

Plankton Studies in the Arabian Gulf II. The Autumn Phytoplankton in the Northwestern Area

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ABSTRACT. The study area extends along the northwestern part of the Arabian Gulf off Kuwaiti, Saudi and Qatari shores. The species composition and biomass of the phytoplankton in addition to the physical and chemical factors of the Gulf water were followed horizontally and vertically during Nov. 1984.

The most characteristic features of the water were the significant low nitrate-phosphate ratio, lack of nutrient balance, and detected high level of oil pollution in some positions. The phytoplankton population was characterized by great diversity of species (223 taxa) and low standing crop. Tight relationship was observed between the physico-chemical parameters and oil pollution in the area, and the diversity of species and biomass of phytoplankton. The studied environmental factors showed variations in the different regions of the investigated area, which were reflected on the phytoplankton population in each region.

Despite the increasing number of publications on the biotic and abiotic characteristics of the Arabian Gulf in the last few decades, it is considered a relatively unknown ecosystem. Phytoplankton is one of the ecosystem components which is not well known. The published works, in this field, are not enough to give a complete figure of the phytoplankton population in the Arabian Gulf. They concern either certain groups of phytoplankton (Bohm 1931, and Oshite 1974 a&b) or with localized areas (Jacob and Zarba 1979, Jacob *et al.* 1979 a&b, Al-Mattar and Al-Khars 1978, Gamal & Pavlov 1981, and Dorgham & Muftah 1987). Al-Kaisi (1976) published data on the phytoplankton collected from the Arabian Gulf off Kuwait, Qatar and U.A.E. during Dec. 1968. Moreover, some reports were dealt with the plankton distribution over the whole Gulf area (Kimor 1973 and Halim 1984).

Most of the above mentioned works depend on a small number of stations and lack information about the autumn phytoplankton. Furthermore, oil exploitation and industrialization have developed very quickly during the last two decades. According to El-Samra, Emara *et al.* (1986) the northwestern region of the Arabian Gulf is heavily polluted and several oil spills were observed. These spills are allowed to disperse either naturally or sometimes by chemical dispersant. The oil dispersant chemicals used in the countries of the Arabian Gulf are Shell, Servo 2000, Exxon OSD 9517 and Shell LTX, which are certainly toxic. These conditions undoubtedly have had a significant effect on the biota of the Arabian Gulf, in general, and phytoplankton, in particular. The previous studies did not include any observations concerning the effect of oil pollution.

The objective of this paper is to present the pattern of the horizontal and vertical distribution of the phytoplankton in the autumn. In addition, the distribution of the phytoplankton in the northwest Gulf will be correlated with the prevailing ecological conditions. The changes in the last 60 years are included. The present study concerns also the phytoplankton of Saudi water, which has not been studied so far. The study area included the Gulf water in the northwestern part between Doha (Qatar) at 25° 18' N & 51° 40' E, and Kuwait at 29° 17' N & 48° 31' E. Sampling stations were chosen to represent the Gulf water of Kuwait, Saudi Arabia and Qatar (Fig. 1).

The depths of the inshore waters ranged from 9.5 to 19.5 m, while the offshore areas varied between 29.5 and 66 m.

It should be mentioned that several kilometers of oil pipelines extend on the Gulf floor between the oil wells and the coast. There are a number of platforms for crude oil export established inside the Gulf. Further, oil spills, which may be discharged from tankers passing the Gulf, were observed in different regions. All these could be sources of oil pollution in the northwest Gulf. On the other hand, the northern end of the Arabian Gulf receives fresh water from Shatt el-Arab.

Material and Methods

During the period 7-24 Nov. 1984, samples for plankton study and physico-chemical parameters were collected concurrently by the R/V of Qatar University "Mukhtabar Al-Bihar".

The physico-chemical parameters were measured either directly on board the vessel or in the laboratories of Qatar University. The water temperature, dissolved oxygen and the salinity were measured by a "Guild-Line CSTD". Determination of the nutrients: nitrate (NO₃), phosphate (PO₄) and dissolved silica (Si) was carried

out according to Strickland and Parsons (1972) and the ammonia (NH_3) according to ROPME (1983).

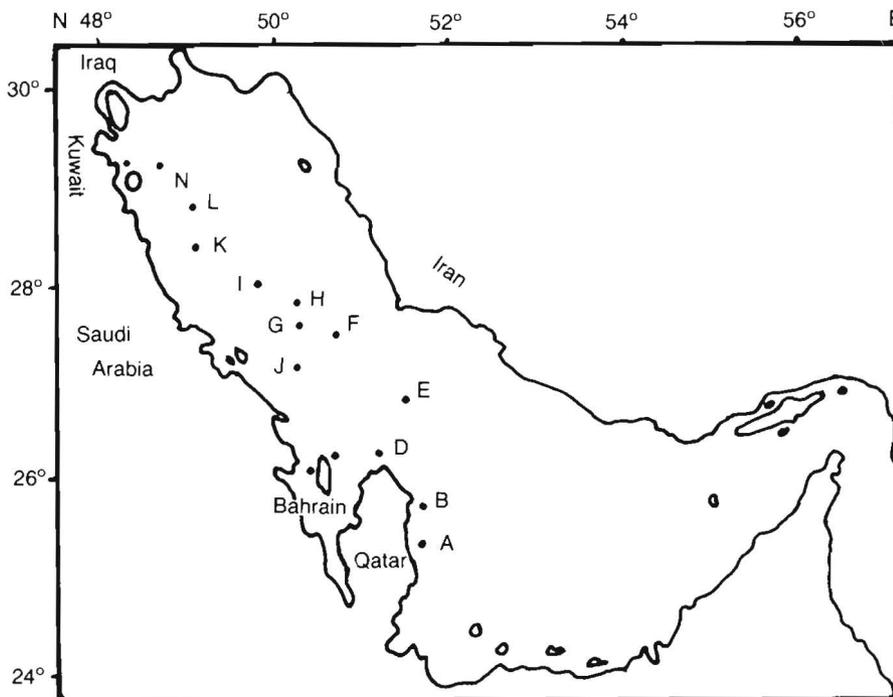


Fig. 1. Locations of the sampling stations in the Northwest Arabian Gulf, Nov. 1984

Fifty seven phytoplankton samples were collected qualitatively and quantitatively. For qualitative collection 5 min. hauls were made in the surface water by a fine net of 55 μm mesh size. Quantitative samples were obtained by Nisken bottle from the surface, 5, 10 and 15 m depths. Examination of the net samples was carried out under a research microscope. The standing crop was estimated as cell l^{-1} using the sedimentation counting method of Utermohl (1936).

