American Journal of Applied Sciences 8 (12): 1328-1336, 2011
ISSN 1546-9239

Fluctuations of Phytoplankton Community in the Coastal Waters of Caspian Sea in 2006

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Abstract: Problem statement: The Caspian Sea ecosystem has been suffered with many problems since 1980s. Aanthropogenic pollution from heavy metals, hydrocarbons, pesticides, changes in the quantity of nutrient inputs by rivers, are significant threats to biodiversity and biological resources such as plankton structure in the Caspian Sea. According to the significant of phytoplankton community in marine system. The state of the fluctuations of phytoplankton communities of the southwestern Caspian Sea was investigated and compared with the findings of before 2006. **Approach:** Phytoplankton abundance and species composition of the Caspian Sea were evaluated by using samples collected at 12 stations along three transects. Samplings were conducted seasonal in 2006 at 5, 10, 20 and 50 m depth were fixed for each transect in the southwestern Caspian Sea. **Results:** A total of 39 species phytoplankton species were distinguished during 2006, the annual phytoplankton abundance were calculated as 57, 300±15,550 cells.l^{-1}, which ranged from 89, 250±35, 062 cells.l^{-1} in September to 16, 200±6, 664 cells.l^{-1} in February. The diatoms formed more than half of the total abundance (61%) while cyanophytes were the second important group in view of contribution to total phytoplankton (26%) in 2006. The study showed that diatoms *Thalassionema nitzschioides*, *Cyclotella meneghiniana* and cyanophyte *Osillatoria* sp. numerically dominated in this area. **Conclusion:** The study revealed that diatoms were higher than other groups of phytoplankton in 2006. The hydrology variation, increased fresh water inflow via rivers and a rise in nutrients concentrations have played important roles in blooming of phytoplankton species, e.g., the diatoms in this study, which is also known from other marines. Similar studies on determination of the effects of environmental degradation on phytoplankton and hydrological processes should be taken into account in near future.

Key words: Abundance, cyanophytes, diatoms, phytoplankton, nutrient, caspian sea

INRTODUCTION

The Caspian Sea is the largest inland water body on earth; it is located at the far end of southeastern Europe, bordering Asia (Kosarev and Yablonskaya, 1994). Approximately, 130 rivers with various sizes drain into the Caspian Sea with an average annual input of about 300 km^3. The most important river is Volga and provides about 80.0% of the total fresh water input (Dumont, 1998). The southwestren of the Caspian Sea receives 80 rivers; (the Sefidrood is the largest river with a 67,000 Km^2 catchment area and discharge of 4,037 million m^3; Lahijani *et al*., 2008). The Anzali wetland is the other freshwater source, which with a catchment area of 3,740 km^2, contributes about 2 million m^3 of fresh water per year, this wetland has a passage to the Sea with the width of 426 m and 11 tributary rivers flow into the Anzali wetland (Sharifi, 2006). The salinity of the Caspian Sea ranges from 0.10-13.50 ppt from north to south. There is also a slight increase in salinity with depth (Kosarev and Yablonskaya, 1994). In the northern Caspian Sea, inorganic phosphate levels are on average 0.12-0.80 µM. Nitrogen is largely present in organic form (10.0-

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250.0µg.l^{-1}). Nitrate reaches up to 0.50µM in spring and summer and 10.0µM in winter. Silica shows a strong seasonal cycle and decreases from 60.0µM in winter to <20.0 µM in summer, when diatoms bloom (Dumont, 1998).

