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ECOLOGY AND SETTLEMENT OF MARINE FOULING IN THE SUEZ BAY, EGYPT

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ABSTRACT: This study deals with seasonal variations, natural correlations and similarities of fouling assemblages on exposure panels in the Suez Bay during January 1992 to January 1993. Three main sources of pollutions flow into the bay; industrial waste products, domestic drainage of Suez city and ships` oil and refuse. The fouling assemblages on the test panels after various periods (1, 2 and 3 months) belonged mainly to the algae (*Ulva rigida*), polychaetes (*Hydroides elegans*), Cirripedes (*Balanus amphitrite*) and amphipods.

The fouling at the 1st station was relatively more dense than at the 2nd station during the summer and autumn seasons. The lowest productivity was achieved at the 3rd station which was considered less polluted being offshore water. The overall paucity of fouling in the bay is because of the silt covering the submerged surfaces, particularly at the 2nd station, leading to the prevention of the settlements or establishment of fouling organisms. The seasonal changes in the intensity of fouling assemblages on submerged surfaces in seawater seems to be closely related to seasonal variations in water temperature. The great fouling communities on the buoys and long exposure panels showed a remarkable variety of species and density rather than on short term exposures, which were more dense during warmer months.

KEY WORDS: Ecology, marine fouling, Suez Bay.

INTRODUCTION

Suez Bay water is subjected to pollution from: industrial waste products, domestic drainage of Suez city and oil spills from ships awaiting transit through the Suez Canal and oil refineries. The drainage freshwater to the bay was estimated to be a volume of 500 m3/h and the domestic drainage reached 2000 m^3/h (Meshal, 1967).

The fouling accumulated on the submerged objects in the bay and the Suez Canal release larvae which may attach to the sailing vessels and become conveyed to any part of the world or vice versa. Previous biological studies in the Gulf of Suez and Suez Canal have been restricted to the results of Cambridge Expedition (Billard, 1926), of the plankton populations (Macdonald, 1933, Ghazzawi, 1939, Dowidar, 1976 and Abd El-Rahman,1993) and the hydrography aspects (Morcos & Messieh, 1973 and Gerges, 1976).

Many ecological studies dealing with marine fouling have been carried out in Egyptian Harbours, particularly at the Eastern Harbour of Alexandria (Ghobashy, 1976, Selim, 1978, Hamada, 1980, Mona, 1982 and El-Komi 1991, 1992a), in the Suez Canal (El-Komi, 1980, and Ghobashy & El-Komi, 1980 a,b) and in the Red Sea (El-Komi 1992b). But the Suez Bay region has not received similar works in respect to the biology of fouling assemblages.

Because of the importance of the Suez Bay as a shallow connection between the Suez Canal and the Gulf of Suez, this study has been conducted on the seasonal variations and the incidence of fouling in relation to the influence of the prevailing environmental conditions.

MATERIAL AND METHODS

The study area (Suez Bay) is a shallow extension of the Gulf of Suez, located between the longitudes 32°28' and 32°34' E and latitudes 29°54' and 29°57' N (Fig.1), with a mean depth of 10 m and an area ca 77.13 km^2. The Suez city and its major industries occupy the northern part of the bay.

Materials were collected monthly from three different stations (Fig.1) during the period January 1992 to January 1993. The 1st station is mainly affected by the industrial drainage of the two oil refineries and the Electricity Power Company. The 2nd station lies in front of the National Institute of Oceanography and Fisheries (NIOF). The 3rd station lies in the middle of the bay which is influenced by the industrial drainage resulting from both the nearshore parts and offshore parts (the transit area and the traffic of ships passing across the Suez Bay to the Suez Canal).

Samples of fouling were collected by using an iron frame sized 76 cm x 37 cm, bearing 8 test panels (18 cm x 18 cm) made of impact resistance polystyrene. The frame was suspended vertically under the buoy of each station at a depth of 2 m. Panels were exposed for variable periods of time (1, 2, and 3 months), after which they were replaced by clean ones.

From the submerged buoys in the three stations fouling organisms were collected monthly by scraper during the study period.

The seawater analysis is included the measurements of physical parameters (transparency and temperature of seawater) and chemical parameters, pH, by using pH-meter model Orion SA 210; salinity, using an inductive salinometer (S.C.T. meter model 33); dissolved oxygen, using the Winkler methods; and chemical oxygen demand by measuring the quantity of oxygen required to oxidize the organic matter under specific conditions of oxidizing agents, temperature and time. These measurements were determined every month over the study period.

RESULTS

1. Environmental Conditions

1.1. Transparency:

The levels of transparency of seawater (Table 1) attained minimal value of 3.2 m at the 1st station during summer while the maximum values were recorded at the 3rd station ranging from 5.4 m to 7.3 m.

1.2. Temperature

Temperature of surface seawater showed marked seasonal variations which varied from 26.5o C to 29.5o C during the period June-August (summer) and dropped to 16°C and 18.5°C in the period December-February (winter).

1.3. Hydrogen ion concentration (pH)

The pH values of surface seawater fluctuated around 8 (Table 1). These values have very narrow limit variations ranging from 8.15 to 8.25 through most of the year.

