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Phytoplankton distribution and variation along a freshwater-marine transition zone (Kızılırmak River) in the Black Sea

by

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Abstract

Both phytoplankton of the Kizilirmak River/Black Sea transition zone and their interactions with nutrients were investigated between July 2007 and December 2008. A total of 447 taxa belonging to the divisions: Cyanobacteria (24), Bacillariophyta (209), Bigyra (1), Cercozoa (1), Charophyta (11), Chlorophyta (32), Cryptophyta (11), Miozoa (119), Euglenozoa (14), Haptophyta (13), Ochrophyta (10) and Protozoa Incertae Sedis (2) were identified at 5 different sites in the study area. Seventy four taxa were recognized as new records for the Algal Flora of Turkey and 41 taxa were determined as HAB (Harmful Algal Bloom) organisms.

According to the hierarchical clustering and MDS analyses, surface phytoplankton were distributed along the salinity gradient from freshwater to saline waters, and the early spring samples were separated from the other samples. However, in addition to the agglomerative hierarchical cluster analysis, the samples were divided into four groups – "Fresh", "Brackish", "Marine" and "Early spring-Marine" – as a result of MDS analysis.

The results of this study revealed that the surface phytoplankton were influenced by the salinity and the Secchi Disc depth together with the seasonal water temperature dynamics and NO_3-N concentrations throughout the research period.

Key words: Phytoplankton, Nutrients, Environmental Parameters, Kizilirmak, Black Sea, Cluster Analysis, HABs

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Introduction

Estuaries and river mouths are transition zones between freshwater and marine habitats, significantly different (in terms of biotic and abiotic features) from rivers and seas. Environmental characteristics of these areas such as temperature salinity and turbidity vary daily and their parameters can reach much higher values compared to values in rivers or seas. Fluctuations in salinity, which result from mixing of river and sea water or extremely turbid water prevent the movement of many organisms between the sea and rivers. Nonetheless, the productivity in these areas is usually very high because of the increased nutrient input. In terms of primary production, pollution and anthropogenic eutrophication have been among the most prevailing forces within these transition zones (McLusky & Elliot 2004). The subsequent effects include severe hypoxia, harmful algal blooms and mass mortalities of fish and benthic organisms (Nesterova & Terenko 2007). It is therefore essential to understand these processes in order to raise awareness and to cope with their negative effects.

There are several bioecological studies investigating the variation, bloom dynamics and biological characteristics of the phytoplankton in the Black Sea (Bat et al. 2007; Baytut et al. 2010; Bologa 1986; Gomez & Boicenco 2004; Gomoiu 1992; Ivanov 1967; Mikaelyan 2008; Moncheva et al. 2002; Nesterova et al. 2008; Oğuz et al. 1996; Polikarpov et al. 2003; Sorokin 2002; Türkoğlu & Koray 2002; Uysal 1999) and in Kizilirmak River (Yildiz & Özkiran 1991; Hasbenli & Yildiz 1995; Dere & Sivaci 2003). To our knowledge, there have been no studies related to the temporal phytoplankton distribution in the transition zone between fresh and saline waters in the Black Sea. Therefore, this study aims to investigate the phytoplankton variation, the bloom dynamics of harmful species and the interactions with nutrients along the salinity gradient through a discharging area of the Kizilirmak River.

Materials and methods

Sampling

Water samples were collected monthly from 5 sites at a depth of 0.5 meter between July 2007 and December 2008 using a Hydro-Bios Free Flow Water Sampler (2.5 liters) (Figure 1). A plankton net with a 20 μm mesh size was also used to collect qualitative samples for the determination of rare species.

Environmental characteristics

Both temperature and pH in samples were measured using a Consort C534 model analyzer. Air temperatures were provided by the Samsun Meteorological Station. Water transparency was determined by a Secchi disk. Salinity and density were determined by Eutech Cyberscan Con 11. Nutrients; nitrite nitrogen (NO_2-N), nitrate nitrogen (NO_3-N), ammonium nitrogen (NH_4-N), orthophosphate phosphorus (PO_4-P) and silica (SiO_2) were measured spectrophotometrically according to the standard methods (APHA 1995). Chlorophyll *a* was measured after pheophytin *a* correction by acidification (APHA 1995).

Phycological characteristics

Microscopic observations were conducted under a Prior phase-contrast inverted microscope, a Prior phase-contrast and Nikon E600 florescence microscope. Certain diatoms like *Pseudonitzshia* spp. and *Skeletonema* spp. were identified under a transmission electron microscope (JEOL-100SX). Thecate dinoflagellates were identified under a florescence microscope. The Lugol-fixed water samples were concentrated to 1-3 ml and then counted in the Sedgewick-Rafter chamber under an inverted microscope (Guillard 1978). Phytoplankton species were classified according to the taxonomic groups. Phytoplankton taxa were identified according to the following identification keys: Round et al. (1990), Krammer & Lange-Bertalot (1991a,b; 1999a,b), Sims (1996), Hasle & Syvertsen (1997), Steidinger & Tangen (1997), Throndsen (1997), Lange-Bertalot (2000), John et al. (2003). Potential HAB species were verified with the IOC HAB list and the Manual on Harmful Algae (Hallegraeff 2004). New records of taxa from the Turkish Algal Flora were checked according to Gönülol's (2016) website. Furthermore, valid taxa names and arrangement of taxonomic groups were determined according to the website of Guiry & Guiry (2016).

Statistical Analyses

The PRIMER-E statistical package was used for ecometric analyses. A similarity matrix was defined according to the Bray-Curtis similarity method after the square-root transformation was applied on the phytoplankton abundance matrix. Agglomerative Hierarchical Cluster Analysis and an nMDS algorithm was performed and the results were plotted on the two-dimensional MDS configuration. ANOSIM, SIMPER,

Figure 1

Location of the sampling sites in the Kızılırmak River/Black Sea transition zone

BVSTEP and BIOENV routines of the PRIMER-E package (Clarke & Warwick 2001) and CCA (Ter Braak 1986) were applied on the data sets to determine relationships between clusters of samples and environmental variables.

Results

Environmental Parameters

Temperature fluctuated throughout the sampling period between 4.60°C and 27.50°C (Fig. 2A). The highest temperatures were observed during summer, while the lowest in winter. The pH varied from nearly neutral (7.26 in August 2008) to slightly alkaline (9.20 in March 2008) (Fig. 2B). Water density was at higher levels in the summer period, while the lowest density was recorded in the rainy period, in winter and spring. It varied from 1.00053 g cm^{-3} to 1.0132 g cm^{-3} (Fig. 2C). The lowest conductivity was observed in April 2008 (1.09 mmhos cm^{-1}) and the highest in July 2007 (34.00 mmhos cm^{-1}; Fig. 2D).

The Secchi disk depth varied between 0.30 meter (N1 and N2, January 2008) and 10.50 meter (K2, August 2007) (Fig. 2E). Figure 2F shows the inorganic N:P ratio ranging from 0.13 (site A1, December 2008) to 37 (site N1, March 2008). The highest value (29.63) of the inorganic N:Si ratio (Fig. 2G) was observed at the inner river station (N1) in October 2008 while the lowest (0.13 at 10 meter depth) was determined at the coastal site (K1) in December 2008. The concentrations of Chl-*a* (Fig. 2H) varied between 0.19 mg m^{-3} (K1, in May 2008) and 4.90 mg m^{-3}, N1, in August 2008). The highest values were observed at the inner river and river mouth in late summer.

Phycological Properties

A total of 447 taxa belonging to the divisions; Cyanobacteria (24), Bacillariophyta (209), Bigyra (1), Cercozoa (1), Charophyta (11), Chlorophyta (29), Cryptophyta (10), Miozoa (118), Euglenozoa (14), Haptophyta (13), Ochrophyta (10) and Protozoa Incertae Sedis (2) were identified in the study area. Phytoplankton composition, potential harmful species and new records for the algal flora of Turkey were given in Table 1. Seventy five of the total number of taxa were determined to be new records for the Algal Flora of Turkey and 41 were found to be HAB (Harmful Algal Bloom) organisms. Phytoplankton consisted of 52% freshwater and 48% marine species. However, 40% of the total phytoplankton was represented by euryhaline and brackish water species.