In an early study of phytoplankton in the Caspian, the total number of phytoplankton species found from 1962-1974 was 449 (Kosarev and Yablonskaya, 1994). These species consisted of 163 diatoms, 139 chlorophytes, 102 cyanophytes, 39 dinoflagellates, 5 euglenophytes and 1 chrysophyte. In addition, the species number was found to decrease from the north (414 species) to the middle (225 species) and the southern area (71 species) mainly due to the disappearance of fresh water forms towards the south (Dumont, 1998). Recently, Kideys *et al*. (2005; 2008) reported there was a significant increase in phytoplankton abundance and noxious visibility in the Caspian Sea. Moreover, Nasrollahzadeh *et al*. (2008a) and Bagheri *et al*. (2010) observed an increase in phytoplankton abundance in 2001-2002 and 2005 as compared to previous years. According to Khodaparast (2006) and Makaremi *et al*. (2007) cyanophytes *Nodularia spumigena* and dinoflagellates *Heterocapsa* sp. produced two anomalous algal blooms for the first time in the southwestern Caspian in September 2005 and October 2006. The increased nutrient load into the southwestern Caspian Sea caused an increase in primary productivity which was reflected by high chlorophyll *a* levels (2.71-35.25µg.dm^{-3}) in 2006 and the levels were 0.56-1.34µg.dm^{-3} in 1994 (Khodaparast, 2006; CEP, 2006; Jamshidi *et al*., 2009). In the Caspian Sea, the fauna that have developed there are largely endemic and are therefore particularly susceptible to external influences (Dumont, 1998). There are also major anthropogenic impacts on the system originated from domestic pollutants (e.g., phosphorous-containing detergents), industrial pollutants (e.g., heavy metals and other industrial byproducts) and agricultural pollutants (e.g., nitrogen-containing fertilizers and pesticides). Furthermore, development of oil and gas fields creates stress on the ecosystem and its biological producers especially fish species (Salmanov, 1999; Aladin and Plotnikov, 2003). Stone (2002) described most of the acute problems in the Caspian Sea: reduction of the river run-off; the unstable water level; the various sources of pollution. Therefore, varied hydrological regimes and nutrient levels input by the Anzali wetland and the Sefidrood river can impact the phytoplankton structure in the coasts of southwestern Caspian Sea.

A few phytoplankton studies have been conducted on the south Caspian Sea in recent years (Nasrollahzadeh *et al*., 2008a, 2008b, 2008c; Roohi *et al*., 2010; Ganjian *et al*., 2010). They documented the annual and seasonal fluctuation of phytoplankton communities and nutrient concentrations in the southern Caspian from 1996-2005. The authors concluded that the comb jellyfish, ctenophores have played an important role in increasing in nutrients levels and phytoplankton populations in the Caspian after 2000, at present there is only a survey on the phytoplankton community in the southwestern Caspian Sea during 2001-2002 by Bagheri *et al*. (2010) and a few reports and local publications for this region. In order to investigate the situation that has developed since 2005, a new survey was undertaken in 2006. In this survey, the state of the composition of phytoplankton communities of the southwestern Caspian Sea was investigated and compared with the findings of before 2006.

MATERIALS AND METHODS

Phytoplankton abundance and species composition of the Caspian Sea were evaluated by using samples collected at 12 stations along three transects (Lisar, Anzali and Sefidrood) in the western Iranian coasts of the Caspian Sea. Samplings were conducted in 2006 (February, September, October, December), four stations located at 5 m (L1, A1, and S1), 10 m (L2, A2, and S2), 20 m (L3, A3 and S3) and 50 m (L4, A4, and S4) were fixed for each transect in the southwestern Caspian Sea (Fig. 1). Water samples were collected by using of Nansen water sampler 1.71 liter (Hydro-Bios, Germany, TPN; Transparent Plastic Nansen water sampler, No: 436201), water temperature level of the seawater at 5, 10, 20 and 50 m was measured *in situ* by using a reverse thermometer (Hydro-Bios, TPN) and salinity was estimated salinometer (Beckman; RS-7B, U.S. Patent, No: 2542057). Water transparency was determined with a Secchi disk depth. Water samples were deep frozen for analyses of inorganic nutrients. Dissolved Inorganic Phosphorus (DIP = P-PO_4), Dissolved Inorganic Nitrogen (DIN = N-NO_2, N-NO_3, N-NH_4) and dissolved Silicate (DSi = Si-Sio_2) were determined with a spectrophotometer system using standard methods (Clesceri *et al*., 2005).

Phytoplankton samples were collected from different depths with a Nansen water sampler. The samples were kept in 500 mL bottles and preserved using buffered formaldehyde 4%. The samples were let to settle for at least 10 days following which the water was siphoned off from the top layer to a volume of approximately 250 mL.