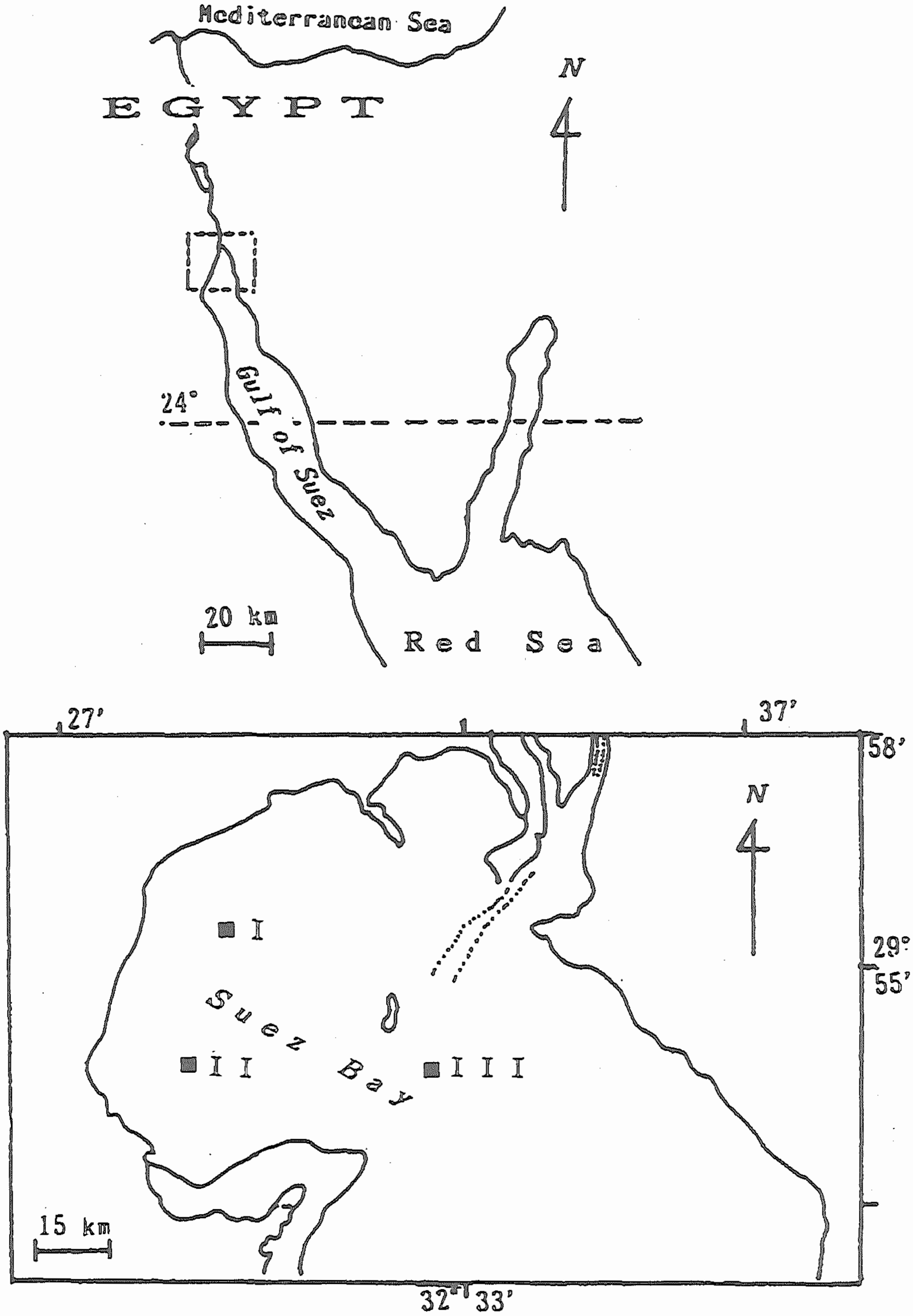

Fig. 1. Locations of the investigated area in the Suez Bay. I Electricity Power Company, II National Institute of Oceanography and Fisheries (NIOF), and III Middle of the bay.

Table 1. Monthly changes of fouling biomass developed on the test panels in relation to the temperature, transparency, and pH values of seawater in the Suez Bay during January 1992 to January 1993.

Parameters	Total wet weight (gm/100 cm²)			Temperature (°C)			Transparency (m)			pH		
Stations	1	2	3	1	2	3	1	2	3	1	2	3
Jan-92	4.9	0.9	0.5	17.0	17.5	18.0	4.0	4.0	7.0	8.20	8.26	8.26
Feb	5.3	1.1	2.4	18.0	18.0	18.5	2.4	3.9	5.0	8.20	8.23	8.23
Mar	10.9	8.5	2.3	19.0	19.0	18.0	4.0	4.3	7.9	8.22	8.27	8.28
Apr	20.8	12.0	3.9	23.0	22.0	22.5	4.3	3.0	6.0	8.23	8.26	8.26
May	18.1	11.6	3.9	24.0	24.0	23.0	4.5	3.5	8.0	8.26	8.27	8.35
Jun	23.1	21.2	10.0	26.5	26.5	26.0	3.9	4.5	7.0	8.23	8.23	8.20
Jul	29.3	31.5	15.0	28.0	27.0	27.0	3.1	4.7	9.0	8.16	8.22	8.24
Aug	37.0	23.9	10.3	29.5	29.0	29.0	2.7	2.9	5.0	8.18	8.22	8.23
Sep	16.9	13.1	9.0	27.5	27.5	27.0	4.5	4.9	5.0	8.22	8.24	8.23
Oct	14.5	11.6	6.2	25.5	26.0	26.0	4.6	4.5	8.0	8.18	8.22	8.19
Nov	7.0	6.2	1.9	21.0	21.0	21.0	4.5	4.0	5.0	8.10	8.12	8.13
Dec	5.7	2.9	1.5	19.0	19.0	18.0	3.4	6.8	3.1	8.12	8.15	8.16
Jan-93	2.8	1.8	0.6	18.5	18.0	17.0	3.7	4.3	6.3	8.22	8.24	8.26
Winter	4.7	1.7	1.3	18.1	18.1	17.9	3.4	4.8	5.4	8.19	8.22	8.23
Spring	16.6	10.7	3.4	22.0	21.7	21.2	4.3	3.6	7.3	8.24	8.27	8.30
Summer	29.8	25.5	11.8	28.0	27.5	27.3	3.2	4.0	7.0	8.19	8.22	8.22
Autumn	12.8	10.3	5.7	24.7	24.8	24.7	4.5	4.5	6.0	8.17	8.19	8.18

