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PHYTOPLANKTON ASSEMBLAGES IN THE COASTAL ZONE OF THE GULF OF İSKENDERUN - NORTH EASTERN MEDITERRANEAN

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Abstract

In order to determine the phytoplankton species in the Gulf of İskenderun and the environmental factors that affect the distributions of the species, samples were collected horizontally with a plankton net at 9 stations in November 2005 and June 2006. As a result of the examination of the samples, 95 phytoplankton species belonging to 3 classes were identified. 12 species were new records for the Gulf of İskenderun, one (*Navicula transitans* Cleve, 1883) of them was a new report for all the Turkish seas. Dinoflagellates were the majority group of the species composition (53.7%), followed by diatoms (45.3%). Most of the species identified in this study consist of phytoplanktonic algae reported in the Eastern Mediterranean earlier. These species were neritic, oceanic, temperate and subtropic. In this study, 18 species defined as potentially harmful algal species and three of them were also toxic. Primary hydrographic conditions, such as temperature (20.2-28.7 ºC), salinity (31.0-39 ppt) and dissolved oxygen (7.21-8.60 mg l^{-1}), were recorded on each sampling occasion. In addition, a check-list of the phytoplankton species recorded up to this date was given and totally 269 species were recorded from the Gulf of İskenderun.

Introduction

The eastern part of the Mediterranean is one of the most oligotrophic area in the world in terms of nutrient concentrations and productivity (Azov, 1986; Krom *et al*., 1991) and the oligotrophy increases from the west to the east of the Mediterranean Sea (Ignatiades *et al.*, 2002). The coastal zone receives considerable amounts of freshwater, nutrients, dissolved and particulate organic matter, sediment and contaminants. It is a transition area between land and the open ocean (Gazeau, 2004). There are also limited upwelling areas and few rivers discharging nutrients to the Mediterranean (Dugdale & Wilkerson, 1988). The nutrient distribution and phytoplankton production in the eastern Mediterranean is principally determined by the durations and intensity of deep winter mixing, which provides transport of nutrients from deeper layer to the surface (Yılmaz & Tuğrul, 1998).

There are many local studies on phytoplankton communities, including information regarding their spatial and temporal variations along the eastern Mediterranean coastline (Lakkis & Lakkis, 1980; Azov, 1986; Aktan, 2011; Drira *et al*., 2010). Gulf of İskenderun an important area for fisheries is located in the northeast of the eastern Mediterranean. Primary production in the gulf is about 2-4 times higher than that in the north-eastern Mediterranean; average production is 115gC/m^2/year. The average depth is 70m and the depth of 1% light transmission ranges between 40-70m (Yılmaz *et al*., 1992). Especially, pollutants coming from highly populated cities, agricultural areas, industrial facilities and the inputs from the regional rivers are the main factors affecting the structure of the water column in the area (Polat *et al*., 2006). As oligotrophic areas are very sensitive to environmental variations, their monitoring is essential for the evaluation of the long-term changes in the community structure. Gulf of İskenderun, regularly sampled since 1972 (Gökalp, 1972), is especially interesting due to several studies conducted in this area which facilitates comparison. Detailed studies on phytoplankton and their ecological features were carried out in the Gulf of İskenderun (Polat *et al*., 2000, 2005, 2006; Polat & Işık, 2002; Polat & Piner, 2002; Polat, 2002, 2004, 2007a, 2007b, 2007c, 2008; Aka & Polat 2006; Polat & Koray 2007).

The aim of this study was to determine the composition of microphytoplankton species in this area and to report, if any, species that would be new for this region and existing harmful algal species (HAS). A list of phytoplankton species, of Gulf of İskenderun along with nomenclatural changes if any, is also provided.

Materials and Methods

This research was carried out in neritic waters of the Gulf of İskenderun in Nowember 2005 and June 2006. The samples were gathered from the subsurface using a 40cm diameter plankton net with a 55µm mesh size at 9 stations (Fig. 1). Material was fixed with neutral 4% formaldehyde solution and observed by using an Olympus CK2 inverted phase-contrast microscope equipped with a microphotosystem at a magnification of 400x. References used to identify the phytoplankton species can be found in previous work (Balkis, 2003, 2005). The recent revisions of phytoplankton species were presented according to MarBEF Data System-European of Marine Species (ERMS) (http://www.marbef.org/data/erms.php), Hasle & Syvertsen (1997) and Gomez (2005).

Water samples for physical and chemical analyses were collected using a 3 l Ruttner bottle with a thermometer. Temperature (°C), salinity (ppt) and dissolved oxygen (mg l^{-1}) were measured at each sampling point (Fig. 2). The Mohr-Knudsen method (Ivanoff, 1972) was used for measuring the salinity values, and the Winkler (1888) method was used for determining dissolved oxygen (DO).

