Incidence and Ecology of Marine Fouling Organisms in the Eastern Harbour of Alexandria, Egypt

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The seasonal changes, intensity and constituents of fouling developed on exposed test panels for short and long term intervals are studied in relation to the prevailing environmental conditions in the Eastern Harbour of Alexandria, during March 1983 to March 1984. The intesity of fouling on exposed test panels for long durations is considerably more dense than the total fouling developed on exposed panels for short term successively during the same period. The fouling colonized on submerged panels for long intervals reach to a "saturation point" after 3 to 6 successive months.

The Eastern Harbour of Alexandria is relatively a small semi-circular polluted Bay, covering an area of about 2.8 km^2. It receives many kinds of vessels specially fishing boats in addition to a large amount of untreated sewage that flows into it amount about 36,000 m^3/day (Said and Maiyza 1987). The environmental conditions, in this area are greatly variable. The fouling communities in the Eastern Harbour of Alexandria were reported by Banoub (1960), Megally (1970) and Ghobashy (1976). The present work was conducted to demonstrate the seasonal variations, intesity and constituents of attachment of fouling organisms on exposed test panels for short and long duration of time. The occurrence of main stages of foulers in sea water was indicated in relation to the prevailing environmental parameters in the Harbour to give an idea about the respective periods of immersion. It is possible to make interesting successional the growth and longivity of fouling groups inhabited the the submerged objects.

Materials and methods

Observations were made during the period from March 1983 to March 1984 at a raft located in the Eastern Harbour of Alexandria. The fouling organisms were collected monthly by exposing test panels made of polystyrene (15 x 15 cm) fixed to an iron fram sized 1 x 0.8 m in two rows. This fram was immersed vertically from the raft at about 1.5 m below the sea surface. The panels were replaced and taken regularly at the beginning of every month. The exposed test panels were arranged in two series, a short term for one month exposure period and a long term for various intervals of immersions from two months to one year successively. The settling number of organisms, wet weight of the principal fouling groups and the growth of organisms with the knowledge of the approximate time of settlement on test panels were carried out. Water samples were taken monthly from the surface and 4.5 m depth. These samples were used for the measurements of salinity, dissolved oxygen, oxidizable oxygen and alkalinity according to Strickland and Parsons (1968). Plankton hauls were taken to examine the occurrence of the pelagic stages of common fouling organisms in the study area.

Results

1) *Environmental conditions*

The physical and chemical data are illustrated in Fig. 1. The annual fluctuation in temperature of sea water ranged from 28°C in August 1983 (summer) to 16°C in February 1984 (winter). On the other hand, the fluctuations in the values of pH, dissolved oxygen and salinity of seawater througout most of the year were not too great.

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2) *Seasonal changes in the fouling populations*
Short-term exposure panels
The fouling developed on the submerged panels for one month duration was very little both in settlement density and growth. A total of 34 different kinds of fouling were found to have settled every month of the year. These are listed in Table 1. The general fouling picture will be presented seasonly rather than monthly.

1. *Spring fouling (March-May).* The average water temperature was 22°C.
During this period the fouling developed on panels every month was relatively poor.Algae were predominated by *Ulva intestinalis,Ectocarpus conferroides,Cladophora* sp., *Enteromorpha* sp.The growth of these plants had to be 11, 4, 8 and 13.4 cm long after one month of settlement, respectively. While, *Bugula neritina* was encountered in large numbers during April and May 1983 with an average of 118 col/100 cm^2, attanined small size from 2 to 9 bifurcations.
The plankton samples included mostly of Polychaeta, barnacles and *Bugula* larvae (Table 2) during May 1983 were encounted by 1026,1944 and and 108 larvae/ m^3, recorded in the vertical hauls, respectively.

2. *Summer fouling (June-August).*The average water temperature was 27°C.
The fouling was also very poor. It was relatively more dense on the June panel weighed an average of 38 g /100 cm^2. It embraced mainly calcareous tube worms weighed 27 g. Alga,*Ectocarpus conferroides* dominated during summer monthes whereas *Chaetomorpha* sp. was common on August panel. The growth of algae, on the other hand, was very little about one cm long.
The majority of plankton samples recorded in the vertical hauls were embraced of Polychaeta, barnacles,larvae and Leptomedusae,reaching more than 7410, 855, and 114 org / m^3, respectively.