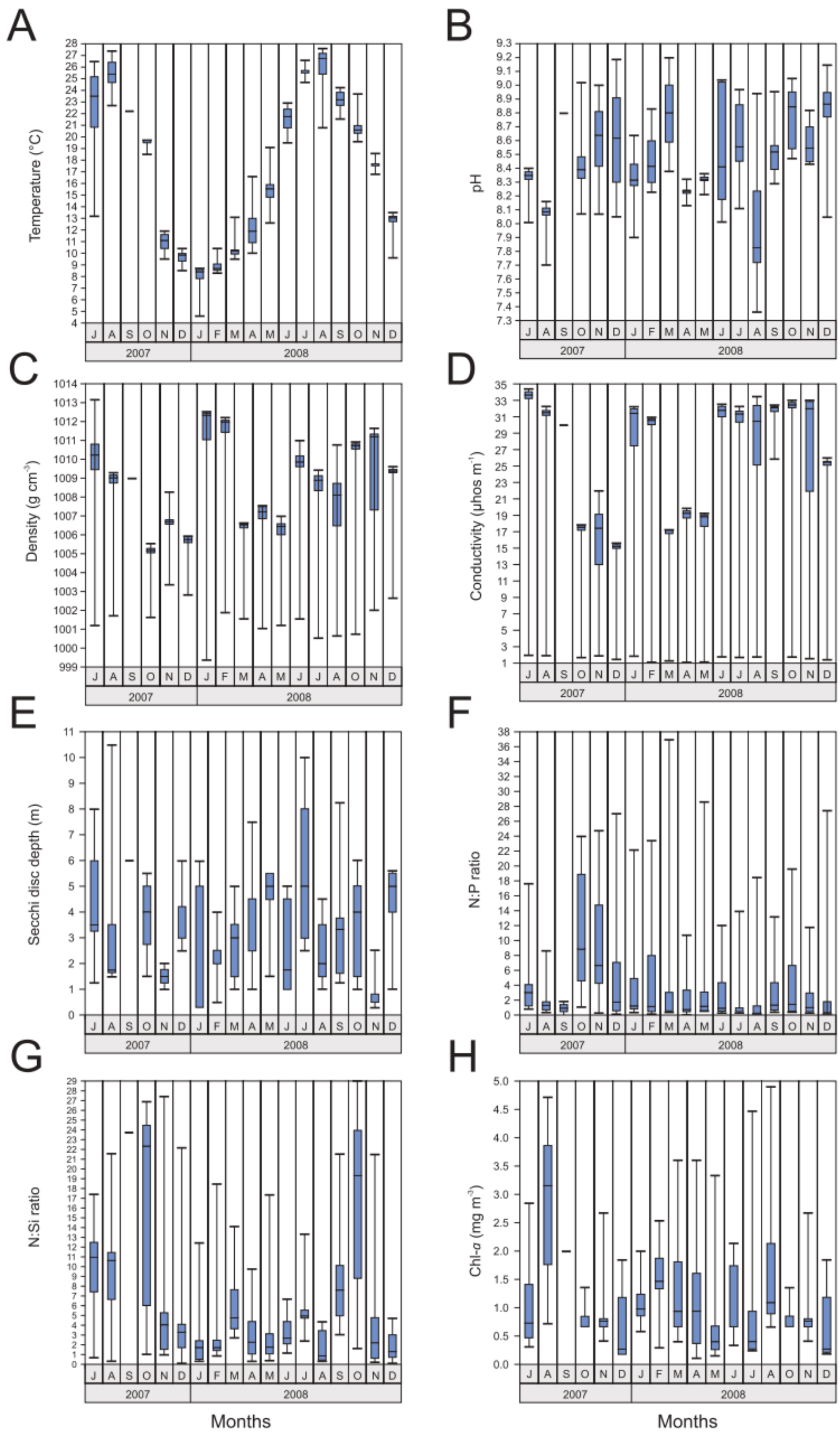

Figure 2

Environmental characteristics in water samples collected from the study area. A: Water Temperature, B: pH, C: Density, D: Conductivity, E: Secchi Disc Depth, F: Inorganic N:P ratio, G: Inorganic N:Si ratio, H: Chl-*a*

Table 1

The list of phytoplankton taxa identified in water samples from the transition zone of the Kızılırmak River mouth. Potentially harmful species are denoted by an asterisk. New records are given in bold. Species found in quantitative samples of hypothetical groups are given in parentheses as follows: Freshwater (A1), Brackish (A2), Early Spring-Marine (B), Marine (C)