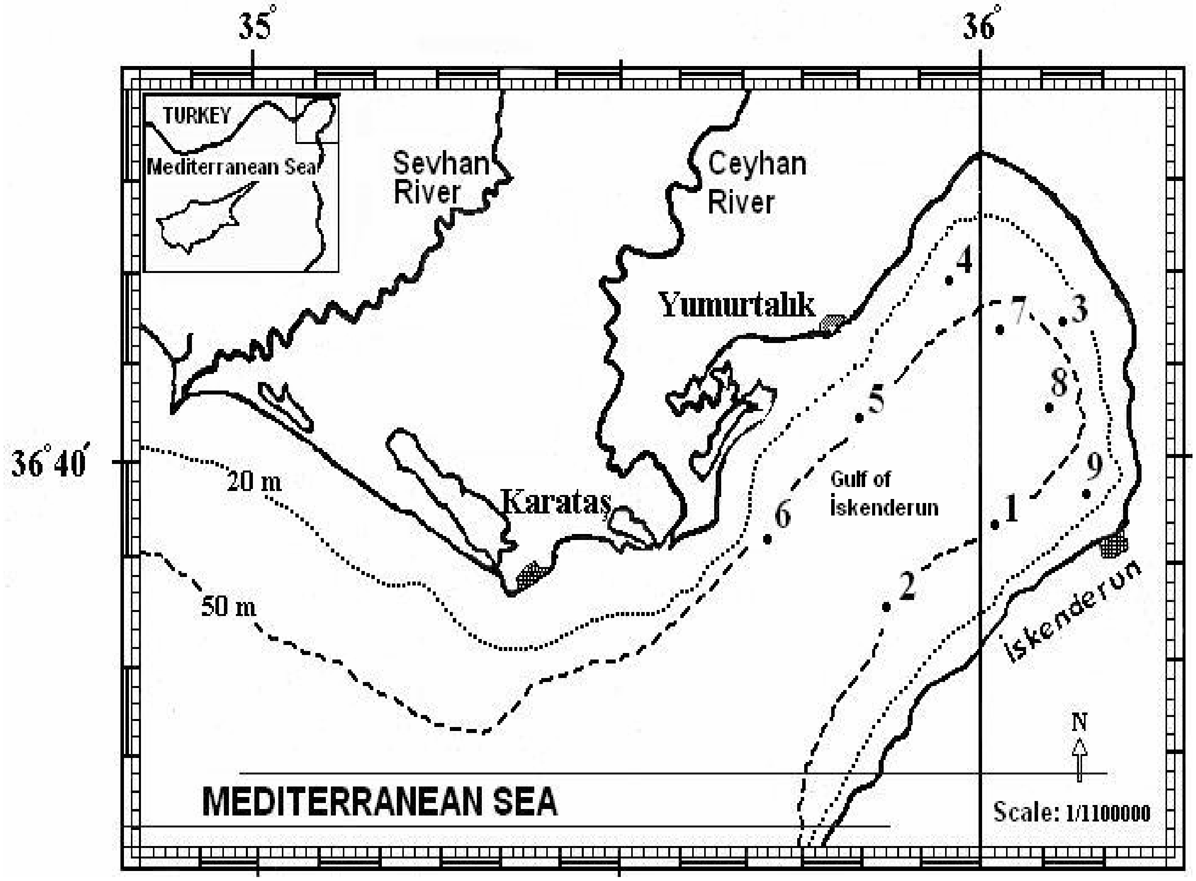

Fig. 1. Research stations in neritic waters of the Gulf of İskenderun.

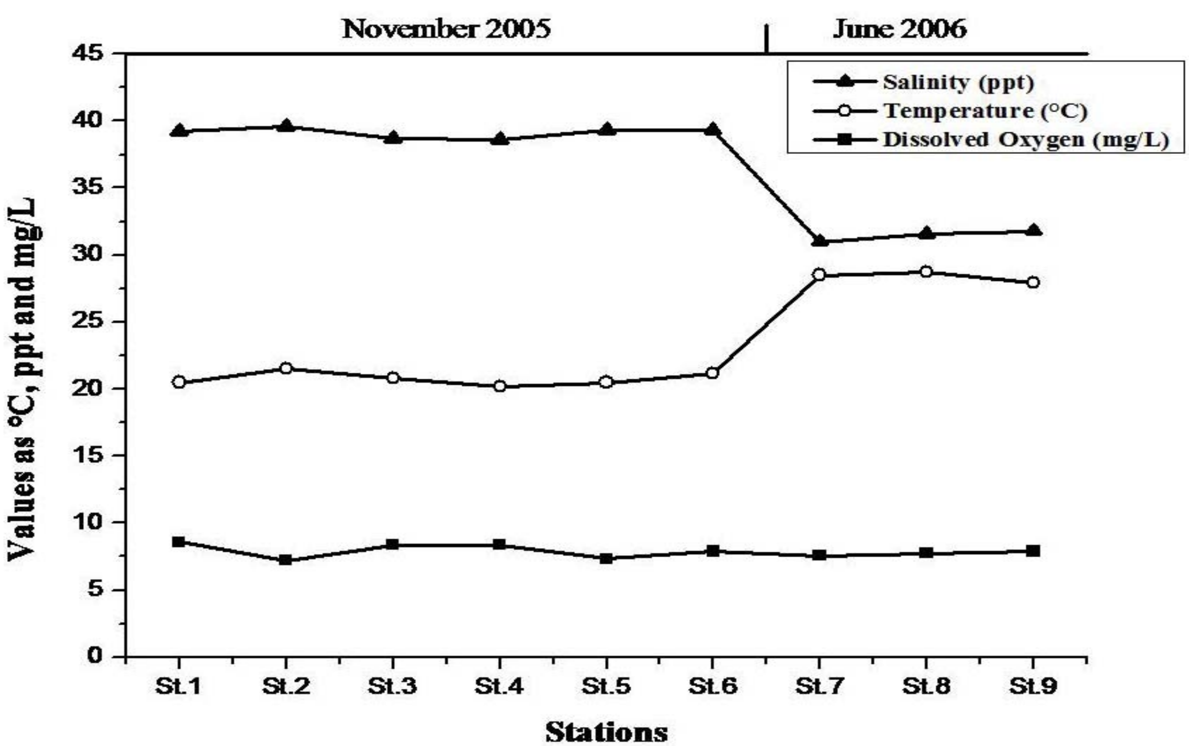

Fig. 2. Variations of temperature (°C), salinity (ppt) and dissolved oxygen (mg l^{-1}) at the research stations.

The occurrence of each species at the sampling stations were categorized into frequency groups as followed; V: very abundant (81-100%), A: abundant (61-80%), C: common (41-60%), R: rare (21-40%) and X: present sporadically (1-20%) (Fig. 3). The Sorensen similarity matrix (Sorensen, 1948) was performed in order to group the sampling stations according to the species involved (Fig. 4).

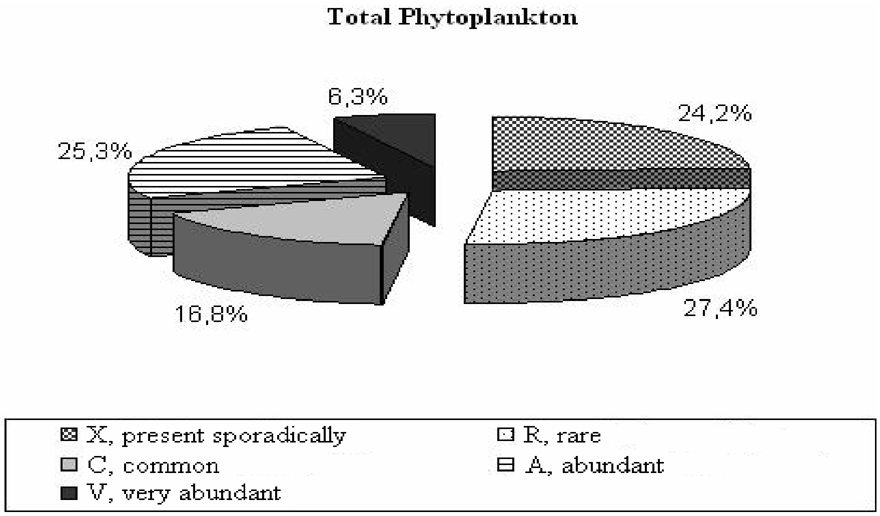

Fig. 3. Distribution of phytoplankton species according to frequency index.