3. *Autumn fouling (September-November).* The average water temperature was 23°C.
The quantity and quality of fouling colonized on panels during autunm months was also very poor. The wet weight of fouling was about 7 g/100 cm^2. It consisted mainly of algae (*Ectocarpus conferroides* and *Ulva intestinalis*), tube worms (*Hydriodes elegans* and *Serpula vermicularis*) and Hydriods (*Obelia geniculata*) while, *Balanus amphitrite* is the only barnacle species settled during this season and encounted in few number (5-36 ind/100 cm^2) attained sexual maturity at 8 mm in basal diameter. Polychaet, Barnacles and leptomedusae were still abundant in the plankton samples numbered 1500, 1300, and 530 org/ m^3, respectively. Bivalve veliger larvae dominated during September (1385 org/m^3).

4. *Winter fouling (December 1983-February 1984).* The water temperature decreased to 16 °C in January.
The fouling assemblaged during winter months was represented by about 3 -13 g/100 cm^2.They contained large quantity of algae,*Ulva intestinalis* and *Ectocarpus conferriodes* rather than *Cladophora* sp. and *Ceramium* sp. The other fouling included few colonies of Hydriods (*Obelia geniculata* and *Tubularia larynx*), Bryozoa (*Bugula neritina* and *B. turbinata*), and few individuals of tube worms and barnacles were recorded.
Barnacles larvae yielded high values during December (2585 org/ m^3). It does not reflect the real attachment numbers of barnacles grown on the month panel. This may be due to low temperature during December.

3) *Species composition and settlement of fouling organisms on long-term exposure panels*
During the investigation period from March 1983 to March 1984, a total of 41 species of sedentary marine fouling organisms were recorded on the long term panels (Table 3). These species belonged to 8 main fouling groups namely,Barnacles,Serpulid tube worms,Ascidians, Bryozoa, Amphipod mud building tubes, Hydriods. Algae and Sponges.
They are considered among the main constituents of fouling organisms growing in many harbours of the world. In addition to 21 species of free-living form, four Polychaet, five Decapod, seven Amphipod, five Isopod and unidentified Platyhelminthes species.

1) Barnacles were the predominant population and the most persistant fouling grown on the submerged surfaces especially for prolonged durations of immersion (Fig.2). They showed maximum growth rate during the first two months and their survival extended for 8 successive months or more. They were represented by four species namely, *Balanus amphitrite, B. eburneus, B. perforatus* and *B. trigonus.*

2) Serpulid calcareous tube worms were numerically the most abundant animals which were attached in considerable amount forming a dense mat, usually reaching a thickness of more or less 3 cm. They flourished well on the panels exposed during spring and early summer months for longer intervals (Fig. 2). This may be attributed to the breeding seasons and the overcrowded tube worms can be easily removed under the effect of the external circumstances. This community included 6 species of Serpulids (Table 3), predominated by *Hydriodes elegans* and *Serpula vermicularis.* The other four species were found in few numbers.

3)The solitary Ascidians *Ciona intestinalis,Styela partita, S.plicata* and *Ascidia mentula* grew well on panels immersed for long periods. The first species dominated on the bimonthly panels. *S. partita* and *S. plicata* could survive for 6 to 8 successive months.

4) *Bugula neritina* and *B. turbinata* were the main erect Bryozoa prevailed on the submerged test panels for long term.They appeared in large numbers of colonies reaching more than 20-bifurcations , could survive for about 4 successive months. They developed at the same time of the development of algae on the exposed panels except during summer months. Two species of encrusting and stolonate bryozoans species were recorded on the long term panels (Table 3).

5) Amphipod building tubes were found in large quantities during the year. The densely fouled panels are more favourable for the formation of these muddy tubes in particular on long exposure panels during summer and autumn seasons. The predominance of amphipod species is as follows: *Corophium sextomi* and *Elasmopus pectenie* outnumbered both *Erichthonius barasilie* and *Stenothoe* sp. while each of *Jassa falcata, Tanias cavolinii* and the tubuless *Caprella equilibra* were less frequent

6) Hydriods occured in few quantities on test panels during most of the year, especially on prolonged exposure panels. Colonies of *Obelia geniculata* were outnumbered by *Tubularia larynx.* The latter species was found during April, May and December 1983 after 2,3 and 10 months immersion, respectively.

