

PERIODICITY AND DISTRIBUTION OF BOTTOM FAUNA IN THE HYPER-SALINE BARDAWIL LAGOON (EGYPT).

SAWSAN M. ABOUL-EZZ.

Institute of Oceanography and Fisheries, Alexandria, Egypt.

ABSTRACT

Quantitative estimation of macro-bottom fauna in Bardawil Lagoon was carried out seasonally during the years 1986 and 1987. The lagoon is a shallow hypersaline water basin with a depth ranging between 0.5 and 2 meters. It is located at the northern extremity of Sinai Peninsula (Egypt) and is in a direct connection with the Mediterranean Sea through two narrow openings. Twelve stations were selected to represent the different habitats in the lagoon.

Most of the recorded species of benthos are typical euryhaline marine forms which can withstand hypersaline conditions. The community consists mainly of members of Annelida (61% by number of the total benthos), Arthropoda (32.7%) and Mollusca (12.6%). Other groups of less frequency comprised Nematoda, Medusae and Echinodermata.

The polychaete *Hydroides*, *Sabella* and *Nereis*, the amphipods *Corophium* and *Gammarus*, the Chironomid larvae of insects and the molluscs *Brachiodontes* and *Cerithium*, represented the main components of macrobenthos.

The annual counts of the total bottom fauna averaged 3893 and 3528 organisms/m² during 1986 and 1987, respectively. Their average biomasses amounted to 60.4 gm/fresh weight/m² for the two successive years.

INTRODUCTION

The Bardawil Lagoon represents a hypersaline shallow water basin lying along the northern coast of Sinai Peninsula between longitudes E 32° 40' and 33° 30' and at latitude N 31° 10'. It extends for about 90 km and has a maximum width of 22 km, (Fig. 1). The flooded area is approximately 65000 hectare. The water depth ranges between 0.5 and 2 meters, being separated from the Mediterranean Sea by a narrow sedimentary bar with a maximum width of about 2 km. The Lagoon is directly connected to the sea through two narrow openings named as Boughaz I and Boughaz II. Its main water supply comes from the Mediterranean Sea which flows constantly into the Lagoon through these two openings. Due to its shallowness, the Lagoon is subjected to excessive water evaporation, particularly during summer. Accordingly, the water salinity in the Lagoon appeared mostly

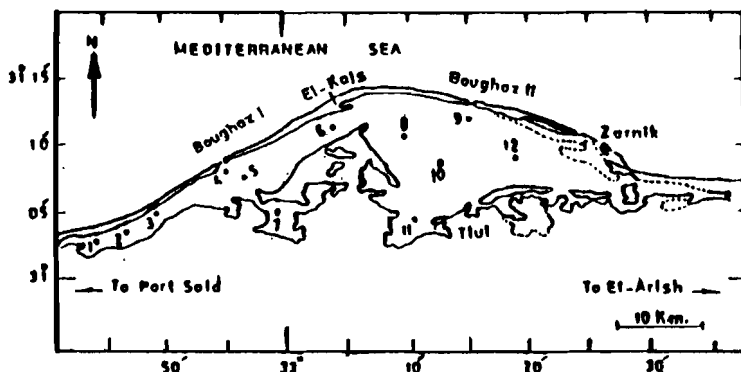


Fig. 1
Morphometry of Bardawil Lagoon and location of stations.

Its horizontal distribution showed a gradual increase from the Boughaz regions towards the southern margins.

The average monthly water temperature fluctuated between 15°C in winter and 31°C during summer. The pH values of the Lagoon water fluctuated within narrow range between 7.6 and 8.5 throughout most of the year with an average of 8.1. The dissolved oxygen was relatively low during spring and summer (average 3.8 ml O₂/l) but it increased gradually to 4.1 and 6.2 ml O₂/l in autumn and winter, respectively (Ibrahim et al., 1987).

The upper layer of the bottom sediments of Bardawil Lagoon is sandy at the periphery and clayey sand in the rest of the area except in the deepest parts which are silty clay (Levy, 1974). Stretched areas of the Lagoon bottom are covered with the sea grass *Ruppia* species (Lipkin, 1969 & 1977 and Pisanty, 1980).

MATERIALS AND METHODS

Quantitative sampling of bottom fauna was performed at twelve stations representing the different habitats in the Lagoon, using a modified Ekman bottom sampler, (Fig. 1). Two dredges were taken from each station representing area equivalent to 0.06 square meter of the upper layer of the bottom deposits.