CYANOBACTERIA
CYANOPHYCEAE
Aphanizomenon flos-aquae Ralfs ex Bornet and Flahault* (A1); ***Chroococcopsis chroococcoides*** (Fritsch) Komárek & Anagnostidis (A1); *Chroococcus minor* (Kützing) Nägeli (A1); *Chroococcus minutus* (Kützing) Nägeli (A1); *Heteroleibleinia epiphytica* Komárek (A1); *Kamptonema formosum* (Bory ex Gomont) Strunecký, Komárek & Smarda* (A1, A2, C); *Leptolyngbya fragilis* (Gomont) Anagnostidis & Komárek (A1); *Merismopedia elegans* A. Braun ex Kützing (A1); *Merismopedia tenuissima* Lemmermann (A1); *Microcystis aeruginosa* (Kützing) Kützing * (A1, A2); *Microcystis flosaquae* (Wittrock) Kirchner (A1, A2); ***Nostoc caerulescens*** Rabenhorst (A1); *Oscillatoria limosa* C. Agardh ex Gomont (A1, A2, C); *Oscillatoria subbrevis* Schmidle; ***Phormidium aerugineocaeruleum*** (Gomont) Anagnostidis & Komárek ; *Phormidium breve* (Kützing ex Gomont) Anagnostidis & Komárek (A1); *Phormidium lucidum* Kützing ex Gomont (A1, A2); *Planktothrix agardhii* (Gomont) Anagnostidis & Komárek*; *Pseudanabaena catenata* Lauterborn* (A1, A2, C); *Pseudanabaena limnetica* (Lemmermann) Komárek (A1); *Snowella lacustris* (Chodat) Komárek & Hindák* (A1, A2); *Spirulina major* Kützing ex Gomont; *Spirulina subsalsa* Oerstedt ex Gomont (A1); *Trichormus variabilis* (Kützing ex Bornet & Flahault) Komárek & Anagnostidis (A1)
BIGYRA
BIKOSEA
Bicosoeca mediterranea Pavillard
BACILLARIOPHYTA
BACILLARIOPHYCEAE
Achnanthes brevipes C. Agardh (C); *Achnanthes longipes* C. Agardh (C); *Achnanthes coarctata* (Brébisson ex W. Smith) Grunow (A2); ***Adlafia brockmannii*** (Hustedt) Bruder & Hinz (A1); ***Amphora cingulata*** Cleve (A1); *Amphora eximia* Carter in Haworth (A1); *Amphora laevis* Gregory; ***Amphora ocellata*** Donkin ; *Amphora ovalis* (Kützing) Kützing (A1, A2, C); *Amphora pediculus* (Kützing) Grunow ex Schmidt ; *Asterionella formosa* Hassal (C); *Bacillaria paxillifera* (O. F. Müller) Marsson (A2, B, C); *Caloneis amphisbaena* (Bory) Cleve var. *subsalina* (Donkin) Cleve (A1, A2); *Caloneis bacillum* (Grunow) Cleve (A1); *Caloneis permagna* (Bailey) Cleve (A1); *Caloneis undulata* (W. Gregory) Krammer; *Caloneis westii* (W. Smith) Hendey (A2); *Cocconeis pediculus* Ehrenberg (A1, A2, C); *Cocconeis placentula* Ehrenberg (A1, A2, C); *Cocconeis scutellum* Ehrenberg (A2, C); *Coronia decora* (Brébisson) Ruck & Guiry; ***Cosmioneis lundstroemii*** (Cleve) D. G. Mann ; *Ctenophora pulchella* (Ralfs ex Kützing) Williams & Round (C); *Cylindrotheca closterium* (Ehrenberg) Reimann & Lewin; *Cymatopleura elliptica* (Brébisson) W. Smith (A1, A2); *Cymatopleura solea* (Brébisson) W. Smith; *Cymbella affinis* Kützing (A1, A2, B, C); *Cymbella cistula* (Hemprich & Ehrenberg) Kirchner (A1, A2); *Cymbella cymbiformis* C. Agardh (A1, A2, B, C); *Cymbella cymbiformis* var. *nonpunctata* Fontell; *Cymbella helvetica* Kützing (A1); *Cymbella hustedtii* Krasske; *Delicata delicatula* (Kützing) Krammer (A1, A2); *Diatoma moniliformis* Kützing (A1, A2, C); *Diatoma tenuis* C. Agardh (A1, A2, C); *Diatoma vulgaris* Bory (A1, A2, B, C); *Diploneis chersonensis* (Grunov) Cleve (C); *Diploneis smithii* (Brébisson) Cleve (A2, C); *Encyonema leibleinii* (C. Agardh) W. J. Silva, R. Jahn, T. A. Veiga Ludwig & M. Menezes (A1); *Encyonema minutum* (Hilse) D. G. Mann (A1, A2, C); *Encyonopsis cesatii* (Rabenhorst) Krammer (A1, A2); *Eolimna minima* (Grunow) Lange-Bertalot (C); *Epithemia sorex* Kützing (C); *Eunotia arcus* Ehrenberg (A1); ***Eunotia bigibba*** Kützing ; *Eunotia septentrionalis* Østrup; ***Fallacia forcipata*** (Greville) Stickle & D. G. Mann (C); *Fallacia pygmaea* (Kützing) Stickle & D. G. Mann (A1, A2, C); *Fragilaria amphicephaloides* Lange-Bertalot in Hofmann, Werum & Lange-Bertalot (A1, A2); *Fragilaria capucina* Desmazières (A1, A2); *Fragilaria crotonensis* Kitton (A1, A2, B, C) ; *Fragilaria gracillima* Mayer (C); ***Fragilaria inflata*** (Heiden) Hustedt (A1); *Fragilaria vaucheriae* (Kützing) J. B. Petersen (A1); *Frustulia creuzburgensis* (Krasske) Hustedt (C); *Gomphonema affine* Kützing (A1, A2, C); *Gomphonema minutum* (C. Agardh) C. Agardh (A1, A2, B, C); *Gomphonema olivaceum* (Hornemann) Brébisson (A1, A2, B, C); *Gomphonema subtile* Ehrenberg (A1); *Gomphonema truncatum* Ehrenberg (A1, A2, B, C); *Grammatophora marina* (Lyngbye) Kützing (A2); ***Grunowia solgensis*** (Cleve-Euler) Aboal ; *Gyrosigma acuminatum* (Kützing) Rabenhorst (A2, C); *Gyrosigma eximium* (Thwaites) Boyer (A2, C); *Gyrosigma fasciola* (Ehrenberg) Griffith & Henfrey; *Gyrosigma obscurum* (W. Smith) Griffith & Henfrey (A2, C); *Halamphora acutiuscula* (Kützing) Levkov; *Halamphora coffeaeformis* (C. Agardh) Levkov* (A2, C); *Halamphora exigua* (Gregory) Levkov (A2); *Halamphora holsatica* (Hustedt) Levkov (C); *Halamphora normanii* (Rabenhorst) Levkov (A2); ***Halamphora turgida*** (Gregory) Levkov; *Halamphora veneta* (Kützing) Levkov (C); *Hannaea arcus* (Ehrenberg) Patrick (A1); *Hantzschia amphioxys* (Ehrenberg) Grunow (A1, A2); *Licmophora ehrenbergii* (Kützing) Grunow (A1, A2, B, C); *Licmophora lyngbyei* (Kützing) Grunow ex Van Heurck (A1); ***Lyrella abrupta*** (Gregory) D. G. Mann ; *Martyana martyi* (Héribaud) Round (A2, C); ***Mastogloia exigua*** Lewis; *Mastogloia pumila* (Cleve & Möller; Grunow) Cleve (C); *Mastogloia smithii* Thwaites ex W. Smith; *Navicula cincta* (Ehrenberg) Ralfs (A1,A2, C); *Navicula cryptotenella* Lange-Bertalot (A1, A2, C); ***Navicula globosa*** Meister (A1, A2); *Navicula gregaria* Donkin; *Navicula libonensis* Schoeman (A1, A2); *Navicula pennata* Schmidt (A1, A2, C); ***Navicula pennata* var. *pontica*** Mer.; *Navicula phyllepta* Kützing (A1); ***Navicula resecta*** Carter (C); *Navicula rhynchocephala* Kützing (A1, A2, C); *Navicula salinarum* Grunow (A2, C); *Navicula sigma* Ehrenberg; *Navicula trivialis* Lange-Bertalot; *Navicula veneta* Kützing (A1, A2, B, C); ***Neidiopsis levanderi*** (Hustedt) Lange-Bertalot & Metzeltin; *Neidium dubium* (Ehenberg) Cleve (A1); *Nitzschia acicularis* (Kützing) W. Smith (A1, A2); *Nitzschia amplectens* Hustedt; *Nitzschia clausii* Hantzsch (A1, A2); *Nitzschia dissipata* (Kützing) Grunow (A1, A2, C); *Nitzschia flexa* Schumann (A1, A2); *Nitzschia incerta* (Grunow) M. Peragallo; *Nitzschia linearis* West (A2); *Nitzschia longissima* (Brébisson) Ralfs (A2, B, C); *Nitzschia nana* Grunow; *Nitzschia obtusa* W. Smith (A2); *Nitzschia ovalis* Arnott (A1, A2, C); *Nitzschia palea* (Kützing) W. Smith (A1, A2, C); *Nitzschia recta* Hantzsch ex Rabenhorst (A1); *Nitzschia sigma* (Kützing) W. Smith (A2); *Nitzschia sigmoidea* (Nitzsch) W. Smith (A1, A2, B, C); *Nitzschia tryblionella* Hantzsch (C); *Nitzschia umbonata* (Ehrenberg) Lange-Bertalot (A2); ***Pinnularia aestuarii*** Cleve (A1); *Pinnularia bipectinalis* (Schumann) Greguss (A1); *Pinnularia borealis* Ehrenberg (A1); ***Pinnularia claviculus*** (Gregory) Rabenhorst (C); *Pinnularia gentilis* (Donkin) Cleve (A1); *Pinnularia lundii* Hustedt (A1, A2, C); *Pinnularia microstauron* (Ehrenberg) Cleve (A1, A2); *Plagiotropis lepidoptera* (Gregory) Kuntze (A1); ***Pleurosigma aestuarii*** (Brébisson ex Kützing) W. Smith (C); *Pleurosigma elongatum* W. Smith (A2); *Psammodictyon panduriforme* (W. Gregory) D. G. Mann; *Pseudo-nitzschia australis* Frenguelli* (C); *Pseudo-nitzschia calliantha* Lundholm, Moestrup et Hasle* (A2, C); *Pseudo-nitzschia delicatissima* (Cleve) Heiden* (A2, C); *Pseudo-nitzschia pseudodelicatissima* (Hasle) Hasle* (A2, C); *Pseudo-nitzschia pungens* (Grunow ex Cleve) Hasle* (A2, C); ***Rhabdonema minutum*** Kützing (A1); *Rhoicosphenia abbreviata* (C. Agardh) Lange-Bertalot (A1, A2, C); *Striatella unipunctata* (Lyngbye) C. Agardh (A2); *Surirella angusta* Kützing; *Surirella elegans* Ehrenberg (A1, A2, C); *Surirella minuta* Brébisson (A1, A2, C); ***Surirella muelleri*** Hustedt ; *Surirella ovalis* Brébisson (A1, A2, C); *Tabularia fasciculata* (C. Agardh) Williams & Round (A2, C); ***Tabularia investiens*** *(W. Smith) Williams & Round (A2); Thalassionema nitzschioides (Grunow) Mereschkowsky (A2, B, C) ; Thalassiothrix mediterranea* Pavillard (A2, C); *Ulnaria danica* (Kützing) Compére & Bukhtiyarova (A1, A2)
COSCINODISCOPHYCEAE
Actinocyclus normanii (Gregory) Hustedt f. ***subsalsus*** (Juhlin-Dannfelt) Hustedt (C) ; *Actinoptychus octonarius* (Ehrenberg) Kützing (A2, C); *Aulacoseira granulata* (Ehrenberg) Simonsen (A1); *Coscinodiscus concinnus* W. Smith* (C); *Coscinodiscus janischii* Schmidt (C); *Coscinodiscus perforatus* Ehrenberg (A2, B, C); *Coscinodiscus radiatus* Ehrenberg (C); *Coscinodiscus wailesii* Gran & Angst* (A2, C); *Dactyliosolen fragilissimus* (Bergon) Hasle (A2, C); ***Hyalodiscus scoticus*** (Kützing) Grunow (A2, C); *Melosira moniliformis* (O. F. Müller) C. Agardh (A2); *Melosira nummuloides* C. Agardh (A2); *Melosira varians* C. Agardh (A1, A2, B, C); ***Podosira hormoides*** (Mont.) Kutzing (C); *Proboscia alata* (Brightwell) Sündstrom (A2, C); *Pseudosolenia calcar-avis* (Schultze) Sundström (A2, B, C); *Rhizosolenia acuminata* (Peragallo) Peragallo (A2, C); *Rhizosolenia hebetata* Bailey (A2, C); *Rhizosolenia imbricata* Brightwell (C); *Rhizosolenia setigera* Brightwell (A2, C); ***Rhizosolenia setigera*** f. ***pungens*** (Cleve-Euler) Brunel (C); *Rhizosolenia styliformis* Brightwell (A2, B, C)
MEDIOPHYCEAE
Cerataulina pelagica (Cleve) Hendey (A2, C); *Chaetoceros affinis* Lauder (A2, B, C); *Chaetoceros constrictum* Gran (C); *Chaetoceros compressus* Lauder; *Chaetoceros curvisetum* Cleve (A2, B, C); *Chaetoceros decipiens* Cleve; *Chaetoceros diversus* Cleve; *Chaetoceros lorenzianus* Grunow (A2, B, C); ***Chaetoceros neogracile*** VanLandingham (C); *Chaetoceros pendulus* Karsten (A2, C); *Chaetoceros peruvianus* Brightwell (C); *Chaetoceros pseudocurvisetus* Mangin (A2); *Chaetoceros simplex* Ostenfeld (C); *Chaetoceros socialis* Lauder* (B, C); *Chaetoceros subsecundus* (Grunow ex Van Heurck) Hustedt (B); *Chaetoceros tenuissimus* Meunier (A2); *Chaetoceros wighamii* Brightwell (A2, C); *Cyclotella atomus* Hustedt (A1, A2, C); ***Cyclotella choctawhatcheeana*** Prasad (A1, A2, C); *Cyclotella meneghiniana* Kützing (A1, A2, C); *Cyclotella glomerata* Bachmann (A1); *Detonula confervacea* (Cleve) Gran (A2); *Ditylum brightwellii* (West) Grunow (B, C); *Hemiaulus hauckii* Grunow ex Van Heurck; *Leptocylindrus danicus* Cleve (A2, C); *Leptocylindrus minimus* Gran (C); ***Odontella obtusa*** (Kützing) Denys (A2); *Pontocsekiella kuetzingiana* (Thwaites) K. T. Kiss & E. Ács in Ács (A1, A2, C); ***Skeletonema dohrnii*** Sarno & Kooistra (A2, B, C); *Stephanodiscus hantzschii* Grunow; *Stephanodiscus minutulus* (Kützing) Cleve & Möller (A1, A2, C); *Thalassiosira angulata* (Gregory) Hasle (A2, C); *Thalassiosira anguste-lineata* (Schmidt) Fryxell & Hasle (C); ***Thalassiosira antiqua*** (Grunow) Cleve (B); *Thalassiosira eccentrica* (Ehrenberg) Cleve (B, C);

