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STATUS OF PLANKTON ALGOCENOSIS IN THE WATER AREA OF THE PORT OF TUAPSE AND BEYOND IT IN THE SPRING-SUMMER PERIOD OF 2019

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The article presents the research of qualitative structure and quantitative development of phytoplankton in the water area of the port of Tuapse and beyond it in the spring-summer period of 2019. In April 2019, 43 phytoplankton species of 5 divisions were found. In the port area, the mean values of abundance and biomass were of 568 thousand cells·L^{-1} and 206 mg·m^{-3}, respectively; in the open sea area, the values were 1.5 times higher. In the port area and beyond it, diatoms developed abundantly: 98–99 % of the total phytoplankton abundance and 62–65 % of the biomass. Small-cell species *Pseudo-nitzschia* spp. and *Skeletonema costatum* s. l. formed the basis of the abundance; *Pseudosolenia calcar-avis*, *Dactyliosolen fragilissimus*, and *Chaetoceros affinis* formed the basis of the biomass as well. In June 2019, a decrease was recorded in qualitative (13 species from 4 divisions) and quantitative values of phytoplankton development. In the port area, the mean values of planktonic algae abundance and biomass were of 59 thousand cells·L^{-1} and 81 mg·m^{-3}, respectively; in the open sea area, these values were more than 2 times lower. In the water area of the port, euglenids developed abundantly: 94 % of the phytoplankton abundance and 83 % of the biomass; those were represented by a mesosaprobic species *Eutreptia lanowii*. Beyond the port of Tuapse, euglenids were not found; in terms of abundance, diatoms predominated (95 %): *Skeletonema costatum* s. l. and *Thalassionema nitzschioides*. The following Dinophyta species formed the basis of the phytoplankton biomass (82 %): *Ceratium tripos*, *C. furca*, *Ensiculifera carinata*, *Glenodinium paululum*, *Prorocentrum micans*, and *Protoperidinium crassipes*.

Keywords: phytoplankton, taxonomic composition, abundance, biomass, water area of the port of Tuapse, northeastern Black Sea coast

In recent decades, many researchers have recorded changes in the structure and functioning of marine plankton communities in the waters of Russian Black Sea shelf (Korpakova et al., 2014 ; Safronova et al., 2015 ; Safronova & Naletova, 2017 ; Selifonova & Yasakova, 2012). First of all, zones of environmental stress are the water areas of large seaports, such as the port of Tuapse, with constantly increasing cargo turnover. Phytoplankton studies in the water area of the port of Tuapse and beyond it under progressive pollution of the marine environment were carried out in different seasons of 2009–2011 (Selifonova & Yasakova, 2012 ; Yasakova & Makarevich, 2017). The investigation of qualitative and quantitative characteristics of phytoplankton, the most vulnerable link in marine ecosystems under anthropogenic eutrophication of port waters in the modern period, seems to be urgent. Therefore, the aim of this work is to conduct a study of the species composition and quantity of planktonic algae in the water area of the port of Tuapse and beyond it in spring and summer of 2019 and to compare these indicators with corresponding data for 2009–2011.

MATERIAL AND METHODS

The material for the study was the phytoplankton samples collected at 15 stations in the water area of the port of Tuapse (st. 1–14) and beyond it (st. 15) in April 2019 (Figs 1 and 2). In June 2019, planktonic algae were sampled at 5 stations; st. 1–4 were located in the port water area, and st. 5 – beyond it (Figs 3 and 4). The location of the sampling spots was due to different levels of anthropogenic load on these water areas. During the study period, the water temperature on the sea surface varied +11.1 °C (23.04.2019) to +24 °C (12.06.2019); wind speed was 5–10 $m \cdot s^{-1}$, and sea roughness degree was 1–2. Samples of 1–1.5 L were taken from the sea surface using a 5-L Niskin bottle in the daytime from the research vessel, fixed with formalin up to a final concentration of 1–2 %, and kept in a dark cool place for at least 15 days. Then, the samples were concentrated using a siphon tube with an end bent 2 cm up, which was tightened with a No. 77 sieve. Abundance and volume of phytoplankton cells were counted using 0.05-mL and 0.1-mL cameras under a Mikmed-2 microscope with 10×/0.30 and 40×/0.65 objectives (Kol'tsova et al., 1979 ; Rukovodstvo, 1980 ; Fedorov, 1979). The cells were measured using an eyepiece micrometer; the minimum size of the counted cells was of 3–5 μm. The biomass was calculated by the volumetric counting. The volume of cells was calculated by equating their shape to corresponding geometric figure (Kol'tsova, 1970). The generally accepted species identification guides were used (Kiselev, 1950 ; Konovalova et al., 1989 ; Proshkina-Lavrenko, 1955, 1963 ; Dodge, 1982 ; Identifying Marine Phytoplankton, 1997). Phytoplankton species composition was classified in accordance with S. P. Wasser system (Vodorosli : spravochnik, 1989). The species were considered mass when forming more than 10 % of the total abundance or biomass, common – 1–10 %, and rare – less than 1 %. The arithmetic means of abundance (or biomass) were determined as a number equal to the sum of abundance (or biomass) at each station, divided by the number of stations studied.

