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Distribution and Biomass of Macrobenthic Fauna in the Chahbahar Bay (North Eastern Sea of Oman)

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Abstract: Population density, distribution and biomass of macrobenthic fauna in Chahbahar Bay were investigated from May 1995 to March 1996 on a bimonthly basis. The most abundant groups were Amphipods (21%), Polychaetes (19%), Gastropods (15.7%) and Bivalves (10.6%). Maximum (13000 individuals/m^2) and minimum (4600 individuals/m^2) were observed in May and July respectively. The changes in density were influenced by monsoon season of the Indian Ocean. Spatial and temporal variations in biomass were recorded for all groups separately. The lowest biomass was observed during monsoon period (July - September) with a mean of 51.5 g dry wt/m^2 and the highest in premonsoon period (March - May) with an average of 164.8 g dry wt/m^2. The results are discussed in terms of understanding secondary production of Chahbahar Bay.

KEY WORDS: Macrofauna, Distribution, Biomass, Monsoon, Chahbahar Bay

Introduction

The north west Indian Ocean including the sea of Oman is mainly influenced by monsoonal periods (Southwest Summer monsoon and Northeast Winter monsoon). The Southwest Summer monsoon usually starts in July and terminates in September, while the Northwest Winter monsoon starts in December and ends in March. The amplitude and effect of Summer monsoon is more pronounced in the Oman Sea and usually is marked by ceasation of all fishing activities for at least three months.

The intertidal and subtidal ecosystems of the sea of Oman and particularly Chahbahar Bay is very diverse and composed of many unique resources such as lobsters, shrimps and intense algal coverage. The macrobenthic fauna of the subtidal zone of this area is the least studied component. Studies concerned with the population density, distribution and biomass of benthic organisms in aquatic ecosystems would lead to useful information about the interrelations and

interactions in the ecosystems as well as evaluation of fisheries capacities and stock assessment.

Having a peculiar ecological position in the coastal waters of Sistan and Baluchestan Province, Chahbahar Bay has attracted a considerable attention as the main fishing ground for lobsters in the region. No adequate study relevant to understanding the ecosystem of this water body has yet been undertaken, however some investigation on the intertidal benthic fauna of this area have been conducted (Sari , 1992 ; Samaie , 1993 ; Ardalan , 1993 ; Saiedpour, 1994). The purpose of present study was therefore to investigate the population density, distribution and biomass of macrobenthic fauna of Chahbahar Bay which is part of a comprehensive study on the macrobenthic communities of the bay conducted in 1995.

Materials and Methods

Chahbahar Bay with an area of 320 km^2 is located in the Northeast of the sea of Oman, along the Sistan and Baluchestan Province. The average depth of the Bay is 6m while the deepest part at the entrance is about 19m.

The area is geographically located within 60° 37′ to 60° 24′ E and 25° 27′ to 25° 17′ N. Samples were collected at 14 sampling stations out of 30 initial stations covering depths from 5 to 19 m based on the statistically differences in the sediment grain size. Another site in the mouth of the Bay (22 m deep) acted as control station (Fig. 1). A bimonthly sampling strategy in May, July, September, November, January and March 1995-96 was adopted. Sediment samples were collected using a peterson grab with a sampling area of 0.1 m^2 . Three bottom samples from each station were collected, fixed and analysed according to methods outlined by Holme & McIntyre , 1984. The sediment samples were washed on board using a 1 mm mesh sieve, species were identified and their individuals were counted in laboratory. The identification was done using available literature and keys (Tucker, 1991 ; Kotpal, 1993 ; Campbell, 1976 ; Vine, 1986 ; Smythe, 1982 ; Jones, 1986). To assess the inter and intra variabilities in the biomass, the macrobenthos were divided into four groups: polychaetes, gastropods, bivalves and others. The biomass content of each group for each station and month was calculated. The seasonal changes of faunal density in relation to Indian Ocean Southwest Monsoon was also investigated. Two ways factorial analysis of variance (ANOVA) was used to identify the significant

differences in the density of three abundant group and all macrofauna within the stations and various monsoon periods.