Table 2. Monthly changes of the fouling biomass on test panels in relation to the salinity, dissolved oxygen and organic matter values in the Suez Bay during January 1992 to January, 1993.

Parameters	Total wet weight (gm / 100 cm²)			Salinity (‰)			Dissolved oxygen (mg O_2/L)			Organic Matter (mg O_2/L)		
Stations	1	2	3	1	2	3	1	2	3	1	2	3
Jan-92	4.9	0.9	0.5	41.65	41.70	41.81	4.85	4.75	4.85	2.80	2.80	1.76
Feb	5.3	1.1	2.4	41.60	41.70	41.95	5.48	4.95	5.22	4.00	3.16	2.79
Mar	10.9	8.5	2.3	41.42	41.55	41.65	4.95	5.15	4.80	3.19	2.77	1.72
Apr	20.8	12.0	3.9	42.25	41.85	42.30	5.32	4.34	4.69	2.38	2.38	0.88
May	18.1	11.6	3.9	41.20	41.40	42.43	4.50	4.42	4.55	2.36	2.16	1.20
Jun	23.1	21.2	10.0	42.45	42.45	42.60	4.94	4.83	4.92	2.33	2.00	7.56
Jul	29.3	31.5	15.0	41.80	42.33	42.69	3.98	4.00	4.25	7.25	2.80	0.95

Table 2. Contd...

Aug	37.0	23.9	10.3	42.35	42.50	42.73	4.13	4.15	4.17	6.50	4.55	1.20
Sep	16.9	13.1	9.0	41.37	41.45	41.53	4.40	3.72	4.03	4.85	3.42	2.15
Oct	14.5	11.6	6.2	41.19	41.33	42.50	5.40	4.87	5.14	2.40	1.62	1.12
Nov	7.0	6.2	1.9	41.89	41.65	42.60	4.64	4.86	4.51	2.35	1.85	1.84
Dec	5.7	2.9	1.5	40.83	41.90	41.25	5.40	5.15	5.31	1.36	1.40	1.20
Jan-93	2.8	1.8	0.6	40.55	40.63	40.84	6.00	6.24	6.16	2.10	1.10	3.20
Winter	4.7	1.7	1.3	41.16	41.48	41.46	5.43	5.27	5.39	2.57	2.12	2.24
Spring	16.6	10.7	3.4	41.62	41.60	42.13	4.92	4.64	4.68	2.64	2.44	1.27
Summer	29.8	25.5	11.8	42.20	42.43	42.67	4.35	4.33	4.45	5.36	3.12	3.24
Autumn	12.8	10.3	5.7	41.48	41.48	42.21	4.81	4.48	4.56	3.20	2.30	1.70

1.4. Salinity

The range of salinity of surface seawater is very narrow ranging from 40.55 to 42.73 ‰ at the different stations as shown in table 2.

1.5. Dissolved oxygen (DO)

The oxygen content of the surface seawater did not show marked fluctuations during the study period as well as at the different stations. These values ranged from 3.72 to 6.24 mg O_2/L where the highest level of DO was recorded in winter season attaining 5.27- 5.43 mg O_2/L at the different stations.

1.6. Chemical oxygen demand (COD)

The values of COD showed a minimum value of 1.27 and 1.70 mg O_2/L in spring and autumn respectively at the 3rd station. But it increased to the average of 6.87 mg O_2/L at the 1st station during July to August.

2. FOULING ASSEMBLAGES AND SETTLEMENT DENSITY

The fouling community which developed on the exposed test panels in the Suez Bay consisted mainly of algae, Bryozoa, Polychaeta, Crustacea (Cirripedia, Amphipoda, Isopoda, Decapoda) and Mollusca.

2.1. Algae

Green algae were represented by 6 species (Table 3) where *Ulva rigida* was the most abundant species. *Codium bursa* was found on the test panels during winter and early spring seasons at the 3rd station, but *Chaetomorpha aerea* occurred rarely. The settlement of *Ulva rigida* was observed over the year, reaching its maximum length (20 mm) in November panels and flourished in May at the 1st and 2nd stations.

2.2. Bryozoa

Erect bryozoans were represented by two species; *Bugula neritina* was the most common species and *Scrupocellaria scruposa* was rarely present. *Micropora complanata* appeared on the exposed test panels during the period from May to October at the 1st and 2nd stations.

Table 3. Species composition of macrofouling organisms recorded on the submerged surfaces in the Suez Bay, during January 1992 to January 1993.

