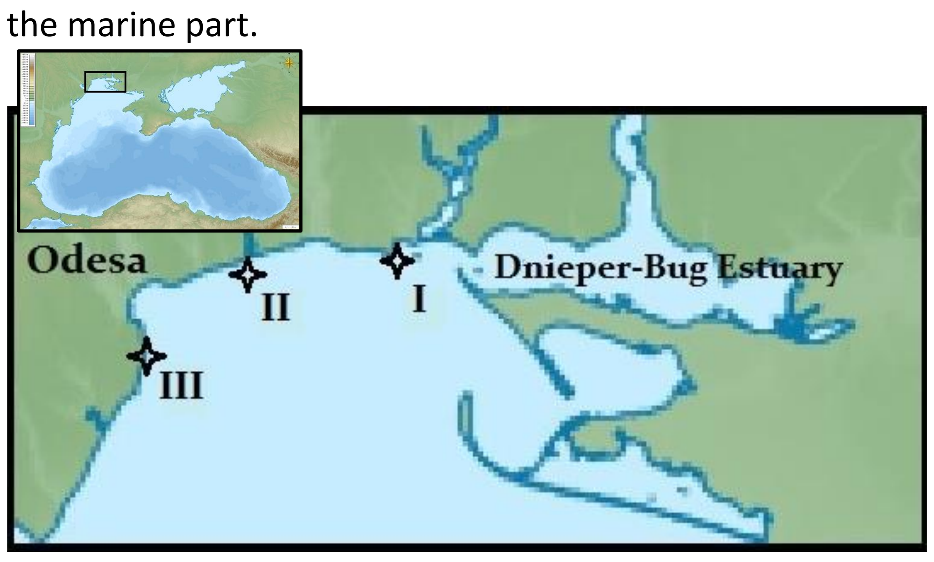
Heterotrophic flagellates are significant members of the microbial communities in aquatic ecosystems. They function as predators on bacteria and small algae, and as prey for larger ciliates and metazoa. Additionally, they facilitate remineralization and recycling of elements essential for algal and microbial growth. For that reason, they are recognised as an important component of natural aquatic ecosystems functioning as an energy transporter in microbial food webs. Whereas the role of meio- and macrofauna received considerable attention, the structure and function of microbenthic communities are largely unknown, and many aspects of their ecology are still poorly understood. There are very few studies investigating of microbenthos, specially in the Black Sea (Prokina et al., 2017, 2019).

The aims of our study were to study species composition and investigate changes in the main integral characteristics (abundance, biomass, size structure) of heterotrophic flagellates from sandy sediments in the transformation zone of river waters of the Dnieper-Bug Estuary.

The study area, Material and methods

The northwestern part of the Black Sea is a shallow shelf zone. Hydrological and hydrochemical regime is formed under the influence of the runoff of large rivers (Danube, Dnieper, and Dniester).

This study was carried out from 2017 to 2020 at 3 sites in the transformation zone of river waters of the Dnieper-Bug Estuary along a salinity gradient from the riverine towards the marine part.



I site - Cape Adzhiyask (the greatest influence of freshwater masses of the Dnieper-Bug Estuary).
II site - Sea shore near Malyi Adzhalykskyi Estuary.
III site - Cape Malyi Fontan (maximum distance from the mouth of the river).

Samples (the upper 3 cm layer of sand sediment) were collected on 2 – 4 times in the year (April, June-July and September-November) in the sublittoral (depth 3 m) and at the water's edge at each site.

Significant fluctuations in water **salinity** were noted at the I site (4.1-16.8 ‰), in the other areas the salinity was higher and more stable (13.1-17.2 ‰ and 14.5-17.7 ‰, respectively). **Sediment** of I and III sites included fine sand, whereas II site contained a small clay fraction, mainly in sublittoral.