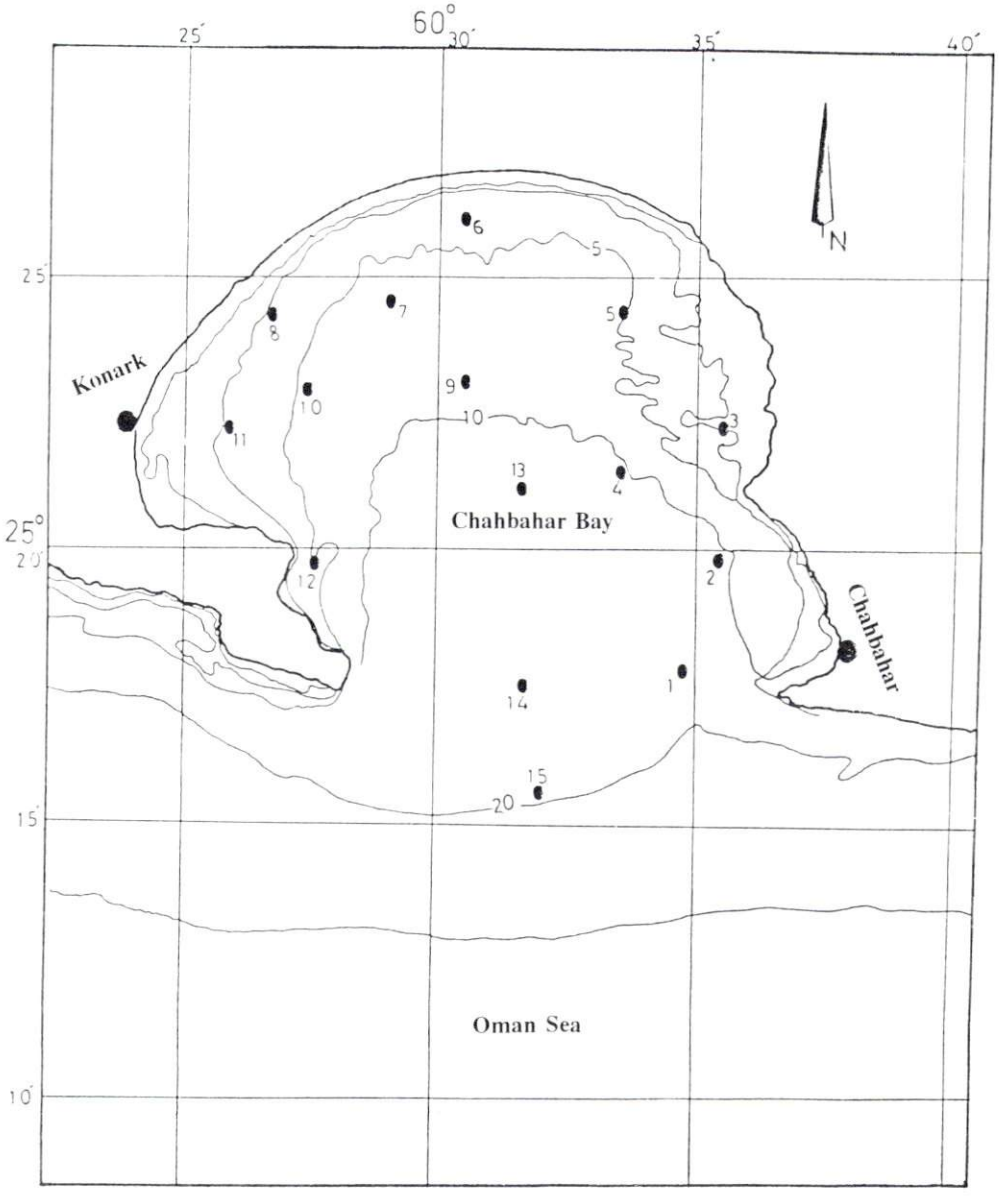

Fig. 1 : Location of sampling stations in the Chahbahar Bay

Results

During the course of this study, 18 different groups of macrobenthic fauna were identified in all samples. Table 1 shows population density and percentage abundance of each group. Among the groups identified amphipods were the most dominant comprising 21% of the total individual. Next to amphipods were polychaetes (19%), gastropods (15.7%) and bivalves (10.6%). The others which consist of the rest of the groups named in the table 1, comprised 29.8% of the total individual (Fig. 2). Temproal variations in the total number of individuals of all macrofaunal groups during the whole sampling period are shown in Fig. 3. Maximum population density was found during January - March 1995 (13000/m^2) and minimum in June (4600/m^2). The variation in number seems to be due to the Indian Ocean summer monsoon (Fig. 4). In this survey, out of six sampling periods, two were regarded as premonsoon period (March and May), two as monsoon period (July and September) and the remaining two as the postmonsoon period (November and January). There was a prononced effect of monsoon period on the number of individual decreasing from 10260/m^2 during premonsoon to 5140/m^2 in monsoon. Spatial variations in the population density of total macrofauna were also assessed (Fig. 5). According to this figure, stations 6 and 14 had the highest densities while stations 9, 12 and 15 (control station) showed the lowest abundance.

The assessment of the biomass for each group can be found in tables 2-7. Maximum biomass was recorded as 194 g dry weight/m^2 in March and the lowest biomass was recorded in July and September as 51.2 and 50.4 g dry weight/m^2 respectively (Fig. 6). Differences in the biomass content of different localities are also evident in Fig. 7. According to the results, stations 5 