RESULTS

Phytoplankton qualitative composition. In April 2019 in the water area of the port of Tuapse and beyond it, 43 phytoplankton species of 5 divisions were found (Bacillariophyta, Dinophyta, Euglenophyta, Cyanophyta, and Cryptophyta), as well as 5 taxonomic units not identified to the species level (Table 1). The maximum species diversity was recorded in diatoms (20 species) and dinophytic algae (20 species). Other divisions were represented by 1 species each. In June 2019, phytoplankton taxonomic composition amounted to 13 species of 4 divisions: Bacillariophyta (2 species), Dinophyta (9 species), Euglenophyta (1 species), and Chlorophyta (1 species).

Table 1. Phytoplankton taxonomic composition in the research area in April and June 2019

Algae divisions and species	23.04.2019				12.06.2019			
	Port of Tuapse		Open sea area		Port of Tuapse		Open sea area	
	N	B	N	B	N	B	N	B
Bacillariophyta								
Amphora sp.	R	R	–	–	–	–	–	–
Bacillaria paradoxa J. F. Gmelin	R	R	–	–	–	–	–	–
Cerataulina pelagica (Cleve) Hendey	R	R	–	–	–	–	–	–
Chaetoceros affinis Lauder	O	O	O	O	–	–	–	–

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Algae divisions and species	23.04.2019				12.06.2019			
	Port of Tuapse		Open sea area		Port of Tuapse		Open sea area	
	N	B	N	B	N	B	N	B
Chaetoceros compressus Lauder	R	R	O	R	–	–	–	–
Chaetoceros curvisetus Cleve	R	R	–	–	–	–	–	–
Chaetoceros insignis Proschkina-Lavrenko	R	R	–	–	–	–	–	–
Chaetoceros scabrosus Proschkina-Lavrenko	R	R	R	O	–	–	–	–
Chaetoceros simplex Ostenfeld	R	R	R	R	–	–	–	–
Chaetoceros sp.	R	R	–	–	–	–	–	–
Coscinodiscus sp.	R	O	–	–	–	–	–	–
Dactyliosolen fragilissimus (Bergon) Hasle	R	O	R	O	–	–	–	–
Gyrosigma sp.	R	R	–	–	–	–	–	–
Licmophora gracilis (Ehrenberg) Grunow	R	R	R	R	–	–	–	–
Licmophora flabellata (Greville) C. Agardh	R	R	–	–	–	–	–	–
Melosira moniliformis (O. F. Müller) C. Agardh	R	R	–	–	–	–	–	–
Navicula viridula (Kützing) Ehrenberg	R	R	–	–	–	–	–	–
Nitzschia tenuirostris Mereschkowsky	O	R	R	R	–	–	–	–
Pleurosigma elongatum W. Smith	R	R	–	–	–	–	–	–
Pseudo-nitzschia delicatissima (Cleve) Heiden; *Pseudo-nitzschia pseudodelicatissima* (Hasle) Hasle (complex)	M	M	M	M	–	–	–	–
Pseudo-nitzschia seriata (Cleve) H. Peragallo	O	O	–	–	–	–	–	–
Pseudosolenia calcar-avis (Schultze) B. G. Sundström	R	M	R	M	–	–	–	–
Skeletonema costatum (Greville) Cleve s. l.	M	O	M	O	–	–	M	O
Synedra sp.	R	R	–	–				
Thalassionema nitzschioides (Grunow) Mereschkowsky	R	O	R	R	O	O	M	M
Dinophyta								
Akashiwo sanguinea (K. Hirasaka) Gert Hansen & Moestrup	–	–	–	–	R	R	R	O
Ceratium furca (Ehrenberg) Claparède et Lachmann	R	O	–	–	R	O	R	M
Ceratium tripos (O. F. Müller) Nitzsch	R	O	–	–	R	O	R	M
Cochlodinium citron Kofoid & Swezy	R	R	R	O	–	–	–	–
Diplopsalis lenticula Bergh	R	R	R	O	–	–	–	–
Dinophysis rotundata Claparède & Lachmann	R	R	–	–	–	–	–	–
Enisculifera carinata Matsuoka, Kobayashi & Gains	R	O	–	–	R	R	R	O
Glenodinium sp.	–	–	–	–	R	R	–	–
Glenodinium paululum Lindernann	–	–	–	–	R	R	O	O
Gymnodinium simplex (Lohmann) Kofoid & Swezy	R	R	–	–	–	–	–	–

