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SPATIAL VARIABILITY OF THE SPRING PHYTOPLANKTON DISTRIBUTION IN PORT SAID COAST (EGYPT).

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Abstract

The coastal area of Port Said is subjected to water exchange with two different water bodies, the Suez Canal and Lake Manzalah. Samples were collected from area subjected to both Suez Canal and Lake Manzalah waters (western coast), also from area eastern coast of Port Said and from the northern entrance of the Suez Canal in spring of two years 2004 and 2005. Surface water temperature, salinity, pH and dissolved oxygen were measured and phytoplankton species composition and abundance were studied. Surface water salinity showed visible variations along the coast with values ranged between 26 ‰ and 40 ‰. The western coast in front of lake Manzalah displayed the lowest number of phytoplankton species (14 species) with the highest standing crop (273 $x10^3$ individuals/L). The diatoms were the dominant group in both western and eastern coasts; by contrast, the dinoflagellates dominated all the phytoplankton groups at the coastal area near to the mouth of the Suez Canal. Phytoplankton community of the Port Said coast was dominated with different species. Western area was dominated by *Cyclotella menegheniana*, *Nitzschia closterium*, *Cyclotella kutzingiana*, *Anabaena torulosa* and *Anabaena spiroides* while eastern coast was dominated by *Synedra pulchella*. The lowest values of diversity indices were observed in the western coast during both two seasons and in the eastern coast in spring 2005. Different phytoplankton species composition and abundance were observed at the same stations in the springs of the two years. The variations of phytoplankton community structure and abundance at the coastal area of Port Said were discussed.

Key words: Phytoplankton – Port Said – Species diversity – Suez Canal –Lake Manzalah.

Introduction

For more than a million of years, the regular autumnal flood of the River Nile remained the most important environmental phenomenon in the south eastern part of the Levant. Each year from late summer throughout the autumn the River Nile discharged huge quantities of biogenic salts into the coastal waters of the south eastern Mediterranean rendering them fertile and teeming with marine life (Dowidar, 1984). After the construction of the Aswan High Dam only a modest flow (not exceeding $1/15^{th}$ of the former water discharge) reaches the Mediterranean Sea. The subsequent abrupt curtailment of the seasonal out-flow of nutrient-rich Nile flood water into the sea has had dramatic changes in the

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biological and physico-chemical characteristics of the water of the Egyptian coasts.

In the 18th and 19th centuries, the Egyptian coasts had been subjected to the effect of two important man made events, the opening of the Suez Canal in 1869 and the damming of the River Nile in 1965. In the case of Port Said coast, the surface water is predominantly of Mediterranean origin which influenced greatly by the two water bodies, the Suez Canal and Lake Manzalah. According to available literature, a considerable large number of erythrean species have migrated through the Suez Canal to invade the eastern Mediterranean (Halim, 1963, 1970, 1990; Ben-Tuvia, 1966, 1978; Steinitz, 1967; Dowidar, 1971, 1974, 1976; Dowidar and Ramadan, 1972; Ramadan and Dowidar, 1972, Dorgham, 1985; Por, 1990; Kimor, 1990; Madkour, 2000). The introduction and success of many of these species in the south eastern Mediterranean, undoubtedly, have affected the structure of the total community which previously has been stable. In addition, the western coast of Port Said is subjected to outflow of brackish water discharged from Lake Manzalah throughout Boughaz El-Gamil. The degree of freshening caused by the outflowing lake water has a seasonal variation according to the prevailing wind in the area, which is mostly north to north-west with a velocity ranging between 6 and 14.5 knots (Amer, 1999).

Phytoplankton studies in the south-eastern Mediterranean have been performed mostly on the Egyptian coast. The majority of these studies have concentrated on localized areas of the Alexandria inshore waters, such as Abu-Kir Bay (Dorgham and Osman, 1987; Samaan and Mikhail, 1990; El- Sherif and Gharib, 1994) and Eastern and Western Harbors (El-Maghraby and Halim, 1965; Zaghloul and Halim, 1990; Labib, 1994). Other investigations have extended to include the whole coastal water of Alexandria or other areas of the Egyptian coasts rather than Port Said area (El-Sherif, 1989; Zaghloul, 1992, 1994; Dorgham, 1997). The present study deals with the spatial distribution of the phytoplankton in the surface water of Port Said coast during spring with respect to the effect of the two different water bodies joined with the coast on this distribution. Also it compares the composition and abundance of phytoplankton during spring seasons of the two years 2004 and 2005.