Results and Discussion

Physical and Chemical Parameters

Except for temperature and salinity all other parameters were measured in the surface water and at different depths.

Surface distribution of the temperature showed that Saudi water was warmer than both Kuwaiti and Qatari waters. The ranges were 24-30, 25-27, and 24-27°C respectively. The surface salinity in Kuwaiti water (39.3-40.8 ‰) was slightly lower than those observed off Saudi and Qatari shores (40-42 ‰). The dissolved oxygen in the surface water of the whole area varied between 4.21 and 5.32 ml l⁻¹. In the water column up to 40 m, the oxygen concentrations were mostly more than 4 ml l⁻¹. The variation ranges of nutrient salts in the surface water of the investigated areas are shown in Table 1. Figures 2 & 3 give profiles of the vertical distribution of the phytoplankton standing crop and the nutrients: ammonia, nitrate, phosphate and dissolved silica at several stations.

Table 1. Variation ranges of the nutrients in the surface water of the investigated areas (µg at l⁻¹)

Area	Ammonia N			Nitrate N			Phosphate P			Dissolved silica Si		
	min.	max.	aver.	min.	max.	aver.	min.	max.	aver.	min.	max.	aver.
Kuwait	0.07	0.15	0.11	0.16	0.38	0.26	0.14	0.18	0.15	11.07	22.07	15.05
Saudi Arabia	0.08	0.22	0.15	0.09	1.27	0.37	0.00	0.34	0.11	5.04	11.06	6.57
Qatar	0.18	0.19	0.185	0.30	0.38	0.34	0.20	0.88	0.54	3.92	6.48	5.20

From Table 1 it is clear that the surface ammonia varied within narrow ranges. The average concentration in Qatari water was higher than in Saudi and Kuwaiti waters. Vertical distribution of ammonia at profiled stations (Fig. 2) showed different patterns. At some stations the maximum concentration was recorded at the surface, while at others it was found at different depths.

The surface nitrate showed very wide range of variations particularly in Saudi water. However, the average value in Saudi water was slightly higher than in Qatari water, whilst Kuwaiti water was of the lowest nitrate content (Table 1). Along the water column, nitrate at the most stations showed gradual increase in the upper 10 m and then it either increased or decreased (Fig. 2).

The phosphate content in the surface water varied widely in both Saudi and Qatari waters (Table 1). The highest concentration was recorded in Qatari water. Vertically, phosphate increased mostly with depth to 10 m while deeper it decreased at stations, G, I, J, K & L and increased at stations E, F & H (Fig. 3).

The nitrate-phosphate ratio in the northwest Gulf was significantly low (Table 2). This may indicate a low nitrogen supply and the lack of nutrient balance.