Algae
a) Green algae
Ulva rigida C. Ag.
Enteromorpha prolifera (Mull.) J.Ag.
Enteromorpha linza (Linnaeus) J.Ag.
Chaetomorpha aerea (Dillywn) Kutz.
Caulerpa racemosa (Forssk.)
Codium bursa (L.) Kutz.
b) Brown algae
Padina pavonica (Linnaeus) Thivy
Ectocarpus irregularis Kutz.
Cystoseira sp.
c) Red algae
Ceramium cilliatum (Ellis) Ducl.
Ceramium rubrum (Huds.) C.Ag.
Polysiphonia sp.
Halymenia dichotoma (J.Ag.)

Prolifera (Sponges)
Clathrina sp.
Nematoda (Round worms)
Epsilonema sp.
Hydroids
Obelia geniculata (L.)
Halocordyle disticha (Goldf.)
Dynamena cavolinii (Neppi)

Bryozoa
a) Erect bryozoans
Scruparia chelata (Linne)
Bugula neritina (Linne)
Srupocellaria scruposa (Linne)
b) Encrusting bryozoans
Schizoporella errata (Watters)
Cryptosula pallasiana (Moll.)
Micropora complanata (Norman)
Watersipora subovoidea (d`Orbigny)

Crustacea
a) Cirripedeia
Balanus amphitrite var. *denticulata* Broch
Chthamallus stellatus Poli.
b) Amphipoda
Erichthonius brasiliensis Dana
Elasmopus pectenicrus (Bate)
Elasmopus rapax Costa
Corophium sextoni (Crawford)
Corophium volutator (Pallas)
Stenothoe gallenesis Walker
Gammarus locusta Linne
Tanias cavolini Milne-Edwards
Melita fresnellii (Auduin)
Jassa falcata Montigu
c) Isopoda
Sphaeroma serratum Fabricius
Sphaeroma walkeri Stebbing
Cymodoce truncata Leach
Cirolana bovina Barnard
Dynamene edwardi (Lucas)
Paradella heptaphymata (Shoukr. et al.)
d) Decapoda (Brachyura)
Pilmnus hirtellus (L.)
Porcellana patycheles (Penn.)

Polychaetes
a) Sedentary forms
Hydroides elagans (Haswell)
Hydroides heterocera (Grube)
Serpula concharum Langerhans
Serpula vermicularis Linne
Dasychone lacullana (Delle Chiaje)
Spirorbis borealis Daudin
Spirobranchus tetraceros (Schmarda)
Pomatoceros triqueter Grube
Polycirrus aurantiacus (LoBianco)
Chaetozone setosa Malmgren
Sabella pavonina Savigny
Cirratulus cirratus (O.F. Muller)
Eupolymenia nebulosa (Mont.)
b) Errantia forms
Nereis diversicolor M.O. Muller
Nereis (Ceratonereis) costea Grube
Pseudonereis anomala (Gravier)
Perinereis sp.
Cirrifomia sp.
Syllis (Trypanosyllis) zebra (Grube)
Syllis (Tryposyllis) variegata Grube
Lepidontus clava (Montagu)
Phyllodoce sp.
Halla parthenopeia (Delle Chiaje)
Eunice tubifex (Crossland)
Eulalia sp.

Mollusca
a) Gastropoda
Fusinus rostratus (Olivi)
Courmya (Thericium) vulgata (Brug.)
Trochus dentatus Forskal
Mitra ebenus Lamarck
b) Bivalvia
Brachiodontes variabilis (Krauss)
Modiolus auriculatus (Krauss)
Ostrea sp.

Ascidians
Styela partita (Stimpson)
Styela plicata (Leseur)

Bugula neritina was observed on the exposed test panels from June to August at the 1st station and during July to September at the 3rd station. The number of colonies reached 5 per 100 cm^2/month. This species was more dense on panels after long exposure period and among the bulk community of fouling collected from the buoys. The rate of growth of *Bugula neritina* was low and achieved 2-4 bifurcations after one month of settlement, whereas it reached sexual maturity at 9-bifurcations during one month in Lake Timsah, Suez Canal (El-Komi, 1980).

2.3. Polychaeta

The polychaetes constitute the main group of fouling organisms inhabiting the Suez Bay as shown in figure 2. The errant worms included, Nereidae, Phyllodacidae and Syllidae; the sedentary worms involved the calcareous tube-dwelling, Serpulidae; slim tubes, Cirratulidae, Terebellidae; mud tubes, Polynoidae and Sabellidae (sand or silt tubes). Among the above mentioned families 25 species were identified of which 13 species were errant (Table 3); *Hydroides elegans, Serpula concharum, S. vermicularis, Dasychone lacullana* and *Spirorbis borealis* settled on the exposed test panels while, *H. heterocera, Spirobrancus tetraceros* and *Sebella pavonina* were recorded only in the bulk community of fouling on the buoys.

Hydroides elegans is the most common species of polychaete on the submerged surfaces in the bay. The average number of tube worms greatly varied and yielded 368 tubes/100 cm^2/month at the 1st station throughout the study period. The maximum encountered number was 1120 tubes in December 1992 and the minimum number was 34 tubes/ 100 cm^2 on the test panel in January 1992.

The settlement of tube worms, in general, increased on the submerged surfaces for long duration which ranged from 1000-3000 tubes/ 100 cm^2 after 3 months during January to March at the different stations. The growth rate of tube worms was high during the autumn season sustained 15 mm after one month of settlement while decreased to 3 mm during the cold season at the 1st station. The maximum length of tubes reached up to 25 mm after 3 months exposure from January to March.