Materials and Methods

Surface water samples were collected from localities along the coast of Port Said during springs of two years 2004 and 2005. Station 1 is situated in front of the mouth of Boughaz El-Gamil at the western coast of Port Said which is subjected to the brackish water discharged from Lake Manzalah. Station 2 lies at the fishing harbor close to the northern entrance of the Suez Canal and station 3

was taken in the navigable channel at the extreme northern entrance of the Suez Canal. Station 4 is situated at the eastern coast of Port Said (Fig. 1).

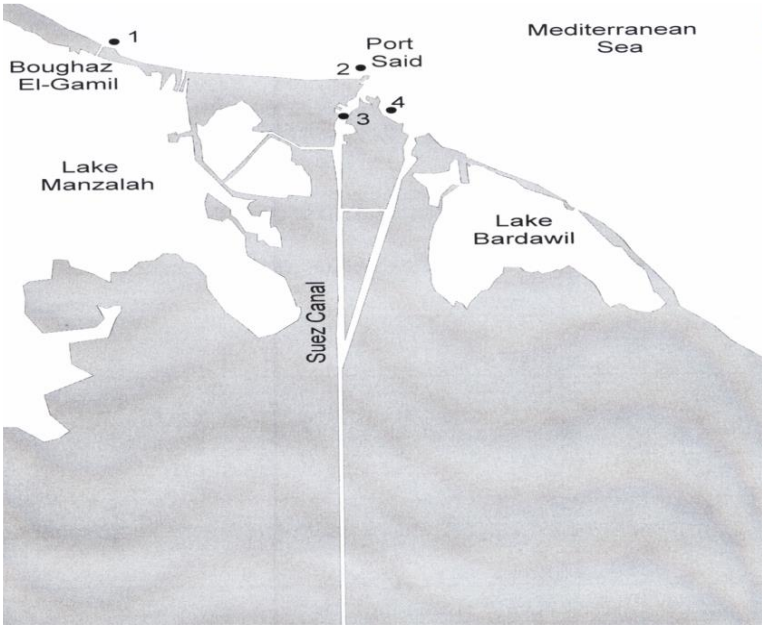

Figure (1): Map of Investigation Sites.

Surface water samples for phytoplankton investigation were collected by 2 L bottles and preserved immediately in 4% formalin. Phytoplankton samples were concentrated by sedimentation method and the abundance of different species was calculated as their total number per liter (individuals/L). The phytoplankton was identified to species level using inverted microscope and the main references used for identification were Lebour (1925, 1930), Cupp (1943), Prescott (1951), Hendey (1964), Dodge (1982) and Tomas (1996).

The following parameters were measured in the field: temperature was measured by a glass mercuric 110°C thermometer graduated to 0.5°C. and salinity by a hand refractometer (ATAGO, Salinity 0-100 ‰). Dissolved oxygen was measured using an oxygen meter (Cole Palmer) and pH by a pH-meter (JENWAY, Model 3070). Diversity indices were calculated using a computer program PRIMER version 5.2.2. Species diversity index was calculated based on Shannon-Weaver (1963) index. Species richness was worked out using

Margalef's (1958) formula and evenness was computed using Pielou's (1977) formula.

Results

Hydrographical Conditions

The surface water temperature of the all investigated area showed almost close values during the same season. Temperature variation between two seasons at each station was generally small and not exceeding 0.4 ºC with values ranged between 26ºC at station 4 during spring 2004 and 26.6 ºC at station 2 during spring 2005 (Fig. 2a).