Thalassiosira gravida Cleve (A2, B, C); *Thalassiosira nordenskioeldii* Cleve (C); *Thalassiosira gravida* Cleve (A2, B, C); ***Thalassiosira parva*** Lavrenko (C); *Toxarium undulatum* Bailey (C); *Trieres mobiliensis* (Bailey) Ashworth & Theriod in Ashworth; *Trigonum alternans* (Bailey) A. Mann
CERCOZOA
FILOSA
Paulinella ovalis (Wulff) Johnson, Hargraves & Sieburth
CHAROPHYTA
ZYGNEMATOPHYCEAE
Closterium aciculare West (A1); *Closterium acutum* Brébisson (A1); *Closterium dianae* Ehrenberg ex Ralfs (A1); ***Closterium juncidum*** Ralfs (A1); *Closterium praelongum* Brébisson (A1); *Cosmarium formosulum* Hoffmann; *Spirogyra condensata* (Vaucher) Kützing; *Spirogyra daedalea* f. *daedaleoides* (Czurda) V. Poljansky (A1); *Spirogyra fluviatilis* Hilse (A1); *Spirogyra subsalsa* Kützing; *Netrium digitus* (Brébisson ex Ralfs) Itzigsohn & Rothe (A1)
CHLOROPHYTA
CHLOROPHYCEAE
Acutodesmus acutiformis (Schröder) Tsarenko & D. M. John (A1, A2); *Carteria marina* Diesing (A2, C); *Chlamydomonas platyrhyncha* Korshikov in Pascher; ***Chlamydomonas pulsatila*** Wollenweber; *Chlamydomonas reinhardtii* Dangeard (A1); *Coenochloris fottii* (Hindák) Tsarenko (A1); *Desmodesmus armatus* (Chodat) Hegewald (A1); *Desmodesmus communis* (Hegewald) Hegewald (A1, A2, C); *Desmodesmus denticulatus* (Lagerheim) An, Friedl & Hegewald; *Desmodesmus magnus* (Meyen) Tsarenko (A1); *Desmodesmus opoliensis* (Richter) Hegewald (A1); *Dunaliella tertiolecta* Butcher; *Microspora tumidula* Hazen (A1); *Pseudodidymocystis planctonica* (Korshikov) Hegewald & Deason; *Scenedesmus ellipticus* Corda (A1); *Stigeoclonium tenue* (C. Agardh) Kützing (A1); *Tetraedron minimum* (Braun) Hansgirg (A1, A2, C)
NEPHROSELMIDOPHYCEAE
Nephroselmis minuta (Carter) Butcher (A2, C)
PYRAMIMONADOPHYCEAE
Halosphaera viridis Schmitz (A2, C); ***Pyramimonas adriaticus*** Schiller (A2, C); *Pyramimonas plurioculata* Butcher (A2, C); *Pyramimonas propulsa* Moestrup & Hill (C)
TREBOUXIOPHYCEAE
Closteriopsis acicularis (Chodat) Belcher et Swale (A1, A2, C); *Lagerheimia genevensis* (Chodat) Chodat (A1); *Pseudopediastrum boryanum* (Turpin) Hegewald (A1)
ULVOPHYCEAE
Cladophora glomerata (Linnaeus) Kützing (A1, A2); *Ulothrix aequalis* Kützing; *Ulothrix implexa* (Kützing) Kützing; *Ulothrix zonata* (Weber & Mohr) Kützing (A1)
CRYPTOPHYTA
CRYPTOPHYCEAE
Chroomonas baltica (Büttner) Carter (A2, C); ***Cryptomonas nordstedtii*** (Hansgirg) Senn (A1, A2, C); *Cryptomonas ovata* Ehrenberg (A1, A2); ***Hemiselmis rufescens*** Parke (C); ***Hillea fusiformis*** (Schiller) Schiller (A2, C); ***Plagioselmis prolonga*** Butcher ex Novarino, Lucas & Morrall (A2, B, C); *Plagioselmis nannoplanctica* (Skuja) Novarino, Lucas & Morrall (A2, C); ***Rhodomonas marina*** (Dangeard) Lemmermann (A2, C); ***Rhodomonas salina*** (Wislouch) Hill & Wetherbee (A2, C); ***Teleaulax acuta*** (Butcher) Hill (A2, C)
EUGLENOPHYTA (=EUGLENOZOA)
EUGLENOPHYCEAE
Euglena acusformis Schiller; *Euglena elastica* Prescott (A1); *Euglena elongata* Schewiakoff; *Euglena granulata* (Klebs) Schmitz; *Euglena hemichromata* Skuja (A1); *Euglena oblonga* Schmitz; *Euglena texta* (Dujardin) Hübner (A1); *Euglena variabilis* Klebs (A1); *Euglena viridis* (O.F. Müller) Ehrenberg (A1); *Euglenaformis proxima* (Dangeard) Bennett & Triemer (A1, A2); ***Eutreptia lanowii*** Steuer (A2, C); *Lepocinclis globulus* Perty (A1); *Lepocinclis oxyuris* (Schmarda) Martin & Melkonian (A1); *Monomorphina aenigmatica* (Drezepolski) Nudelman & Triemer (A1)
HAPTOPHYTA
COCCOLITHOPHYCEAE
Calyptrosphaera globosa Lohmann (B, C); *Coccolithus pelagicus* (Wallich) Schiller (C); ***Coronosphaera mediterranea*** (Lohmann) Gaarder (C); ***Discosphaera tubifer*** (Murray & Blackman) Ostenfeld (C); *Emiliania huxleyi* (Lohmann) Hay & Mohler (C); ***Holococcolithophora sphaeroidea*** (Schiller) Jordan et al. (C); ***Periphyllophora mirabilis*** (Schiller) Kamptner (C); ***Phaeocystis globosa*** Scherffel* (A2, C); ***Phaeocystis pouchetii*** (Hariot) Lagerheim* (A2); ***Prymnesium parvum*** Carter* (C); ***Prymnesium saltans*** Massart ex Conrad*; ***Sphaerocalyptra quadridentata*** (Schiller) Deflandre (C); ***Syracosphaera grundii*** Schiller (C)
MIOZOA
DINOPHYCEAE
Aureodinium pigmentosum Dodge (A2, B, C); *Alexandrium affine* (Inoue & Fukuyo) Balech ; *Alexandrium minutum* Halim* (A2, C); *Alexandrium tamarense* (Lebour) Balech* (C); ***Amphidinium acutissimum*** Schiller (A2, C); ***Amphidinium amphidinioides*** (Geitler) Schiller (A1); ***Amphidinium carteriae*** Hulburt* (A2, C); ***Amphidinium crassum*** Lohmann (A2, C); ***Amphidinium operculatum*** Claparède & Lachmann* (A2, C); ***Amphidinium ovum*** Herdman ; ***Amphidinium steinii*** Lemmeremann (A2); ***Amphidinium sphenoides*** Wülff (A2, C); ***Amphisolenia globifera*** Stein (A2, C); *Amylax triacantha* (Jorgensen) Sournia; ***Archaeperidinium minutum*** (Kofoid) Jorgensen (A2, C); ***Borghiella tenuissima*** (Lauterborn) Moestrup, Hansen & Daugberg; *Ceratium cornutum* (Ehrenberg) Claparède & Lachmann (A1, A2); *Ceratium furcoides* (Levander) Langhans (A2,C); *Ceratium hirundinella* (O. F. Müller) Dujardin (A1, A2); ***Cochlodinium archimedes*** (Pouchet) Lemmermann (A2, C); ***Cochlodinium citron*** Kofoid & Swezy* (A2); ***Cystodinium bisotesum*** (Lindemann) Huber-Pestalazi ; *Dinophysis acuminata* Claparède & Lachmann* (A2, C); *Dinophysis acuta* Ehrenberg* (A2, B, C); *Dinophysis caudata* Saville-Kent* (A2, C); *Dinophysis fortii* Pavillard* (C); *Dinophysis hastata* Stein (C); ***Dinophysis pulchella*** (Lebour) Balech (A2, C); *Dinophysis sphaerica* Stein (A2, C); *Diplopsalis lenticula* Bergh (A2, C); ***Durinskia agilis*** (Kofoid & Swezy) Saburova, Chomérat & Hoppenrath (A2, C); *Gonyaulax grindleyi* Reinecke* (A2, C); *Gonyaulax polygramma* Stein* (A2); *Gonyaulax scrippsae* Kofoid (C); *Gonyaulax spinifera* (Claparède & Lachmann) Diesing (A2, C); *Gonyaulax verior* Sournia (A2); ***Gymnodinium agiliforme*** Schiller (A2, B, C); ***Gymnodinium catenatum*** Graham* (A2); ***Gymnodinium elongatum*** Hope (A2, B, C); ***Gymnodinium fusus*** Schütt (C); *Gymnodinium fuscum* (Ehrenberg) Stein; ***Gymnodinium gracile*** Bergh; ***Gymnodinium najadeum*** Schiller ; ***Gymnodinium neapolitanum*** Schiller (B, C); ***Gymnodinium paradoxum*** Schilling; ***Gymnodinium rhomboides*** Schutt; *Gymnodinium simplex* (Lohmann) Kofoid & Swezy (A2, C); ***Gymnodinium wilczekii*** Pouchet (A2); ***Gymnodinium wulffii*** Schiller (A2, C); ***Gyrodinium dominans*** Hulbert; ***Gyrodinium estuariale*** Hulbert (A2, C); *Gyrodinium fusiforme* Kofoid & Swezy (A2, C); ***Gyrodinium helveticum*** (Penard) Y. Takano & T. Horiguchi ; ***Gyrodinium hyalinum*** (Schilling) Kofoid & Swezy; ***Gyrodinium impendens*** Larsen ; *Gyrodinium lachryma* (Meunier) Kofoid & Swezy (B, C); ***Gyrodinium nasutum*** (Wulff) Schiller (A2, C); ***Gyrodinium pingue*** (Schütt) Kofoid & Swezy (A2, C); *Gyrodinium spirale* (Bergh) Kofoid & Swezy (A2, B, C); ***Gyrodinium wulffii*** Schiller ; ***Heterocapsa rotundata*** (Lohmann) Hansen (A2, C); *Heterocapsa triquetra* (Ehrenberg) Stein (A2, B, C); ***Kapelodinium vestifici*** (Schütt) Boutrup, Moestrup & Daugbjerg (A2, C); ***Karenia brevis*** (Davis) Hansen & Moestrup (A2, C); *Karenia mikimotoi* (Miyake & Kominami ex Oda) Hansen & Moestrup* (A2, C); ***Karlodinium veneficum*** (Ballantine) Larsen (A2, C); *Katodinium fungiforme* (Anissimova) Loeblich III (A2, C); ***Lebouridinium glaucum*** (M. Lebour) F. Gómez, H. Takayan, D. Moreira & P. López-García; ***Levanderina fissa*** (Levander) Moestrup, Hakanen, Hansen, Daugbjerg & Ellegaard; *Lingulodinium polyedrum* (Stein) Dodge* (A2, C); *Noctiluca scintillans* (Macartney) Kofoid et Swezy (A2, C); *Peridiniopsis borgei* Lemmermann (A1); *Peridinium bipes* Stein (A1); *Peridinium cinctum* (O. F. Müller) Ehrenberg (A1); *Phalacroma oxytoxoides* (Kofoid) Gómez, Lopez-Garcia & Moreira (C); *Phalacroma rotundatum* (Claparéde & Lachmann) Kofoid & Michener (A2, B, C); *Podolampas palmipes* Stein (A2, C); *Polykrikos kofoidii* Chatton (A2, B, C); ***Polykrikos geminatus*** (Schütt) Qiu & Lin; ***Pronoctiluca acuta*** (Lohmann) Schiller; *Prorocentrum compressum* (J. W. Bailey) Abé ex J. D. Dodge (A2, B, C); *Prorocentrum cordatum* (Ostenfeld) Dodge* (A2, B, C); *Prorocentrum micans* Ehrenberg* (A2, C); ***Prosoaulax lacustris*** (Stein) Calado & Moestrup (A2, C); *Protoperidinium bipes* (Paulsen) Balech ; *Protoperidinium brevipes* (Paulsen) Balech (A2, C); *Protoperidinium conicum* (Gran) Balech (C); *Protoperidinium crassipes* (Kofoid) Balech* (A2, C); *Protoperidinium depressum* (Bailey) Balech (A2, C); *Protoperidinium divergens* (Ehrenberg) Balech (A2, C); ***Protoperidinium elegans*** (Cleve) Balech (C); *Protoperidinium globulus* (Stein) Balech (A2, C); *Protoperidinium mediterraneum* (Kofoid) Balech (C); *Protoperidinium oblongum* (Aurivillius) Parke & Dodge (A2, C); *Protoperidinium oceanicum* (VanHöffen) Balech (A2, C); *Protoperidinium pallidum* (Ostenfeld) Balech (A2, C); *Protoperidinium pellucidum* Bergh exLoeblich Jr. & Loeblich III (A2, C); *Protoperidinium pentagonum* (Gran) Balech (A2, C); *Protoperidinium steinii* (Jorgensen) Balech (A2, C); *Pyrocystis elegans* Pavillard (C);