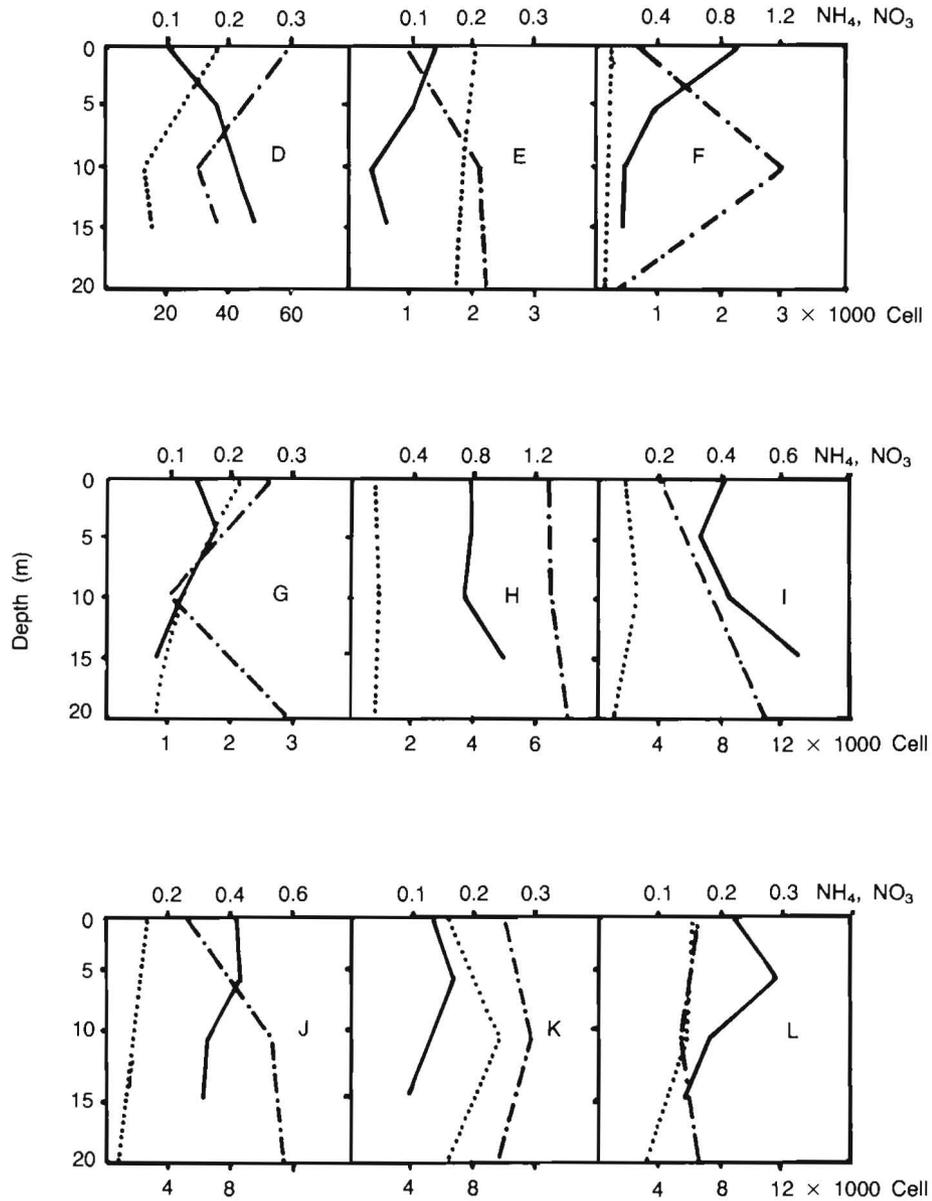


Fig. 2. Vertical distribution of the phytoplankton standing crop (cell 1⁻¹), ammonia and nitrate ($\mu\text{g at l}^{-1}$) at several stations. Nov. 1984 (St. crop, —, NH₄....., NO₃-.-.-, Stations: D,E,F,)

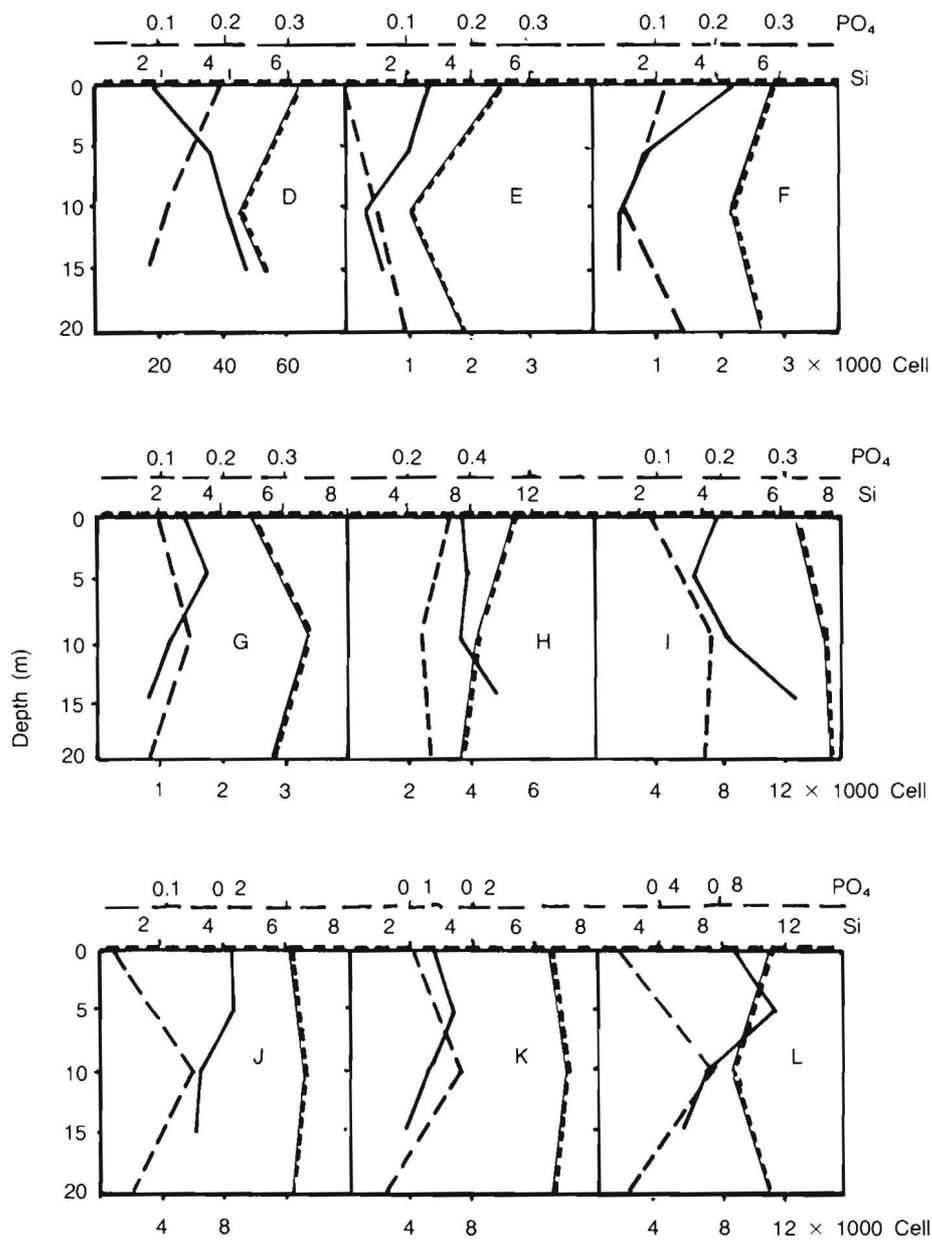


Fig. 3. Vertical distribution of the phytoplankton standing crop (celle l^{-1}), phosphate and dissolved silicon ($\mu\text{g at l}^{-1}$) at several stations, Nov. 1984 (St. crop —, PO₄ ---, Si; Stations: D,E,F,)

Table 2. Nitrate-phosphate ratio at the different stations in the investigated areas

Station no.	N/P	Station no.	N/P
O	4.70	H	8.25
N	3.97	G	6.03
L	2.54	F	4.58
K	5.58	J	28.80
I	4.68	D	3.32

The surface distribution of dissolved silica showed that the Kuwaiti water were characterized by significantly high values, compared to Saudi and Qatari waters (Table 1). This may be attributed to the fresh water inflow entering the northwestern end of the Gulf from Shatt el-Arab. Along the water column, distribution of dissolved silica was not similar at the different stations (Fig. 3). At some stations the concentration increased with depth up to 10 m and then decreased. The opposite was observed at other profiled stations. Generally, the dissolved silica was moderately high in the investigated areas.