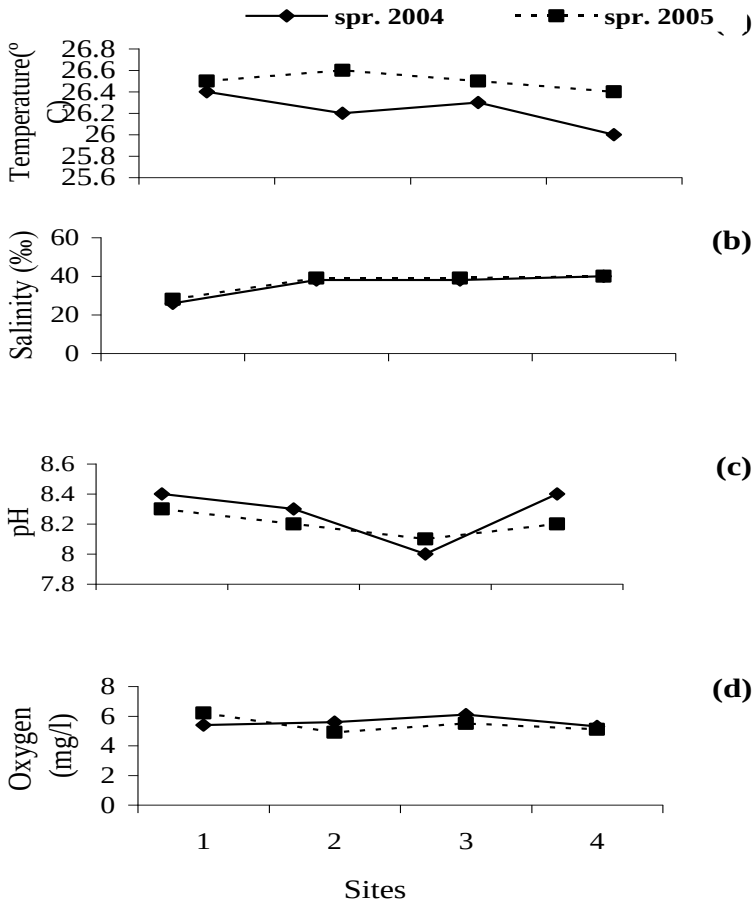

Figure (2): Surface water temperature (a), salinity (b), pH (c) and oxygen (d) at sampling sites.

The surface water salinity at Port Said coast varied according to the different inputs to the coast but with relatively similar trend during both two seasons as shown in Figure (2b). Station 1 which is subjected to the discharges of brackish waters from Lake Manzalah, displayed the lowest value of salinity when the value of the salinity did not exceed 28 ‰ while station 4 observed the highest values of salinity (40 ‰) during both two seasons. The effect of Suez Canal waters on the salinity of the joined coastal area (station 2) was obvious when the same values of salinity were recorded for both stations 2 and 3 during two seasons.

As shown in Figure (2c), the pH of the study area was in the alkaline range. The range of pH during spring 2004 was slightly higher than in spring 2005 except at station 3 and the values of pH fluctuated within a narrow range (8 and 8.4).

The values of dissolved oxygen showed that the surface water of the investigated area was generally well oxygenated (Fig. 2d). The variations between two seasons were rather less pronounced with slightly higher values during spring 2004 except at station 1.The values of dissolved oxygen varied between 4.9 mg O_2/l at station 2 and 6.2 mg O_2/L at station 1 both during spring 2005.

Phytoplankton Composition and Abundance

A total of 75 species of phytoplankton belonging to 5 groups were identified in the present study (Table 1). The most dominant groups in terms of the number of species were diatoms (36 species) and dinoflagellates (28 species) while other groups were represented by a relatively small number of species. Species belonging to Chlorophyta and Cyanophyta were recorded only at station 1 while those belonging to Silicoflagellates were observed throughout the whole investigated area except at station 4. The total number of phytoplankton species observed almost similar distribution pattern within stations with obvious variability between two seasons (Fig. 3a). The highest total numbers of species were observed during spring 2004 throughout the all investigated area. Station 1 was distinguished by the lowest number of species with minimum species number of 14 species during spring 2005 while nearly similar numbers were observed in the other (between 23-27 species). Diatoms dominated other phytoplankton groups in the number of species at stations 1 and 4, by contrast dinoflagellates showed higher number of species at stations 2 and 3 (Figs. 3b, c).

As shown in Fig. 4a, station 1 was characterized by the highest value of the total phytoplankton standing crop during both two seasons with maximum of 273 x 10^3individuals/l during spring 2005. Also station 4 displayed relatively high value (29 x 10^3 individuals/L) during spring 2005. Conversely, stations 2 and 3 exhibited low values of total standing crop and cell number fluctuated between a

Table (1): The recorded phytoplankton species at Port Said coast during spring 2004 (S4) and spring 2005 (S5)