and 14 show the highest biomass whereas the amount of biomass in stations 3 and 12 was recorded as the lowest. The monsoonal effect on biomass is shown in Fig. 8. Accordingly the lowest biomass (51.5 g dry wt/m^2) was observed during monsoonal period and the highest in premonsoonal period equal to 164.8 g dry wt/m^2. The average biomass for the whole Chahbahar Bay was calculated as 109.3±49.5 g dry wt/m^2. Table 8 shows the biomass for all sampling periods in Chahbahar Bay in the bases of wet weight. The results of two ways analysis of variance (ANOVA) are given in table 9.

Tabe 1 : Density (No./m^2) and percentage composition of different macrofauna taxa sampled in Chahbahar Bay

Macrofauna	May		July		September		November		January		March	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
POLYCHAETA	1294	17.3	610	13.2	914	15.9	2265	27.1	2108	18.7	2398	18.4
OLIGOCHAETA	92	1.2	65	1.4	237	4.1	251	3.0	35	0.3	141	1.1
NEMERTENEA	58	0.8	35	0.8	12	0.2	39	0.5	131	1.2	115	0.9
GASTROPODA	881	11.8	829	17.9	1120	19.4	1697	20.3	1589	14.1	1838	14.1
BIVALVIA	969	12.9	739	16.0	567	9.8	350	4.2	758	6.7	1983	15.2
SCAPHOPODA	169	2.3	51	1.1	6	0.1	505	6.0	84	0.7	666	5.1
AMPHIPODA	791	10.6	831	17.9	1464	25.4	865	10.4	4089	36.3	2593	19.9
ISOPODA	15	0.2	12	0.3	12	0.2	45	0.5	22	0.2	62	0.5
DECAPODA	133	1.8	123	2.7	64	1.1	379	4.5	94	0.8	248	1.9
MYSIDS	6	0.1	35	0.8	45	0.8	38	0.5	45	0.4	146	1.1
CUMACEA	512	6.8	55	1.2	42	0.7	54	0.6	652	5.8	622	4.8
TANAIDACEA	85	1.1	70	1.5	18	0.3	262	3.1	74	0.7	9	0.1
OPHIUROIDEA	244	3.3	289	6.2	159	2.8	250	3.0	185	1.6	449	3.4
ECHINOIDEA	35	0.5	33	0.7	15	0.3	237	2.8	500	4.4	356	2.7
BRACHIOPODA	25	0.3	9	0.2	6	0.1	28	0.3	12	0.1	85	0.7
CEPHALOCORDATA	366	4.9	115	2.5	345	6.0	232	2.8	206	1.8	373	2.9
SIPUNCULIDA	712	9.5	87	1.9	69	1.2	55	0.7	143	1.3	394	3.0
OTHERS	1107	14.8	643	13.9	670	11.6	799	9.6	553	4.0	557	4.3
Total	7494	100	4631	100	5765	100	8351	100	1128	100	13036	100