From the above Figure, it is clear that there is a disturbance in the distribution of the nutrient salts along the water depth in the northwestern part of the Arabian Gulf. According to Jackson (1978-1981) the NW wind system in the Gulf area affects the oceanography of the Gulf water. The later conditions may have an impact on the irregular distribution of the nutrients in the Gulf.

Phytoplankton, Biomass Measurements and Temporal Changes

The autumn phytoplankton, in the investigated area, was characterized by significant diversity of species and low biomass as in Gamal and Pavlov (1981). The maximum number of phytoplankton taxa recorded in the area (223) consisted of 134 species and varieties of diatoms, 86 of dinoflagellates, 2 blue green algae and 1 silicoflagellate.

As shown in Table 3 the populations of diatoms in Kuwaiti, Saudi and Qatari waters were represented by nearly the same number of species. The dinoflagellates were significantly varied, indicating the high diversity of Qatari population compared to the other two regions. However, a total of 80 diatom and dinoflagellate species were observed in the all parts of the northwest Gulf. Other species of the two groups were found to be restricted to each of the three concerned regions (Table 4). The number of diatom species restricted to Kuwaiti and Qatari waters were nearly the same but twice that restricted to Saudi water. Otherwise, the dinoflagellates restricted to Qatari water were significantly higher than those in the other two regions (Table 4). Such differences in species composition point to the variations in the water quality in the study area during autumn.

Table 3. Distribution of the phytoplankton taxa in different parts of the investigated area, Nov. 1984

Area	Diatoms			Dinoflagellates		
	G.	sp.	var.	G.	sp.	var.
Kuwait	55	88	4	19	37	1
Saudi Arabia	56	83	5	27	53	3
Qatar	48	82	5	31	63	5
Total	49	125	13	19	81	5

Table 4. Comparison of the occurrence of diatoms and dinoflagellates from the areas studied + species present; - species absent

Diatoms	Kuwaiti waters	Saudi waters	Qatari waters
<i>Actinopterychus senarius</i>	-	+	-
<i>Amphiprora alata</i>	+	+	+
<i>A. gigantea</i>	-	-	+
<i>Amphora osrearia</i>	-	-	+
<i>A. ovalis</i>	-	-	+
<i>A. rostrata</i>	-	-	+
<i>Asteromphalus cleveanus</i>	+	+	-
<i>A. flabellatus</i>	-	+	-
<i>A. heptactis</i>	+	-	-
<i>Bacillaria paxillifer</i>	+	+	+
<i>Bacteriastrium delicatulum</i>	+	-	-
<i>B. elongatum</i>	-	+	-
<i>B. hyalinum</i>	+	+	-
<i>B. hyalinum</i> var. <i>princeps</i>	+	-	-
<i>B. mediterraneum</i>	+	-	-
<i>B. varians</i>	+	+	-
<i>Bellerochea malleus</i>	+	+	+
<i>Biddulphia alternans</i>	-	+	-
<i>B. aurita</i>	-	-	+
<i>B. mobiliensis</i>	+	+	+
<i>B. regia</i>	+	+	-
<i>B. sinensis</i>	+	+	+
<i>B. thuomeyi</i>	-	-	+
<i>Cerataulina pelagica</i>	+	+	+
<i>Chaetoceros affine</i>	+	+	+
<i>Ch. atlanticum</i>	+	-	-
<i>Ch. atlanticum</i> f. <i>audax</i>	+	+	+
<i>Ch. breve</i>	+	+	+
<i>Ch. coarctatum</i>	+	+	+
<i>Ch. compressum</i>	+	-	-
<i>Ch. crinitum</i>	+	-	-

Table 4. Contd.

Diatoms	Kuwaiti waters	Saudi waters	Qatari waters
<i>Ch. curvisetum</i>	+	+	+
<i>Ch. danicum</i>	+	-	-
<i>Ch. decipiens</i>	+	+	+
<i>Ch. densum</i>	-	-	+
<i>Ch. denticulatum</i>	+	+	+
<i>Ch. diadema</i>	+	-	-
<i>Ch. didymum</i>	+	+	+
<i>Chaetoceros didymum</i> var. <i>protuberans</i>	+	+	-
<i>Ch. diversum</i>	+	+	+
<i>Ch. glandazii</i>	+	-	-
<i>Ch. lacinosum</i>	+	-	-
<i>Ch. laeve</i>	+	+	-
<i>Ch. lorenzianum</i>	+	-	-
<i>Ch. pendulum</i>	-	-	+
<i>Ch. peruvianum</i>	+	+	+
<i>Ch. peruvianum</i> var. <i>gracilis</i>	-	+	-
<i>Ch. tortissimum</i>	+	-	-
<i>Climacodium frauenfeldianum</i>	+	+	+
<i>Climacosphenia moniligera</i>	+	+	+
<i>Corethron criophylum</i>	+	+	+
<i>Coscinodiscus excentricus</i>	+	+	-
<i>C. gigas</i>	+	+	-
<i>C. granii</i>	+	-	-
<i>C. nitidus</i>	+	+	+
<i>C. oculus-iridis</i>	+	-	-
<i>C. perforatus</i>	-	+	+
<i>C. radiatus</i>	+	+	+
<i>C. thorii</i>	+	+	-
<i>C. wailesii</i>	-	+	+
<i>Coscinosira polychorda</i>	+	+	+
<i>Cyclotella</i> sp.	+	+	+
<i>Diploneis crabro</i>	+	+	+
<i>Ditylum brightwellii</i>	+	+	-
<i>D. sol</i>	+	+	-
<i>Donkinia recta</i>	-	-	+
<i>Ethmodiscus gazellae</i>	+	+	+
<i>Eucampia cornutum</i>	-	-	+
<i>E. zodiacus</i>	+	+	+
<i>Eupodiscus radiatus</i>	+	-	-
<i>Fragilaria intermedia</i>	-	+	-
<i>F. islandica</i>	-	-	+
<i>Grammatophora marina</i>	+	-	-
<i>Guinardia flaccida</i>	+	+	+
<i>Hemiaulus membranaceus</i>	+	+	-
<i>H. sinensis</i>	+	+	+
<i>Hemidiscus cuneiformis</i>	+	+	+

Table 4. Contd.