Pyrocystis lunula (Schütt) Schütt (C); *Pyrophacus horologicum* Stein (C) *Scrippsiella acuminata* (Ehrenberg) Kretschmann, Elbrächter, Zinssmeister, Soehner, Kirsch, Kusber & Gottschling* (A2, B, C); ***Spatulodinium pseudonoctiluca*** (Pouchet) Cachon & Cachon ex Loeblich (A2, C); ***Torodinium robustum*** Kofoid & Swezy (A2, C); ***Tovellia leopoliensis*** (Woloszynska) Moestrup, Lindberg & Daugbjerg (C); *Tripos candelabrus* (Ehrenberg) F. Gómez, D. Moreira & P. López-Garcia (A1, A2); *Tripos declinatus* (Karsten) Gómez (A2, B, C); *Tripos eugrammus* (Ehrenberg) Gomez; *Tripos furca* (Ehrenberg) Gómez (A1, A2, B, C); *Tripos fusus* (Ehrenberg) Gomez* (A2, B, C); *Tripos inflatum* (Kofoid) F. Gómez*; *Tripos longipes* (Bailey) Gómez (B); *Tripos muelleri* Bory; *Tripos platicornis* (Daday) Gomez (A2); *Tripos teres* (Kofoid) Gómez; ***Warnowia fusus*** (Schütt) Lindemann; ***Woloszynskia pascheri*** (Suchlandt) von Stosch (A2)
OCHROPHYTA
CHRYSOPHYCEAE
Dinobryon sertularia Ehrenberg
DICTYOCHOPHYCEAE
Dictyocha fibula Ehrenberg (C); *Dictyocha octonaria* Ehrenberg (A2, B, C); *Dictyocha speculum* Ehrenberg (A2, B, C); *Pseudopedinella pyriformis* Carter (C); *Pseudopedinella thomsenii* Sekiguchi, Kawachi, Nakayama & Inouye
RAPHIDOPHYCEAE
Chattonella subsalsa Biecheler*; *Gonyostomum semen* (Ehrenberg) Diesing; *Heterosigma akashiwo* (Hada) Hada ex Hara & Chihara* (A2, C); *Oltmannsia viridis* Schiller
PROTOZOA INCERTAE SEDIS
EBRIOPHYCEAE
Ebria tripartita (Schumann) Lemmermann (B, C); *Hermesinum adriaticum* Zacharias (C)