The samples were then washed in the field through a small hand net of bolting silk (23 mesh/cm) and preserved in polyethylene jars after adding 10% formaline solution. Sorting and identification of the different species were carried out in the laboratory. The different groups were counted and

their biomasses were determined. Results were given as the total numbers of bottom fauna per square meter as well as their biomasses in gram fresh weights per square meter.

RESULTS AND DISCUSSION

Distribution and Seasonal Variations Of The Total Fauna

The living benthic macrofauna in Bardawil Lagoon comprised about 46 species within 36 families, belonging to the phyla Annelida, Arthropoda, Mollusca, Echinodermata, Coelentrata and Nematoda.

The average annual numbers and biomasses of the total fauna recorded at the different stations are illustrated in Figure 2. The highest counts were recorded at station 7 which represents a semiclosed area lying along the southern margins of the Lagoon, while the lowest appeared at stations 4 and 5 during 1986 and 1987, respectively. On the other hand, the maximum biomasses of the total bottom fauna were observed at stations 8 and 10 during the two successive years, respectively, mainly due to the presence of big mussels. The lowest records appeared at station 11 during 1986.

The total number of bottom fauna were subjected to seasonal fluctuations within a narrow range (Fig. 3A). The peaks of 4679 and 5293 organisms/m² were recorded during spring of the two successive years, mostly due to the increased numbers of polychaetes, amphipods and Chironomid larvae. The lowest standing stock was observed in the summer of 1986 (3129 organisms/m²) and autumn of 1987 (2345 organisms/m²).

The seasonal fluctuations of the total biomasses of benthic fauna were diversified in the two successive years. Thus, the winter and autumn of 1986 sustained, respectively the lowest and highest biomasses (42.9 and 78.4 gm fresh weight/m²). During 1987, the autumn harboured the lowest biomass of 44.5 gm fresh weight/m², otherwise they remained more or less constant throughout the rest of the year which averaged 65.7 gm fresh weight/m² (Fig. 3B). Lamellibranchs contributed a big fraction of the total biomasses of benthic fauna during the autumn of 1986 and throughout 1987 and polychaetes were more dominant in the spring of 1986.

Distribution Of The Dominant Groups

1- Annelida

a- Polychaeta

Polychaetes formed numerically about 80% of the total benthos. Their dominance in the Lagoon appears to be related to the nature of the bottom sediments which is in most parts clayey sand or silty clay. Their tolerance to low O₂ concentration also explains their wide distribution in the Lagoon.

Twenty three species had been identified and were dominated by the families Serpulidae (41% by number of the total polychaetes) and Nereidae (16.8%) as shown in Table 1. Members of polychaetes were recorded at all stations, being more dominant at the southern margins (stations 7 and 11) particularly due to *Hydroides norvegica* (Fig. 4). Their maximum