Species	1		2		3		4	
	S4	S5	S4	S5	S4	S5	S4	S5
Diatoms								
Amphiprora hyalina Eulenstein ex Van Heurck	x	x						
Biddulphia alternans (Bailey) Van Heurk				x				x
B. aurita (Lyngbye) de Brebisson			x				x	
B. laevis Ehrenberg			x					
B. mobiliensis (Bailey) Grunow ex Van Heurk		x		x				x
Cerataulus smithii Ralfs in Pritchard							x	x
Chaetoceros boreale Bailey			x	x	x	x	x	x
Campylodiscus echeneis Ehrenberg	x							
Cocconeis placentula Ehrenberg							x	x
Coscinodiscus centralis Ehrenberg			x	x	x	x		
C. excentricus Ehrenberg	x		x			x		
C. lineatus Ehrenberg							x	
Cyclotella capsia Grunow	x							
C. kutzingiana Th. Wattes	x						x	
C. meneghiniana Kutzing	x	x	x	x	x	x	x	x
Grammatophora marina (Lyngbye) Ktzing							x	x
Leptocylindrus danicus Cleve					x			
Licmophora flabellata (Greville) Agardh							x	x
L. lyngbyei (Kutzing) Grunow ex Van Heurck							x	x
Lithodesmium undulatum Ehrenberg							x	x
Melosira nummuloides Agardh		x	x					
Nitzschia closterium (Ehrenberg) Wm. Smith	x	x	x	x	x	x	x	x
N. seriata Cleve					x			
Pinnularia rectangulata (Gregory) Rabenhorst							x	x
Pleurosigma angulatum (Quekett) Wm. Smith			x	x			x	x
P. cuspidatum Cleve							x	
P. formosum Wm. Smith			x					
Rhizosolenia stolterfothii H. Peragallo						x		
Skeletonima costatum (Greville) Cleve				x	x	x		
Streptotheca tamensis Shrubsole					x		x	x
Surirella ovalis de Brebisson						x		
S. smithii Ralfs							x	
S. striatula Turpin	x	x						
Synedra pulchella Kutzing								x

Table (1): continue

Species	1		2		3		4	
	S4	S5	S4	S5	S4	S5	S4	S5
S. ulna (Nitzsch) Ehrenberg			x					
Thalassionema nitzschioides Hustedt				x		x	x	x
Dinoflagellates								
Amphidinium manannini Herdman			x	x				
Ceratium furca (Ehren.) Claparede and Lachmann			x	x	x	x	x	
C. lineatum (Ehrenberg) Cleve			x	x	x	x	x	x
C. tripos (O. F. Muller) Nitzsch			x					
Dinophysis acuminata Clap. and Lach.			x		x			
D. caudata Saville-Kent					x	x		
D. rotundata Clap. and Lach.							x	x
Glenodinium cinctum Ehrenberg	x	x						
Gonyaulax polygramma Stein								
G. spinifera (Clap. And Lach.) Diesing			x	x				
Oblea rotunda (lebour) Balech ex Sournia			x		x	x		
Oxytoxum sceptrum (Stein) Schroder			x	x	x	x	x	x
Podolampas palmipes Stein					x	x		
Prorocentrum gracile Schutt			x	x	x	x		
P. micans Ehrenberg	x		x		x	x	x	
P. minimum (Pavillard) Schiller					x		x	
Protoperidinium depressum (Bail) Balech			x	x	x	x		
P. diabolum (Cleve) Balech			x	x	x	x	x	
P. divergens (Ehrenberg) Balech			x	x	x			
P. globulum (Stein) Balech					x			
P. granii (Ostenf.) Balech			x		x			
P. inconspicum Ehrenberg		x						
P. steinii (Jorg.) Balech	x		x		x	x	x	
P. thulesense (Balech) Balech					x			
Pyrocystis noctiluca Murray ex Haeckel					x			
Scrippsiella trochoidea (Stein) Loeb. III					x	x		
Triadinium polyedricum (Pouchet) Dodge			x		x			
Zygabikodinium lenticulatum (Paul.) Loeb.and Loeb.			x	x	x	x	x	
Chlorophyta								
Ankistrodesmus falcatus (Corda) Ralfs	x							
Coelastrum microporum Naeg.	x							
Scenedesmus dimorphus (Turp.)	x	x						
S. quadricauda (Turp.) de Breb.	x	x						
Tetraedron minimum (A. Br.) Hansgirg	x							

Table (1): continue

Species	1		2		3		4	
	S4	S5	S4	S5	S4	S5	S4	S5
Cyanophyta								
Anabaena spiroides Klebahn		x						
A. torulosa Lagerheim		x						
Merismopedia tenussismia Lemmermann	x	x						
Phormidium sp.	x							
Silicoflagellates								
Dictyocha fibula Ehrenberg		x	x	x	x	x		
Octactis octonaria Ehrenberg			x		x			

minimum of 1190 individuals/l at station 2 during spring 2005 and a maximum of 7 x 10^3 individuals/Lat station 3 during spring 2004.