Continue on the next page…

Algae divisions and species	23.04.2019				12.06.2019			
	Port of Tuapse		Open sea area		Port of Tuapse		Open sea area	
	N	B	N	B	N	B	N	B
Gymnodinium wulffii J. Schiller	R	R	–	–	–	–	–	–
Gyrodinium spirale (Bergh) Kofoid & Swezy	R	O	–	–	–	–	–	–
Katodinium glaucum (Lebour) Loeblich III	R	R	–	–	–	–	–	–
Lessardia elongata Saldarriaga & F. J. R. Taylor	R	R	–	–	–	–	–	–
Oblea baculifera Balech ex Loeblich Jr. & Loeblich III	R	O	R	O	–	–	–	–
Prorocentrum compressum (Bailey) T. H. Abé ex J. D. Dodge	R	R	R	R	–	–	–	–
Prorocentrum cordatum (Ostenfeld) J. D. Dodge	R	R	–	–	–	–	–	–
Prorocentrum lima (Ehrenberg) F. Stein	R	R	–	–	–	–	–	–
Prorocentrum micans Ehrenberg	R	R	–	–	R	O	R	O
Protoperidinium brevipes (Paulsen) Balech	–	–	–	–	R	O	–	–
Protoperidinium crassipes (Kofoid) Balech	–	–	–	–	R	O	R	M
Protoperidinium pallidum (Ostenfeld) Balech	R	O	–	–	–	–	–	–
Polykrikos kofoidii Chatton	R	M	R	M	–	–	–	–
Pronoctiluca pelagica Fabre-Domergue	R	R	–	–	–	–	–	–
Scrippsiella trochoidea (F. Stein) A. R. Loeblich III	R	R	–	–	R	R	R	O
Dinophyta, cysts	R	R	–	–	–	–	–	–
Cyanophyta								
Planktolyngbya limnetica (Lemmermann) Komárková-Legnerová & Cronberg	–	–	R	R	–	–	–	–
Cryptophyta								
Plagioselmis prolonga Butcher ex G. Novarino, I. A. N. Lucas & S. Morrall	R	R	O	R	–	–	–	–
Euglenophyta								
Eutreptia lanowii Steuer	–	–	R	R	M	M	–	–
Chlorophyta								
Pterosperma undulatum Ostenfeld	–	–	–	–	R	R	–	–

Note. Species status in terms of abundance (N) and biomass (B): R – rare species; O – ordinary; M – mass.

Phytoplankton quantitative composition. In April 2019, the mean abundance and biomass in the port water area amounted to 568 thousand cells·L^{-1} and 206 mg·m^{-3}, respectively. Beyond the port, the values were 1.5 times higher: 875 thousand cells·L^{-1} and 334 mg·m^{-3} (Figs 1 and 2). Specifically high values of the abundance in the port were observed at st. 5, 8, 12, and 13 (734–986 thousand cells·L^{-1}), and the minimum ones – at st. 1 and 9 (350–378 thousand cells·L^{-1}). The highest values of the biomass during this period were registered at st. 5 (424 mg·m^{-3}); those were more than 3 times higher than the minimum values noted at st. 1–3 (107–124 mg·m^{-3}).