Figure 3 shows the phytoplankton variation among the sampling sites. The highest cell concentration was measured at the inner river site (N1) and three peaks were observed from May to October 2008.

Multivariate Analyses

The agglomerative hierarchical cluster analysis and the MDS plot from the surface water abundance data revealed assemblages with a stress value of 0.15 (Fig. 4 A-E). Accordingly, assemblages in the MDS plot were consistent with those resulting from hierarchical cluster analysis. Samples were divided into four groups: "Freshwater", "Brackish", "Marine" and "Earlyspring-Marine" at 44% similarity level. The assemblages from the MDS plots and cluster dendrograms were confirmed by the ANOSIM procedure (Global R values are 0.858 for surface groups and 0.746 for subsurface groups).

The BIOENV procedure applied to the surface phytoplankton data revealed the best correlation coefficient (0.68) not only for one environmental variable but also for the density, Secchi Disc depth, NH_3-N and silica. Figure 4(B-E) shows the effects of related parameters on the groups of samples in the MDS plot.

Discussion

Temporal phytoplankton variation, distribution and interactions with environment were investigated at 5 sampling sites in the Kizilirmak River/Black Sea transition zone between July 2007 and December 2008.

During the sampling period, the sea and river water temperature varied between 4.60 and 27.50°C. Water temperature was significantly correlated with air temperature (4-30°C). Phytoplankton abundance increased due to the higher temperatures and peaked twice in August and September. However, some centric diatoms such as *Chaetoceros socialis* (5.6×10^4 cells l^{-1}), *Pontocsekiella kuetzingiana* (1.28×10^5 cells l^{-1}), *C. meneghiniana* (1.14×10^5 cells l^{-1}) and *P. calcar-avis* (4.3×10^4 cells l^{-1}) and coccolithophores such as *Calyptosphaera globosa* (6.6×10^4 cells l^{-}), *Holococcolithophora sphaeoridea* (6.5×10^4 cells l^{-1}) and *Emiliana huxlei* (5.5×10^5 cells l^{-1}) occurred with their highest abundance in the cold period as compared to other studies located in the Black Sea (Türkoğlu & Koray 2002; Sorokin 2002; Baytut et al. 2010). Longterm data showed that centric taxa such as *Aulacoseira* and *Cyclotella* are dominant in the Danube river phytoplankton (Dokulil & Donabaum 2014).

Water samples in this study were consistent with the ratios declared by the European Commission and the inorganic N:P ratio varied during sampling period between 0.13 and 37.00 (European Commission 2002). Higher values were observed in the inner river (N1) and in the river-sea transition zone (N2). According to these findings, the phytoplankton production is limited by inorganic phosphorus in surface waters and by inorganic nitrogen in subsurface waters. The N:Si ratio was usually between 1 and 2 units in the healthy marine ecosystem and heterotrophic flagellates become dominant when it increases over 2 units (Roberts et al. 2003). Inorganic N:Si ratios ranged from 0.13 to 29.00 units. Diatom production was limited by higher inorganic N:Si values and the abundance of flagellates and cyanobacteria were dominant in the phytoplankton community.