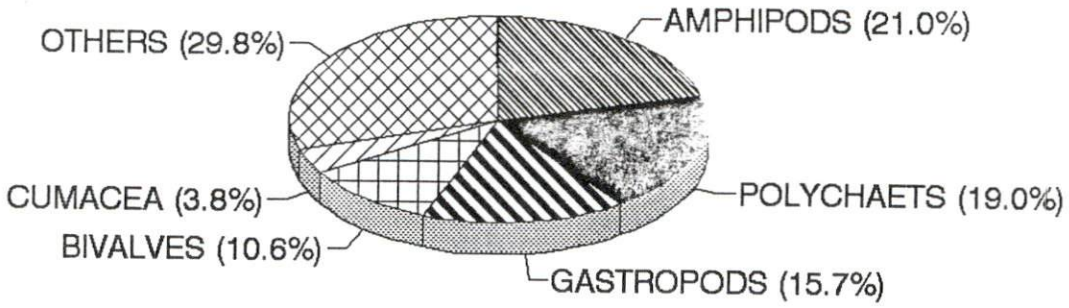

Fig. 2 : Precentage composition of different macrobenthic group in the Chahbahar Bay

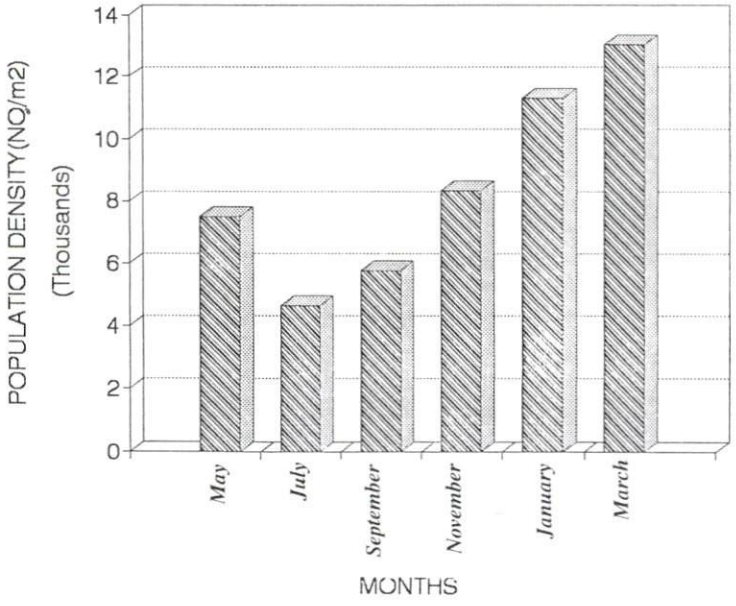

Fig. 3: Bimonthly variation of macrobenthic density (No./m^2) in the Chahbahar Bay

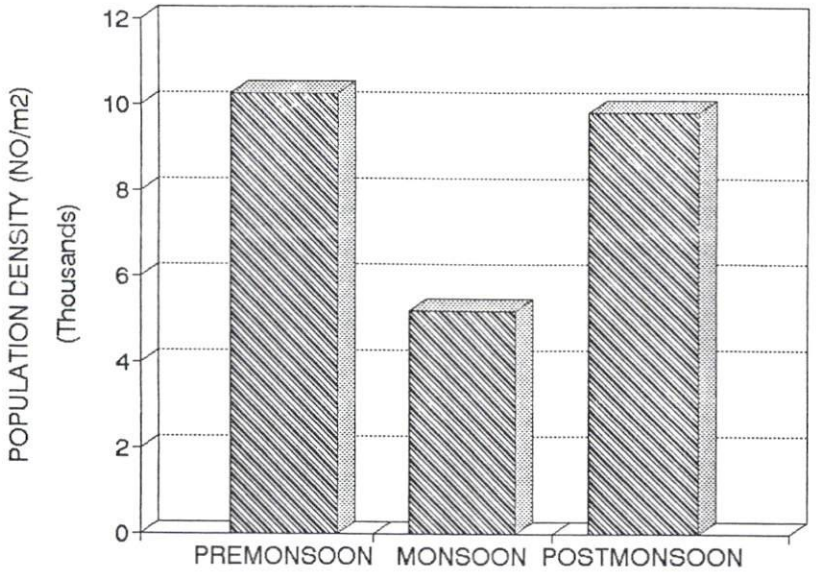

Fig. 4 : Monsoonal variation of macrobenthic density (No./m^2) in the Chahbahar Bay