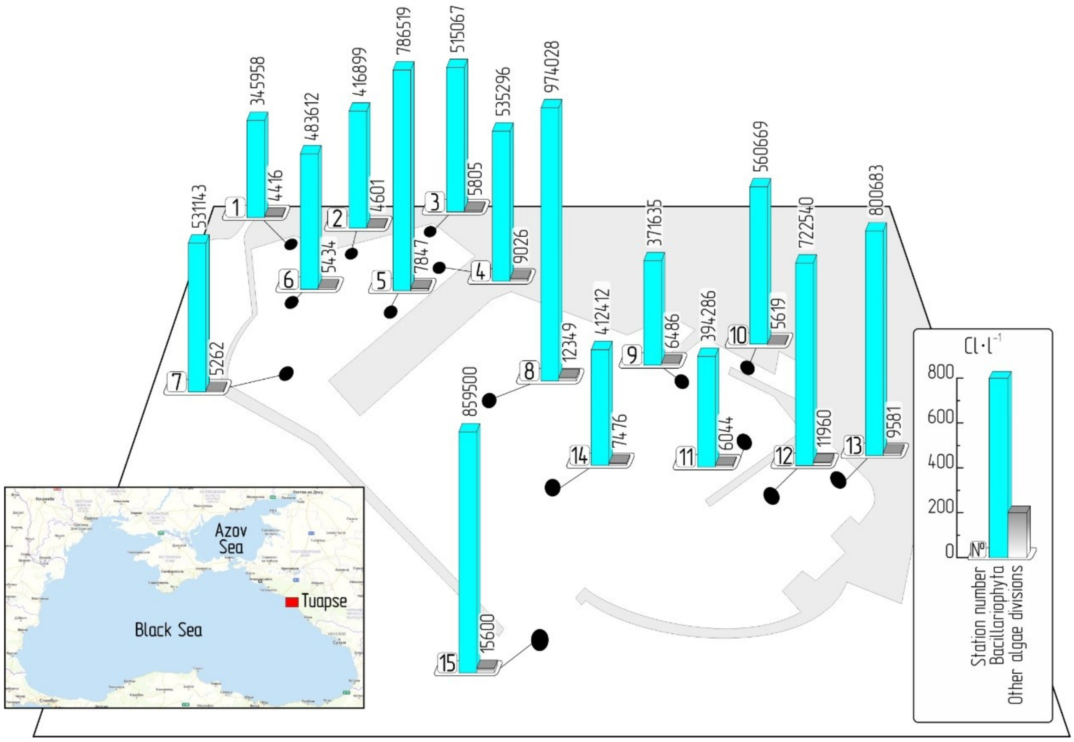

Fig. 1. Distribution of the phytoplankton abundance (cells·L^{-1}) in the water area of the port of Tuapse and beyond it in April 2019

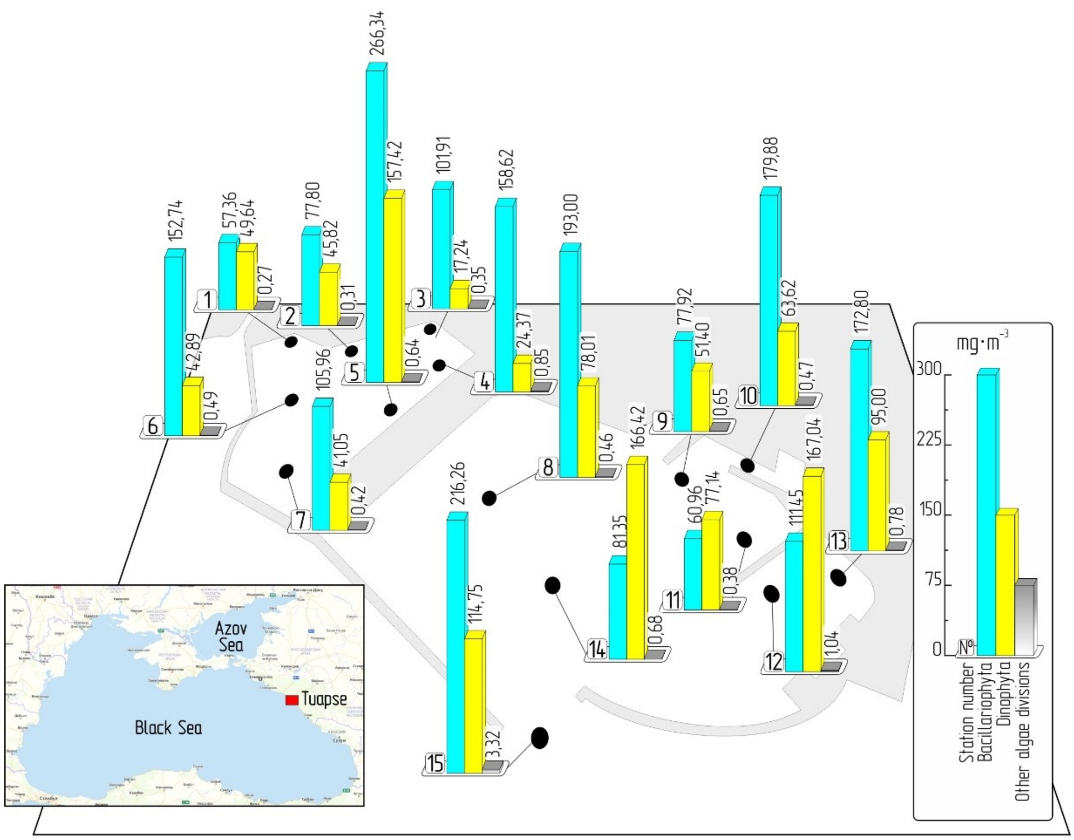

Fig. 2. Distribution of the phytoplankton biomass (mg·m^{-3}) in the water area of the port of Tuapse and beyond it in April 2019