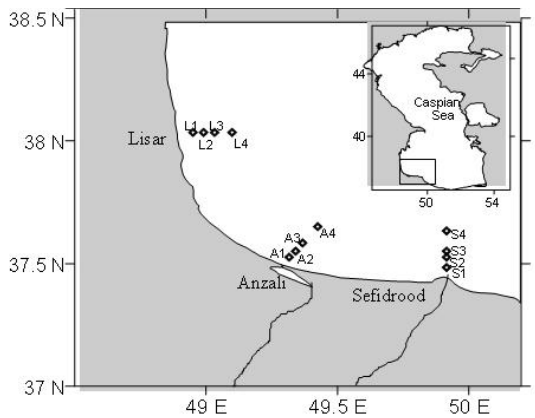

Fig. 1: Sampling transects and stations in the southwestern Caspian Sea in 2006

The samples were then centrifuged (ALC-PK131R; Germany, No: 30206372) for 5 min with 3000 rpm and further siphoning off to a volume of 30ml, phytoplankton present in a subsample of 0.1ml was counted using a Sedgewick-Rafter cell under a binocular microscope (cover slip 24×24 mm and with magnifications of 10×, 20× and 40×) (Prescott, 1962; Newell and Newell, 1977; Sournia, 1978; Clesceri *et al*., 2005). Phytoplankton taxonomic classification was performed based on Tiffany and Britton (1971). Statistical comparisons between months were made using statistical software SPSS version 13 for Windows. Analysis of variance comparisons (One-way ANOVA) for water parameters and nonparametric test (Kruskal-Wallis) for phytoplankton number were used to identify the importance of variables between different months. Spearman rank correlation coefficients (r) were used to evaluate the relationships between phytoplankton abundance and environment parameters.

RESULTS

No difference was noted in the spatial distribution of phytoplankton (non-parametric test; Kruskal-Wallis) and water parameters (one-way analyses of variance; ANOVA) between the three transects of Lisar, Anzali, and Sefidrood. Therefore, the data of the three transects were combined per months.

Hydrophysical characteristics: Temporal variations of surface temperature and salinity in the southwestern Caspian Sea in the period of February and December 2006 are demonstrated in Table. 1. The surface temperature ranged between 8.83 and 25.74°C due to monthly variations in weather temperature throughout year. Monthly temperature variations were significant (ANOVA, $p<0.01$).

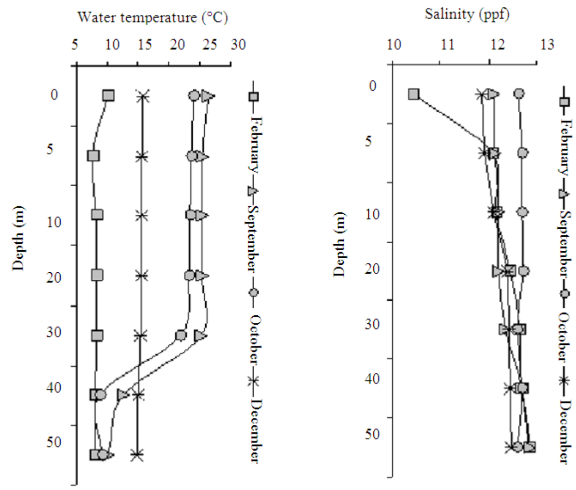

Fig. 2: Vertical profiles of water temperature and salinity at the station A4 of the Anzali transect in the southwestern Caspian Sea in 2006

The drastic thermocline was observed in September and October which formed in nearly 30 m depth. The average of water temperature varied between 25.7, 9.7°C, respectively in above and below of thermocline layers. In February and December, the temperature of the water column was nearly uniform, varying between 10-15.8°C at the surface and 8-14.9°C at the bottom, respectively (Fig. 2).