Among stations, the abundance of the taxonomic groups of phytoplankton displayed different patterns in which the diatoms were the most abundant group (Figs. 4b, c). The abundance of diatoms appeared obviously at station 1 during both two seasons. In spring 2004, the highest cell number of diatoms was recorded (195 x 10^3 individuals/L) at station 1 constituting about 95.3% of the total cell number. Also station 4 exhibited relatively large cell number of diatoms (28 x 10^3 individuals/L) constituting 99.6% of the total cell number in spring 2005. In the case of dinoflagellates, the cell number tends to be higher at stations 2 and 3. The cell number of dinoflagellates fluctuated between 120 cells/L at station 4 in spring 2005 and 6 x 10^3 cells/L at station 3 in spring 2004. Although Cyanophyta represented by few number of species at station 1, it occurred with a relatively high cell number (129 x 10^3 individuals/L) comprising 47.3% of the total cell number in spring 2005.

At station 1, the high values of standing crop in two seasons were attributed to different species. In spring 2004 was due to coexistence of four species of diatoms, namely, *Cyclotella meneghiniana* with cell number of 149 x 10^3 cells/L (72.8% of the total phytoplankton), *Nitzschia closterium* (25 x 10^3 cells/L) comprising 12.2% of the total phytoplankton, *Cyclotella kutzingiana* (13 x 10^3 cells/L constituting 6.3%) and *Amphiprora hyalina* (8 x 10^3 cells/L) with one species of Chlorophyta, *Scenedesmus dimorphus* (5 x 10^3 individuals/L) comprising about 2.5%. Whereas in spring 2005 the high value of standing crop was attributed to the association of two species of diatoms *Cyclotella meneghiniana* (100 x 10^3 cells/L) and *Nitzschia closterium* (40 x 10^3 individuals/L) with two species of Cyanophyta, *Anabaena torulosa* (68 x 10^3 individuals/L) and *Anabaena spiroides* (60 x 10^3 individuals/L).

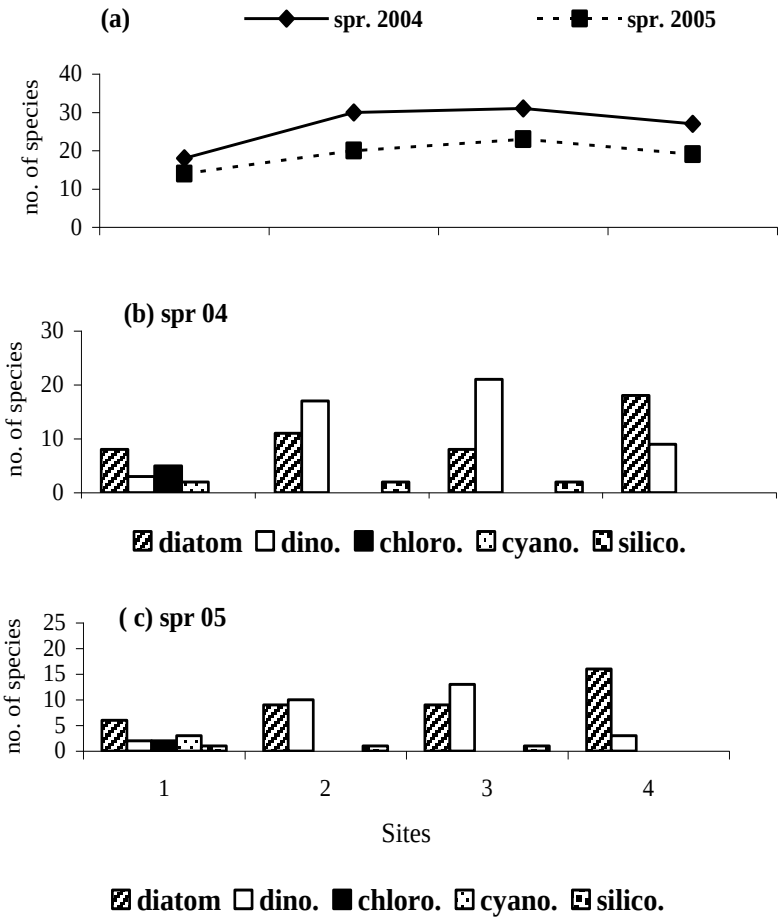

Figure (3): Total species number during two seasons (a), species number of each group during spring 2004 (b) and 2005 (c) at sampling sites.

