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Quantitative (Chlorophyll-a) and Qualitative (Species Composition) Seasonal Fluctuations of Phytoplankton in Lavan Coastal Waters (North of the Persian Gulf)

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Abstract: Phytoplankton species composition as well as amount of Chlorophyll-a and their relation to physico–chemical parameters were studied. The samples were collected monthly from October 1996 until September 1997 in two stations, i.e. Lavan and Douberkeh coastal waters. In this study, 65 phytoplankton species related to 3 groups of diatoms, dinoflagellats and Blue-Green Algae (24 genus and 44 species of diatoms, 6 genus and 18 species of dinoflagellats and 3 genus blue-green algae) were identified. Diatoms and dinoflagellats were abundant during periods of low salinity and temperature (November-May), while blue-green algae were abundant from July till September.

Although the amount of chlorophyll-*a* was higher during the periods of low salinity and temperature, there was not statically significant difference between the two stations and different seasons (P>5%). Also, there were not significant differences between such physico-chemical factors as temperature, salinity, pH and oxygen content. Transparency between the two stations showed significant differences (P<5%). Correlation matrix test showed no relationship between physico-chemical parameters and the amount of chlorophyll-a in two stations. The results suggest that increasing the temperature and/or salinity cannot cause significant reduction in chlorophyll-a amount in Lavan and Douberkeh regions.

KEY WORDS: Phytoplankton, Seasonal fluctuations, Chlorophyll-a, Persian Gulf, Iran

Introduction

The wide distribution of phytoplankton and their frequent abundance account for the great importance of the phytoplankton as a major basic food material in the food cycle of aquatic situations. Phytoplanktons are of great ecological importance because they comprise the major portion of primary producers in sea to provide basic food in sea for all consumers such as zooplankton and fish. Wide fluctuations exist in production and distribution of phytoplankton pigments, depending on seasons and geographical locations. Temperature, salinity, and availability of foods are the main factors that affect phytoplankton communities / structures and may cause seasonnal variations in species compositions (Harris, 1986 ; Hsiao, 1992). In tropical and subtropical regions, salinity is considered the main factor controlling species compositions of phytoplankton, but temperature does not have direct effect on this phenomenon (Murugan & Ayyakkannu, 1993).

Concerning the whole Persian Gulf (PG), considerable information is available on biomass, distribution and abundance of phytoplankton population of the eastern part of PG (Dorgham & Moftah, 1989; Habashi *et al.*, 1992; Gindy & Dorgham, 1992). However, much less information is available on northern part of PG in particular (Savari, 1981 ; Roohani, 1996).

As a preliminary attempt, the objective of the present study was to provide a clear picture of the seasonal fluctuations of phytoplankton and the value of cholorophyll-*a* (as biomass) in northern part of the Persian Golf.

Material and Methods

Samples for quantitative (Chlorophyll-*a*) and qualitative (species composition) studies of phytoplankton were collected from two areas, i.e. Lavan and Doberkeh coastal waters. All two stations were chosen from the northern part of the Persian Gulf (PG). The samples were collected every month (from October 1996 till September 1997). Using net of 55-micron pore size, phytoplankton samples were collected for qualitative and taxonomic studies; samples were then preserved immediately in 4% formalin solution. Identification of phytoplankton cells was performed with ordinary microscope and with the aid of identification keys to genus level and sometimes to species level.

For the analysis of chlorophyll-*a* and physico-chemical parameters, such as temperature, salinity and pH, water samples were collected using Nansen bottle (reversible water sampler). For the extraction of chlorophyll-*a*, 1-2 litters of seawater was immediately filtered under reduced pressure through a 0.45 micron, 47 mm Millipore GF/F glass-fibre filter. Chlorophyll-*a* was determined spectrophotometrically in 90% acetone as prescribed by Parson *et al.* (1992). A portable salinometer (refractometer) was used to measure salinity, and water temperature was determined using classical reversing thermometer. A portable pH meter was used to measure the pH, and transparency was determined using a secci disk.