During this period, diatoms were recorded ubiquitously forming 98–99 % of phytoplankton total abundance and 62–65 % of biomass. Out of them, small-cell species *Pseudo-nitzschia* spp. and *Skeletonema costatum* s. l. predominated (72–74 and 21–22 % of the abundance, respectively), whose abundant development is characteristic of the spring season. *Chaetoceros affinis*, *Pseudo-nitzschia seriata*, and *Nitzschia tenuirostris* were found in minor abundance in the port water area (no more than 5 % of the diatom population). In the open sea area, 4 % of the diatom abundance was formed by a complex of species: *Ch. affinis*, *Ch. compressus*, *Ch. scabrosus*, *N. tenuirostris*, and *Thalassionema nitzschioides*.

Pseudo-nitzschia spp., *Pseudosolenia calcar-avis*, *Dactyliosolen fragilissimus*, *Skeletonema costatum* s. l., and *Ch. affinis* formed the basis of diatoms: 86 and 91 % in the port and beyond it, respectively. In the port water area, *P. seriata*, *Th. nitzschioides*, and *Coscinodiscus* sp. amounted to 11 % of the biomass of diatoms; in the open sea area, *Ch. scabrosus* formed more than 5 % of the biomass. For most of common species, a relatively uniform distribution was observed in the port water area. *Ch. affinis* abundance and biomass at st. 5 (100 thousand cells·L^{-1} and 112 mg·m^{-3}, respectively) exceeded these values at other stations by more than an order of magnitude.

In sum, other algae divisions formed no more than 1–2 % of the total phytoplankton abundance. Dinophytes accounted for 0.5 % of the total abundance and 34–37 % of the biomass. In terms of abundance, *Oblea baculifera* predominated: 31–36 % of the abundance and 6 % of the biomass. *Polykrikos kofoidii* was recorded in significant abundance: 14–18 % of the abundance and 55–74 % of the biomass of dinophytic algae. In the port area, a notable proportion of the abundance (37 %) was formed by *Scrippsiella trochoidea*, *Gyrodinium spirale*, *Ensiculifera carinata*, *Gymnodinium simplex*, and *Lessardia elongate*; the large species *Ceratium furca* and *C. tripos* accounted for 22 % of the biomass. In the open sea area, *Diplopsalis lenticula* and *Cochlodinium citron* in sum amounted to 34 % of the abundance and 17 % of the biomass of dinophytes at this time.

Cryptophytic alga *Plagioselmis prolonga* was ubiquitous: from 2 thousand cells·L^{-1} (st. 1) to 10.8 thousand cells·L^{-1} (st. 15); on average, 5 thousand cells·L^{-1}. Whereon, this species formed 1 % of the phytoplankton abundance and 0.3–0.5 % of the biomass. Cyanobacteria and euglenids were recorded in minor abundance (2 thousand cells·L^{-1}) at st. 15 only; that accounted for less than 1 % of the total phytoplankton abundance.

In June 2019, the mean values of the abundance and biomass of planktonic algae in the port amounted to 59 thousand cells·L^{-1} and 81 mg·m^{-3}, respectively (Figs 3 and 4). Beyond the port, the values were more than 2 times lower: 25 thousand cells·L^{-1} and 34 mg·m^{-3}, respectively. During this period, abundant development of euglenids was recorded in the port water area: the mesosaprobic species *Eutreptia lanowii* formed 94 % of the phytoplankton abundance and 83 % of biomass. The diatom *Th. nitzschioides* and dinophytes *C. tripos*, *C. furca*, *Prorocentrum micans*, *Protoperidinium brevipes*, and *P. crassipes* were ubiquitous: 5 % of the abundance and 16 % of the biomass. The representative of green algae *Pterosperma undulatum* was recorded at st. 4 only.

It should be noted that in the water area of the port of Tuapse in the spring-summer period of 2010 and 2011, cyanobacteria and euglenids formed a notable proportion of phytoplankton as well: 35–47 % of the total abundance. The intensive development of these mesosaprobic algae was probably facilitated by the increased concentration of nutrients coming from storm sewers (Yasakova & Makarevich, 2017). Beyond the port, there were no euglenids; diatoms *Skeletonema costatum* s. l. and *Th. nitzschioides* predominated in terms of abundance (95 %). The basis of the phytoplankton biomass (82 %) was formed by dinophytic algae, mainly *Ceratium tripos*, *C. furca*, *Ensiculifera carinata*, *Glenodinium paulum*, *P. micans*, and *Protoperidinium crassipes*.