Serpula concharum and *S. vermicularis* were more frequent on panels than *Spirorbis borealis*. The first two species were found accompanying *Hydroides elegans* in considerable numbers. The number of *S. borealis* was 120 tubes/ 100 cm^2 in January 1992 at the 3rd station, with tubes 2.5 mm in diameter. *Pomatoceros triqueter*, and *Dasychone lacullana* were represented by few numbers.

The errant worms, *Nereis diversicolor, Syllis (Trypanosyllis) zebra* and *S. (Tryposyllis) variegata* were recorded in small numbers during spring and autumn seasons.

2.4. Crustacea

2.4.1. Cirripedia (Acorn barnacles)

Balanus amphitrite var. *denticulata* is the predominant species of barnacles among the fouling organisms in the Egyptian Harbours (Ghobashy, 1976, El-Komi, 1980, 1991, 1992a,b). In the present study it had the least occurrence on the exposed test panels during the cold seasons (Figure 2). The maximum number of individuals was 215 and 126 per 100 cm^2/month in October at the 1st and 2nd station respectively. They varied from 48 to 93 ind./100 cm^2/month at the 3rd station over the year (Table 4). The growth

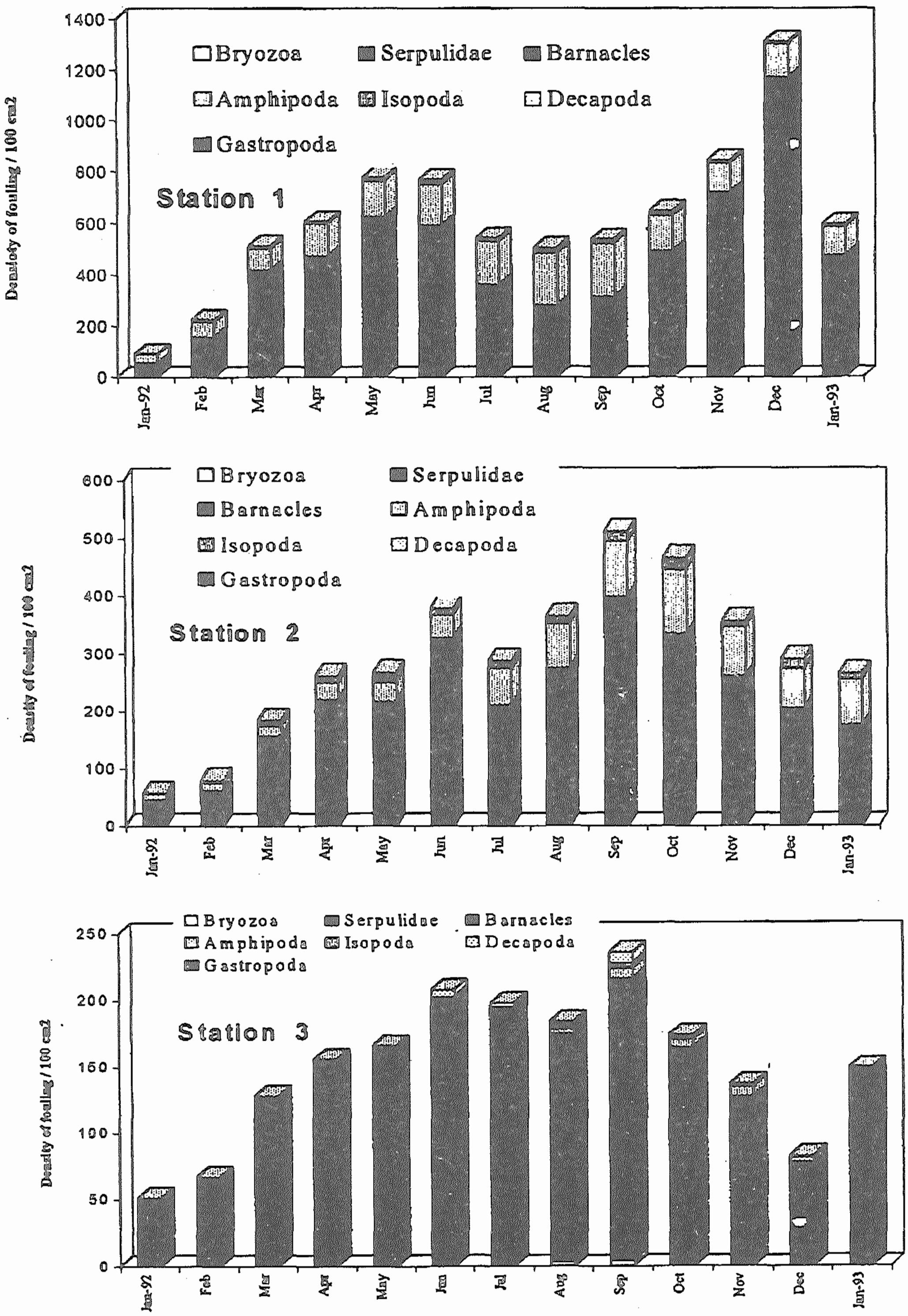

Fig. 2. Monthly variations in density of seven main groups of fouling organisms developed on the exposed test panels in the Suez Bay during Janaury 1992 to January 1993.

of barnacles was relatively high during the periods of maximal attachment achieving 10 mm in basal diameter in September and the largest diameter was 15 mm after 3 months of settlement.