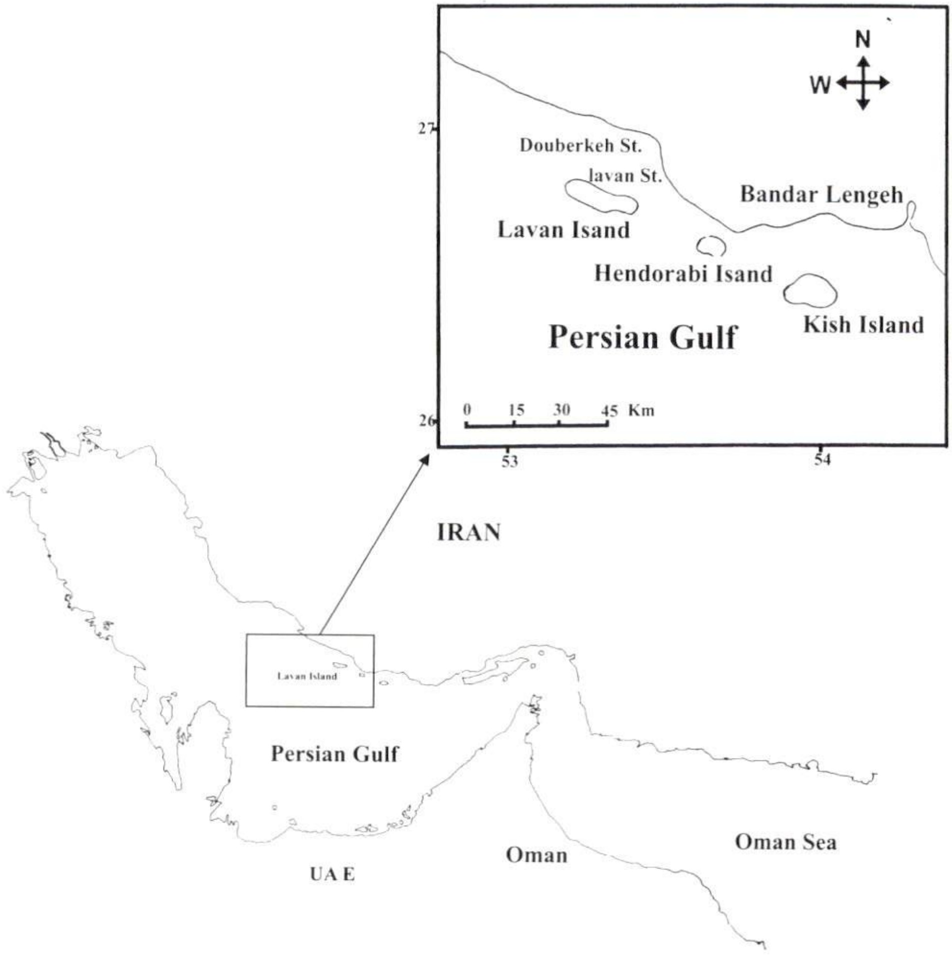

Fig. 1: Sampling stations in Lavan coastal waters

Results

During this study, sixty-five species of such phytoplankton as diatoms, dinoflagellats and Blue-green algae were identified. diatom represented 44 species, followed by 18 species of dinoflagellats and 3 genus of blue-green algae.

The diversity of diatom species were markedly more than the diversity of dinoflagellats. The former was mainly composed of *Rhizosolenia* (12 species), *Chaetoceros* (6 species), *Nitzschia* (3 species) and *Biddulphia* (2 species), and the later were composed of *Ceratium* (11 species) and *Dinophysis* (2 species). The communities of both groups were significantly more diversified than the blue-green algae. Dominant species of blue-green algae was *Trichodesmium*, which was abundant in warm months (i.e., July till October).

Variations of 3 groups of phytoplankton are shown in Fig. 1. Fluctuation of phytoplankton was more obvious in relatively cool months, especially for dinoflagellats and diatoms but not for blue-green algae. Diatoms and dinoflagellats were abundant in cool months (November till May), whereas blue-green algae were abundant from July till September.

The biomass of the phytoplankton, which is measured by assay of chlorophyll-a value, showed narrow range of regional variations. Although high value of chlorophyll-a was generally recorded during the periods of low salinity and temperature (February till June), there were not any statistically significant difference between the two stations and different seasons ($P<5\%$).