On the other hand, the fairly large number of the diatoms at station 4 during spring 2005 was due to *Synedra pulchella* (28 x 10^3 cells/L). At station 3, the large number of dinoflagellates during spring 2004 was related to the high numbers of *Prorocentrum micans* (2 x 10^3 cells/L) and *Ceratium furca* (1280 cells/L).

Richness, Shannon-Weaver diversity and evenness indices were calculated by using the data on phytoplankton species and numerical abundance (cell number) and shown in Fig. 5. Throughout the all investigated area, richness values were higher during spring 2004, ranging from 1.04 at station 1 during

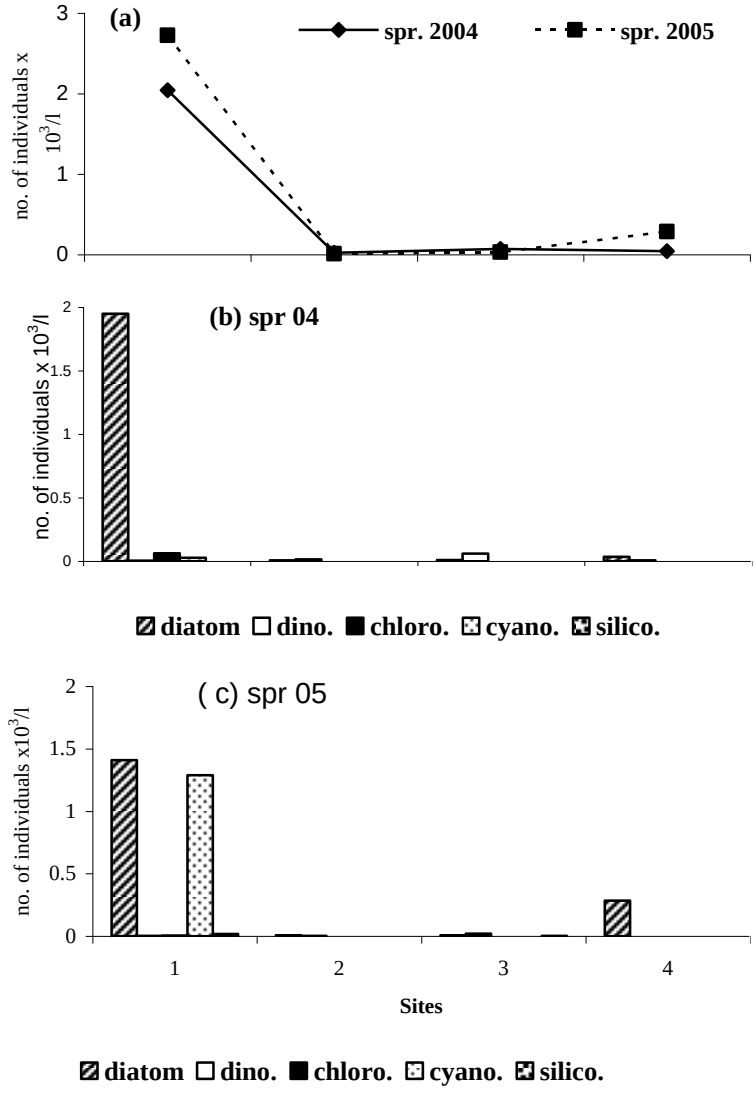

Figure (4): Total standing crop during two seasons (a), standing crop of each group during spring 2004 (b) and 2005 (c) at sampling sites.