7) Sponges were found in very little numbers on long term panels.They occurred on November,1983 panels after 3,6 and 9 months and on January, 1984 panel after 3 months immersion. The colony attained size about 8 to 22 mm long.

8) Free-living fouling organisms were represented by small numbers in particular on prolonged test panels almostly during the year. They included 3 species of Polychaet, 5 species of Isopod (Table 3).

9) Platyhelminthes were found on panels immersed for long periods and encounted in few number inhabited the shells of barnacles especially on June, 1983 panels after one and 4 months immersion .

10) Algea appreared on the submerged panels during most of the year, except in summer months. Flora was mainly belonging to green algae.

Discussion

Pollution caused by the draining 36,000 m^3/day of untreated sewage into the harbour obviously results seasonal fluctuations in the environmental conditions in paticular the dissolved oxygen, oxidizable oxygen and alkalinity of seawater. The presence of fouling larval stages in plankton samples through most of the year did not demonstrate the real settlement intensity of fouling grown on monthly exposed panels especially during the hot months. Therefore, the larvae were prevented from reaching the attachement stage or futher growth smothered.

The fouling complex on the exposed test panels tend to be dominated by barnacles, tube worms, bryozoans and ascidians on which barnacles community firstly settled and was sequented by tube worms, colonial and solitory ascidians and erect Bryozoa. The fouling colonized on panels submerged for long durations was considerably more dense than the total fouling collected on short term panels exposed successively during the same period. According to Meadows (1969) the correlation between short and long term fouling biomass is 1:2:3 after one,two and three months exposure periods,respectively. This condition may apply under the same conditions of growth, life span and the density of fouling.The fouling constitution on exposed panels for long term reach to "saturation point" after 3 to 6 successive months and some fouling communities attained a dominant position.The same was recorded in lake Timsah,Suez Canal,which the panels reached a saturated point after 6 or 9 months depending on the time of immersion (El-Komi,1980; Ghobashy and El-Koim 1980). New attachment of barnacles larvae have to be prevented to make highly fouled surfaces with adult barnacles (Connell,1961). The growth of fouling organisms reduced during the winter where the animals grow rapidly during warm seasons even the fouling density is high. Therefore, the water temperature detected the distribution of marine aniamls and changes in abundance in different seasons (Connell,1974). In this study, however, the large seasonal changes in water temperature dissolved oxygen, oxidizable oxygen and tansparency of sea water directly affected the settlement and growth of fouling organisms. On the other hand, the occurrence of large amount of larvae in sea water and the variety of fouling organisms grown on exposed panels for one month period suggests that the adult animals fail to reach maturity during short period.