The variation of surface salinity was recorded as 9.32 and 12.25 ppt in the southwestern Caspian Sea (Table 1). Based on the ANOVA findings, the salinity differences was not meaningful monthly ($p>0.05$) although a decreasing trend in the average salinity values was observed during February (Table 1). The gradient of salinity from surface to bottom is presented in Fig. 2 in which the salinity increase from 10.43 to 12.85 ppt, between surface and deep water (50 m depth) in the southwestern Caspian Sea. Temporal variations of Secchi disk depths in the period of February and December is presented in Table. 1. The Secchi disk depth, an indicator of water turbidity, the average Secchi disk depth was measured 5.0 m and changed between 3.8 and 6.4 m, respectively in September and February during the study period. Statistical variance analysis (ANOVA) showed that Secchi disk depths were not significantly different between the months ($p>0.05$). Furthermore, the occurrence of Secchi disk depths was negatively correlated with phytoplankton abundance in this study ($r = -0.870$, $p<0.05$).

Table 1: Hydro-physicochemical parameters (±SD) at three transects and all stations in the southwestern Caspian Sea (Rivers discharge data by: GWRO, 2010)

	Nutrient (μM)					ppt	°C	m	million m^3
Parameters	DIN	DIP	DSi	DSi:DIN	DSi:DIP	Salinity	Temperature	Secchi	Discharge
February	2.57±0.69	0.63±0.40	9.33±2.43	3.6	15.04	9.32±2.67	8.83±1.12	6.4±2.3	58
September	2.15±0.82	1.31±0.25	8.24±4.43	3.83	6.3	11.32±0.95	25.74±0.33	4.2±1.2	33
October	1.71±0.73	1.02±0.37	6.50±3.97	3.8	6.37	12.25±0.36	23.35±0.55	4.5±1.7	22.8
December	1.45±0.05	0.90±0.22	7.31±6.23	5.04	8.12	12.10±0.16	15.80±0.60	5.3±2.4	49
Average	1..97± 0.49	0.96±0.28	7.85±1.21	4.06	8.95	11.45±1.47	18.43±7.67	5.0±1.1	42

Table 2: Phytoplankton checklist of southwestern Caspian Sea during period of February and December 2006

Phytoplankton taxonomic groups and species Chlorophytes	February 2006	September 2006	October 2006	December 2006
Actinastrum hantzschii Lagerheim, 1882	-	+	-	-
Ankistrodesmus acicularis Korshikov, 1987	-	+	-	-
Ankistrodesmus convolutus Corda, 1838	-	+	-	-
Crucigenia tetrapedia West, 1902	-	+	-	-
Scenedesmus acuminatus Chodat, 1902	+	+	-	-
Scenedesmus communis Hegewald, 1977	-	-	-	-
Tetraselmis Stein, 1878	-	+	-	-
Cyanophytes				
Anabaenopsis cunningtonii Tylor, 1932	-	+	-	-
Anabeanopsis raciborskii Wolos, 1923	-	-	+	-
Merismopedia elegans Braun ex Kützing, 1849	-	-	+	-
Microsystis Kutzing, 1833	-	-	+	-
Oscillatoria Vaucher ex Gomont, 1893	+	+	+	-
Oscillatoria limosum Silva, 1996	+	+	-	-
Planktolyngbya limnetica Legnerova & Cronberg, 1992	-	+	+	-
Spirulina laxissima West, 1907	-	+	+	-
Diatoms				
Aulacoseira granulata Simonsen, 1979	+	-	-	-
Chaetoceros Ehrenberg, 1844	-	+	-	+
Chaetoceros socialis Lauder, 1864	-	-	-	+
Cyclotella meneghiniana Kutzing, 1844	-	+	+	+
Dactyliosolen fragilissimus Hasle, 1997	-	-	-	+
Diatoma vulgare Saint-Vincent, 1824	-	+	-	-
Gyrosigma attenuatum Rabenhorst, 1853	-	+	-	+
Melosira varians Agardh, 1827	+	+	-	-
Navicula Bory, 1822	-	-	-	+
Nitzschia Hassall, 1845	+	-	-	-
Nitzschia tenuirostris Manguin, 1952	-	+	-	-
Nitzschia acicularis Smith, 1853	-	+	+	+
Nitzschia lorenziana Grunow, 1880	-	+	-	-
Skeletonema costatum Cleve, 1878	-	+	-	-
Thalassionema nitzschioides Van-Heurck, 1896	+	+	+	+
Ulnaria ulna Jahn et al., 2001	-	+	-	-
Dinoflagellates				
Gymnodinium variable Herdman, 1924	-	+	-	-
Peridinium latum Paulsen, 1908	-	+	-	-
Peridinium Ehrenberg, 1832	-	-	+	-
Prorocentrum cordatum Ostenfeld, 1975	-	-	+	-
Prorocentrum scutellum Schroder, 1990	+	+	+	-
Protoperidinium pallidum Balech, 1973	+	+	+	-
Euglenoids				
Euglena viridis Ehrenberg, 1832	-	+	-	-
Trachelomonas Ehrenberg, 1833	-	+	-	-