The average values of chlorophyll-a in Lavan and Douberkeh stations were 1.1 mg/m^3 and 1.02 mg/m^3, respectively. Maximum chlorophyll-*a* in Lavan and Douberkeh were recorded to be 1.8 mg/m^3 (in June) and 1.43 mg/m^3 (in October), respectively. Also minimum value of chlorophyll-a for the same regions were recorded to be 0.75 mg/m^3 (in September) and 0.89 mg/m^3 (in August).

There was not any statistically significant difference between the two stations, in terms of such physico-chemical parameters as temperature, salinity, pH and dissolved oxygen. However, transparency between the two stations showed significant difference ($P<5\%$). Monthly variations of chlorophyll-*a*, temperature, salinity, pH, oxygen and transparency are illustrated in Fig. 2.

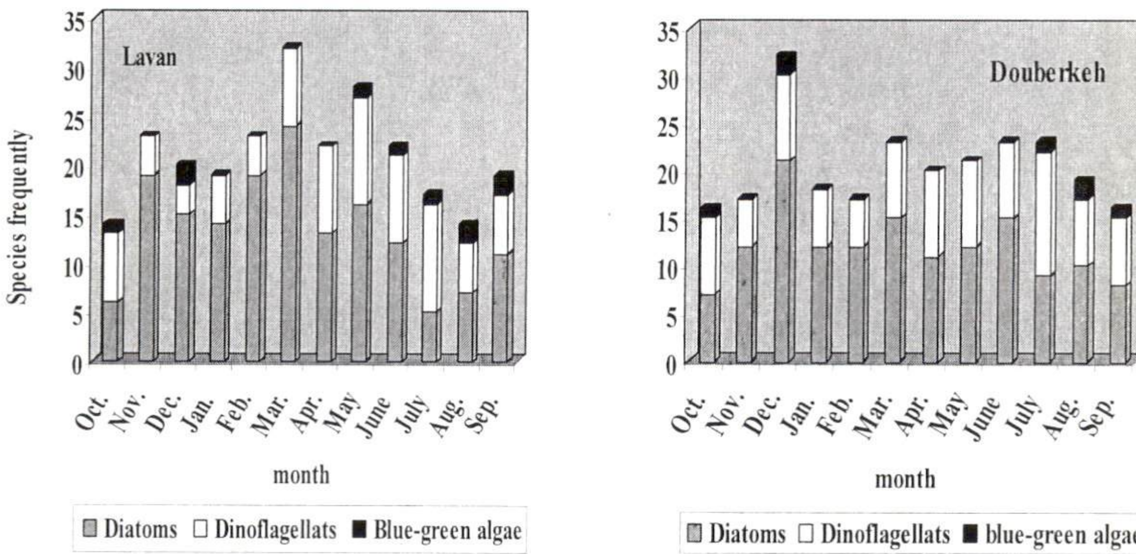

Fig. 1: Chlorophyll-a and physio-chemical parameters in coastal waters of Lavan and Douberkeh (from October 1996 till September 1997)