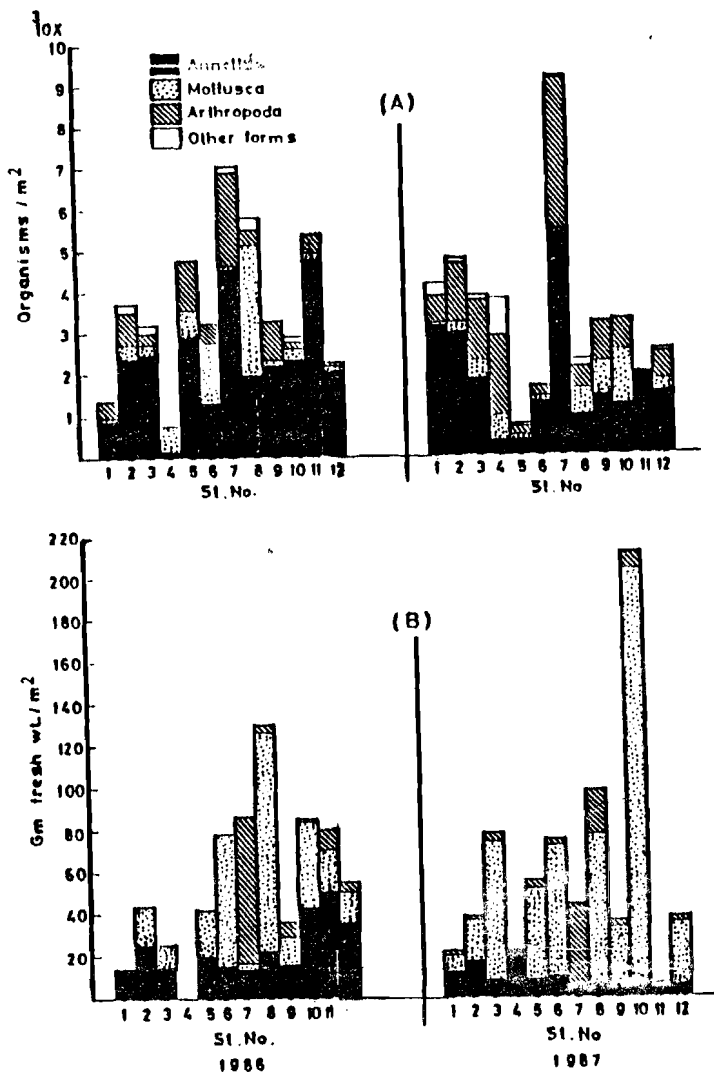


Fig. 2
 Annual distribution of the different groups of bottom fauna in Bardawil Lagoon during 1986 & 1987.
 A: Number (organisms/m²) B: Biomass (gm fresh wt./m²).

TABLE 1
Average annual values of the different species of polychaetes (Organisms/m²) and their percentage frequencies during 1986 & 1987.

Species	1986		1987	
	No./m ²	%	No./m ²	%
<i>Hydroides norvegica</i> (Sarsus)	1120	45.0	816	40.6
<i>Subellia fabricia</i> (Ehrenb.)	78	3.1	212	11.3
<i>Elysipta rostris</i> (Aud et Milne Ed W.)	377	15.0	73	3.6
<i>Capitella capitata</i> (Fabr.)	327	13.0	129	6.9
<i>Nereis diversicolor</i> (O.F. Mull.)	150	6.0	514	27.5
<i>Nelusetta</i> sp.	84	3.3	35	1.9
<i>Polychaetes lacteus</i> (Schm.)	93	3.7	73	4.0
<i>Eupolygona nebulosa</i> (Verri)	135	5.4	49	2.6
<i>Capitellus musmanni</i> (Bontalini)	61	2.5	-	-
<i>Chaetopterus</i> sp.	42	1.7	1	0.1
<i>Cirratulus pseudocirrata</i> (Bridgman)	-	-	25	1.8
<i>Acanthosyllis subopacitor</i> (Larock)	1	0.04	27	1.4
<i>Eniceta torquata</i> (Quatref.)	4	0.2	-	-
<i>Stylarctides pilimana</i> (O.F. Muller)	8	0.32	-	-
<i>Dolichoglossus</i> sp.	4	0.2	-	-
<i>Aerolita maritima</i> (L.)	-	-	11	0.6
<i>Arctolytes</i> sp.	-	-	1	0.1
<i>Dasytyrochus calceus</i> (Grube)	1	0.04	-	-
<i>Phoronopsis viridis</i> (Milton)	-	-	1	0.1
<i>Physosoma</i> sp.	-	-	9	0.5
<i>Aegleteria</i> sp.	-	-	30	1.6
<i>Brania clavelata</i> (Clap)	-	-	3	0.2
<i>Prorhale tubularia</i> (Montagu)	25	1.0	-	-
Total polychaete species	2510	100%	2010	100%