There was observed an extent variation of nutrients concentrations in 2006 (Table 1). In February, Dissolved Inorganic Nitrogen (DIN = 2.57μM.dm^{-3}) was high. In December, DIN concentration dropped to value of 1.45μM.dm^{-3}. The Dissolved Inorganic Phosphorus (DIP) concentration ranged between 0.63 and 1.31μM.dm^{-3}, respectively in February and September. The average of silicate concentrations was reported 7.85 μM.dm^{-3} in 2006 and varied from 6.50 to 9.33 μM.dm^{-3} in October and February.

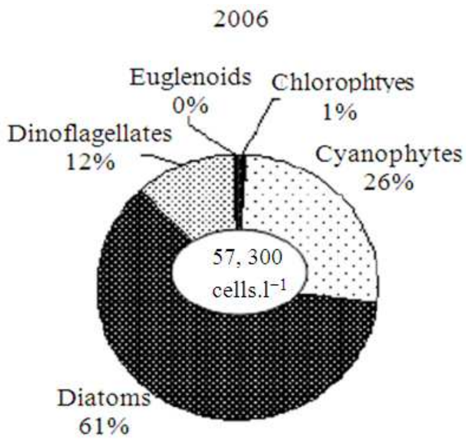

Fig. 3: Contributions of different taxonomic groups to the average total phytoplankton number at three transects and all stations in the southwestern Caspian Sea in 2006

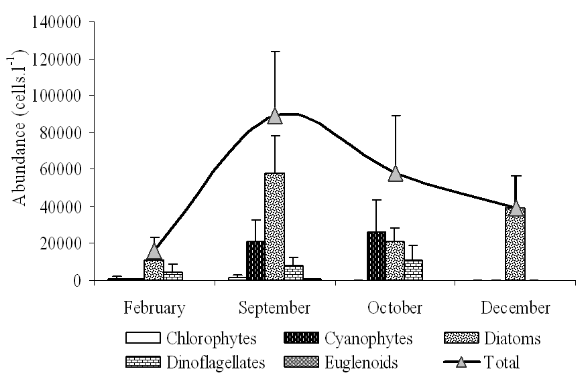

Fig. 4: Contributions of different phytoplankton groups to the total phytoplankton abundance in different months in the southwestern Caspian Sea in 2006

The Dissolved Silicate/Dissolved Inorganic Nitrogen (DSi: DIN) and the dissolved silicate/Dissolved Inorganic Phosphors (DSi: DIP) ratios were estimated 4.06, 8.95 in 2006. The Dissolved Inorganic Nitrogen (DIN) and the Dissolved Inorganic Phosphorus (DIP) concentration were significantly different during months ($p<0.05$), while the silicate concentration was not significantly different according to ANOVA findings ($p>0.05$).

Qualitative phytoplankton composition: The phytoplankton checklist, together along with annual presence (+) or absence (-) indexes and contributions of different taxonomic groups to the total phytoplankton are presented in Table 2. A total of 39 phytoplankton species were identified in 2006. Of these, 16 (41.1%) were diatoms (12 genera, 16 species); 6 (15.4%) dinoflagellates (4 genera, 6 species); 7 (17.9%) chlorophytes (5 genera, 7 species); 8 (20.5%) cyanophytes (6 genera, 8 species) and 2 (5.1%) euglenoids (2 genera, 2 species).