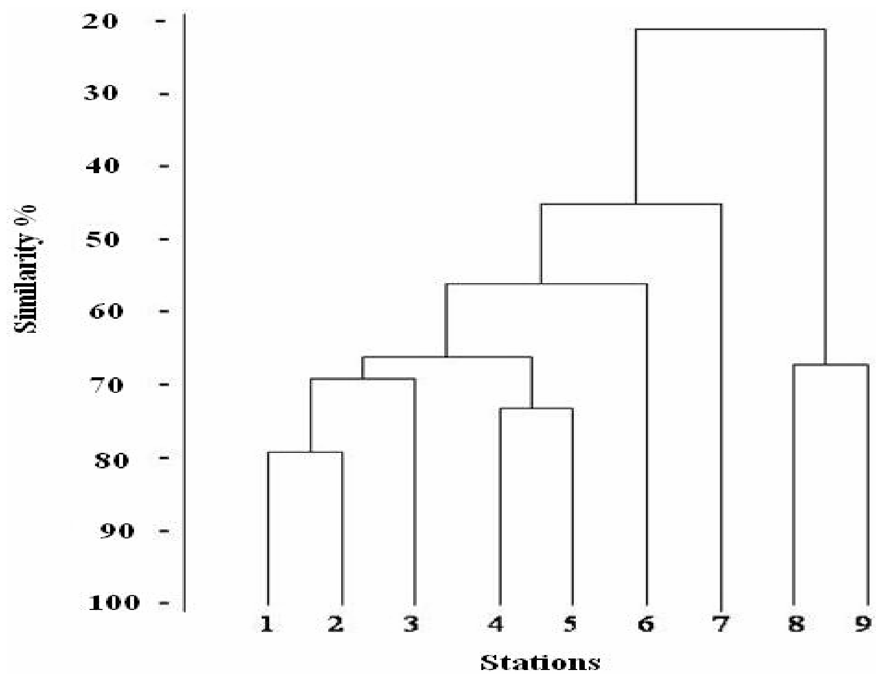

Fig. 4. Sorensen similarity dendogram of the sampling stations in neritic waters of the Gulf of İskenderun.

Results

From the analysis of phytoplankton community composition, 95 species of three different algal groups were identified: 51 dinoflagellates (53.7%), 43diatoms (45.3%) and 1 dictyochophyceans (1%) (Table 1). Of these, 1 species (*Navicula transitans* Cleve) was new to Turkish seas, and so were 11 species (*Dinophysis diegensis* Kofoid, *D. fortii* Pavillard, *Prorocentrum gracile* Schütt, *P. triestinum* Schiller from dinoflagellates, *Amphora ovalis* (Kützing) Kützing, *Dactyliosolen antarcticus* Castracene, *Diploneis bombus* (Ehrenberg) Cleve, *Nitzschia lorenziana* Grunow in Cleve & Grunow, *Petrodictyon gemma* (Ehrenberg) D.G. Mann, *Pseudo-nitzschia pseudodelicatissima* (Hasle) Hasle and *Thalassiothrix longissima* Cleve & Grunow from diatoms) to the Gulf of İskenderun. The most common genera were as follows: *Ceratium* Schrank (22 species), *Chaetoceros* Ehrenberg (9 species) and *Protoperidinium* Bergh (6 species).

Table 1. List and frequency distribution of phytoplanktonic taxa found during the study perion in the Gulf of İskenderun. V, very abundant (81-100%); A, abundant (61-80%); C, common (41-60%); R, rare (21-40%); X, present sporadically (1-20%).

Species	Stations									
	November 2005						June 2006			f
	1	2	3	4	5	6	7	8	9	(%)
Dinophyceae										
Amphisolenia bidentata			+			+				R
Ceratium arietinum			+						+	R
Ceratium candelabrum	+	+	+	+	+	+	+	+	+	V
Ceratium carriense	+		+			+				R
Ceratium concilians	+	+	+	+	+	+				A
Ceratium contortum	+	+	+			+				C
Ceratium contrarium	+	+	+	+	+	+				A
Ceratium declinatum	+	+	+			+				C
Ceratium euarcuatum	+	+	+	+						C
Ceratium extensum	+	+				+	+	+	+	A
Ceratium falcatum	+			+						R
Ceratium furca	+	+		+	+		+	+	+	A
Ceratium fusus	+	+		+			+	+	+	A
Ceratium hexacanthum		+				+				R
Ceratium horridum	+	+	+	+	+	+				A
Ceratium kofoidii	+	+	+	+	+	+	+			A
Ceratium macroceros	+	+	+	+	+					C
Ceratium pentagonum				+		+				R
Ceratium ranipes		+								X
Ceratium symmetricum		+		+	+	+				C
Ceratium teres	+	+	+	+		+				C
Ceratium trichoceros	+	+	+	+	+	+				A
Ceratium tripos	+	+	+	+	+	+		+	+	V
Ceratocorys horrida	+		+			+	+	+	+	A
Dinophysis caudata	+	+			+	+	+	+	+	A
Dinophysis diegensis							+			X
Dinophysis fortii									+	X
Dinophysis hastata		+								X
Dinophysis ovum	+	+	+		+			+	+	A
Diplopsalis lenticula								+	+	R
Goniodoma polyedricum	+	+	+	+	+	+	+	+		V
Gonyaulax polygramma									+	X
Ornithocercus heteroporus						+				X
Ornithocercus magnificus	+	+	+	+	+	+				A
Ornithocercus quadratus		+								X
Ornithocercus steinii	+	+	+			+			+	C
Phalacroma doryphorum	+		+	+						R
Phalacroma rapa			+				+	+		R
Podolampas bipes	+	+	+		+					C
Prorocentrum gracile	+						+			R
Prorocentrum triestinum								+		X
Protoperidinium conicum			+							X
Protoperidinium divergens								+	+	R
Protoperidinium globulus								+	+	R
Protoperidinium mediterraneum	+									X
Protoperidinium oceanicum			+							X
Protoperidinium steinii	+							+	+	R

Table 1. (Contd.)