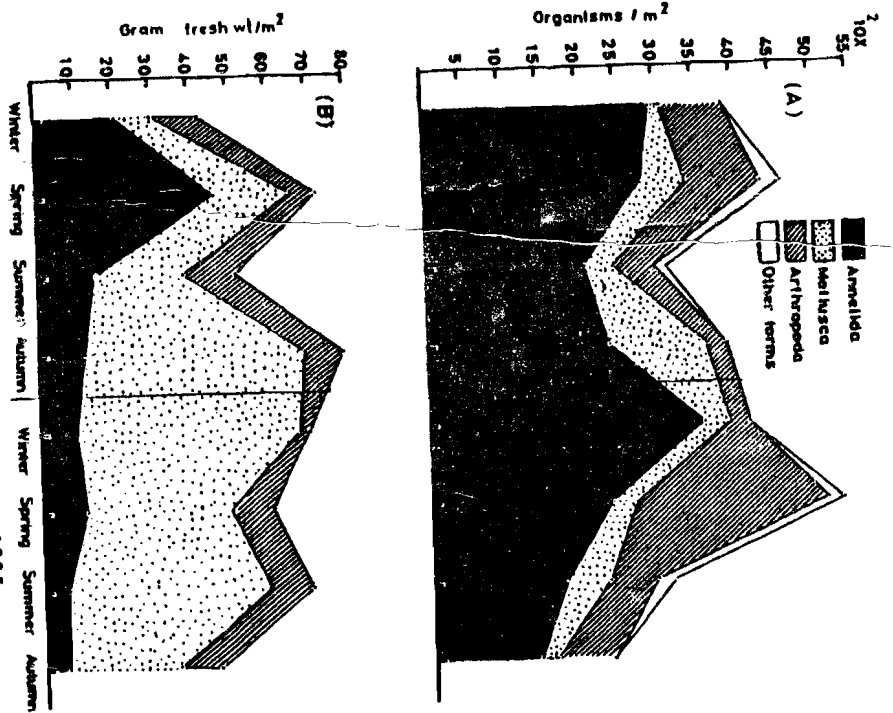


Fig. 3
Seasonal variations of the total bottom fauna in Bardawli Lagoon during 1986-1987.
A: Number (organisms/m²) B: Biomass (gm fresh wt./m²).

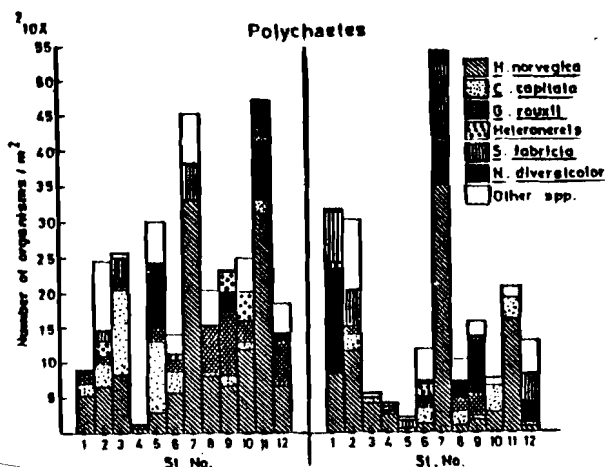


Fig. 4
Annual distribution of polychaetes (organisms/m²) at the different stations in Bardawil Lagoon during 1986 & 1987.

persistence was in winter as produced by the increased number of *Hydroides* and *Nereis*. While the summer and autumn harboured the lowest counts (Fig. 5).

The biomasses of the total polychaetes averaged 23.3 and 9.5 gm fresh wt/m² during the two successive years. The highest weights were recorded in the spring of 1986 particularly at stations 10, 11 and 12.

b- Oligochaeta

The Oligochaete *Enchitraeus adriaticus* (VEJD) was rarely recorded in the Lagoon, forming numerically about 1.1% of the total benthos. It was mostly confined to the western sector (stations 1-6) during one season or the other, showing maximum persistence in the summer of 1986. Its annual counts averaged 45 and 33 organisms/m² during 1986 and 1987, respectively.

2- Arthropoda

a- Crustacea

Crustaceans contributed numerically about 12% of the total benthos. They comprised eight species and were dominated by *Corophium* sp. and *Gammarus locusta* (Table 2).

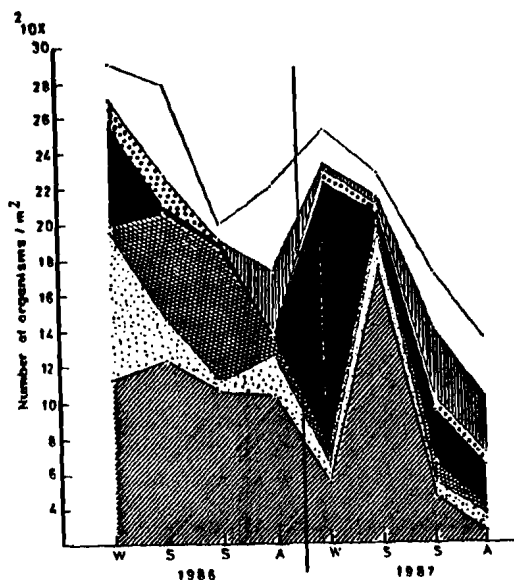


Fig. 5
Seasonal variations of polychaetes (organisms/m²)
in Bardawil Lagoon during 1986-1987.