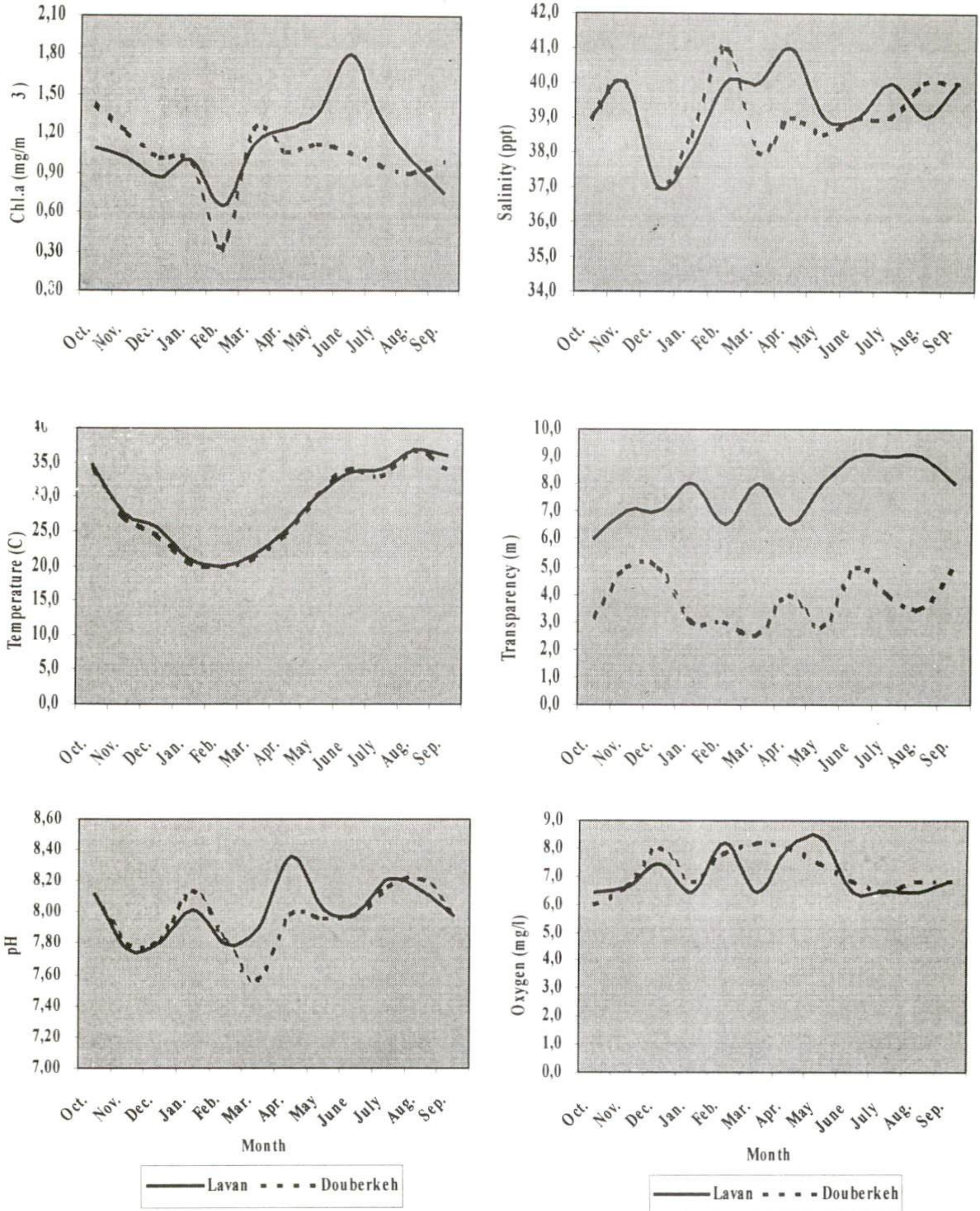

Fig. 2: Monthly variations of Chlorophyll a and physico-chemical parameters in the coastal waters of Lavan and Douberkeh (Oct. 1996 to Sep. 1997)

Discussion

Phytoplankton communities in Lavan and Douberkeh coastal waters are less different in terms of species composition depending upon seasonal environmental factors, including temperature, salinity and available foods (Harris, 1986; Hsiao, 1992). Among these factors, salinity is the main factor which controls species compositions of phytoplankton, whereas temperature dose not has direct effect on this phenomenon (Murugan & Ayyakkannu, 1993).

Species compositions of phytoplankton in Lavan and Douberkeh are shown in table 1 which indicates that fluctuation of phytoplankton in cool months were relatively larger than warm months, conspicuously diatoms and blue-green algae. The high variation of diatoms species was from December till May, resulting from the low temperature and salinity due to precipitation and entrance of drainage fresh water by seasonal rivers in these months. This situation can be caused by salinity as a limiting factor for growth of diatoms. In tropical and subtropical regions, temperature is not a limiting factor in reproduction of diatoms (Murgan & Ayyakkannu, 1993).

Therefore, in warm months due to the increase in salinity, there was not some species of diatoms in our samples unlike blue-green algae which was highly presents in warm months, when both salinity and temperature were high. The possible reason for such situation is that this group of phytoplankton is thermophile, and the existence of *Trichodesmium sp.* as the major constituent of species composition is a characteristic phenomenon for the tropical and subtropical waters (Dorgham & Moftah, 1989). In this study, *Trichodesmium sp.* was more abundant in warm months. In a given period, dinoflagellats species diversity and abundance were high in all months, and they showed fewer fluctuation to the temperature and salinity. This situation may be due to their high tolerance to salinity. Furthermore, when the diversity of diatoms was abundant, dinoflagellats had fewer communities. These observations are analogous to those in southern parts of the Persian Gulf (Dorgham & Moftah, 1989; Habashi *et al.*, 1992).