Quantitative phytoplankton composition: The contributions of different phytoplankton groups to the total phytoplankton abundance during different month of 2006 are figured in Fig. 3 and 4. In this study, average number of phytoplankton were 57,300±15,550 cells.l^{-1}. Among the phytoplankton groups, diatoms formed almost half of the total abundance (61%). Cyanophytes were the second important group contributing to total phytoplankton (26.0%). Dinoflagellates (12.0%), chlorophytes and euglenoids (1.0 and 0.0%, respectively) were other contributors (Fig. 3).

In 2006, the diatoms *Thalassionema nitzschioides* Van Heurck, *Cyclotella meneghiniana* Kutzing (27.0, 29.0% total abundance, respectively) and the cyanophytes *Oscillatoria* Vaucher ex Gomont (80.2%), were the species which have the highest abundance among phytoplankton species in the southwestern Caspian Sea. Diatoms were dominant and reaching the maximum (58,133±20,235 cells.l^{-1}) during September, the total phytoplankton number changed between 89,250±35,062 cells.l^{-1} and 16,200±6,664 cells.l^{-1} in September and February during 2006 (Fig. 4). Statistical nonparametric test (Kruskal-wallis) showed that phytoplankton abundance were significantly different between the months in 2006 ($p < 0.05$). Furthermore, there was a strongly positive correlation annually (significant: 0.01 level; Spearman rank correlation; 2-tailed) between phytoplankton, Dissolved Inorganic Phosphorus (DIP), water temperature during different months.

DISCUSSION

Hydrophysical characteristics: Many researchers (Dumont, 1998; Kideys and Moghim, 2003; Bagheri and Kideys, 2003; Roohi *et al*., 2008; Nasrollahzadeh *et al*., 2008a; Bagheri *et al*., 2010) reported that temperature variations in surface water in the southern Caspian Sea varied between 7.00°C (in winter) and 29.0°C (in summer). However, during this study, temperature variation in surface water varied between 8.83°C (in Febuary) and 25.74°C (in September) during 2006 (Table 1). The annual surface water temperature was lower than in 2006 (annual average: 18.43°C; Table 1) as compared to 2001-2002 and 2005

(Nasrollahzadeh *et al*., 2008a; Bagheri *et al*., 2010; annual average: 19.83-21.14°C). In this study thermocline were observed in September and October which occured in nearly 30 m depth and the stratification started to break up in December and February (Fig. 2). Kideys and Moghim (2003) and Zaker *et al*. (2007) noted, a strong thermocline located between 30m and 50m depths in the beginning of autumn with 15°C temperature, the thickness of the thermocline was located between 30 m and 45 m depths in the southern Caspian Sea, as was observed in our study, they reported the depth of the mixed layer was not the same as in the Caspian. In additions, we believed the stratification of water layers could be related to meteorological monthly fluctuations in the Caspian Sea.

In 2006, the average annual surface salinity was low (11.45 ppt; Table 1) as compared to 2001-2002 and 2005 (Nasrollahzadeh *et al*., 2008b; Bagheri *et al*., 2010; annual average: 12.54-12.20 ppt). The salinity varied between 9.32 ppt and 12.25 ppt, there was a decreasing trend in the average salinity values of the surface water in February 2006 (Table 1), also salinity was increased from surface water to deep layer (50 m depth; Fig. 2). These trends could be related to fresh water inputs from the Anzali wetland and the Sefidrood river in this month. According to Bagheri *et al*. (2010) and GWRO (2010), there was a strongly negative correlated between salinity and freshwater discharge in the southwestern Caspian Sea during 2001-2002. In additions, our findings were similar to the previous findings reported by; Dumont (1998); Kideys and Moghim (2003); Bagheri and Kideys (2003); Zaker *et al*. (2007); Nasrollahzadeh *et al*. (2008a, 2008b) in the Caspian.

In this study, average Secchi disk depth was recorded 5.0m in 2006 in the southwestern Caspian Sea (Table 1). Increase of anthropogenic inputs from Lisar and Sefidrood rivers and Anzali wetlands, has caused an accumulation of suspended inorganic and organic materials in the southwestern Caspian Sea. Nasrollahzade *et al*. (2008b) reported that the mean values of the Secchi depth were 6.65 m in 1996-97. The reduced Secchi disk depth in 2006 could be related to the increase of phytoplankton occurring during our study (57,300 cells.l^{-1}; Fig. 3) as compared to 1996-1997 (Nasrollahzadeh *et al*., 2008b; annual average: 13,000 cells.l^{-1}) and the beginning of eutrophication in coastal of marine ecosystem (Yunev *et al*., 2005). Unfortunately, we could not talk strongly regarding this relationship, as there are no phytoplankton biomass data during 2006.