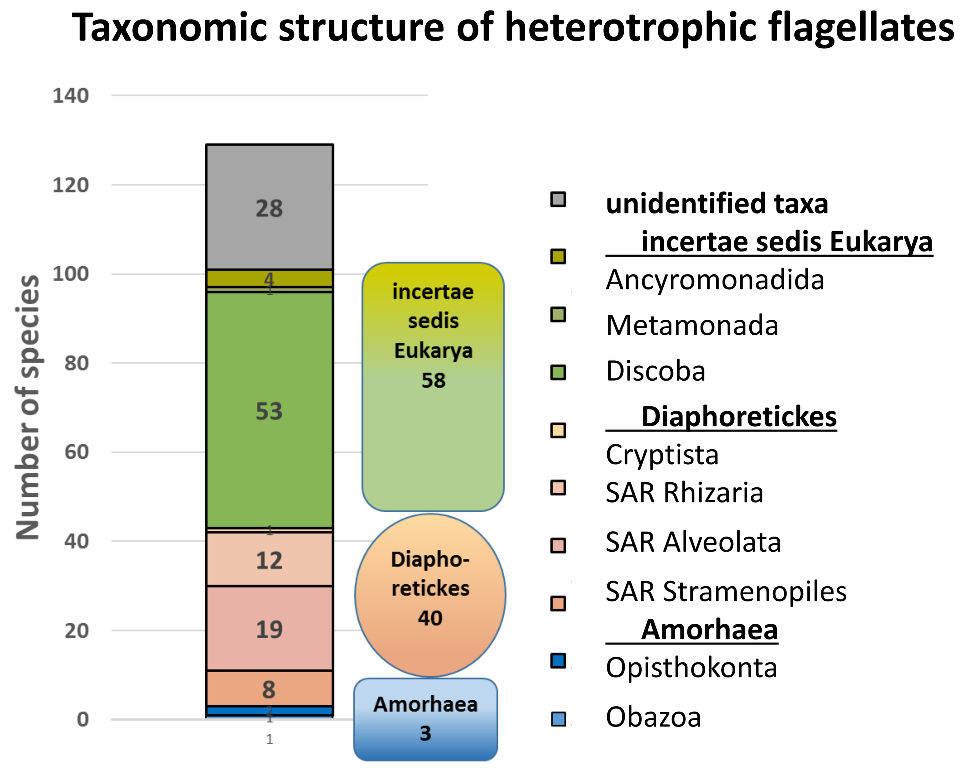
Taxonomic identification of heterotrophic flagellates, measurements, photographs and descriptions were made from living material. We used the system of classifying eukaryotes and protists presented in paper by Adl et al. (2019).

Species composition

The active species composition included 129 taxa, of which 101 species of heterotrophic flagellates belonged to 55 genera, and 28 taxa that could not be identified. Thirty-six species were identified only to genus level.

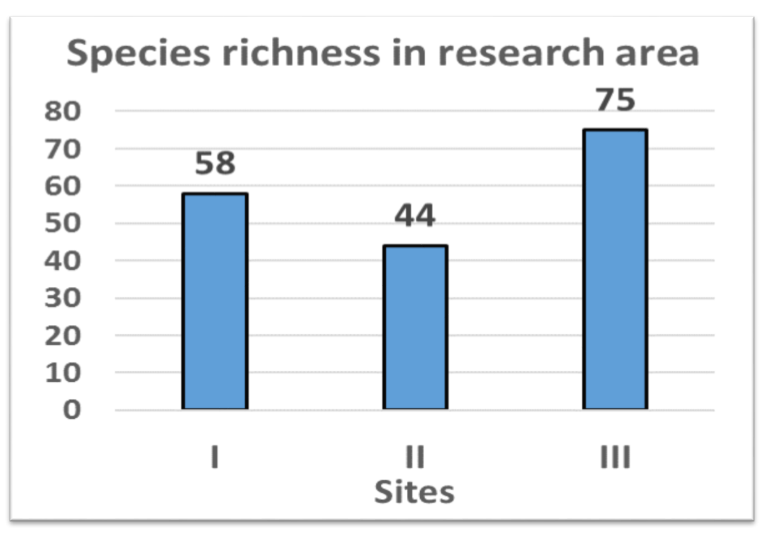
Euglenids (43 species) and dinoflagellates (17 species) were the most species-rich groups.