Fig 1: Monthly variations of Chlorophyll a and physico-chemical parameters in the coastal waters of Lavan and Douberkeh (Oct. 1996 to Sep. 1997)

No	Phytoplankton groups	Spring			Summer			Autumn			Winter		
	BACILLARIOPHYCEAE	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1	*Biddulphia sinesis*	L,D	L	D					L,D	L	L,D	D	L,D
2	*B.mobiliensis*											D	
3	*Bacteriastrum sp.*	L,D	L,D	L	D		L,D		L,D	L,D	L,D		L,D
4	*Chaetoceros lorenzianum*	D	L,D	L,D	L,D	L,D	L,D		D	D	L	L,D	L,D
5	*C.denticulatum*	L,D	L							D		L	L,D
6	*C.coarctatum*					L,D		L,D					
7	*C.peruvianum*		L,D	L,D					L,D	L,D	L,D		L,D
8	*C.curvisetum*	L,D	L	L,D	L,D	L,D	L		D	L	L		L
9	*C.laeve*												
10	*Coscinodiscus sp.*	L,D	L	L	D	D		D		D	D	L	D
11	*Corethron sp.*								L,D	L,D	L,D	L,D	L,D
12	*Climacodium sp.*		D							D	L		L,D
13	*Ditylium sp.*		L						L,D	L,D			
14	*Eucampia sp.*	L,D	L,D						L	L,D			
15	*Guinardia sp.*	L,D	L						L			L	L
16	*Gyrosigma sp.*			D		L,D	L,D						
17	*Hemiaulus sp.*			L,D				L	D				
18	*Lacmophora sp.*							L,D			L,D	L	L
19	*Lauderia sp.*	L,D	D	D			L				D	L,D	L,D
20	*Leptocylindrus sp.*	L,D		L,D	L,D	L,D	L,D				L,D	L	
21	*Navicula sp.*										L	L,D	L,D
22	*Nitzschia seriata*	L,D	L	L,D	D	D	L,D	L,D	L,D	L,D			L,D
23	*N.closterium*		L,D	L,D				D					
24	*N.paradoxa*			D	D								
25	*Planktonella sp.*									L,D			
26	*Pleurosigma sp.*			L	L		L,D		L	D			
27	*Rhizosolenia alata*	L,D	L,D		D				L,D			L	L
28	*R.cochlea*								L			L	L
29	*R.delicdtula*												
30	*R.setigera*	L,D	D	L,D		L,D	L,D		L,D			D	L
31	*R.imbricata*				L,D		L		L	L,D	L,D	L	L,D
32	*R.bergonii*								L	D			
33	*R.stolterfothii*			D		D			L,D	L		L,D	L
34	*R.clevei*	L	L					D		L,D	L	L	L,D
35	*R.robusta*		L,D									L,D	
36	*R.hebitata*							L		D	D		
37	*R.alata f.indicus*									D			
38	*R.calcar-avis*		D				L	L,D		D			
39	*Skeletonema sp.*		L,D	L,D		L,D	D			L,D	L,D	D	L,D
40	*Stephanopyxis sp.*								L,D			L,D	L
41	*Streptotheca sp.*											L	
42	*Thalassiothrix sp.*								L	L,D		L	L,D
43	*Thalassiosira sp.*								L	L,D			
44	*Thalassionema sp.*								L		L,D	L,D	L
DINOFLAGELLATA													
45	*Ceratium fusus*	L,D	L,D	L,D	L,D	D		L,D		D	L,D	L,D	L
46	*C.belone*		D										
47	*C.candelabrum*		L										
48	*C.dens*				L,D							D	
49	*C.furca*	L,D	L,D	L,D	L,D	L,D	L,D		L,D	L,D			
50	*C.kofoidi*	D	L,D		L,D			D		D		D	
51	*C.tripos*	D	L	L,D	L,D			L,D			L,D		L,D
52	*C.massiliense*								L	D			
53	*C.trichoceros*	L,D	L,D	L	L,D		D	L,D		D	D		L
54	*C.gibberum*				L,D				D	D			
55	*C.pennatum*	L			D	L,D							
56	*Dinophysis caudata*	L,D	L,D	L,D	L,D	L,D	L,D	L,D	L,D	L,D	L,D		L,D
57	*D.caudata var.tripos*	L,D	L,D	L,D	L,D		L,D	L,D	D	D	D	D	L,D
58	*Noctiluca sp.*											L,D	
59	*Peridinium sp.*	L,D	L,D	L,D	L,D	L,D	L,D	L,D	L,D	L,D	L,D	L	L,D
60	*Prorocentrum sp.*	L,D	L	L,D	D	L,D	L,D						L,D
61	*Pyrophacus sp.*	L	L,D	L,D	L,D	L,D	L,D	L,D					
62	*Pyrocystis sp.*				L,D	L,D	L,D						
CYANOPHYCEAE													
63	*Oscilatoria sp.*		L					L,D		L,D			
64	*Phormidium sp.*					L,D	L			L,D			
65	*Trichodesmium sp.*			L	L,D	L,D	L,D						