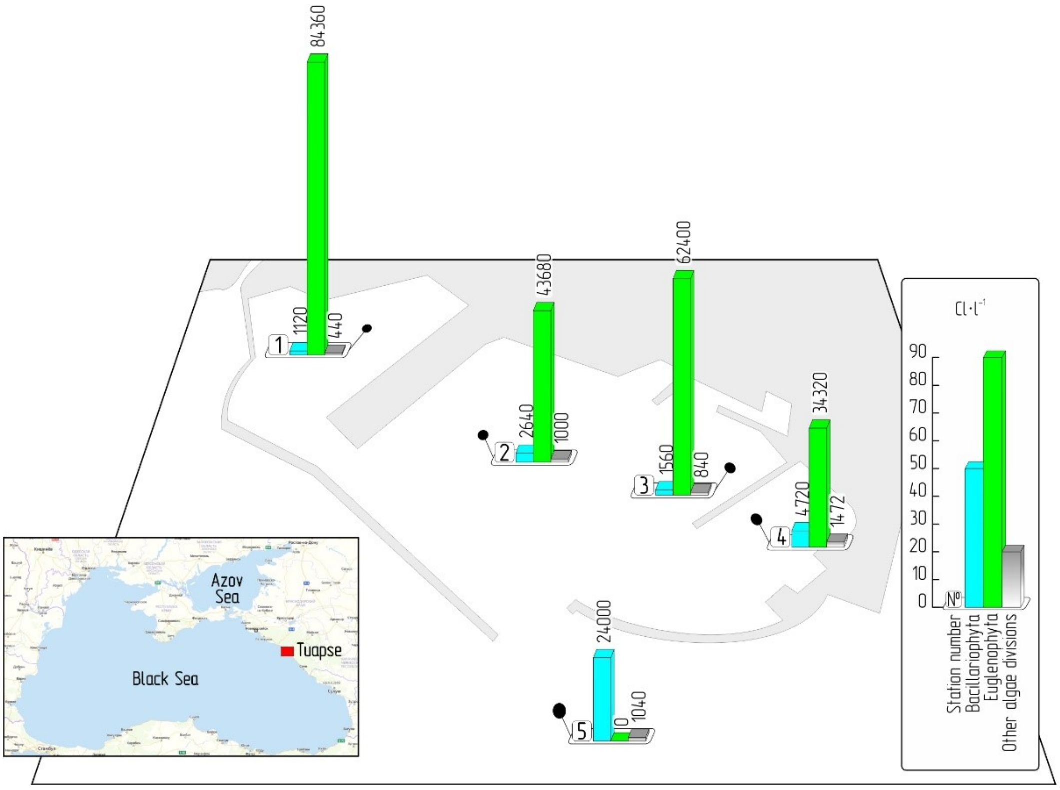

Fig. 3. Distribution of the phytoplankton abundance (cells·L^{-1}) in the water area of the port of Tuapse and beyond it in June 2019