2.4.2. Amphipoda

Amphipods building mud tubes in the Suez Bay include 10 species (Table 3); *Erichthonius brasiliensis, Elasmopus pectenicrus, Corophium sextoni* and *C. volutator* were more common species over the year. They were, in general, more dense on long term panels. The number of mud building tubes reached 208 per 100 cm^2/month on average during the observation period. Mud building tubes were more dense in August and September at the 3rd station, which encountered 200 tubes/100 cm^2/month. The minimal average attained 45 tubes in winter and 85 tubes in autumn.

2.4.3 Isopoda

Three species were detected among the fouling community on the exposed test panels over the year in the bay namely; *Sphaeroma serratum, S. walkeri, Cymodoce truncata., Cirolana bovina, Dynamen edwardi* and *Paradella heptaphymata* were also recorded among the bulk community of fouling on the buoys during most of the year. Isopoda were found in few numbers (5 ind./100 cm^2/month on average). The number of individuals ranged from 4 to 19 ind./100 cm^2/month and it was greater on long term panels (35 ind./100 cm^2).

2.4.4 Decapoda

Two decapod brachyurans *Pilumnus hirtellus* and *Porcellana platycheles* appeared in small numbers 1-3 during May to August at the 1st station.

2.4.5. Mollusca

Bivalves *Brachiodontes variabilis, Modiolus auriculatus* and *Ostrea* sp. were recorded only the buoys and on the long term exposure panels. On the other hand, Gastropoda were observed on short term panels including *Trochus dentatus, Fusinus rostratus, Courmya (Thericium) vulgata* and *Mitra ebenus*. The number of gastropod reached 8 ind./100cm^2/month in October at the 1st station and in September at the 3rd station.

3. SEASONAL CHANGES OF FOULING COMMUNITY:

The density of fouling on the submerged surfaces in the Suez Bay in seawater revealed that the 1st station is the most productive, followed by the 2nd station and the least is the 3rd station (Fig.2). The barnacles and tube worm communities dominated fouling at the 1st station. Calcareous tube worms contributed 63%, barnacles showed 13%, Amphipoda 21% and Isopoda 1.5% of the total fouling as listed in table 4. At the 2nd station the above mentioned groups contributed respectively 50%, 27%, 19% and 3.7% of the total fouling settlement. The most important fouling groups at the 3rd station were the tube worms and barnacles which represented by 56% and 40% of the total fouling while, Amphipoda and Isopoda contributed 3.5%.

3.1. Winter season (December-February), Average temperature 18.0°C ±0.6, Average salinity 41.37‰ ±0.84.

During this season the fouling biomass yielded 1.3-4.7 gm/100 m^2/month. The fouling assemblages were represented by small amount of *Codium bursa, Cladophora sp., Enteromorpha prolifera, E. linza, Ulva rigida, Chaetomorpha aerea, Ceramium rubrum* and *Ectocarpus irrgularis*. Barnacle *Balanus amphitrite* were encountered at 15-50, 12-40 and 10-30 ind./100 cm^2/month at the 1st, 2nd and 3rd stations respectively. Calcareous tube worms included *Hydroides elegans, Serpula concharum, S. vermicularis* and *Spirorbis borealis* and the errant worms *Dasychone lacullana* and *Nereis diversicolor*. The number of tube worms ranged from 40 to 1120 tubes/100 cm^2/month at the 1st station and varied from 34 to 164 tubes at the 2nd and 3rd stations.

Mud tube building Amphipoda were more dense at the 1st station (35-134 tubes/ 100 cm^2/month) than at the 2nd station (10-70 tubes). They involved 5 species: *Corophium sextoni, C. volutator, Erichthonius brasiliensis, Elasmopus rapax* and *E. pectinicrus*.

Isopoda appeared in few numbers, *Sphaeroma serratus, S. walkeri* and *Cymodoce truncata* which were represented by 6-9, 4-16 and 1-2 ind./ 100 cm^2/month at the 1st, 2nd and 3rd station respectively.

3.2. Spring season (March-May), Average temperature 21.6°C ±2.5, Average salinity 41.76‰ ±0.29.

The fouling developed slightly on the exposed test panels during the spring season at the 3rd station (3.4 gm/100 cm^2/month) and average 16.6 gm at the 1st station and 10.7 gm at the 2nd station. The fouling constituents during this season did not differ greatly from those in winter. *Dasychone lacullana* and small colonies of *Micropora complanata* were recorded in few numbers: polychaetes, barnacles and amphipoda as revealed from table 4 were more predominant on the panels at the 1st station than at the other stations. They reached up to 318-560 ind. (tube worms), 69-125 ind. (*Balanus amphitrite*) and 85-141 ind./100 cm^2/month (Amphipoda species) at the three stations respectively.

3.3. Summer season (June-August), Average temperature 27.6°C±1.3, Average salinity 42.43‰ ±0.13.

The intensity of fouling which colonized on the panels was greatest during this period which yielded 29.8, 25.5 and 11.8 gm / 100 cm^2/month on average at the 1st, 2nd and 3rd stations respectively. The new settlers of fouling in summer were the erect Bryozoa *Bugula neritina* was reached 8 colonies/ 100 cm^2/month and the gastropods *Fusinus rostratus* and *Trochus dentatus* (1st and 2nd stations), *Courmya (Thericium) vulgata* and *Mitra ebenus* (3rd station) which numbered 1-5 ind./ 100 cm^2.