TABLE 2
Average annual values of the different species of crustacea
(Organisms/m²) and their percentage frequencies during 1986
and 1987

Species	1986		1987	
	No/m ²	%	No/m ²	%
Corophium sp.	270	91.0	124	21.7
Gammarus locusta L.	18	6.7	201	49.8
Mysis relicta Loven	2	0.6	-	-
Anthura gracilis Mont.	7	2.4	93	16.3
Balanus amphitrite Darwin	-	-	64	11.9
Lepas sp.	1	0.3	-	-
Palaeomon sp.	-	-	7	1.2
Cancer sp.	-	-	2	0.4
Total	298	100%	571	100%

Crustaceans appeared more frequent at station 2 of the western sector as well as about the middle of the Lake (Stations 5-9) during 1986 particularly due to the increased number of *Corophium* sp. Their maximum persistence was in winter and spring (426 and 573 organisms/m², respectively). In 1987, they were recorded at most stations, being more dominant in the western sector (stations 2-4). An outstanding peak of 1559 organisms/m² was recorded in the spring of 1987 and was dominated by *Gammarus locusta* and less so by *Anthura gracilis* (Figs. 6 & 7).

Corophium sp. formed more than 90% of the total crustaceans during 1986 and was mostly confined to the winter and spring. During 1987, the species formed only 21.7% of the total crustaceans, being more frequent at stations 9 and 10 in summer.

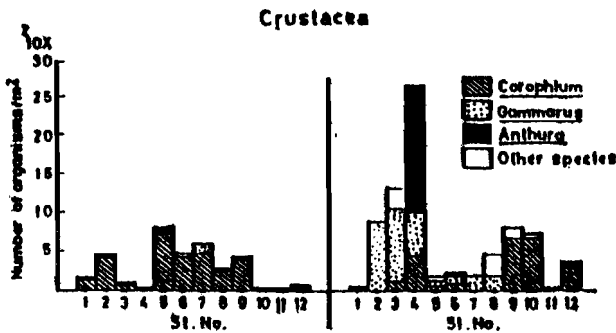


Fig. 6
Annual distribution of crustaceans (organisms/m²) at the different stations in Bardawil Lagoon during 1986 & 1987.

Gammarus locusta appeared more dominant in 1987, forming more than 49% by number of the total crustaceans. Its maximum persistence was in the western sector (stations 2, 3 & 4) during the spring.

Mysis relicta which is a tycho planktonic species was rarely noticed in the bottom samples during the winter and spring of 1986 at stations 1 and 3, respectively.

The isopod *Anthura gracilis* appeared only at station 5 in winter, 1986 with 334 organisms/m² and at station 4 in spring, 1987 (3340 organisms/m²).

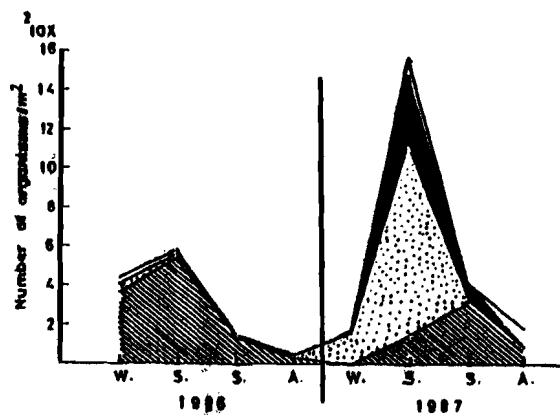


Fig. 7
Seasonal variations of crustaceans (organisms/m²) in Bardani Lagoon during 1986-1987.

The cirriped *Balanus amphitrite* was rarely recorded at scattered stations growing mainly attached to *Cerastoderma* shells during 1987 forming about 11.2% of the total crustacean counts. Their highest frequency appeared at station 3 in spring (785 organisms/m²) and at stations 8 in summer (1085 organisms/m²). Its distribution in the Lagoon agrees with the observations of Harding (1962) where the species is more dominant at high temperatures. The species is also more common at higher salinity and located in polyhaline waters (Relini, 1981).

Lepas sp. appeared once in the spring of 1986 at station 6 with 34 organisms/m².