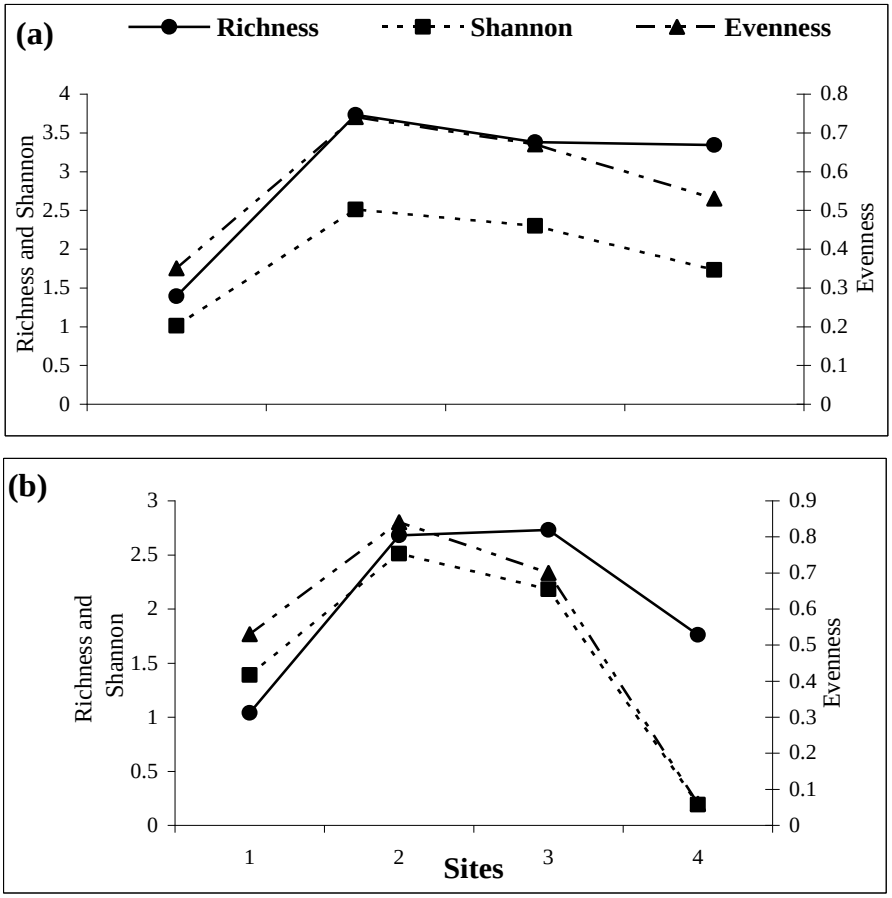

Figure (5): Diversity indices during spring 2004 (a) and 2005 (b) at sampling sites.

spring 2005 and 3.73 at station 2 during spring 2004. On the other hand, the Shannon-Weaver diversity and evenness values were more or less equal during both two seasons except at station 4 when the values were higher in spring 2004. Generally, the Shannon-Weaver diversity index fluctuated between 0.19 at station 4 during spring 2005 and 2.51 at station 2 during spring 2004, while evenness values fluctuated between 0.06 and 0.84.

Discussion and Conclusion

The coastal water of Port Said is characterized by the presence of relatively similar spatial pattern of the hydrographic parameters, except for those of salinity. Water temperature showed a little variation along the study area with slightly higher temperature during spring 2005. The values of pH and oxygen

showed little higher values at station 1. Three water masses can be distinguished in Port Said coast with respect to salinity resulting in the presence of three different areas characterized by different phytoplankton species composition and abundance during time of study. Two of these areas were greatly influenced by two different water bodies connected with the coastal region of Port Said (the Suez Canal and Lake Manzalah).

The first area is the western coast facing Boughaz El-Gamil, lying about 10 km west of Port Said. It is subjected to the influence of brackish waters flowing from Lake Manzalah through Boughaz El-Gamil. The approximate amount of water which would ultimately flow out of the Lake Manzalah into the sea throughout Boughaz El-Gamil was computed at about 4,391x 10^3 m^3 (Amer 1999). In the present study, the value of salinity recorded at this region (26-28 ‰) appears the prevailing of brackish water conditions. The effect of brackish water was greatly obvious on the phytoplankton composition and abundance. This area was generally poor in the number of phytoplankton species; this may be a result of the dominance of *Cyclotella menegheniana*, *Nitzschia closterium*, *Cyclotella kutzingiana*, *Anabaena torulosa*, *Anabaena spiroides* and *Scenedesmus dimorphus*. Gaballah (1990) reported that the peak of phytoplankton in the Lake Manzalah was found in spring season which dominated mainly by Cyanophyta and diatoms and rarely by Chlorophyta. She also reported that *Cyclotella menegheniana* and *Nitzschia closterium* were the most abundant species of diatoms. Whereas *Cyclotella menegheniana* was reported as a littoral form more common in coastal waters than offshore and recorded also in brackish water (Dorgham, 1974) and *Nitzschia closterium* known as neritic species which tend to flourish when the temperature of the water rises and the salinity becomes reduced (Hendey 1964). Huge numbers of these two species in addition to the occurrence of some Cyanophyta and Chlorophyta species known as brackish and freshwater species reflect the prevailing of brackish water habitat with allochthonous origin in the western coast of Port Said.