Chlorophyll-*a* in lagoons of the Kızılırmak Delta ranged from 0.50 to18.00 mg m^{-3} (Soylu & Gönülol 2006; Soylu et al. 2007; Gönülol et al. 2009). For the northwestern Black Sea, it was reported as 15.00 mg m^{-3} in the 1980s and 4-5 mg m^{-3} in the 1990s (Yunev et al. 2007). The results of this study revealed that chlorophyll-*a* concentrations were lower than those measured in the lagoons of the Kızılırmak delta but higher compared to hypereutrophic waters of the

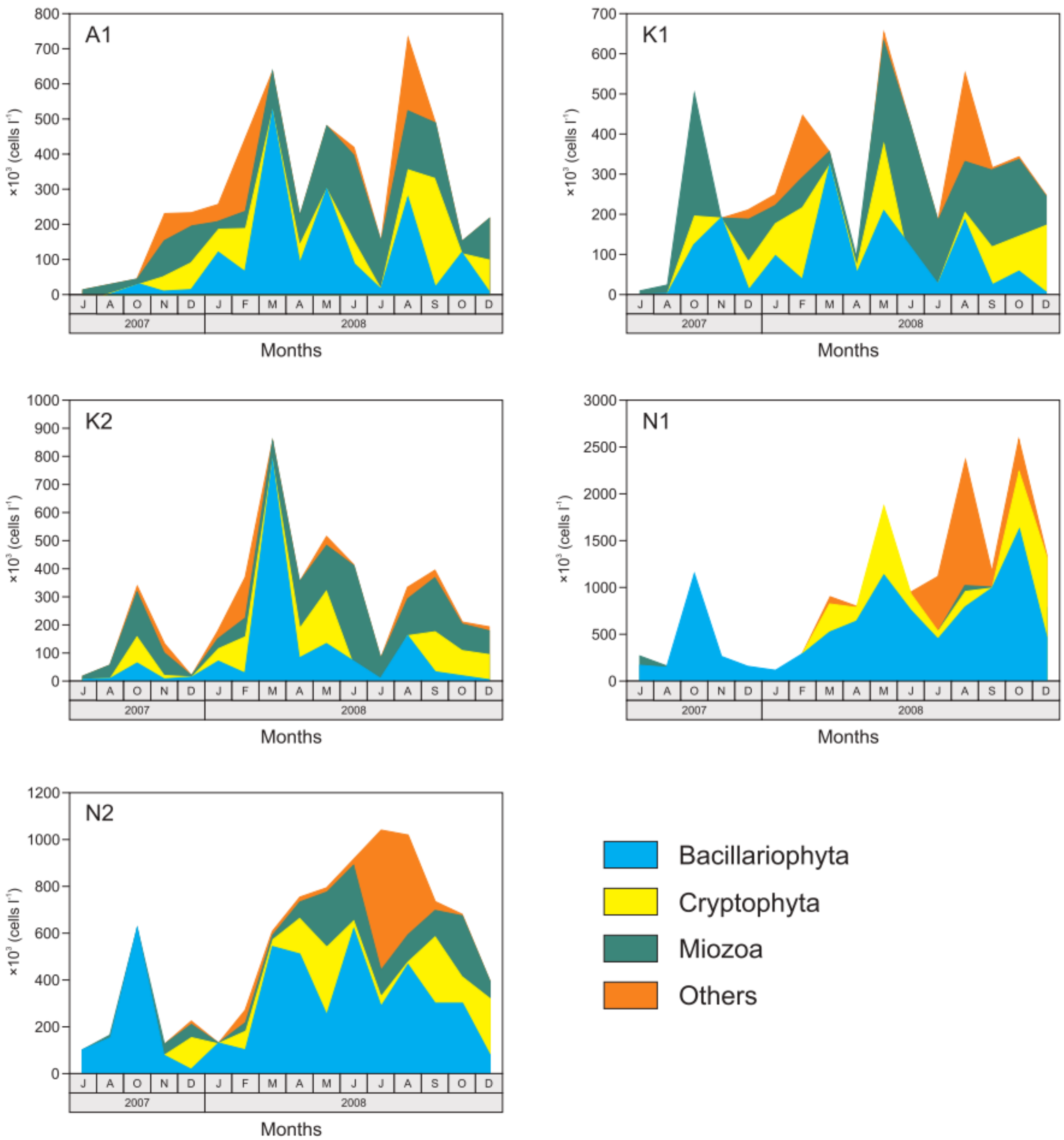

Figure 3

Abundance and variation of the phytoplankton in water samples collected from the study area during the sampling period

northwestern Black Sea. Chlorophyll-*a* values oscillated between 0.19 mg m^{-3} (May 2008) and 6.90 mg m^{-3} (August 2008).

Surface phytoplankton composition, especially at the inner river (N1) and at the river mouth (N2) site, consisted mainly of freshwater and euryhaline taxa. Remaining species were typically coastal marine species. The freshwater species belonged to the divisions: Cyanobacteria, Charophyta, Chlorophyta, Euglenozoa and their most abundant representatives were *Pseudoanabaena catenata*, *Spirogyra fluviatilis*, *Oocycstis elliptica* and *Eutreptia lanowii*, respectively. It was indicated that these species are common in nutrient-rich, eutrophic, polluted and shallow or slow flowing water systems (John et al. 2003).

The sampling sites in the study area showed major differences in the phytoplankton abundance. For instance, phytoplankton abundance at the inner river site (N1) exceeded 1×10^6 cells l^{-1} in October, May and August, while it reached only 0.5×10^6 cells l^{-1} at the river-sea transition zone (N2) in October, March and August. Bacillariophyta was the dominant taxonomic group in the inner river and in the transition zone. *Cocconeis pediculus*, *Pontocsekiella kuetzingiana*, *C. meneghiniana*, *Gomphonema minutum*, *G. oliviaceum*, *Melosira varians*, *Navicula cryptocephala*, *Nitzschia* spp., *Pseudosolenia calcar-avis*, *Rhoicosphenia abbreviata*, *Thalassiosira antiqua* and *Ulnaria oxyrhyncus* were the most abundant species of diatoms. Dinoflagellates, however, were absolutely dominant at the marine sites except for centric diatoms which peaked in March and May. The most abundant representatives of this group were *Amphidinium crassum*, *Gymnodinium elongatum*, *Gymnodinium simplex*, *Gyrodinium estuariales*, *Heterocapsa rotundatum*, *Karlodinium micrum*, *Karenia brevis*, *Prorocentrum caudatum* and *P. micans*.

Temporal changes in the abundance were usually consistent with chlorophyll-*a*. In certain months, however, various differences occurred during the sampling period. For instance, relatively lower chlorophyll-*a* values (1.20-1.36 mg m^{-3}) were observed at the inner river and river mouth sites (N1 and N2), while the increased values of abundance (0.6-2.3 $\times$ 10^6 cells l^{-1}) were recorded in October 2007 and August 2008. The reason for this contradistinction could be the fact that benthic diatom cellswere included in the count (benthic cells may influence the phytoplankton through the water movement). Former studies in the Kizilirmak River (Dere & Sıvacı 2003; Hasbenli & Yıldız 1995; Yıldız & Özkıran 1991) reported that *Amphora, Cocconeis*, *Cyclotella*, *Cymbella*, *Diatoma*, *Encyonema*, *Fragilaria*, *Gomphonema*, *Melosira*, *Navicula*, *Nitzschia* and *Rhoicosphenia* were the most common taxa in the benthic community and they were frequently encountered in the inner river and in the riverine transition zone in the study area.

MDS and hierarchical cluster analyses revealed that there are four groups of samples. The results were tested and confirmed by ANOSIM in order to check the significance of differences between the groups of samples. These samples were divided into the following groups: "Freshwater", "Brackish", "Marine" and "Early spring-marine". However, MDS and hierarchical cluster analyses of the subsurface phytoplankton abundance data, however, showed that the groups of samples varied according to the seasonal variation. Sample group A included the early spring samples (March and April), while group B1 comprised the late spring-early fall samples (from May to September). Group B2 included fall and winter samples (October and February) and group C comprised samples collected from July to August.

Reynolds (2006) reported that only 20-30 species succeed in the whole community even if resident taxa are represented by large numbers. Likewise, dissimilarities between groups of samples determined by the SIMPER routine and Spearman rank correlations performed on the data subsets (BVSTEP) revealed that 35 successful species were found in the phytoplankton community in spite of the 430 taxa identified in the Kizilirmak River/Black Sea transition zone. Some of them were typical eutrophic freshwater and marine diatom species in the surface water phytoplankton, except for a few eutrophic dinoflagellates. For instance, the diversity of *Nitzschia* species in polluted and eutrophic zones was usually at the highest levels (Petrov et al. 2010). Similarly, the *Nitzchia* genus was represented by 20 species in this study. In the eutrophic Varna Bay, which receives a great part of the Danube's freshwaters, the most abundant species of the phytoplankton community were similar to those occuring in the current study area (*C. socialis*, *E. huxleyi*, *P. delicatissima* and *P. cordatum*) (Petrova et al. 2006).