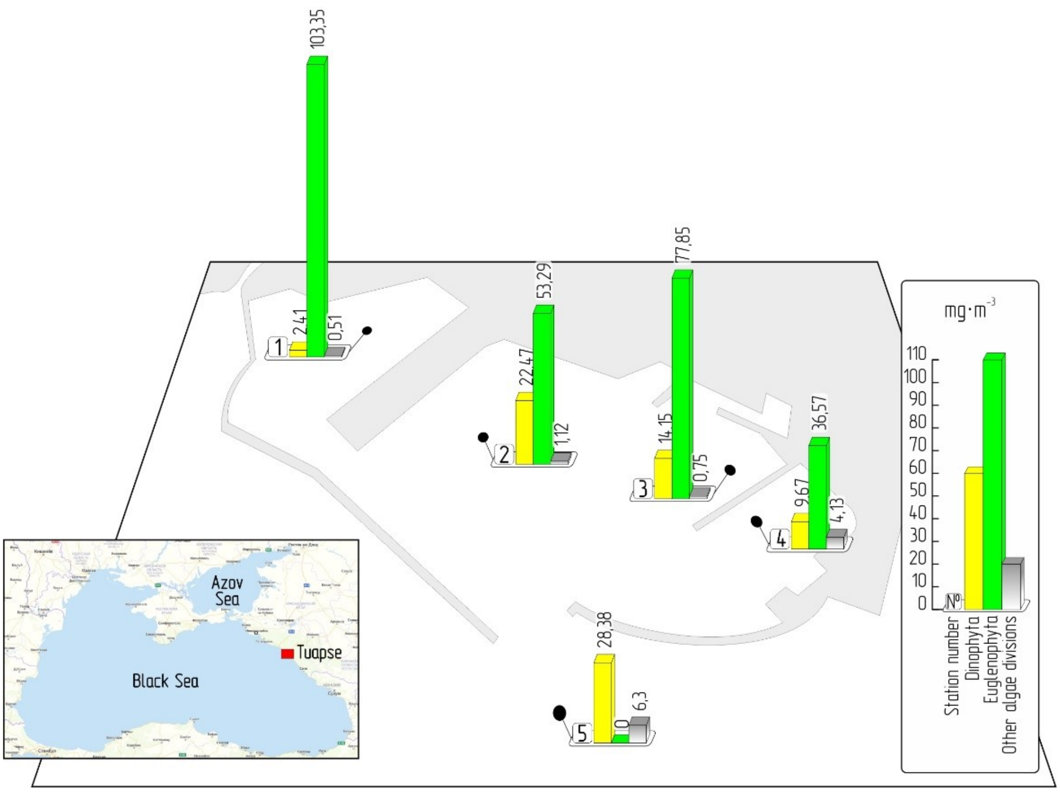

Fig. 4. Distribution of the phytoplankton biomass (mg·m^{-3}) in the water area of the port of Tuapse and beyond it in June 2019

DISCUSSION

In the port, 95 species of planktonic algae were registered earlier (2009–2011); in the open sea area, the species diversity was significantly lower (62 species) (Selifonova & Yasakova, 2012 ; Yasakova & Makarevich, 2017). In the port water area, the mean phytoplankton abundance for the period studied was of 105 thousand cells·L^{-1}, and the biomass was of 0.228 g·m^{-3}. In the open sea area, subject to a lower anthropogenic load, with similar abundance values (120 thousand cells·L^{-1}), the biomass was 2 times higher than in the port water area (0.505 g·m^{-3}), which indicated the presence of large-cell phytoplankton. The peaks of phytoplankton abundance (115–245 thousand cells·L^{-1}) were recorded in March and May 2009 and 2011, as well as in June 2010. Diatoms made a notable contribution to the abundance (35–38 %) and biomass (66–70 %). Moreover, this ratio changed little in the open and port water. The contribution of dinophytes was significant only in the total phytoplankton biomass (26–28 %), wherein they formed 6–7 % of the total abundance. Along with the role of diatoms, the role of primnesian algae, in particular *Emiliania huxleyi*, was great; its abundance was maximum (56 %) in the open sea area, and it was 2 times higher than the values noted in the port (27 %). At the same time, cyanobacteria of the genera *Oscillatoria* and *Lyngbya* and euglenids *Eutreptia lanowii* and *Euglena* sp., presence of which can indicate the unfavorable ecological conditions of coastal water, were a component of phytoplankton in the port water area (11 and 8 % of the total abundance, respectively). In June 2010 and May 2011, their record abundance was registered: in the port water area, they formed up to 35–47 % of the total phytoplankton abundance. Beyond the port, those algae were almost completely absent (no more than 0.02 %).

In 2019, the mean values of the abundance of planktonic algae in the port and beyond it were as follows: 313 thousand cells·L^{-1} in April and 450 thousand cells·L^{-1} in June. Those were almost 2–2.5 times higher than the values for the port water area (145–223 thousand cells·L^{-1}; on average, 184 thousand cells·L^{-1}) and in the open sea (108–207 thousand cells·L^{-1}; on average, 172 thousand cells·L^{-1}) in May and June 2009–2011. Studies carried out shown as follows: in April 2019, the phytoplankton abundance (568 and 875 thousand cells·L^{-1}) was an order of magnitude higher than in June 2019 (59 and 25 thousand cells·L^{-1}). In April 2019, the phytoplankton biomass in the port water area and in the open sea area (on average, 206 and 334 mg·m^{-3}, respectively) was also notably higher (2.5–10 times) than in June 2019 (81 and 34 mg·m^{-3}, respectively). However, those were close to the biomass values observed in the port (80–242 mg·m^{-3}; on average, 175 mg·m^{-3}) and beyond it (165–400 mg·m^{-3}; on average, 293 mg·m^{-3}) in May and June 2009–2011.

The maximum abundance and biomass of planktonic algae were registered in April 2019 beyond the port (875 thousand cells·L^{-1} and 334 mg·m^{-3}, respectively); those were 1.5 times higher than the values for the port water area. This was due to the intensive development of predominantly small-cell diatom species. It should be noted that upwellings, observed in spring along the entire North Caucasus coast, to a significant extent contribute to saturation of coastal water with nutrients and, consequently, to water bloom with small diatoms (Korpakova et al., 2014 ; Proshkina-Lavrenko, 1955). In terms of composition of dominants and the level of abundance, phytoplankton state corresponded to the beginning of the early spring phase of the succession (Makarevich & Oleinik, 2017). The lowest phytoplankton abundance during this period was recorded at the extreme point of the port water area (st. 1). Probably, the hindered water exchange with the open sea resulted there in the formation of unfavorable conditions for the development of planktonic algae.