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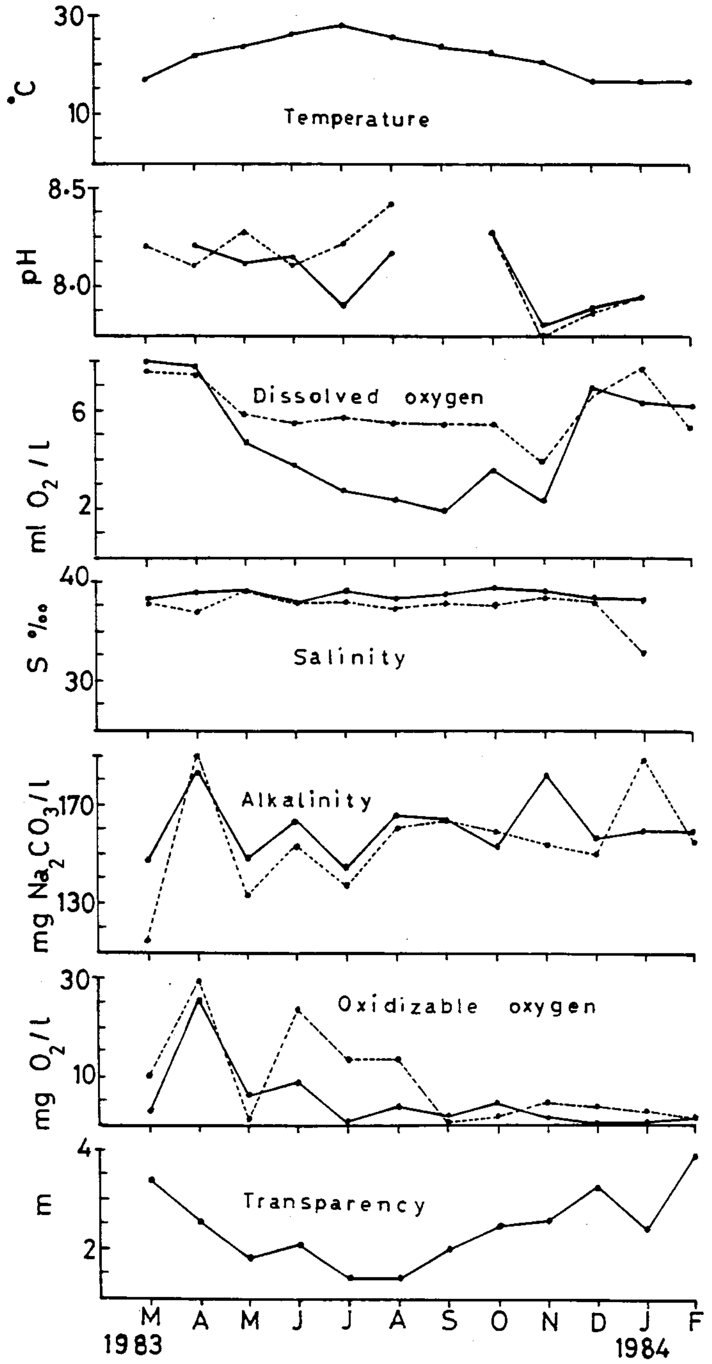

Fig. 1 Seasonal varaitions of environmental factors in the Eastern Harbour of Alexandria at the surface (----) and a depth of 4.5 m below the sea surface (—),during March 1983 to March 1984.