The decapods *Palaemon* sp. and *Cancer* sp. were scarcely noticed at scattered stations during 1987, being more frequent during the autumn which harboured an average of 27 organisms/m².

b- Insecta

The chironomid larvae of *Cricotopus mediterraneus* formed numerically about 11.3% of the total benthos. The species was previously recorded in the Lagoon by Por and Ben Tuvja (1981). It appeared at scattered stations throughout the whole investigation period, being more frequent at the semiclosed station 7. Their average annual counts reached 361 and 462 organisms/m² during the two successive years. The peak was recorded in spring of 1987 (Figs. 8 & 9).

Insecta

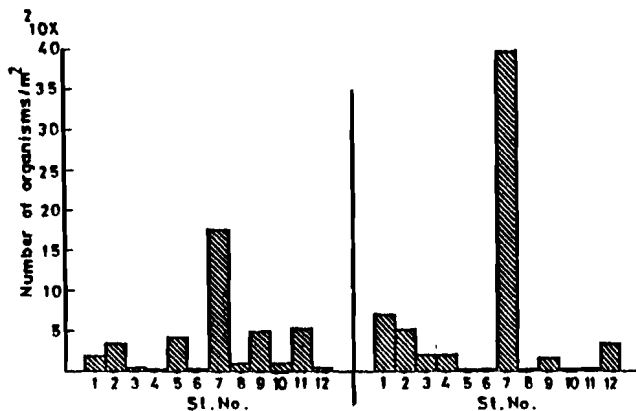


Fig. 8
Annual distribution chironomid larvae (organisms/m²) at the different stations in Bardawil Lagoon during 1986 & 1987.

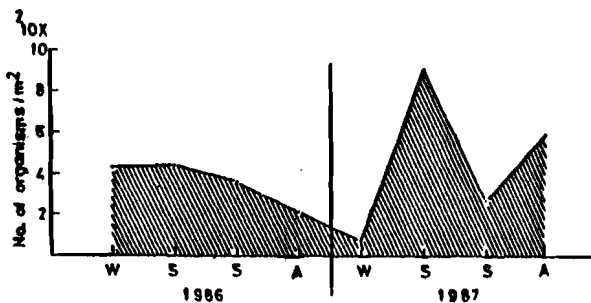


Fig. 9
Seasonal variations of chironomid larvae (organisms/m²) in Bardawil Lagoon during 1986-1987.

3- Mollusca

a- Lamellibranchiata

Lamellibranchs contributed about 10% by number of the total zoobenthos, showing maximum persistence at station 8 during the first year of investigation (Fig. 10). They were represented in the Lagoon by 9 species as illustrated in Table 3. *Brachiodontes variabilis* appeared as the most dominant species while *Cerastoderma edule* and *Mactra corallina* were less frequent, the other species persisted as rare forms.

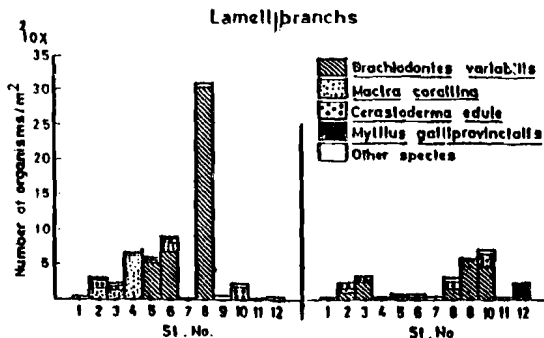


Fig. 10
Annual distribution of Lamellibranchs (organisms/m²) at the different stations in Bardawil Lagoon during 1986 & 1987.

Regarding their seasonal variations, the highest counts of lamellibranchs were in the autumn of 1986. They remained less frequent during the spring of 1986 and summer of 1987, otherwise they persisted as rare forms in other seasons. *Brachiodontes variabilis* formed the main component of the recorded peaks (Fig. 11).

The average biomass of lamellibranchs exceeded 41% of the total zoobenthos (25.1 gm fresh wt/m²). This is particularly due to the large specimens recorded in the autumn of 1986.

b- Gastropoda

Gastropods contributed about 2.5% by number of the total benthos. They were represented in the Lagoon by 5 species and were dominated by *Cerithium vulgatum* (Table 3). Station 6 harboured the highest standing crop in 1986, while they appeared more dominant at stations 4, 8 and 10 during 1987 (Fig. 12). The summer of 1986 and winter 1987 harboured the highest gastropod counts (Fig. 13).