The BIOENV procedure revealed the Spearman rank correlations between the Bray-Curtis similarity matrix of the abundance data and Euclidean distance matrix of environmental parameters. Thus, the surface phytoplankton assemblages varied along the salinity gradient and the Secchi disc depth. Subsurface assemblages differed due to the water temperature and the N:P ratio. Flagellates (including Dinoflagellata) were reported to be able to bloom in eutrophic coastal waters in the Black Sea (Nesterova et al. 2008). There are, however, some differences in the phytoplankton dynamics between the findings from the study area and the studies from the whole Black Sea basin. The abundance of the coccolithophore *Emiliana huxleyi* reached 9 $\times$ 10^6 cells l^{-1} in spring and summer. It was, however, noted in the former studies that the coccolithophores were also able to increase their abundance in winter (Krupatkina et al. 1991). Another discrepancy related to the phytoplankton community from the Kizilirmak River/Black Sea transition zone is the low abundance of a hypereutrophic water species from the genus *Skeletonema* which bloomed several times and caused massive fish kills due to the hypoxia in the northwestern Black Sea (Nesterova & Terenko 2007). The highest abundance of *Skeletonema* determined in the water samples was only 15 $\times$ 10^3 cells l^{-1} and this may be a result of allelopathic stress caused by the neritic toxic dinoflagellate *Prorocentrum cordatum*. Tameishi et al. (2009) made an abundance model between *Skeletonema* and *P. cordatum* and reported that *P.cordatum* allelopathically suppressed the abundance of *Skeletonema*. It was also reported that *P. cordatum* is able to form harmful toxic blooms in temperate or subtropical waters (Steidinger & Tangen 1997) and is gradually able to form dense blooms in eutrophic coastal waters (Heil et al. 2005).

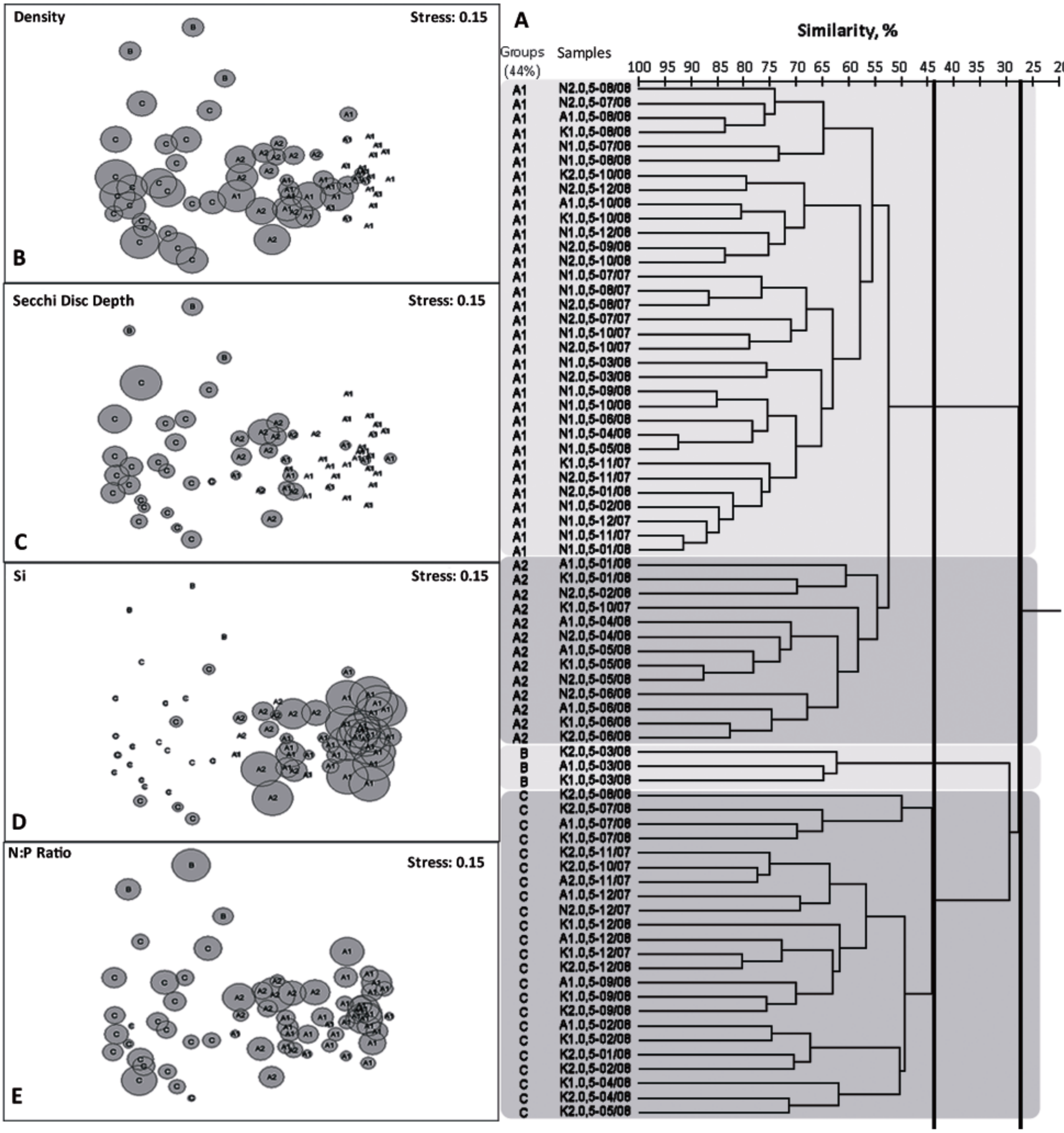

Figure 4

A) Hierarchical Clustering Dendrogram of the surface water phytoplankton abundance data, using the group average clustering based on Bray-Curtis similarities calculated from the squareroot transformed surface phytoplankton abundance data. Samples are divided into four groups at the 44% similarity level (solid line). B), C), D), E) Two-dimensional MDS configurations of the samples' groups at the similarity level of 44% with the circles representing Density, Secchi Disc Depth, Silica concentration and N:P ratio, respectively.

A total of 41 potentially harmful algal species were identified in the phytoplankton of the study area. Some of them were among succeeding species of the phytoplankton community. The abundance of harmful taxa in the study area becomes even more important in the context of the fact that only 300 taxa among the thousands of algal species form blooms able to change the color of seawater and 80 of them are toxic (Hallegraef 2004). It was noted that these events have recently increased worldwide due to anthropogenic eutrophication and the global climate change (Hallegraeff 2004). Some taxa may be harmful even when present in small numbers in the seawater. For instance; shellfish farms and fisheries activities must be closed in many parts of the world when the abundance of *Dinophysis* and *Phalachroma* spp. exceeds 500 cells l^{-1} in the seawater (European Commission 2002). In this study, the abundance of the potentially harmful *Dinophysis caudata* reached 5200 cells l^{-1} (July 2007) at the coastal sites (K1 and K2) at a depth of 10 meter. *Phalachroma rotundatum* reached 8000 cells l^{-1} at a depth of 5 and 10 meter at the open water site (A1) in September 2008. Not only brackish and marine harmful species, but also potentially toxic freshwater species were observed in the phytoplankton community of the Kizilirmak River/Black Sea transition zone. Among them, *Aphanizomenon flos-aquae*, *Microcystis aeruginosa*, *M. flos-aquae*, *Phormidium formosum*, *Planktothrix agardhii*, *Pseudanabaena catenata*, *Snowella lacustris* and *Trichormus variabilis* were found to be toxic in the community of polluted, eutrophic freshwaters (Cronberg et al. 2004).

This study provides new contributions to the algal flora of the Turkish Seas together with additional taxonomic and ecological investigations. A total of 71 new taxa and 41 potentially harmful taxa have been identified in this study for the first time. Taxonomic, physicochemical and statistical analyses have revealed that the predominance of heterotrophic and mixotrophic species instead of the autotrophic ones, as well as the increase in number of potentially HAB species and severe eutrophication contribute to an unstable system and pose a threat to the ecosystem and human health.

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