Taxonomic structure of heterotrophic flagellates



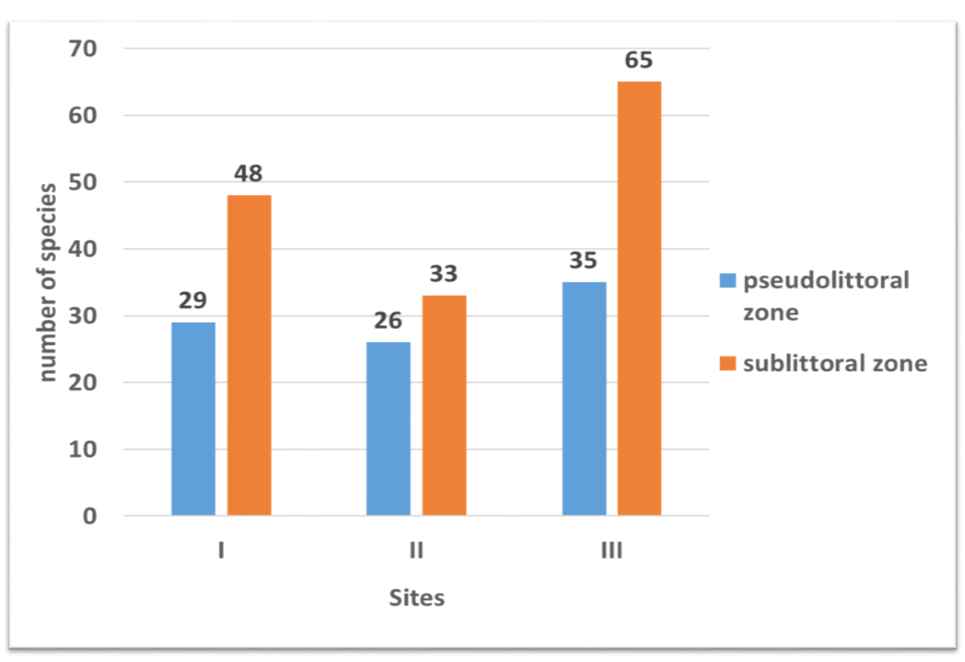
Results

Heterotrophic flagellates community showed a clear increase in diversity from the riverine towards the marine part.

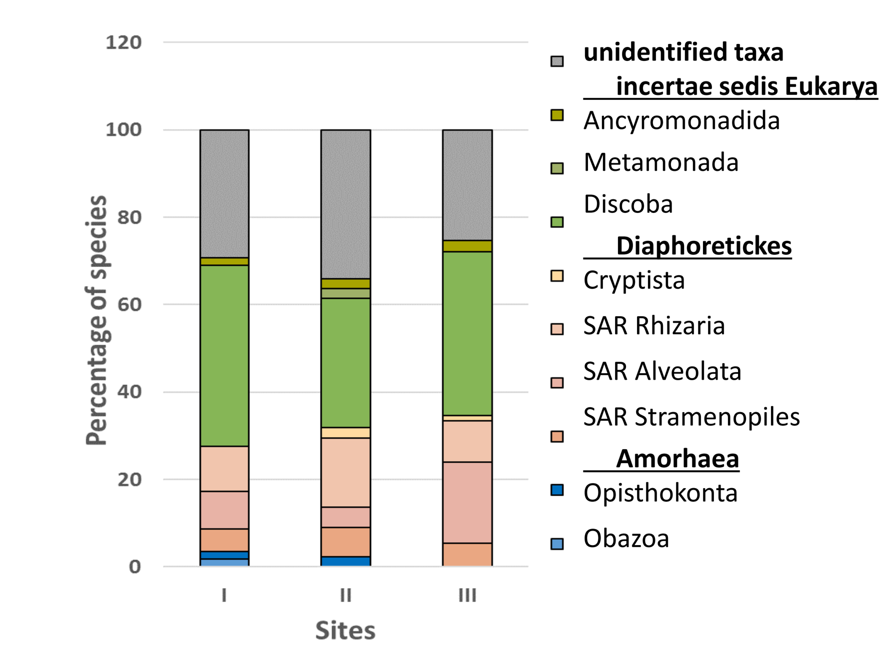


In total, 58 taxa were found in I site, 44 taxa in II site, the largest number of taxa (75) was recorded in III site.

Differences in species richness of the heterotrophic flagellate communities of the pseudolittoral and sublittoral zones.



The taxonomic structures of the flagellate communities were similar in different locations, however, on site III the share of Diaphoretickes has increased due to the increase of dinoflagellate species (including 4 new species for Black Sea [Nikonova, 2019]: *Aduncodinium glandula* (E.C.Herdman) N.S.Kang, H.J.Jeong & Ø.Moestrup, 2014, *Amphidinium herdmanii* Kofoid & Swezy, 1921, *Gyrodinium dominans* Hulbert, 1957, Katodinium asymmetricum (Massart) A.R.Loeblich, III, 1965).

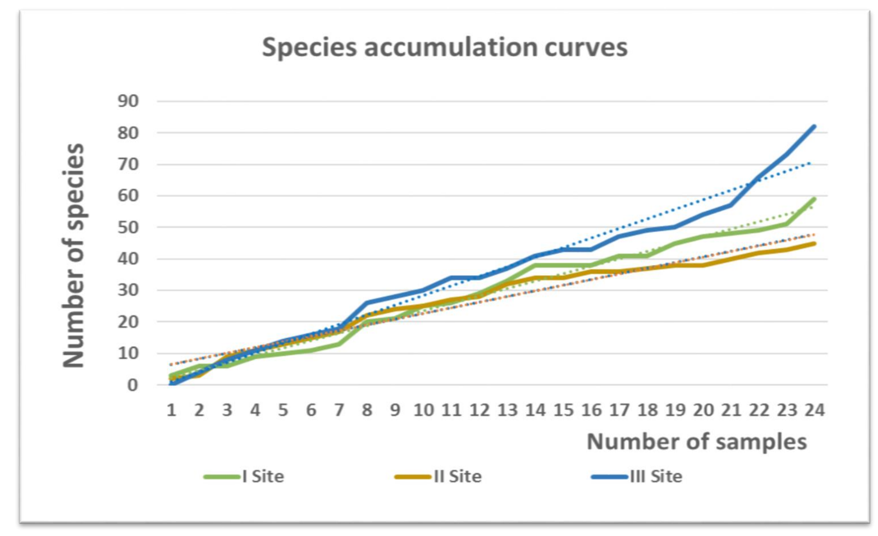


Amphidinium herdmanii

Aduncodinium glandula

Estimating total species richness in the area

The total number of the recorded species increased with an increase of sampling effort. The rate of increase not reduced, and the curve did not reach a plateau, which indicates that further sampling should increase the number of species recorded from the Black Sea.