Diatoms	Kuwaiti waters	Saudi waters	Qatari waters
<i>H. hardmanianus</i>	+	-	-
<i>Lauderia borealis</i>	+	+	+
<i>Leptocylindrus danicus</i>	+	-	+
<i>Lithodesmium undulatum</i>	+	-	-
<i>Mastogloia lineata</i>	-	-	+
<i>Navicula atlantica</i>	-	-	+
<i>N. lyra</i>	-	+	+
<i>N. lyroides</i>	-	-	+
<i>N. sp.</i>	+	+	+
<i>Nitzschia angularis</i>	+	-	-
<i>N. closterium</i>	-	+	-
<i>N. delicatissima</i>	+	+	-
<i>N. longissima</i>	-	-	+
<i>N. longissima</i> var. <i>reversa</i>	-	+	+
<i>N. seriata</i>	+	+	+
<i>N. sigma</i>	-	+	-
<i>N. sigma</i> var. <i>intercedens</i>	-	-	+
<i>N. sigmoidea</i>	+	+	+
<i>Paralia sulcata</i>	+	+	+
<i>Plagiogramma vanhcurckii</i>	-	+	-
<i>Planktoniella sol</i>	+	+	-
<i>Pleurosigma angulatum</i>	+	+	+
<i>P. directum</i>	-	+	+
<i>Podosira stelliger</i>	-	+	+
<i>Rhizosolenia alata</i> f. <i>alata</i>	-	+	+
<i>Rh. alata</i> f. <i>gracillima</i>	+	+	+
<i>Rh. alata</i> f. <i>indica</i>	+	+	+
<i>Rh. bergonii</i>	+	+	+
<i>Rh. calcar-avis</i>	+	+	+
<i>Rh. clevei</i>	+	+	+
<i>Rh. cochlea</i>	+	-	+
<i>Rh. fragilissima</i>	-	-	+
<i>Rh. hebetata</i> f. <i>semispina</i>	+	+	+
<i>Rh. imbricata</i>	+	+	+
<i>Rh. robusta</i>	+	+	+
<i>Rh. setigera</i>	+	+	+
<i>Rh. shrubsolei</i>	-	+	+
<i>Rh. stolterlothii</i>	+	+	+
<i>Rh. styliformis</i>	+	-	-
<i>Rh. styliformis</i> f. <i>latissima</i>	-	-	+
<i>Skletonema costatum</i>	-	+	-
<i>Stauroneis membranacea</i>	+	+	+
<i>Stephanopyxis palmeriana</i>	-	+	-
<i>Streptotheca thamesis</i>	+	+	+
<i>Surirella fastuosa</i>	+	+	+
<i>S. gemma</i>	+	-	-

Table 4. Contd.

Diatoms	Kuwaiti waters	Saudi waters	Qatari waters
<i>S. javanica</i>	—	—	+
<i>Synedra hennedyana</i>	—	+	+
<i>S. undulata</i>	—	+	+
<i>Thalassionema nitzschioides</i>	+	+	+
<i>Thalassiosira subtilis</i>	+	+	+
<i>Thalassiothrix curvata</i>	—	—	+
<i>Th. frauenfeldii</i>	+	+	+
<i>Th. longissima</i>	+	+	+
<i>Th. mediterranea</i> var. <i>pacifica</i>	+	—	—
<i>Triceratium favus</i>	+	+	+
<i>T. formosum</i> f. <i>pentagonales</i>	—	—	+
Dinoflagellates			
<i>Ceratium arietinum</i>	+	+	+
<i>C. boebmi</i>	—	+	+
<i>C. breve</i>	+	+	+
<i>C. candelabrum</i>	—	—	+
<i>C. declinatum</i>	—	+	—
<i>C. deflexum</i>	+	+	+
<i>C. dens</i>	+	+	+
<i>C. extensum</i>	—	—	+
<i>C. falcatum</i>	+	—	+
<i>C. furca</i>	+	+	+
<i>C. furca</i> var. <i>eugrammum</i>	—	+	+
<i>C. fusus</i>	+	+	+
<i>C. fusus</i> var. <i>seta</i>	—	—	+
<i>C. gallicum</i>	—	+	+
<i>C. gibberum</i>	+	+	—
<i>C. horridum</i>	+	+	—
<i>C. inflatum</i>	—	—	+
<i>C. kofoidii</i>	+	+	+
<i>C. lineatum</i>	—	—	+
<i>C. macroceros</i>	—	—	+
<i>C. massiliense</i>	+	+	+
<i>C. massiliense</i> var. <i>protuberans</i>	—	+	+
<i>Ceratium minutum</i>	—	—	+
<i>C. pennatum</i>	+	+	+
<i>C. sumatranum</i>	—	+	—
<i>C. trichoceros</i>	+	+	+
<i>C. tripos</i>	+	+	+
<i>C. vultur</i>	—	+	—
<i>Ceratocorys armata</i>	+	—	+
<i>Dinophysis caudata</i>	+	+	+
<i>D. caudata</i> var. <i>tripos</i>	+	+	+

Table 4. Contd.