Species	Stations									
	November 2005						June 2006			f
	1	2	3	4	5	6	7	8	9	(%)
Pyrophacus horologium			+				+			R
Pyrocystis elegans			+							X
Pyrocystis hamulus		+				+				R
Spiraulax Jolliffei						+				X
Dictyochophyceae										
Dictyocha fibula	+		+	+	+	+				C
Bacillariophyceae										
Amphora ovalis			+							X
Asterolampra marylandica	+	+				+				R
Bacillaria paxillifera	+									X
Bacteriastrum delicatulum	+	+	+	+	+	+	+		+	V
Bacteriastrum elegans	+	+	+	+	+	+				A
Cerataulina pelagica	+	+			+					R
Chaetoceros affinis	+	+	+	+						C
Chaetoceros dadayi	+	+	+							R
Chaetoceros danicus	+	+	+	+	+		+			A
Chaetoceros decipiens	+	+	+	+	+	+			+	A
Chaetoceros didymus	+	+	+	+	+					C
Chaetoceros diversus	+	+							+	R
Chaetoceros lorenzianus	+	+	+	+	+	+	+			A
Chaetoceros peruvianus	+	+	+	+	+					C
Chaetoceros rostratus	+	+		+	+		+	+		A
Coscinodiscus radiatus							+		+	R
Cylindrotheca closterium		+	+		+		+			C
Dactyliosolen antarcticus	+	+	+		+		+			C
Dactyliosolen mediterraneus				+			+			R
Diploneis bombus			+							X
Eucamphia zodiacus	+									X
Guinardia striata	+	+	+	+	+	+	+			A
Hemiaulus hauckii	+	+	+	+	+	+	+			A
Leptocylindrus minimus	+	+	+	+	+	+	+			A
Lithodesmium undulatum				+						X
Navicula transitans					+	+	+			R
Nitzschia longissima	+		+				+			R
Nitzschia lorenziana			+							X
Nitzschia sigma						+				X
Odontella aurita	+									X
Odontella mobiliensis				+						X
Petrodictyon gemma		+							+	R
Pleurosigma normanii	+		+	+	+	+		+		A
Proboscia alata	+	+	+		+	+	+	+	+	V
Pseudo-nitzschia pseudodelicatissima	+		+	+			+			C
Pseudosolenia calcar-avis	+	+	+	+	+	+				A
Rhabdonema adriaticum			+							X
Rhizosolenia imbricata	+	+	+	+	+	+				A
Rhizosolenia styliformis	+	+	+	+						C
Striatella unipunctata	+		+		+					R
Thalassionema frauenfeldii	+	+	+	+	+	+	+			A
Thalassionema nitzschioides	+	+	+	+	+	+	+	+	+	V
Thalassiothrix longissima					+	+	+			R

Of the 95 species that belong to the classes Dinophyceae, Dictyochophyceae and Bacillariophyceae, the number of present sporadically species is 23 (24.2%), rare species is 26 (27.4%), common species is 16 (16.8%), abundant species is 24 (25.3%) and very abundant species is 6 (6.3%) (Fig. 3). Of the very abundant species, the frequency for the species *Ceratium candelabrum* and *Thallasionema nitzschioides* is 100%.

When the dendogram was analysed the similarity between the stations in terms of identified species was produced (Fig. 4) using Sorensen's (1948) similarity formula and 8 of the stations showed 50% and more similarity. Among these stations, the similarity between stations 1 and 2 is 79%, stations 4 and 5 is 73%, and stations 8 and 9 is 67%. It was also found that especially the stations that belong to the same sampling period are grouped noticeably among each other.

In the present study, it was determined that out of 95 species 18 are potentially harmful phytoplankton species, and the diet and dangerous effects of these species were shown in Table 2. While three of these species (*Dinophysis caudata, D. fortii, Pseudo-nitzschia pseudodelicatissima*) are toxin-producing species at the sime time, It was seen that the highest number of HAB species belong to diatoms.

Table 2. Potentially harmful species (HAS) observed in the coastal zone of the Gulf of İskenderun during the sampling dates which have had harmful impacts indicated elsewhere.

Species	Trophic state	Harmful
Dinophyceae		
Ceratium furca	Mixo	Bloom-forming, fish-killing, anoxia
Ceratium fusus	Mixo	Fish-killing
Dinophysis caudata	Auto	Bloom-forming, DSP toxin, ichthyotoxins
D. fortii	Auto	Bloom-forming, DSP toxin
Gonyaulax polygramma	Auto	Fish and shellfish kills due to anoxia after red tide
Prorocentrum triestinum	Auto	Bloom-forming, fish-killing
Pyrophacus steinii	Auto	Bloom-forming
Dictyochophyceae		
Dictyocha fibula	Auto	Fish-killing
Bacillariophyceae		
Bacillaria paxillifera	Auto	Bloom-forming
Cerataulina pelagica	Auto	Bloom-forming
Chaetoceros didymus	Auto	Bloom-forming
Cylindrotheca closterium	Auto	Bloom-forming
Eucamphia zodiacus	Auto	Bloom-forming
Nitschia longissima	Auto	Bloom-forming
Odontella aurita	Auto	Bloom-forming
Proboscia alata	Auto	Bloom-forming
Pseodo-nitzschia pseudodelicatissima	Auto	ASP toxin
Thalassionema nitzschioides	Auto	Bloom-forming

Trophic state (auto-, hetero- or mixotrophic), DSP: diarrhetic shellfish poisoning, ASP: amnesic shellfish poisoning. The effects of HAS were summarized according to Hallegraeff (1993), Faust and Gulledge (2002), Lu and Hodgkiss (2004), and Vila and Masó (2005).

The list of phytoplankton species recorded up to this date were given in Table 3 and a total of 269 microalgae, 11 of them were identified at the generic level: 1 Cyanophyceae, 148 Dinophyceae, 2 Dictyochophyceae, 115 Bacillariophyceae, 1 Prasinophyceae and 2 Prymnesiophyceae (Table 3). Dinoflagellates represented the majority of the population (55%), followed by diatoms (42.8%). The genera *Ceratium* (40 species), *Chaetoceros* (28 species) and *Protoperidinium* (27 species) were dominant in terms of diversity.

Discussion

So far, a total of 269 taxa have been identified from the Gulf of İskenderun. Gökalp (1972) reported 23 species, Polat *et al*., (2000) 153 species, Polat & Işık (2002) 129 species, Polat & Piner (2002) 90 species, Polat (2004) 1 species, Polat *et al*., (2005) 11 species, Aka & Polat (2006) 71 species, Polat *et al.,* (2006) 36 species, Polat (2007a) 1 species, Polat (2007b) 6 species, Polat (2007c) 160 species, Polat & Koray (2007) 140 species, Polat (2008) 30 species and in the present resarch 95 species.