Calcareous tube worms embraced mainly of *Hydroides elegans, Serpula concharum* and *S. vermivularis* (ranging from 82 to 518 tubes/100 cm^2) beside a few of *Dasychone lacullana* and *Nereis diversicolor*.

Barnacle *Balanus amphitrite* dominated on the panels at the 2nd station with a number 89 ind./ 100 cm^2 on average and reached 65 ind./100 cm^2 at the other two stations. Mud tube building Amphipoda increased in number at the 1st station (157-207 tubes) and were very rare in August (4 tubes) at the 3rd station. Isopoda species attained a number up to 16 ind./ 100 cm^2 at the 1st station and 5 ind. at the 3rd station.

Table 4. Abundance of the fouling assemblages settled on the submerged test panel per 100 cm2 at the different investigated stations in the Suez Bay.

St. 1	Bryozoa	Serpulidae	Barnacles	Amphipoda	Isopoda	Decapoda	Gastropoda
Jan-92	0	40	15	35	0	0	0
Feb	0	117	40	61	6	0	0
Mar	0	318	100	85	10	0	0
Apr	0	349	125	126	7	0	0
May	2	560	60	141	12	0	3
Jun	5	518	70	157	16	0	2
Jul	8	288	65	170	10	2	1
Aug	7	222	50	207	11	6	2
Sep	13	215	88	208	14	0	0
Oct	11	267	215	137	12	8	0
Nov	0	650	70	112	5	7	0
Dec	0	1120	50	134	9	0	0
Jan-93	3	352	120	113	6	0	0
%	0.6%	63.0%	13.4%	21.2%	1.5%	0.3%	0.1%
Station 2							
Jan-92	0	34	12	10	0	0	0
Feb	0	43	18	14	4	0	0
Mar	0	59	95	19	9	0	0
Apr	0	110	110	30	11	0	0
May	1	135	80	34	17	0	0
Jun	2	260	65	40	10	1	0
Jul	4	151	55	65	10	2	0
Aug	3	124	148	78	12	0	0
Sep	0	268	130	97	16	0	0
Oct	0	185	150	110	19	2	0
Nov	0	211	50	86	6	3	0
Dec	0	164	40	70	16	0	0
Jan-93	0	113	60	81	10	0	0
%	0.3%	49.4%	26.9%	19.5%	3.7%	0.2%	0.0%
Station 3							
Jan-92	0	39	10	2	0	0	0
Feb	0	48	15	2	2	0	0
Mar	0	85	40	1	2	0	0
Apr	0	98	55	0	3	0	0
May	0	112	50	0	4	0	0
Jun	0	141	60	0	2	5	0
Jul	1	138	55	0	1	3	0
Aug	3	82	90	4	5	0	0
Sep	4	93	120	7	4	8	0
Oct	0	85	80	6	3	0	0
Nov	0	67	60	8	2	0	0
Dec	0	47	30	4	1	0	0
Jan-93	0	45	100	2	2	0	0
%	0.4%	55.8%	39.5%	1.9%	1.6%	0.8%	0.0%

3.4. Autumn season (September-November), Average temperature 24.7°C ± 4.7, Average salinity 41.72‰ ±0.8.

The biomass of fouling amounted to 12.8, 10.3 and 5.7 gm / 100 cm^2/month at the 1st, 2nd and 3rd stations respectively. Small patches of algae *Cladophora* sp., *Enteromorpha linza, Ulva rigida* and *Ceramium rubrum*. Bryozoa *Micropora complanata* was found on October at the 1st station. Tube worms *Hydroides elegans* increased in both settling and growth which reached 600 tubes/ 100 cm^2 in November at the 1st station with 20 mm length. On the other hand, *Balanus amphitrite* attained maximal settlement 215 ind./ 100 cm^2 with a basal diameter 10 mm in September at the 1st station. Amphipods and isopodes were also found more frequently at the 1st station in September (208 mud tubes). The gastropods *Fusinus rostratus* and *Trochus dentatus* were present in few number (2-8 ind./ 100 cm^2) during October and November at the 1st and 2nd stations and in September at the 3rd station.

4. FOULING ASSEMBLAGES ON BUOYS

The fouling community which collected monthly from the buoys at the three stations in the bay were colonized by great density and variety of fouling organisms. The main constituents of these communities are as follows:

4.1. Algae

Enteromorpha prolifera , *E. linza, Chaetomorpha aerea, Caulerpa racemosa* and *Padina pavonica* were observed on buoy at the 3rd station. These algae were covered by grey to black sandy silt.

Ceramium cilliatum, C. rubrum, Ectocarpus irregularis, Cystoseira sp., *Polysiphonia* sp. and *Halymenia dichotoma* appeared on the buoys at the 1st and 2nd stations, where *Padina pavonica* was common during the summer season at the 3rd station.

4.2. Porifera

Clathrina sp. was recorded among the bulk of fouling collected from the buoys at the 1st and 2nd stations during autumn season (October and November).

4.3. Hydroids

Very small amounts of colonial of Hydroids, *Obelia geniculata* were found on buoys at the 1st and 2nd stations during September to November period. While *Dynamena cavolinii* settled in March, April and November and *Halocordyle disticha* settled during October to December at the 2nd station.

4.4. Nematodes (Round worms)

In the Suez Bay the nematode group was represented by *Epsilonema* sp. among the fouling colonized on the buoy at the 2nd station.

4.5. Nemertinea

Nemertine worms were recorded only on the buoy at the 1st station during May, June and August, but they were found in high number of individuals at the 2nd station in September.