Diatoms	Kuwaiti waters	Saudi waters	Qatari waters
<i>D. uracantha</i>	-	+	-
<i>Exuviaella compressa</i>	-	+	+
<i>Glenodinium borges</i>	-	-	+
<i>Gonyaulax diacantha</i>	+	-	+
<i>G. diegensis</i>	+	-	-
<i>G. digitale</i>	+	+	+
<i>G. monocantha</i>	+	+	+
<i>G. Polyedra</i>	-	+	-
<i>G. polygramma</i>	-	+	+
<i>Gymnodinium fuscum</i>	-	-	+
<i>G. sp.</i>	-	-	+
<i>Hemidinium nasutum</i>	+	+	+
<i>Histioneis elongata</i>	-	-	+
<i>H. vouckii</i>	-	+	+
<i>Ornithocercus splendidus</i>	-	+	-
<i>O. steinii</i>	-	-	+
<i>O. thurnii</i>	+	+	+
<i>Oxytoxum curvatum</i>	+	+	-
<i>O. scolopax</i>	-	+	-
<i>Phalacroma acuta</i>	-	-	+
<i>P. rapa</i>	-	+	+
<i>P. rotundatum</i>	-	-	+
<i>Podolampas bipes</i>	-	+	+
<i>P. elegans</i>	-	+	+
<i>P. palmipes</i>	-	-	+
<i>Prorocentrum micans</i>	+	+	+
<i>P. scutellum</i>	-	-	+
<i>Protoperidinium cerasus</i>	-	-	+
<i>P. conicum</i>	+	+	+
<i>P. conicum var. asamubsi</i>	-	-	+
<i>P. depressum</i>	+	+	+
<i>Protoperidinium diabolus</i>	-	+	+
<i>P. divergens</i>	+	+	+
<i>P. globulus</i>	-	-	+
<i>P. grande</i>	-	+	+
<i>P. granii</i>	+	+	+
<i>P. heterocanthum</i>	-	-	+
<i>P. leonis</i>	+	+	+
<i>P. minutum</i>	+	-	-
<i>P. murrayi</i>	-	+	+
<i>P. oceanicum</i>	+	+	+
<i>P. ovatum</i>	-	+	+
<i>P. ovum</i>	+	+	-
<i>P. pallidum</i>	-	-	+
<i>P. pellucidum</i>	-	+	-
<i>P. pendunculatum</i>	+	+	-

Table 4. Contd.

Diatoms	Kuwaiti waters	Saudi waters	Qatari waters
<i>P. steinii</i>	-	-	+
<i>Pseudophalacroma nasatum</i>	-	-	+
<i>Pyrocystis fusiformis</i>	+	+	+
<i>P. lunula</i>	+	-	-
<i>P. noctiluca</i>	-	+	-
<i>P. obtusa</i>	+	-	+
<i>P. pseudonociluca</i>	-	+	-
<i>Pyrophacus horologium</i>	+	+	+
<i>Triadinium polyedricum</i>	-	+	+
Silicoflagellates			
<i>Dictyocha fibula</i>	+	+	+
Blue green algae			
<i>Anabaena</i> sp.	-	+	+
<i>Trichodesmium</i> sp.	-	+	+

The dominant diatom species in the whole area were *Thalassionema nitzschioides*, *Thalassiothrix frauenfeldii* and *Climacodium frauenfeldianum*. In addition to these species, *Chaetoceros* sp. dominated in Saudi and Kuwaiti waters. The dinoflagellates were dominated by *Ceratocorys magna* (st. D only), *Ornithocercus thurnii*, *Dinophysis caudata*, *D. caudata* var. *tripos*, *Ceratium massiliense* and *C. furca*. It is worth mentioning that, the blue green algae: *Anabaena* sp. and *Trichodesmium* sp. were the most abundant among the phytoplankton species in both Saudi and Qatari waters. These two algae may contribute to the slightly higher nitrate-phosphate ratio in the latter two regions as a result of nitrogen fixation compared to Kuwaiti water, which was depleted of such algae. El-Samra, Moftah *et al.* (1986) detected the algal nitrogen fixation in the Gulf water in autumn. This may indicate the importance of this source in the total nitrogen budget of the Gulf. El-Samra, Moftah *et al.* (1986) estimated the contribution of nitrogen fixation to be $0.4-6.3 \text{ kg N km}^{-2} \text{ day}^{-1}$.

The standing crop in the surface water was significantly low in the whole area. The cell count varied between 1400 and 42000 cells l^{-1} (Fig. 4). The extremely low values (1400-2200 cells l^{-1}) were observed at stations E, F & G. This may be attributed to the effect of the oil pollution. El-Samra, Moftah *et al.* (1986) observed the highest level of oil pollution at these stations.

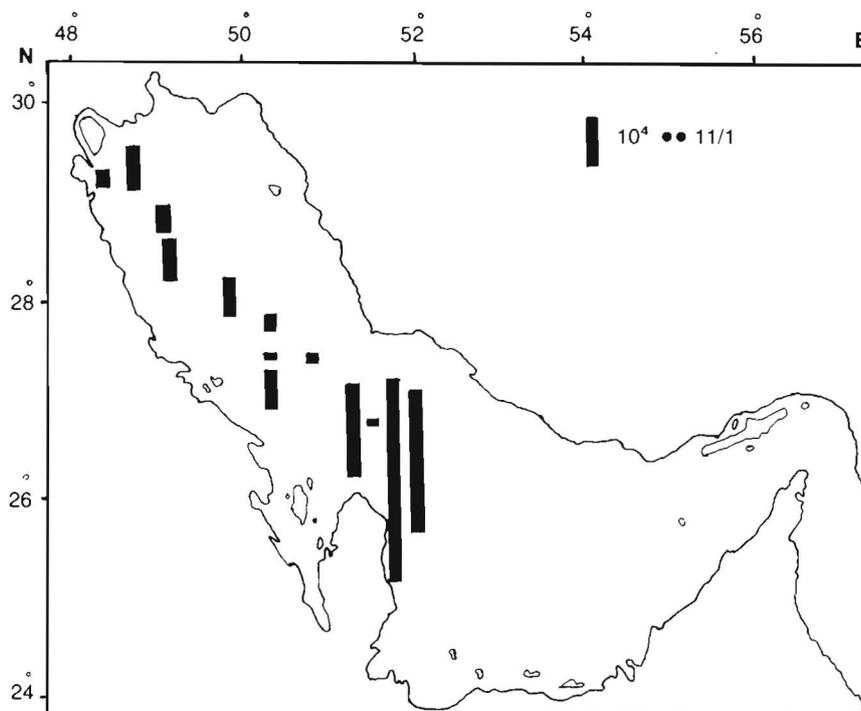


Fig. 4. Distribution of the standing crop of the phytoplankton in the surface water of the Northwest Gulf, Nov. 1984.