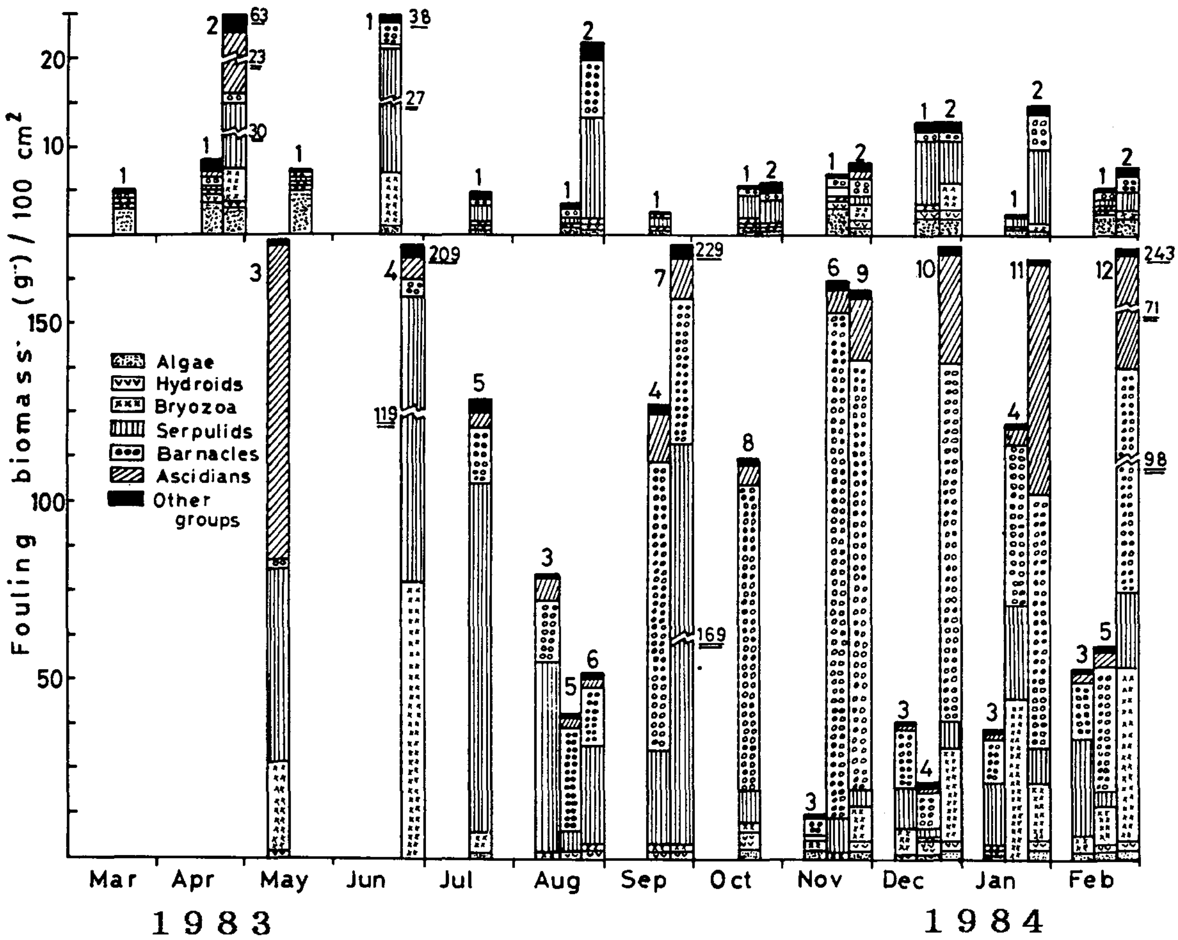

Fig. 2 Seasonal variations of fouling biomass (wet weight/100cm^2) developed on submerged test panels monthly and bimonthly (the upper half) and long term exposure periods from 3 to 12-months (the lower half) during March 1983 to February 1984 in the Eastern Harbour of Alexandria. Numbers illustrate the immersion durations in months.

Table 1. Monthly changes in the settlement of fouling organisms on panels (No. org/100 cm^2) and the total biomass during March 1983 to February 1984 in the Eastern Harbour of Alexandria.

Species	Mar 1983	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 1984	Feb
ALGAE												
Ulva intestinalis	-	C	C	P	-	-	P	P	P	A	A	P
Cladophora sp.	P	-	-	-	-	-	-	-	-	P	P	C
Chaetomorpha sp.	-	-	-	-	-	C	C	-	-	-	-	-
Enteromorpha sp.	A	-	-	P	-	-	-	-	-	-	C	P
Ectocarpus sp.	C	C	C	C	C	C	C	A	A	A	C	C
Ceramium sp.	-	-	-	-	-	-	-	P	P	P	-	P
HYDRIODS												
Obelia geniculata	-	-	C	-	P	C	C	C	P	C	-	P
Tubularia larynx	-	5	-	-	-	-	-	-	7	11	-	-
BRYOZOA												
Bugula neritina	10	118	88	41	11	-	-	4	28	26	4	66
Bugula turbinata	-	1	-	-	-	-	-	-	-	-	-	-
Zoobatryon sp.	-	-	-	-	-	-	C	P	P	-	-	-
Bowerbankia sp.	-	-	-	-	-	-	-	-	P	-	-	-
Watersipora sp.	-	-	-	-	-	-	-	P	-	-	-	-
POLYCHAET												
Hydriodes elegans	-	5	506	5280	352	83	739	4400	2640	1012	154	29
Serpula vermicularis	-	88	P	P	P	P	P	P	P	P	P	P
Spirorbis sp.	-	-	-	-	-	4	-	-	-	-	-	-
Syllis sp.	-	-	-	-	4	5	-	9	6	8	-	-
Nereis diversicolor	-	1	18	4	5	7	-	14	4	-	-	3
BARNACLES												
Balanus amphitrite	1	1	1	7	4	4	5	12	36	10	11	16
Balanus eburneus	-	-	-	2	1	1	-	1	-	2	-	-
Balanus perforatus	-	4	2	32	2	2	-	-	-	-	1	9
Balanus trigonus	-	-	-	1	1	-	-	-	-	-	-	-
Amphipod tubes	308	792	704	1100	103	154	88	352	1100	1012	88	88
Corophium sextomi	4	46	28	23	6	8	37	70	79	100	15	15
Erichthoneus brasi.	42	238	370	286	-	7	5	8	-	37	-	8
Jassa falcata	210	8	17	66	3	-	-	-	-	-	-	3
Stenothoe sp.	26	-	-	21	11	14	-	33	11	27	8	4
Elasmopus pectenicrus	-	-	-	117	-	-	17	26	59	52	40	9
Caprella equilibra	-	6	6	2	-	-	-	-	-	-	-	-
Tanais cavolinii	2	5	4	2	1	-	7	23	40	18	10	5
Idotea baltica	2	4	1	-	-	-	-	-	-	-	-	-
Cymodoce truncata	-	-	1	-	-	-	-	-	-	-	-	-
Dynamene bidentata	-	-	-	37	-	-	-	-	-	-	-	-
ASCIDIANS												
Diplosoma listerianum	-	-	1	-	-	-	-	-	-	-	-	-
Botryllus schlosseri	-	10	-	-	-	-	-	-	-	-	-	-
Platyhelminthes	-	-	-	10	-	-	-	-	-	-	-	-
Total wet weight	4	8	6	38	4	3	2	6	7	13	2	5