4.6. Bryozoa

The erect bryozoan *Bugula neritina* and four species of encrusting forms namely; *Schizoporella errata, Cryptosula pallasiana, Micropora complanata* and *Watersipora subovoidea* which were common in autumn and *S. errata* which was detected in summer season. *Scruparia chelata* appeared occasionally and predominated during autumn season. In general encrusting bryozoans were recorded only on the buoys through most of the year.

4.7. Mollusca

Bivalves *Brachiodontes variabilis, Modiolus auriculatus* and *Ostrea* sp. were recorded only buoys and on long term exposure panels.

4.8. Ascidians

Two ascidian species: *Styela plicata* and *S. partita* were found on buoys during spring and winter seasons.

5. RELATION BETWEEN THE OCCURRENCE OF FOULING AND ENVIRONMENTAL CONDITIONS

The physical and chemical factors affecting the spatial distribution and settlement intensity of fouling organisms are, in general, complex and difficult to appraise (Connell, 1974; Orton, 1919 and Weiss, 1948). In the present study the impact of temperature, salinity, pH, transparency, dissolved oxygen and chemical oxygen demand on density and biomass of fouling were determined using linear regression analysis. These are not clarified by our findings because the calculated values of the regression coefficient for each variable is less than the table value ($P_{0.05} = 0.553$, n = 13) as shown in table 5.

Table 5. Comparison of regression coefficient values of different environment variables in Suez Bay in relation to fouling biomass developed on monthly test panels.

Parameter	Station	ΣX^2 (biomass)	ΣXY	ΣY^2	r (Reg. Coeff>)
Temperature	I	4277	4974	6986	0.934
	II	2722	3724	6882	0.899
	III	598	1717	6731	0.889
Salinity	I	4277	8205	22466	0.237
	II	2722	6143	22637	0.210
	III	598	2859	23010	0.142
pH	I	4277	1609	873	0.038
	II	2722	1204	880	0.029
	III	598	556	881	0.0
Transparency	I	4277	732	196	-0.180
	II	2722	602	247	-0.180
	III	598	344	316	0.430
Dissolved oxygen	I	4277	911	319	-0.762
	II	2722	646	295	-0.638
	III	598	306	305	-0.640
Chemical oxygen demand	I	4277	816	187	0.678
	II	2722	404	89	0.419
	III	598	155	96	0.123

$P_{0.05}(11) = 0.553$

On the other hand, general abundance is closely related to seasonal variations in water temperature where the table value is less than the calculated value of r (~ 0.9) at the three stations. But the organic matter values show a distinct relationship to the fouling biomass (r = 0.68) only at the 1st station.

The minimum temperature values ranged from 17°C to 19°C during the winter which is considered favourable conditions for the growth of algae. During warm months *Codium bursa* disappeared while *Ulva rigida* dominated in November at 21°C. On the other hand, *Bugula neritina* flourished during the period from June to August at temperatures 26-29°C and disappeared in cold months. Barnacle *Balanus amphitrite* settled during most of the year but its density increased through the warm months especially in October at the 1st station. Calcareous tube worms *Hydroides elegans* attained high settlement during late spring and summer (May and June) at 23-26.5°C, but was recorded in great amount in December at 10°C.

DISCUSSION

According to Morcos (1960) agitation caused by strong wind in the Gulf of Suez and the swift currents of tides ranged between 80 cm at neap tides and 140 cm at the spring tides. These led to getting silt, the major settler in Suez region. Therefore, the metamorphosed larvae will be prevented from reaching attachment stages and if some succeed, further growth will be smothered. The paucity of fouling in the southern region of the Suez Canal was observed by El-Komi (1980) and in the Red Sea, El-Ghardqa (El-Komi, 1992b), where barnacles and encrusting bryozoans attached to exposed test panels and such paucity of fouling is not able to produce larvae enough to form dense fouling community in the Red Sea region. At the Suez Bay the principal settlers are similar to those abundant along the Suez Canal, such as *Obelia geniculata, Bugula neritina, Balanus amphitrite, Hydroides elegans* and algae, *Ulva rigida, Enteromorpha* sp. and *Chaetomorpha* sp.

The calcareous forms of fouling namely; encrusting Bryozoa, tube worms, barnacles, and Mollusca were prevailing as in the southern part of the Suez Canal in the Kabret station and declined quantitatively until the Suez Harbour (El-Komi, 1980, Ghobashy and El-Komi, 1980b), which may be attributed to the high concentration of calcium carbonate owing to the increase of salinity. Anwar and Mohamed (1970) reported that the increase in the salinity of seawater leads to an increase in the concentration of calcium carbonate and this supports the settlement of shelled animals.

The link between the environmental parameters and the changes in the density and fouling biomass seems to bo closely attributed to the marked seasonal variations in the temperature of seawater. On the other hand, no obvious relationship was obtained between the parameters and the fouling settlemt on the exposure test panels, since the fluctuation in the variable parameters were very narrow.

However, there are no marked variations in the fouling settlemt at the different stations, supporting the suggestion that the fouling biomass differences over the year are more a result of natural fluctuations (biotic factors) in population than of the effects of abiotic factors.

In conclusion, the protection of navigation constructions in seawater against the effect of fouling, the methods of control to kill or repel the organisms will be required during the warm seasons as intense fouling becomes high, whereas it may be unnecessary in cold seasons because the settlement and growth rates of fouling were very low.

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