The population densities of the diatoms and dinoflagellates were subjected to significant variations in different regions (Fig. 5). In Qatari water, dinoflagellates represented 9-23% and diatoms up to 73%. In Kuwaiti water, dinoflagellates showed higher percentage: 31-42% of the total biomass. Two patterns were observed in Saudi water; the oil-polluted region (Sts. E, F & G) was characterised by a larger number of dinoflagellates (38-65%), while in other parts they did not exceed 30%. Furthermore, the number of diatom species was significantly higher than dinoflagellates at most stations of the area, but the opposite figure was observed at the highly polluted stations. The abundance and higher diversity of dinoflagellates in the polluted area may indicate their greater tolerance to the oil pollution than the diatoms.

The low standing crop, the irregular distribution of diatoms and dinoflagellates, and the variations in the dominance of species in the different regions of the northwest Gulf were related to the prevailing ecological conditions. Such conditions are the lack of nutrient balance and oil pollution. El-Samra, Emara *et*

al. (1986) recorded the highest concentration of the dissolved hydrocarbon ($546.4 \mu\text{g l}^{-1}$) in Saudi water, particularly in the area of the significantly low phytoplankton biomass. Moreover, the oil pollution in the Arabian Gulf is 47 times the average estimated amount for a marine environment of similar area (Golob and Brus 1984).

Vertical distribution of the standing crop showed that the maximum values were found mostly within the depth range: 5-15 m (Fig. 2).

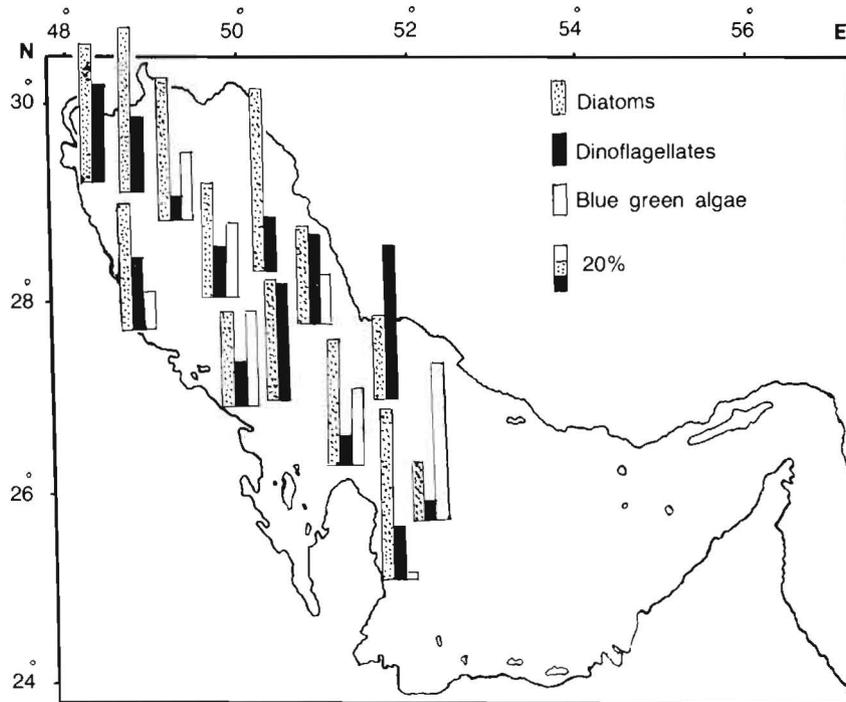


Fig. 5. Percentage of the major groups of the phytoplankton in different parts of the Northwest Gulf, Nov. 1984

Comparisons from previous work on the Gulf phytoplankton with the present work showed that significant variations occurred. The total phytoplankton taxa recorded in the whole Gulf in December 1968 (Al-Kaisi 1976) were 275 and in Kuwaiti water in 1972 were 116 taxa (Gamal and Pavlov 1981). In the present work, 223 taxa were recorded during November in the northwestern part of the Arabian Gulf. The generic and species composition of the phytoplankton

population showed significant variations over the past 15 years. In Kuwaiti water, the number of the diatom genera increased, but the number of species decreased (Tables 3 & 5). On the other hand, the number of genera and species of the dinoflagellates increased in Kuwaiti and Qatari regions.

Table 5. Distribution of the phytoplankton taxa in different parts of the investigated area. Dec. 1968 (Al-Kaisi 1976)

Area	Diatoms			Dinoflagellates		
	G.	sp.	var.	G.	sp.	var.
Kuwait	46	135	19	6	13	—
Saudi Arabia	—	—	—	—	—	—
Qatar	47	72	11	12	40	3
Total	51	160	19	17	49	3

The apparent increase in the number of the dinoflagellate species listed in the available records throughout the last 60 years may be an indication of the allochthonous origin of some of them (Table 6). The current regime in the Gulf supports this assumption as many species can be transferred into the gulf from the Arabian sea and Gulf of Oman. The same conditions are also considered for diatoms. According to the available data (Dorgham and Muftah 1987, and unpublished data) the phytoplankton population of the Arabian Gulf is more diversified than that of the Arabian Sea observed by Wood (1963) and that mentioned by Halim (1969) of the Red Sea.

Table 6. Change of the number of the dinoflagellate species in the Arabian Gulf throughout the past 60 years

No. of species	Area	Reference
34	Whole Iranian waters	Bohm, 1931
102	Arabian Gulf	Al-Khaisi, 1976
152	Qatari waters	Dorgham & Muftah, 1987
192	Qatari and U.A.E. waters	Dorgham & Muftah, (unpublished data)

Concerning the dominance of species, significant variations were observed. In Kuwaiti water, the autumn phytoplankton was dominated by *Coscinodiscus* sp., *Hemidiscus* sp. *Chaetoceros* sp. and *Oscillatoria* sp. (Al-Kaisi 1976). In the present

work, the dominant species in Kuwaiti water were *Thalassiothrix frauenfeldii*, *Chaetoceros* sp., *Thalassionema nitzschioides*, *Biddulphia sinensis* and *Coscinodiscus* sp. The blue green alga *Oscillatoria (Trichodesmium)* sp. was completely absent from Kuwaiti water.