Table 3: Seasonal variations of taxonomic composition in phytoplankton and contributions of different taxonomic groups to the total phytoplankton in the southwestern Caspian Sea in 2006

	2006			
Phytoplankton	Genus	Species	f (%)	cells.l^{-1}
Chlorophytes	5	7	17.9	616
Cyanophytes	6	8	20.5	14832
Diatoms	12	16	41.1	34931
Dinoflagellates	4	6	15.4	6626
Euglenoids	2	2	5.1	253
Total	29	39	100.0	57258

Annual fluctuation of phytoplankton: In our study, the number of chlorophytes and cyanophytes species (Table 3) were more than 1996-1997 (Nasrollahzadeh *et al*., 2008b), 11 dinoflagelltes species were present in 1996-1997, but we observed 6 species during 2006. Nasrollahzadeh *et al*. (2008b) and Bagheri *et al*. (2010) listed 25 and 24 species of diatoms, respectively in 1996-1997 and 2002, we recorded 16 in 2006, the number of euglenoids species was listed four species during 1996-1997, two species identified in 2006 (Table 3).

39 species of phytoplankton were identified in 2006 (Table 2 and 3), we found a decrease from 1983 (71 species: Kosarev and Yablonskaya, 1994; Dumont, 1998), 1996-1997 (50 species: Nasrollahzader *et al*., 2008) and 2002 (43 species: Bagheri *et al*., 2010) in the south of Caspian Sea. In additional, there were changes in the phytoplankton groups forming the blooms. In the 1996-1997 and 2005 study, diatoms were the dominant taxon during all seasons (59-62%), chlorophytes and dinoflagellates made up 13-14% of the total phytoplankton abundance (Nasrollahzadeh *et al*., 2008b), in 2002 the dinoflagellates accounted for 56% and the cyanophytes 29% (Bagheri *et al*., 2010), while in our study the diatoms accounted for 61%, after diatoms; the number of cyanophytes (26%) were prevailing phytoplankton groups in the southwestern Caspian Sea (Fig. 3).

The annual average abundance of phytoplankton reported by Kosarev and Yablonskaya (1994) 14,000 cells.l^{-1}; Nasrollahzadeh *et al*. (2008b) 13,000 cells.l^{-1}; Roohi *et al*. (2010) 39,000 cells.l^{-1} and by us (57,300 cells.l^{-1}) for the period of 1962-2006 displayed increase of the phytoplankton abundance in the southern Caspian Sea. The changes of phytoplankton community in southwestern Caspian Sea in 2006 as compare with previous years, could be related to anthropogenic impact (increased water pollution) and changes in the atmospheric and hydrological regimes of the basin. Since the early 1980s, the southwestern area of the Caspian Sea has become more eutrophic (Salmanov, 1999; CEP, 2006; Stolberg *et al*., 2006). In addition, Nasrollahzadeh *et al*. (2008a) reported, the process of eutrophication is accompanied by a shift in the existing qualitative and quantitative relationship between the major phytoplankton groups. According to Mirzajani *et al*. (2010) the nutrients input via the Anzali wetland were increased in the southwestern Caspian, they documented eutrophication trend (trophic state index) varied between 42 and 46, respectively during 1995 and 2002. It seems that this trend have been continuing in 2006, the dissolved inorganic phosphors concentrations were raised from 0.37μM.dm^{-3} (Nasrollahzadeh *et al*. 2008a) to 0.96μM.dm^{-3} (Table 1), respectively during 1996 and 2006.

The variation of nutrient levels in the different months (Table 1) could be related to fluctuation of fresh water discharge by the rivers. Eker *et al*. (1999); Purcell and Decker (2005); Turkoglu (2010); Mirzajani *et al*. (2010) found similar occurrence in the Black Sea, Chesapeake Bay, Mediterranean Sea, and Caspian Sea. In this study, the nutrient levels fluctuations were contributed in change of phytoplankton number and composition in different months during 2006 (Table 1; Fig. 3 and 4).