Table 3. List of phytoplanktonic taxa recorded up to this date in neritic waters of the Gulf of İskenderun.

Species	Gökalp (1972)	Polat *et al.*, (2000)	Polat & Işık (2002)	Polat & Piner (2002)	Polat (2004)	Polat *et al.*, (2005)	Aka & Polat (2006)	Polat *et al.*, (2006)	Polat (2007a)	Polat (2007b)	Polat (2007c)	Polat & Koray (2007)	Polat (2008)	This research
Cyanophyceae														
Oscillatoria sp.		+	+					+			+			
Dinophyceae														
Akashiwo sanguinea (Hirasaka) G. Hansen & Moestrup								+			+	+		
Amphisolenia bidentata Schröder		+	+								+	+		+
Amphisolenia palaeotheroides Kofoid												+		
Amphisolenia truncata Kofoid & Michener		+										+		
Centrodinium pavillardii F.J.R. Taylor												+		
Ceratium arietinum Cleve		+	+	+							+	+		+
Ceratium azoricum Cleve												+		
Ceratium belone Cleve												+		
Ceratium breve (Ostenfeld & Schmidt) Schröder		+									+	+		
Ceratium candelabrum (Ehrenberg) Stein		+	+	+							+	+	+	+
Ceratium carriense Gourret	+	+	+								+	+		+
Ceratium concilians Jørgensen	+	+	+								+	+		+
Ceratium contortum (Gourret) Cleve		+	+								+	+	+	+
Ceratium contrarium (Gourret) Pavillard	+	+										+		+
Ceratium declinatum (Karsten) Jørgensen		+	+								+	+		+
Ceratium digitatum Schütt												+		
Ceratium euarcuatum Jørgensen		+	+								+	+		+
Ceratium extensum (Gourret) Cleve		+	+	+		+					+	+		+
Ceratium falcatum (Kofoid) Jørgensen	+											+		+
Ceratium furca (Ehrenberg) Clapparède & Lachmann		+	+	+				+			+	+	+	+
Ceratium fusus (Ehrenberg) Dujardin	+	+	+	+				+			+	+	+	+
Ceratium gibberum Gourret		+									+	+		
Ceratium gravidum Gourret												+		
Ceratium hexacanthum Gourret	+	+	+	+							+	+		+
Ceratium horridum (Cleve) Gran		+	+	+							+	+	+	+
Ceratium incisum (Karsten) Jørgensen												+		
Ceratium inflatum (Kofoid) Jørgensen	+	+	+	+							+	+		
Ceratium karstenii Pavillard	+													
Ceratium kofoidii Jørgensen		+	+	+		+				+	+	+	+	+
Ceratium limulus Gourret		+									+	+		
Ceratium lineatum (Ehrenberg) Cleve												+		
Ceratium longirostrum Gourret	+	+	+									+		
Ceratium longissimum (Schröder) Kofoid											+	+		
Ceratium macroceros (Ehrenberg) Vanhöffen	+	+	+	+							+	+		+
Ceratium massiliense (Gourret) Jørgensen	+	+	+	+							+	+	+	
Ceratium paradoxides Cleve											+	+		
Ceratium pavillardii Jørgensen	+													
Ceratium pentagonum Gourret		+	+								+	+		+
Ceratium platycorne Daday												+		
Ceratium ranipes Cleve		+	+								+	+		+
Ceratium schroeteri Schröder												+		
Ceratium symmetricum Pavillard		+	+								+	+	+	+
Ceratium teres Kofoid		+	+	+							+	+		+
Ceratium trichoceros (Ehrenberg) Kofoid	+	+	+	+		+					+	+	+	+
Ceratium tripos (O.F. Müller) Nitzsch		+	+	+							+	+		+
Ceratocorys armata (Schütt) Kofoid		+										+		
Ceratocorys gourreti Paulsen		+	+								+	+		
Ceratocorys horrida Stein	+	+	+	+							+	+		+
Citharistes regius Stein					+							+		
Cladopyxis caryophyllum (Kofoid) Pavillard											+	+		

Table 3. (Contd.).

Species	Gökalp (1972)	Polat *et al*., (2000)	Polat & Işık (2002)	Polat & Piner (2002)	Polat (2004)	Polat *et al*., (2005)	Aka & Polat (2006)	Polat *et al*., (2006)	Polat (2007a)	Polat (2007b)	Polat (2007c)	Polat & Koray (2007)	Polat (2008)	This research
Dinophysis amandula (Balech) Sournia												+		
Dinophysis caudata Saville-Kent		+	+	+				+			+	+		+
Dinophysis diegensis Kofoid														+
Dinophysis doryphorum (Stein) Abé		+									+	+		+
Dinophysis fava (Kofoid & Michener) Abé											+	+		
Dinophysis fortii Pavillard														+
Dinophysis hastata Stein		+									+	+		+
Dinophysis mitra (Schütt) Abé		+		+							+	+		
Dinophysis odiosa (Pavillard) Tai & Skogsberg			+									+		
Dinophysis ovum Schütt												+		+
Dinophysis parvula (Schütt) Balech			+									+		
Dinophysis rapa (Stein) Balech											+	+		+
Dinophysis recurva Kofoid & Skogsberg			+									+		
Dinophysis rotundata Claparède & Lachmann				+				+			+	+		
Dinophysis schuettii Murray & Whitting											+	+		
Dinophysis sphaerica Stein												+		
Dinophysis tripos Gourret								+				+		
Diplopsalis lenticula Bergh		+	+								+	+		+
Diplopsalopsis bomba (Stein) Dodge & Toriumi											+	+		
Goniodoma acuminatum (Ehrenberg) Stein											+	+	+	
Goniodoma polyedricum (Pouchet) Jørgensen		+	+	+										+
Goniodoma sphaericum Murray & Whitting		+										+		
Gonyaulax birostris Stein		+										+		
Gonyaulax diegensis Kofoid		+	+									+		
Gonyaulax digitalis (Pouchet) Kofoid												+		
Gonyaulax monacantha Pavillard		+										+		
Gonyaulax pacifica Kofoid									+			+		
Gonyaulax polygramma Stein		+	+	+				+			+	+		+
Gonyaulax spinifera (Claparède & Lachmann) Diesing		+	+	+				+			+	+		
Gonyaulax turbynei Murray & Whitting		+						+				+		
Gyrodinium fusus (Meunier) Akselman												+		
Gyrodinium lachryma (Meunier) Kofoid & Swezy												+		
Heterodinium milneri (Murray & Whitting) Kofoid												+		
Histioneis elongata Kofoid & Michener												+		
Histioneis oxypteris Schiller												+		
Kofoidinium velelloides Pavillard		+	+	+							+	+	+	
Lingulodinium polyedra (Stein) Dodge		+	+					+			+	+		
Noctiluca scintillans (Macartney) Kofoid								+			+	+		
Ornithocercus francescae (Murray) Balech												+		
Ornithocercus heteroporus Kofoid											+	+		+
Ornithocercus magnificus Stein			+	+							+	+		+
Ornithocercus quadratus Schütt		+	+								+	+		+
Ornithocercus splendidus Schütt												+		
Ornithocercus steinii Schütt												+		+
Ornithocercus thumii (Schmidt) Kofoid & Skogsberg												+		
Oxytoxum compressum Kofoid												+		
Oxytoxum constrictum (Stein) Bütschli												+		
Oxytoxum milneri Murray & Whitting												+		
Oxytoxum reticulatum (Stein) Schütt				+								+		
Oxytoxum sceptrum (Stein) Schröder												+		
Oxytoxum scolopax Stein		+	+	+							+	+		
Phalacroma argus Stein											+	+		
Phalacroma minutum Cleve												+		