The second area in the Port Said coast was adjacent to the northern entrance of the Suez Canal and appeared a great resemblance in salinity and species composition with that of the Suez Canal waters. This could be attributed to the effect of the north-ward current prevailing the Suez Canal at this time in the year on this area (Morcos 1960). This area characterized by the presence of high diversity of phytoplankton species especially among the dinoflagellates group and low value of standing crop. This coincides with that recorded before in the northern area of the Suez Canal during spring (Madkour 2000). In addition, it seems that the effect of the brackish waters discharged into the western coast from Lake Manzalah throughout Boughaz El-Gamil does not extend to this area at that time of the year. Further more, of the total recorded phytoplankton in this area

during the present study, *Dinophysis rotundata* is considered as a new record for the Suez Canal.

The third area was the western coast of Port Said. The value of salinity recorded in this area coincided with that obtained before for the offshore water of the Mediterranean (Hassan 1969). It characterized by the occurrence of some species belonging to the Mediterranean origin such as, *Cerataulus smithii*, *Grammatophora marina*, *Lithodesmium undulatum* and *Ceratium lineatum*, those species did not occur at the other stations. Comparing the phytoplankton composition along the Port Said coast, it is obvious that this area is relatively similar to the region adjoin to the Suez Canal. This indicates that the effect of the Suez Canal waters extend to the eastern coast of Port Said but with less extend. It is obvious that the same season of the two consequent years showed variable species composition and abundance at the same stations. In general, the dominant phytoplankton groups were consistent at the same stations during two seasons but with different species composition. In addition, each station showed different abundant species in two seasons.

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التباين المكاني لتوزيع العوالق النباتية قي الربيع علي شاطئ بورسعيد (مصر)

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تتعرض شواطئ البحر المتوسط الواقعة علي مدينة بورسعيد لتبادل المياه مع كل من قناة السويس و بحيرة المنزلة، وهذا بدوره يؤثر علي التركيب النوعي والكمي للعوالق النباتية التي تو جد في هذه الشواطئ. لتتبع التوزيع النوعي والكمي للعوالق النباتية علي شواطئ بورسعيد تم جمع عينات مياه من الشاطئ الغربي لبورسعيد والذي يقع أمام بحيرة المنزلة. هذا الشاطئ يستقبل مياه متوسطة الملوحة التي تصب من بحيرة المنزلة من خلال بوغاز الجميل. أيضا جمعت عينات من الشاطئ القريب من الفتحة الشمالية لقناة السويس علي البحر المتوسط ومن الشاطئ الشرقي لبورسعيد . أخذت من المجري الملاحي أقصي شمال قناة السويس عينة ممثله لمياه قناة السويس. تم قياس درجة الحرارة و درجة الملوحة و الأس الهيدروجيني و الأكسجين الذائب في المياه أيضا تم دراسة التوزيع النوعي والكمي في كل المحطات. أوضحت الدراسة أنه يمكن تقسيم شواطئ بورسعيد علي حسب التركيب النوعي والكمي للعوالق النباتية إلي 3 مناطق ذات بيئات مختلفة. المنطقة الأولي هي الشاطئ الغربي الواقع تحت تأثير التبادل المائي بين مياه البحر المتوسط و بحيرة المنزلة، إتضح فيها إنخفاض درجة الملوحة التي وصلت إلي 26 جزء في الألف. ايضا إنقردت بأقل عدد نوعي وأكبر قيمة للمحصول القائم و سادت بعض الأنواع المحبة للملوحة المتوسطة من الدياتومات مثل نوع السيكلوتيلا مينيجنيانا وبعض الأنواع من الطحالب الخضراء المزرقة والطحالب الخضراء. المنطقة الثانية تأثرت بالتيارات المائية الشمالية التي تسود قناة السويس في هذا الوقت من السنة. حيث اشتركت الشواطئ القريبة من قناة السويس وشمال قناة السويس بذات قيم درجة الملوحة والتشابه في الأنواع. المنطقة الثالثة هي المنطقة الواقعة علي الشاطئ الغربي لبورسعيد والتي لا يظهرفيها تأثير بحيرة المنزلة, سجلت درجة الملوحة حوالي 40 جزء في الألف وهي قريبة من درجات الملوحة التي تم تسجيلها في دراسات سابقة في جنوب شرق البحر المتوسط , أيضا إنفردت هذه المنطقة بوجود بعض الأنواع التي لم تسجل في المناطق الأخري والتي تعتبر من الأنواع الشائعة في البحر المتوسط هذا بالإضافة إلي وجود تشابه إلي حد ما بين هذه المنطقة والمنطقة الثانية في معاملات التنوع. يتضح مما سبق أن هذه المنطقة تمثل بيئة مياه البحر المتوسط والتي يمتد إليها تأثير مياه قناة السويس ولكن بدرجة قليلة.