TABLE 3
Seasonal variations of the total numbers of Molluscs (Organisms/m²)
recorded in Bardawil Lagoon during 1986-1987.

Species	1986					1987				
	Win.	Spr.	Sum.	Aut.	Aver.	Win.	Spr.	Sum.	Aut.	Aver.
(Lamellibranchata)										
<i>Brachiodontes variabilis</i> (L.)	33	360	50	1229	418	46	11	340	29	106
<i>Cerastoderma edule</i> (L.)	29	103	45	3	45	17	80	24	24	36
<i>Nacra corellina</i> (L.)	64	55	63	38	55	21	43	12	29	29
<i>Mytilus galloprovincialis</i> (L.)	5	18	-	-	5	17	39	2	35	26
<i>Donax trunculus</i> (L.)	-	5	4	2	2	17	2	3	3	6
<i>Tellina edentula</i> (L.)	-	-	-	-	-	-	6	-	-	2
<i>Arca lactea</i> (L.)	-	-	-	2	1	-	-	-	-	-
<i>Barnea candida</i> (L.)	-	-	-	-	-	-	-	-	8	2
<i>Cerastoderma</i> sp.	-	-	4	2	2	-	2	-	-	1
Total mussels	131	541	166	1276	620	118	177	381	128	203
(Gastropoda)										
<i>Cerithium vulgatum</i> (Brugulere)	-	12	177	2	48	209	115	32	26	95
<i>Cerithium reticulatum</i> (d'costa)	-	18	4	2	6	-	-	11	-	3
<i>Pirenella conica</i> (Linn.)	-	11	16	8	9	-	26	59	4	22
<i>Murex tribulus</i> (Linn.)	-	-	-	-	-	-	-	6	1	2
<i>Gastropod</i> sp.	-	-	-	-	-	-	-	2	3	1
Total gastropods	-	41	197	12	63	209	141	109	34	123

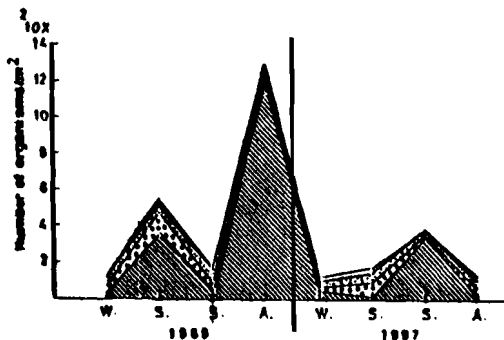


Fig. 11
Seasonal variations of Lamellibranchs (organisms/m²) in
Bardawil Lagoon during 1986-1987.

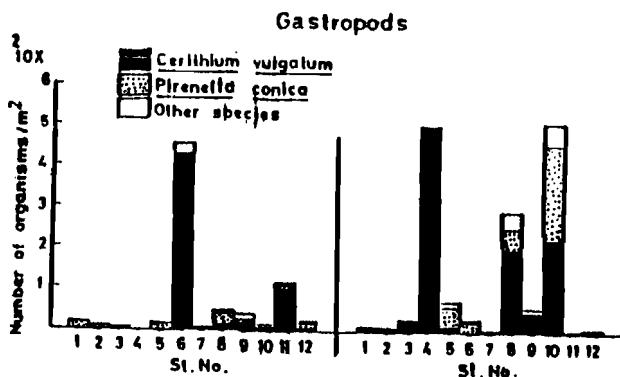


Fig. 12
Annual distribution gastropods (organisms/m²) at the different stations in Bardawil Lagoon during 1986 & 1987.

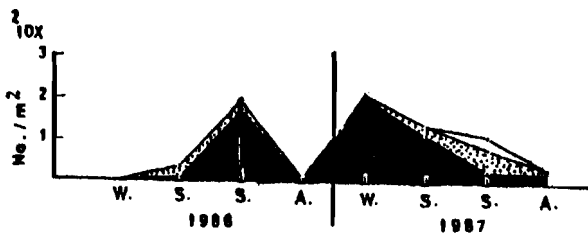


Fig. 13
Seasonal variations of gastropods (organisms/m²) in the Bardawil Lagoon during 1986-1987.

The gastropods formed about 17.8% of the total fresh weights of bottom fauna. Their average annual biomasses amounted, respectively 3.7 and 17.9 gm fresh weight/m² during the two successive years.