Table 3. (Contd.).

Species	Gökalp (1972)	Polat *et al.*, (2000)	Polat & Işık (2002)	Polat & Piner (2002)	Polat (2004)	Polat *et al.*, (2005)	Aka & Polat (2006)	Polat *et al.*, (2006)	Polat (2007a)	Polat (2007b)	Polat (2007c)	Polat & Koray (2007)	Polat (2008)	This research
Podolampas bipes Stein		+	+	+							+	+		+
Podolampas elegans Schütt												+		
Podolampas palmipes Stein											+	+		
Podolampas spinifera Okamura		+	+	+							+	+		
Prorocentrum compressum (Bailey) Abé *ex* Dodge		+	+					+			+	+	+	
Prorocentrum gracile Schütt														+
Prorocentrum micans Ehrenberg		+	+	+		+		+			+	+	+	
Prorocentrum triestinum Schiller														+
Protoceratium areolatum Kofoid												+		
Protoperidinium brochii (Kofoid & Swezy) Balech		+	+								+	+		
Protoperidinium claudicans (Paulsen) Balech		+									+	+		
Protoperidinium conicoides (Paulsen) Balech												+		
Protoperidinium conicum (Gran) Balech		+	+	+						+	+	+		+
Protoperidinium crassipes (Kofoid) Balech											+	+		
Protoperidinium depressum (Bailey) Balech		+	+	+				+			+	+	+	
Protoperidinium diabolus (Cleve) Balech											+	+		
Protoperidinium divergens (Ehrenberg) Balech		+	+	+							+	+	+	+
Protoperidinium globulus (Stein) Balech		+	+	+							+	+		+
Protoperidinium grande (Kofoid) Balech		+										+		
Protoperidinium granii (Ostenfeld) Balech											+	+		
Protoperidinium leonis (Pavillard) Balech		+										+		
Protoperidinium mediterraneum (Kofoid) Balech		+	+	+							+	+		+
Protoperidinium mite (Pavillard) Balech												+		
Protoperidinium oblongum (Aurivillius) Parke & Dodge												+		
Protoperidinium oceanicum (Vanhöffen) Balech		+	+	+								+		+
Protoperidinium oviforme (P. Dangeard) Balech												+		
Protoperidinium ovum (Schiller) Balech											+	+	+	
Protoperidinium pallidum (Ostenfeld) Balech		+									+	+		
Protoperidinium pedunculatum (Schütt) Balech		+	+	+								+		
Protoperidinium pellucidum Bergh			+	+				+			+	+		
Protoperidinium pentagonum (Gran) Balech												+		
Protoperidinium punctulatum (Paulsen) Balech												+		
Protoperidinium pyriforme (Paulsen) Balech		+	+								+	+		
Protoperidinium quarnerense (Schröder) Balech		+	+								+	+		
Protoperidinium steinii (Jørgensen) Balech		+	+	+		+					+	+	+	+
Protoperidinium subinerme (Paulsen) Loeblich III			+								+	+		
Pyrocystis elegans Pavillard												+		+
Pyrocystis fusiformis (Wyville Thomson *ex* Haeckel) Blackman		+										+		
Pyrocystis hamulus Cleve												+		+
Pyrocystis noctiluca J. Murray *ex* Haeckel	+													
Pyrocystis robusta Kofoid												+		
Pyrophacus horologium Stein		+										+		+
Pyrophacus steinii (Schiller) Wall & Dale		+	+	+				+			+	+		
Scripsiella trochoidea (Stein) Loeblich III			+	+		+		+		+	+	+	+	
Spiraulax jolliffei (Murray & Whitting) Kofoid		+	+								+	+		+
Dictyochophyceae														
Dictyocha fibula Ehrenberg		+	+	+				+			+			+
Dictyocha speculum Ehrenberg				+										
Bacillariophyceae														
Amphiprora gigantea Grunow		+					+				+			
Amphiprora sp.			+	+										
Amphora ovalis (Kützing) Kützing														+
Asterionellopsis glacialis (Castracane) Round		+	+	+			+	+			+			

Table 3. (Contd.).