A = Abundant, C = Common, and P = Present

Table 2. Seasonal changes of the planktonic larvae in the Eastern Harbour of Alexandria (No. of larvae/m^3) recorded in the vertical hauls during the period from March 1983 to March 1984.

Groups	Mar 1983	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 1984	Feb	Mar
Leptomedusae	-	-	-	114	57	-	22	69	360	-	220	19	120
Bugula spp. larvae	-	-	108	-	-	-	-	-	-	-	66	-	-
Polychaeta larvae	420	600	1026	7410	2679	1508	1496	1172	168	825	290	230	2112
Barnacles Nauplius l.	240	300	1944	798	342	884	220	414	264	2585	110	38	1248
Barnacles cypris l.	20	120	-	57	-	156	-	-	-	-	-	-	-
Bivalve larvae	-	60	-	114	-	-	1385	161	-	-	44	-	-
Gastropod larvae	-	-	-	-	-	-	-	-	-	165	22	-	-
Ascidians larvae	20	20	-	-	-	-	-	-	-	-	22	-	48
Appendicularia	-	-	-	228	798	156	-	115	-	55	-	-	-
Total No. org/m^3	700	1100	3078	8721	3876	2704	3123	1931	792	3630	774	287	3528

Table 3. Species composition of fouling recorded on long-term panels during various durations of immersion from March 1983 to February 1984, in the Eastern Harbour of Alexandria.

Algae
Ulva intestinalis
Chaetomorpha sp.
Polysiphonia sp.
Ectocarpus sp.
Enteromorpha sp.
Cladomorpha sp.
Codium sp.
Ceramium sp.

Sponges

Hydriods
Obelia geniculata
Tubularia larynx

Bryozoa
Bugula neritina
Zoobotryon sp.
Bowerbankia imbricata
Schizoporella errata
Bugula turbinata
Bowerbankia gracilis
Cryptosula pallasiana

Platyhelminthis

Polychaeta
Hydriodes elegans
Hydriodes dirampha
Pomatoceros triqueter
Polydora sp.
Syllis sp.
Nereis diversicolor
Hydriodes dianthus
Serpula vermicularis
Dasychone sp.
Sabella sp.
Eupolymnia sp..
Scale worms

Barnacles
Balanus amphitrite
Balanus perforatus
Balanus eburneus
Balanus trigonus

Amphipod building tubes

Amphipod
Corophium sextomi
Jassa falcata
Elasmopus pectenia
Tanais cavolinii
Erichthonius brasiliensis
Stenothoe sp.
Caprella equilibra

Isopod
Cirolana aegyptica
Dynamene bidentus
Idotea baltica
Cymodoce truncata
Sphaeroma sp.

Decapod
Pachygrapsus sp.
Eriphia sp.
Alepheus sp.
Xantho sp.
Thia sp.

Mollusca
Venerupus sp.
Anomia ephippium
Cardium sp.

Ascidians
Ciona intestinalis
Styela partita
Diplosoma listeranum
Botryiloides sp.
Ascidia mentula
Styela plicata
Botryllus schlosseri