4- Nematoda

The free living nematod *Enoplus meridionalis* (Steiner) was rarely observed in the Lagoon, forming about 2.6% by number of the total bottom fauna with an average annual of 92 nematodes/m². Their maximum distribution was in the spring and summer of the two successive years. The western sector (Stations 1-3) as well as station 8 harboured the highest population.

5- Echinodermata

Patiria miniata (Brandt.) was only recorded during the spring and autumn of 1987 at stations 5, 6 and 2 respectively. Its average annual counts amounted to 20 organisms/m².

6- Coelentrata

The hydromedusa *Rhizostoma pulmo* (Agassiz) appeared only during 1987 at station 5 and 6 in the spring (334 and 117 organisms/m², respectively) and station 9 in summer (101 organisms/m²).

CONCLUSION

The importance of the macrobenthic fauna in the general productivity of lakes had been discussed by many investigators (cf. Welch, 1952). They feed mostly upon detritus including sedimentary phytoplankton and zooplankton organisms and they in turn furnish a direct food supply for other aquatic organisms including fish (Kawecka, 1977). Since Bardawil Lagoon is very shallow, its entire area belongs to the littoral zone. Such shallow Lagoons were found to support the most productivity benthic fauna (Muttkowski, 1918; Baker, 1918; Eggleton, 1935; Samaan and Aleem, 1972 and Samaan, 1977).

The composition of benthic fauna has long been considered as being a good indicator of water quality because, unlike planktonic organisms, they form relatively stable communities on the sediments which integrate changes over long time intervals, and reflect characteristics of both sediments and the above water column.

The Bardawil Lagoon represents one of the most important hypersaline water bodies in the eastern Mediterranean. It appears as a productive lake with high annual fish yield, where fisheries have been developed in accordance to the modern management principles (Pore and Tuvia, 1981).

Bardawil Lagoon harboured diversified benthic fauna including about 46 species. Their distribution was mainly controlled by the physico-chemical and the biological conditions prevailing the different localities. The most dominant species are euryhaline marine forms which can tolerate salinities exceeding 38‰. According to the muddy nature of the upper bottom sediments, the polychaetes *Hydroides norvegica*, *Sabella fabricia*, *Glycera rouxii* and *Nereis* spp. appeared as the most dominant bottom dwellers.

The Sabellid polychaete was previously recorded as being common in areas covered with *Ruppia* spp. (Gitai, 1970). *Nereis* was previously recorded as the an important bottom animal inhabiting Lake Mariut (Samaan and Aleem, 1972). Por (1972) described a rich fauna of crustaceans and nematodes in the Lagoon. During the present investigation *Corophium* persisted as a dominant amphipod at most stations in 1986. On the other hand, *Gammarus* predominated during 1987 in areas covered with hydrophytes. The chironomid larvae of *Cricotopus mediterraneus* represented an important fraction of the bottom fauna, being more common about at the southern margins of the western sector.

The appearance of the cirriped *Balanus amphitrite* in small number on the bottom confirmed the previous observations of Pisanty (1980).

Molluscs consisted mainly of euryhaline marine species such as *Cerastoderma edule*, *Brachiodontes variabilis*, *Donax trunculus*, *Mactra corallina*, *Pirenella conica* and *Cerithium reticulatum*. *Murex* appeared as rare gastropod inspite of the presence of plenty empty shells of the species in the Lagoon bottom.

Results of the present investigation indicate that the distribution of macro benthic fauna in Bardawil Lagoon is mostly related to ecological conditions prevailing in the different sectors, beside the nature of bottom sediments and fertility of water. The Lagoon contributed a rich biomass of bottom fauna which amounted to an average annual of 60.4 gm fresh weight/m². Such value is higher than that recorded for Lake Borollus which averaged 9.9 gm fresh wt/m² (Aboul Ezz, 1984) and Lake Edku which amounted to 10.41 gm fresh wt/m² (Samaan, 1977). On the other hand, the highly polluted Lake Mariut harboured an averaged low biomass of 0.39 gm fresh wt/m² during 1983 (Abd El-Aziz, 1987) and consisted mostly of *Nereis diversicolor* and of gastropod species.

The annual commercial fish yield in the Lagoon is also high when compared with the other Mediterranean Lagoons (Pisanty, 1980).

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