In June 2019, an increase in the ratio of dinophytes (82 % of the total biomass) was observed in the open sea; that corresponds to the summer phase of the seasonal succession of phytoplankton. In terms of abundance, diatoms predominated again (95 %). Seasonal rearrangement of plant plankton was observed in the port water area as well: there, the predominant plankton component was *E. lanowii*, the mesosaprobic species of euglenids, which formed the basis of the abundance (94 %) and biomass (83 %). In general, the intensive development of euglenids was not typical for the northeastern Black Sea and might manifest the changes in hydrological and hydrochemical environmental conditions: an increase in the eutrophication level, a desalination, and a decrease in the water hydrodynamic activity. The increased level of nutrients in the port water area is also indicated by the twice higher abundance of planktonic algae observed in summer compared to that of the open sea area (st. 5). The minimum phytoplankton abundance in the port water area was again recorded in the tail-end zone (st. 4) characterized by hindered water exchange with the open sea.

In contrast to previous studies, when a significant proportion of the phytoplankton abundance (up to 75 %) at this time of the year was formed by coccolithophorids, the predominant plankton component in 2019 was diatoms and euglenids. Their development may be stimulated by a high concentration of mineral nitrogen and dissolved organic matter in water, while the vegetation of coccolithophorids is limited by mineral phosphorus (Mikaelyan et al., 2013).

Conclusion. The results of the study of phytoplankton, carried out in the spring-summer period of 2019 in the water area of the port of Tuapse and beyond it, notably supplemented the data on the qualitative and quantitative indicators of planktonic microalgae obtained in the previous decade (2009–2011). The state of the plankton community in April 2019 corresponded to the early spring phase of the phytoplankton succession. However, the predominance of the mesosaprobic species of euglenids in plankton in June 2019 may indicate the deterioration of the ecological situation in the port area. Probably, this was facilitated by an increase in the eutrophication level, significant desalination, and stratification of waters, which resulted from the calm weather and an increase in the volume of continental runoff, including wastewater from storm sewers.

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СОСТОЯНИЕ ПЛАНКТОННОГО АЛЬГОЦЕНОЗА В АКВАТОРИИ ПОРТА ТУАПСЕ И ЗА ЕГО ПРЕДЕЛАМИ В ВЕСЕННЕ-ЛЕТНИЙ ПЕРИОД 2019 Г.

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В статье представлены результаты исследования таксономического состава и количества фитопланктона в акватории порта Туапсе и за его пределами в весенне-летний период 2019 г. В апреле 2019 г. обнаружено 43 вида фитопланктона, относящихся к 5 отделам. Средние по акватории порта величи́ны численности и биомассы составили 568 тыс. кл.·л$^{-1}$ и 206 мг·м$^{-3}$ соответственно, что в 1,5 раза ниже, чем в районе открытого моря. Повсеместно в массе (98–99 % общей численности и 62–65 % биомассы фитопланктона) присутствовали диатомовые водоросли. Основу численности составили мелкоклеточные виды *Pseudo-nitzschia* spp.

и *Skeletonema costatum* s. l. Кроме них, основу биомассы формировали *Pseudosolenia calcar-avis*, *Dactyliosolen fragilissimus* и *Chaetoceros affinis*. В июне 2019 г. наблюдали снижение качественных (13 видов из 4 отделов) и количественных величин фитопланктона. Средние значения численности и биомассы планктонных водорослей в порту — 59 тыс. кл.·л$^{-1}$ и 81 мг·м$^{-3}$ соответственно; они в 2 раза превышали величины, отмеченные в открытой части моря. В акватории порта обильно развивались эвгленовые водоросли (94 % численности и 83 % биомассы фитопланктона), представленные мезосапробным видом *Eutreptia lanowii*. За пределами порта Туапсе эвгленовые водоросли отсутствовали, по численности (95 %) доминировали диатомеи — *Skeletonema costatum* s. l. и *Thalassionema nitzschioides*. Основу биомассы (82 %) фитопланктона формировали следующие виды динофитовых водорослей: *Ceratium tripos*, *C. furca*, *Ensiculifera carinata*, *Glenodinium paululum*, *Prorocentrum micans* и *Protoperidinium crassipes*.

Ключевые слова: фитопланктон, таксономический состав, численность, биомасса, акватория порта Туапсе, северо-восточное побережье Чёрного моря