Regarding the occurrence of species in different regions, it is to be noted that, most species recorded by Al-Kaisi (1976) as restricted to Qatari or Kuwaiti waters were not observed during autumn 1984. Some of these species were found in the whole area of investigation, such as *Protoperidinium depressum*, *Ceratium furca*, *Asteromphalus cleveanus*, *Bacillaria paxillifer*, *Biddulphia sinensis*, *Guinardia flaccida* and *Thalassionema nitzschioides*.

The low standing crop of phytoplankton in Kuwaiti water as well as in the whole area during autumn was also detected by Gamal and Pavlov (1981). Similar observations were recorded in Kuwaiti water within the period; January-March 1979 (Jacob *et al.* 1979 b). According to Al-Kaisi (1976), the values of average standing crop in Kuwaiti and Qatari waters during Dec. 1968 (197000 and 148000 cell l^{-1} respectively) were 32 and 4 times those found in the two regions in Nov. 1984 or 22 times that in Kuwaiti water during January-March 1979 observed by Jacob *et al.* 1979 b). These variations in the standing crop throughout the past 15 years may well reflect the impact of the disturbance in the nutrient distribution and oil pollution in the area.

Conclusion

The investigated area was characterized by a low nitrate-phosphate ratio and disturbance in the distribution of the nutrient salts. Data from other sources (El-Samra, Emarat *et al.* 1986) have shown that the oil pollution was significantly detected either as oil spills on the surface water or as dissolved hydrocarbon with high levels at some stations.

In the northwest Arabian Gulf, the changeable environmental conditions, particularly in the past 15 years were reflected on the phytoplankton population. The population showed a high species diversity but low biomass.

The assemblages of the phytoplankton in the whole investigated area were 223 species and varieties and belong mainly to diatoms (134) and dinoflagellates (86). The number of diatom taxa recorded in Kuwaiti, Saudi and Qatari waters were nearly similar, while for the dinoflagellates significant regional variations were observed. However, the dominant species of both phytoplankton groups were nearly the same in the three regions.

The low biomass in the whole area may be attributed to the low nitrate-phosphate ratio and to the effect of the oil pollution.

The current regime in the Arabian Gulf leads to the transference of many phytoplankton species from the Arabian Sea and Gulf of Oman.

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دراسات حول العوالق النباتية في الخليج العربي ٢ - عوالق الخريف النباتية في الجزء الشمالي الغربي

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يتركز البحث في دراسة التوزيع الأفقي والرأسي للعوالق النباتية في الجزء الشمالي الغربي من الخليج العربي خلال فصل الخريف في ضوء الظروف البيئية السائدة. جمعت لذلك عينات من ثلاث عشرة محطة في المياه الإقليمية لكل من الكويت والسعودية وقطر، حيث تم تعريف أنواع العوالق النباتية الموجودة في المناطق الثلاث خلال فصل الخريف وكذلك تقدير المحصول القائم لها (عدد الخلايا في اللتر) في المياه السطحية وعند أعماق ٥، ١٠، ١٥ متر. وللتعرف على العوامل البيئية السائدة في منطقة البحث في ذلك الوقت تم تعيين تركيزات الأملاح المغذية وخاصة الأمونيا والنترات والفوسفات والسليكون الذائب عند الأعماق السابق ذكرها. بالإضافة إلى رصد درجات حرارة المياه ودرجات الملوحة في المياه السطحية وكذلك كمية الأكسجين الذائب في الماء عند أعماق مختلفة. تميزت المنطقة خلال فترة البحث بانخفاض النسبة بين ملحي النترات والفوسفات وعدم التوازن في توزيع الأملاح المغذية، كما تميزت المياه الكويتية بارتفاع كمية السليكون الذائب بدرجة ملحوظة عن المياه السعودية والقطرية، كما بدا واضحا التلوث البترولي في بعض المحطات، إما على هيئة بقع زيتية على سطح الماء، أو في صورة هيدروكربونات ذائبة.

بلغ عدد أنواع العوالق النباتية التي سجلت في منطقة البحث خلال فصل الخريف ٢٢٣ مصنفاً غالبيتها العظمى من الطحالب المشطورة (الدياتومات) وثنائيات السيات. وقد لوحظ أن أعداد أنواع الطحالب المشطورة متساو تقريباً في كل من المياه الكويتية والسعودية والقطرية، بينما ظهر تباين واضح في أعداد أنواع ثنائيات السيات بين المناطق الثلاث، ومع ذلك فإن الأنواع السائدة من هاتين المجموعتين كانت

متشابهة في كل أجزاء منطقة البحث .
تبين من دراسة المحصول القائم للعوالق النباتية إنخفاضه بدرجة ملحوظة وقد لوحظ أن أعلى قيمة توجد عادة عند أعماق تتراوح بين ٥ - ١٠ أمتار، وقد عزى إنخفاض المحصول القائم إلى التلوث البترولي وعدم التوازن بين الأملاح المغذية .
وبمقارنة نتائج البحث الحالي مع نتائج سابقة لباحثين آخرين على نفس المنطقة وجد أنه قد حدثت تغيرات واضحة في أنواع العوالق النباتية السائدة وكذلك في عدد الأنواع الكلي للطحالب المشطورة وثنائيات السياط . . كما لوحظت زيادة مطردة في عدد أنواع ثنائيات السياط في مياه الخليج العربي خلال الـ ٦٠ عاماً الماضية مما يشير إلى إحتمال دخول أنواع جديدة من بحر العرب وخليج عُمان . . الأمر الذي جعل مجتمع العوالق النباتية في الخليج العربي أكثر تنوعاً من البيئات المجاورة في بحر العرب وخليج عُمان .