Species	Gökalp (1972)	Polat *et al.*, (2000)	Polat & Işık (2002)	Polat & Piner (2002)	Polat (2004)	Polat *et al.*, (2005)	Aka & Polat (2006)	Polat *et al.*, (2006)	Polat (2007a)	Polat (2007b)	Polat (2007c)	Polat & Koray (2007)	Polat (2008)	This research
Asterolampra grevillei (Wallich) Greville		+	+								+			
Asterolampra marylandica Ehrenberg		+	+				+				+			+
Asteromphalus flabellatus (Brébisson) Greville		+	+								+			
Asteromphalus heptactis (Bréebisson) Ralf in Pritchard			+								+			
Asteromphalus hookeri Ehrenberg							+							
Bacillaria paxillifera (O.F.Müller) Hendey		+	+	+			+	+			+			+
Bacteriastrum delicatulum Cleve		+	+	+			+				+			+
Bacteriastrum elegans Pavillard											+			+
Bacteriastrum hyalinum Lauder		+	+				+				+			
Biddulphia pulchella Gray			+											
Campylodiscus sp.		+	+								+			
Cerataulina pelagica (Cleve) Hendey		+	+	+			+	+		+	+		+	+
Chaetoceros affinis Lauder	+	+	+	+			+				+		+	+
Chaetoceros anastomosans Grunow		+					+				+			
Chaetoceros atlanticus Cleve		+	+	+			+	+			+		+	
Chaetoceros brevis Schütt							+							
Chaetoceros coarctatus Lauder		+												
Chaetoceros compressus Lauder		+	+	+			+				+			
Chaetoceros constrictus Gran		+					+				+			
Chaetoceros costatus Pavillard		+	+				+				+			
Chaetoceros curvisetus Cleve		+	+	+							+			
Chaetoceros dadayi Pavillard			+	+			+				+			+
Chaetoceros danicus Cleve		+					+							+
Chaetoceros debilis Cleve		+												
Chaetoceros decipiens Cleve		+	+	+			+				+		+	+
Chaetoceros didymus Ehrenberg		+	+	+			+	+			+			+
Chaetoceros diversus Cleve		+	+				+				+			+
Chaetoceros eibenii Grunow in Van Heurck							+				+			
Chaetoceros holsaticus Schütt							+							
Chaetoceros laciniosus Schütt		+	+	+			+				+			
Chaetoceros lorenzianus Grunow		+	+	+			+				+			+
Chaetoceros messanensis Castracane		+												
Chaetoceros neogracilis VanLand		+												
Chaetoceros peruvianus Brightwell		+	+	+			+				+			+
Chaetoceros pseudocurvisetus Mangin		+	+				+	+			+			
Chaetoceros rostratus Lauder		+												+
Chaetoceros teres Cleve											+			
Chaetoceros tetrastichon Cleve		+	+	+			+				+		+	
Chaetoceros tortissimus Gran		+	+				+				+			
Chaetoceros wighamii Brightwell							+							
Climacosphaenia moniligera Ehrenberg		+	+	+			+				+			
Coscinodiscus centralis Ehrenberg											+			
Coscinodiscus perforatus Ehrenberg		+	+				+							
Coscinodiscus radiatus Ehrenberg		+	+				+				+			+
Cylindrotheca closterium (Ehrenberg) Reimann &Lewin		+	+	+			+	+			+			+
Cymbella sp.							+							
Dactyliosolen antarcticus Castracane														+
Dactyliosolen fragilissimus (Bergon) Hasle		+		+			+							
Diploneis bombus (Ehrenberg) Ehrenberg ex Cleve														+
Ditylum brightwellii (T.West) Grunow in Van Heurck		+									+			
Eucampia zoodiacus Ehrenberg		+	+	+			+	+			+			+
Fragilaria sp.							+							
Grammatophora marina (Lyngbye) Kützing							+				+			
Grammatophora sp.		+												
Guinardia delicatula (Cleve) Hasle							+							
Guinardia flaccida (Castracane) H.Peragallo		+	+	+		+	+	+			+		+	
Guinardia striata (Stoltherfoth) Hasle		+	+	+		+	+				+		+	+

Table 3. (Contd.).

Species	Gökalp (1972)	Polat *et al.*, (2000)	Polat & Işık (2002)	Polat & Piner (2002)	Polat (2004)	Polat *et al.*, (2005)	Aka & Polat (2006)	Polat *et al.*, (2006)	Polat (2007a)	Polat (2007b)	Polat (2007c)	Polat & Koray (2007)	Polat (2008)	This research
Gyrosigma balticum (Ehrenberg) Rabenhorst		+	+				+				+			
Gyrosigma spencerii (Quekett) Griffith & Henfrey		+												
Gyrosigma tenuissimum (W. Smith) Griffith & Henfrey		+					+							
Helicotheca tamesis (Shrubsole) Ricard		+									+			
Hemiaulus hauckii Grunow in Van Heurck		+	+	+		+	+				+		+	+
Hemiaulus membranaceus Cleve		+	+	+			+				+			
Hemiaulus sinensis Greville			+				+				+			
Lauderia annulata Gran		+					+							
Leptocylindrus danicus Cleve		+	+	+			+	+			+			
Leptocylindrus mediterraneus (H. Peragallo) Hasle		+	+								+			+
Leptocylindrus minimus Gran		+	+	+			+				+			+
Licmophora abbreviata Agardh		+	+	+							+			
Lithodesmium undulatum Ehrenberg		+	+				+				+			+
Melosira monoliformis (Müller) Agardh							+				+			
Navicula transitans Cleve														+
Navicula sp.		+	+	+			+				+			
Nitzschia longissima (Brébisson in Kützing) Ralfs in Pritchard	+	+	+	+			+				+			+
Nitzschia lorenziana Grunow in Cleve & Grunow														+
Nitzschia sigma (Kützing) W. Smith		+	+								+			+
Nitzschia sigmoidea (Nitzsch) W. Smith							+							
Odontella aurita (Lyngbye) Agardh							+	+			+			+
Odontella mobiliensis (J.W. Bailey) Grunow		+	+	+			+				+			+
Paralia sulcata (Ehrenberg) Cleve		+		+							+			
Petrodictyon gemma (Ehrenberg) D.G. Mann														+
Pleurosigma elongatum W. Smith		+	+	+			+				+			
Pleurosigma normanii Ralfs in Pritchard		+	+	+			+				+			+
Podocystis perrinensis Ricard				+							+			
Podocystis sp.		+												
Proboscia alata (Brightwell) Sundström		+	+	+		+	+	+		+	+		+	+
Pseudo-nitzschia delicatissima (Cleve) Heiden			+				+				+			
Pseudo-nitzschia pseudodelicatissima (Hasle) Hasle														+
Pseudo-nitzschia pungens (Grunow ex Cleve) Hasle		+	+	+			+	+			+			
Pseudosolenia calcar-avis (Schultze) Sundström	+	+	+	+			+				+		+	+
Rhabdonema adriaticum Kützing		+		+			+				+			+
Rhizosolenia castracanei H. Peragallo	+	+												
Rhizosolenia habetata (Bail) Gran	+							+			+			
Rhizosolenia imbricata Brightwell	+	+	+	+			+				+			+
Rhizosolenia robusta Norman in Pritchard		+	+	+			+				+			
Rhizosolenia setigera Brightwell		+	+				+	+			+			
Rhizosolenia styliformis Brightwell		+	+	+			+				+			+
Skeletonema costatum (Greville) Cleve		+									+			
Stephanopyxis sp.			+											
Striatella unipunctata (Lyngbye) Agardh		+	+				+				+			+
Surirella fastuosa (Ehrenberg) Kützing		+	+								+			
Surirella sp.				+										
Synedra ulna (Nitzsch) Ehrenberg		+	+	+			+				+			
Thalassionema frauenfeldii (Grunow) Hallegraeff	+	+	+	+		+	+			+	+		+	+
Thalassionema nitzschioides (Grunow) Van Heurck	+	+	+	+				+			+			+
Thalassiophysa hyalina (Greville) Paddock & Sims			+											
Thalassiosira nordenskioeldii Cleve								+						
Thalassiothrix longissima Cleve & Grunow														+
Thalassiothrix mediterranea Pavillard		+	+	+			+				+		+	
Toxarium undulatum Bailey			+	+							+			
Triceratium sp.			+											
Prasinophyceae														
Halosphaera viridis Schmitz		+												
Prymnesiophyceae														
Anaplosolenia brasiliensis (Lohmann) Deflandre				+							+			
Scyphosphaera apsteinii Lohmann				+							+			