Diatoms require silicate for their shells in addition to these nutrients and about 90% of the silicate input to the global marine is estimated to come from rivers (Sommer, 1994; Eker and Kideys, 2003; Humborg *et al*., 2004). In addition, Bagheri *et al*. (2010) documented, only 20.0% of the phytoplankton abundance were made up of diatoms *Thalassionema nitzschioides* and *Cyclotella meneghiniana* in the southwestern Caspian in 2001. In our study, increase diatoms *T. nitzschioides* and *C. meneghiniana* abundance (61.0%) in 2006 could be related to increased freshwater inflow (the Sefidrood river discharge was estimated 33 and 42 million m^3.year^{-1}, respectively during 2001-2002 and 2006; GWRO, 2010) and silicate levels (7.85 μM.dm^{-3}; Table 1) as compare to 2001-2002 (3.70 μm.dm^{-3}; Bagheri *et al*., 2010).

Nasrollahzadeh *et al*. (2008b) reported with decreasing DSi:DIP ratio from 25 to 11, respectively in 1996-1997 and 2005 the abundance of cyanophytes increased from 4 to 25% in the south of Caspian Sea. In addition, Khodaparast (2006) noted in the Caspian Sea, cyanophytes bloom was observed during periods of decline in nutrients ratios. In our study, the cyanophytes number were increased in September-October (Fig. 4), It could be related to decreased of nutrients ratios in these months as compared to February and December in 2006 (Table 1). Some studies linked drastic changes in the phytoplankton community with comb jellyfish invasion in the Caspian Sea after the year 2000 (Nasrollahzadeh *et al*., 2008a; Ganjian *et al*., 2010; Roohi *et al*., 2010). We could not estimate the impact of comb jellyfish on the fluctuation of phytoplankton and dominant taxa such as, diatoms and cyanophytes in 2006. According to Bagheri *et al*. (2010), the abundance of phytoplankton was not correlated with the number of comb jellyfish in the southwestern Caspian during 2001-2002. Accordingly, it was not possible to determine to what extent the fluctuation of the phytoplankton is due to the impact of comb jellyfish. Recent observations in other seas indicated that the changing phytoplankton community can be related to climatic variability (Polonsky *et al*., 2004; Bilio and Niermann, 2004). Furthermore, the fluctuations of the phytoplankton community's relationship to environmental parameters (pollutions) and nutrient upwelling were not extensively investigated up to now (Kideys *et al*., 2008; Bagheri *et al*., 2010). Since the southern Caspian Sea is influenced to a high extent by fresh water inflow with a heavy load of artificial nutrients (Dumont, 1995; Salmanov, 1999; Yunev *et al*., 2005; Sharifi, 2006; CEP, 2006; Stolberg *et al*., 2006), it is important to assess to which extent the increased eutrophication affects the phytoplankton abundance and species composition in the coasts of Caspian Sea.

CONCLUSION

Our survey documented the temporal distribution of the phytoplankton in the southwestern Caspian Sea in 2006. The study showed that diatoms such as *Thalassionema nitzschioides* and *Cyclotella meneghiniana* and cyanophyte *Oscillatoria* sp. numerically dominated in the southwestern Caspian Sea. We believe that hydrology variation, increased fresh water inflow via rivers, a rise in nutrient concentrations have played important roles in blooming of phytoplankton species in the Caspian Sea, which is also known from other marines. Similar studies on determination of the effects of environmental degradation on phytoplankton communiy must be taken into account in near future.

ACKNOWLEGMENT

The researchers grateful to Sam Allen for improving the English of the draft manuscript. We would like to thank the Inland Waters Aquaculture Institute (IWAI), Iranian Fisheries Research Organization (IFRO) for supporting this project. The University Sains Malaysia (USM) is also gratefully acknowledged. We greatly appreciate the assistance received from H. Babaei, E. Yosefzad, M. Saiyad

Rahim, Y. Zahmatkesh, H. Mohsen-Pour, J. Khoushhal and M. Iran-Pour in this study.

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