In general, the studied community is spatially heterogeneous in species composition. About half of all species (47) are rare; they are found only in one of the samples, suggesting a high degree of heterogeneity of the heterotrophic flagellate community.

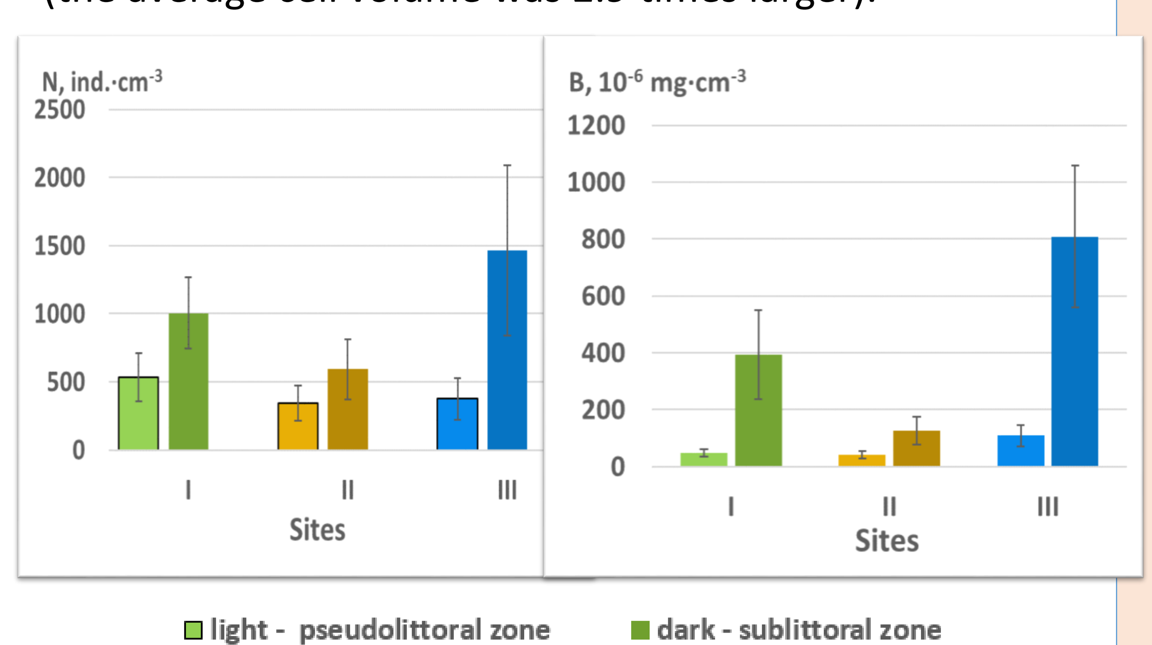
Nine species (*Anisonema acinus, Bodomorpha reniformis, Caecitellus parvulus, Colpodella perforans, Notosolenus* sp. 1, *Petalomonas* sp. 3, *Petalomonas pusilla, Protaspa tegere, Rhynchomonas nasuta*) were noted on all studied sites, it indicates their wide ecological plasticity.

The species composition similarity of the heterotrophic flagellate community of different sites (Sőrensen index) is presented in the Table.

	Sites	Pseudolittoral zone	Sublittoral zone
I – II sites	0.43	0.47	0.30
II – III sites	0.30	0.26	0.35
I – III sites	0.30	0.31	0.28

Abundance and biomass

The abundance of heterotrophic flagellates was 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 abundance of flagellates reached 7740 ind.·cm^{-3}, biomass – 2800·10^{-6} mg·cm^{-3} (average density 1465±624 ind.·cm^{-3}, average biomass 809·10^{-6}±248·10^{-6} mg·cm^{-3}).

At the water's edge, compared with the sublittoral, the community of flagellates is characterized by a depleted species composition, lower abundance and biomass, and the predominance of small-celled flagellates (< 10 µm), which reach 97% of the population.

It was not possible to unambiguously assess the influence of river masses from the riverine towards the marine part on heterotrophic flagellate abundance and biomass. No correlation was found between these indicators and water salinity over a range from 8 to 17 ppt, nevertheless communities become more diverse and attain higher biomass values at the sublittoral zone.