Dinoflagellates (with 148 taxa) and diatoms (with 115 taxa) were dominant in terms of diversity. According to the records of adjacent regions, in northwestern Mediterranean, diatoms and dinoflagellate species represented, respectively, 51% and 36% of the total phytoplankton species (Velasquez & Cruzado, 1995). In the northeastern Mediterranean coast of Turkey, diatoms represented 57.4% and dinoflagellates 37.2% (Polat & Piner, 2002). In the Aegean Sea, diatoms and dinoflagellate species were represented by 45.8% and 41.2% (Koray, 1994). In this research, our data showed that diatoms and dinoflagellate species were represented by 43% and 55% respectively of the total species composition of microphytoplankton. In previous studies, similar results were reported such as 43% of diatoms and 52% of dinoflagellates in Villefranche Bay in northwestern Mediterranean (Gomez & Gorsky, 2003), 31% of diatoms and 48% of dinoflagellates in the Gulf of Genoa (Bernhard & Rampi, 1967), 40% of diatoms and 52% of dinoflagellates in the Sea of Marmara (Balkis, 2003) and 47% of diatoms and 50% of dinoflagellates in the coastal zone of Bozcaada Island (Balkis, 2009). The oligotrophic conditions result in a high diversity of dinoflagellates in the Mediterranean (Gomez, 2003). It was reported that water temperature in the Mediterranean has increased due to global warming and local influences (Turley, 1999) and that increase might have resulted in alterations in the marine biodiversity (Gomez & Claustre, 2003).

In terms of the qualitative distribution of phytoplankton, it can be said that most of the species listed in the present study consisted of phytoplanktonic algae reported in the different regions of the Mediterranean earlier. Most of the species in this Gulf were neritic, oceanic, temperate and subtropic species. In fact, marine species (*P. alata, T. nitzschioides and C. fusus*), brackish species (*C. closterium*) and some benthic species (*P. normanii* and *N. transitans*) which have adapted to plankton life were observed.

The most common genus from Dinophyceae was *Ceratium* with 40 species. Graham (1941) stated that the geographical distribution of *Ceratium* species were especially affected by temperature. During the sampling period of the present study, members of the *Ceratium* genus, *C. candelabrum* was observed at all stations (f=%100) and *C. tripos* was observed at eight stations (f=%89). According to Polat (1997), these species were not affected significantly by temperature changes during a year while Koray & Gökpınar (1983) categorized these species as species that live in habitats with a temperature between 12 and 26ºC. In this study, it was determined that the *Ceratium* species lived in habitats with a temperature between 20.2 and 28.7ºC. The temperature range in the present study is narrower than those of previous studies since the sampling was performed only in two seasons (November 2005, June 2006).

Pseudosolenia calcar-avis and *Hemiaulus hauckii* are distinctive species of oligotrophic waters that are poor of nutrients (Kimor, 1985). These species were encountered during both sampling periods. According to the study conducted in the gulf, *Pseudosolenia calcar-avis* do not reproduce excessively during any of the sampling periods and *Hemiaulus hauckii* continue to maintain its existence in water environment also during the periods following the spring diatom increases (Polat, 1997).

It was reported that the phytoplankton species recorded in world seas, nearly 300 of them caused coloration on the surface of the seas by reproducing excessively and nearly 60 to 80 species negatively affected human health by producing toxins (Hallegraeff, 1993; Van Dolah, 2000). Since these species damage the coastal ecosystems of many countries and are called "Harmful Algal Bloom Species (HABs)" in the international literature. The frequency of harmful algal blooms, which are defined as the local, sudden and excessive growth of one or a small number of phytoplankton species in seas, has increased in recent years. This is generally caused by such factors as the increase of nutrient input into seas due to domestic, agricultural and industrial activities and seasonal changes. As a result of this event, which called "Harmful Algal Bloom", mass deaths are seen in the fauna, fishing and tourism are negatively affected, and the quality of water changes (Hallegraeff, 1993; Vila & Masó, 2005). Dinoflagellates and diatoms are the two most important groups that produce toxin. In the present study, of the 18 species that have excessive algal growth potential three produce toxin. Since the species were not examined quantitively in the sampling, information about the abundancy of these species is not available. In a study in the Gulf of İskenderun, Polat *et al*., (2006) identified 39 phtoplankton species that caused excessive growth and reported that of these 4 species (*Dinophysis tripos, D. caudata, D. rotundata, Pseudo-nitzschia pungens*) were toxin-producing species.

Plant forms cause oxygen enrichment in surface waters as a result of photosynthesis. As seen in the present study, the oxygen values of surface waters which continuously interact with the atmosphere are high. In addition, it was found that the oxygen values in November when the temperature was lower compared to June were also higher than the oxygen values in June. In a study, Polat (1997) determined the highest dissolved oxygen value in April (8.6 mg l^{-1}) and the lowest in June (4.8 mg l^{-1}), and also noted that the oxygen content did not decrease to lower levels during the study. She explained that the reason for the higher value measured in April was the increase in the cell numbers of phytoplankton species and the reason for the lower value measured in summer months was the increasing temperature. The oxygen content in water changes depending on the water movements and the biological occurences in the environment. Open sea waters rich in oxygen flow into the Gulf of İskenderun, circulates in the gulf and then flow out. Therefore, the Gulf of İskenderun has a quite dynamic structure (Polat, 1997).

To conclude, in the present study the phtoplankton species that are distributed in the Gulf of İskenderun and the potentially harmful ones among these species were identified and a new species record was added to the phytoplankton species diversity in Turkish seas. The Mediterranean Sea is exposed to the migration of Red Sea species through the Suez Canal and to the passage of species from the Atlantic Ocean through the Strait of Gibraltar (Polat & Koray 2007). There is need for further research on this topic in order to identify the species that enter Turkish waters.

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