L = Lavan **D= Douberkeh**

Thus, it seems that the growth of these groups of phyto-plankton was affected by other factors such as extraction of some biological material by phytoplankton. During red tide, dinoflagellats extract poisons these materials are limiting factors for growth of other groups of phytoplankton. In regions under investigation in this study, *Noctulica sp.* was observed in high number (February) where the phytoplankton was not dominated by diatoms and blue-green algae. Similar condition was observed during blooming of *Trichodesmium sp.*, when diatoms and dinoflagelates were rare. This phenomenon needs more investigation in the same area for validation purpose.

In addition, regeneration rates of nutrients and their return to the water column by physico-chemical processes can be affected by growth rate and species composition of phytoplankton (Gindy & Dorgham, 1992). In tropical regions, regeneration and transportation of nutrients to surface water is less due to temperature stratification; this results in low productivity (Nybakkan, 1988). In the Persian Gulf and the study area, regeneration of nutrients (because of shallow waters) and consequently productivity is relatively high (Gindy & Dorgham, 1992); therefore, majority of diatoms species and dinoflagellats were observed, except for a few months, in whole year.

Maximum value of chlorophyll-a was observed during relatively cool months in two stations where salinity was low. It seems that salinity not only affected species composition of phyto-plankton but also value of chlorophyll-a. Thus, maximum chlorophyll-*a* were observed during periods of low salinity.

Nakanishi and Nonsi (1965) reported that increasing salinity during warm months is accompanied with a decrease in photosynthesis and respiration of phytoplankton cells, resulting in lower value of chlorophyll-a. The same results were found by Habashi *et al.* (1992) in ROPME Sea area where high value of chlorophyll-a was recorded generally during periods of low salinity.

Phytoplankton population in the Persian Gulf is highly diversified and mainly includes diatoms and dinoflagellats (Dorgham & Moftah, 1986), and the number of diatom taxa is markedly greater than the dinoflagellats. As mentioned before, the great majority of phytoplankton in this study was diatoms and dinoflagellats, and species composition of diatoms was much more diversified than dinoflagellats. These observations are analogous to those in southern part of the

Persian Gulf (Gindy & Dorgham, 1989; Price, 1989; Dorgham & Moftan, 1992). The noticeable phenomenon in this study was the existence of some blooms of dinoflagellats (*Noctiluca sp.* in February), diatoms (*Navicula sp.* in November) and blue-green algae (*Trichodesmium sp.* in June till September), but no mortality of aquatic animals was observed during this phenomenon.

Conclusion

From the results of this study, it is expected that the amount of Chlorophyll-a and relative abundance of two groups of phytoplankton, diatoms and dinoflagelates species, would be controlled primarily by salinity, while blue-green algae are mostly abundant in periods of high temperature and salinity. The most abundant species in this study were mostly *Chaetoceros spp., Rhizosolenia spp., Ceratium sp.* and *Trichodesmium sp.* The distinct phenomenon was the appearance of non-toxic dinoflagelates, such as *Noctiluca sp.*, in significant numbers in Douberkeh coastal waters.

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