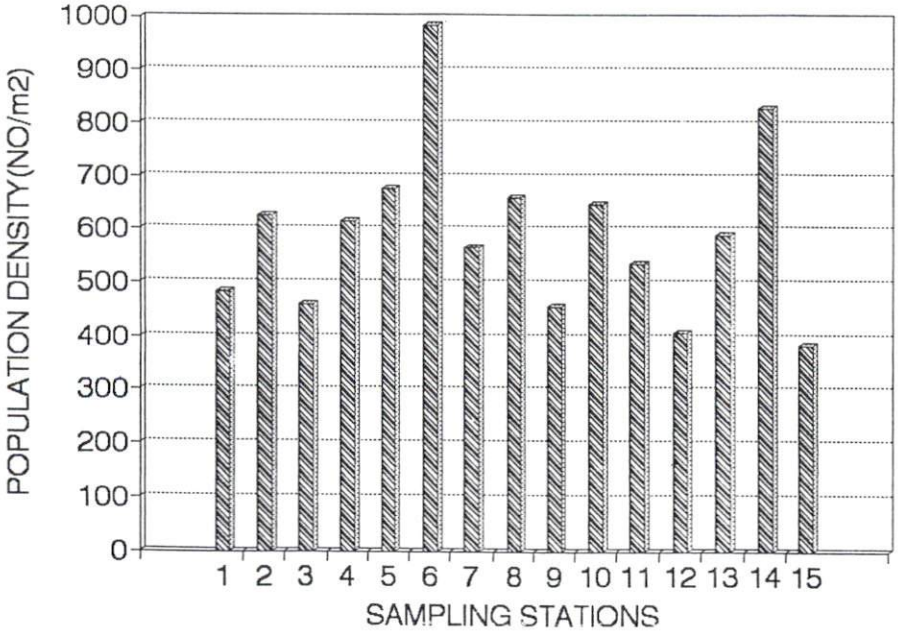

Fig. 5 : Mean population density of macrofauna at different stations in the Chahbahar Bay

Table 2 : Biomass of macrobenthic fauna sampled during May in Chahbahar Bay (g dry wt/m^2)

Stations	Biomass (gdry wt/m^2)			
	Polychaetes	Gastropods	Bivalves	Others
1	0.30	13.74	-------	3.84
2	0.39	0.30	1.20	12.20
3	0.05	4.50	0.35	0.15
4	0.90	0.90	1.80	2.90
5	0.20	284.79	18.60	7.59
6	50.00	213.05	2.70	11.15
7	0.20	5.15	0.60	5.15
8	1.74	2.49	------	4.44
9	0.60	154.85	12.45	23.94
10	0.15	0.65	3.00	3.00
11	1.14	13.55	2.94	32.85
12	0.20	1.35	1.85	16.55
13	1.14	5.34	0.50	66.99
14	10.95	674.25	12.15	117.0
15	5.85	194.55	19.70	8.30
Total	72.98	1569.44	77.82	316.11
Average	4.87	104.63	5.19	21.07

Table 3 : Biomass of macrobenthic fauna sampled during July in Chahbahar Bay (g dry wt/m^2)

Stations	Biomass (gdry wt/m^2)			
	Polychaetes	Gastropods	Bivalves	Others
1	1.85	22.44	16.14	35.60
2	6.65	16.05	28.14	9.00
3	0.80	2.49	------	2.85
4	3.90	66.39	36.09	15.79
5	0.50	0.30	2.00	2.25
6	0.20	1.35	3.45	2.40
7	0.15	0.45	0.15	14.10
8	1.55	11.34	6.84	29.10
9	-----	11.19	0.05	0.05
10	0.05	6.30	26.25	2.64
11	0.84	7.74	9.30	7.35
12	0.54	4.74	1.20	9.75
13	3.24	14.74	3.50	2.70
14	5.64	199.65	0.65	89.30
15	2.60	9.50	3.50	5.90
Total	28.47	374.57	137.24	228.77
Average	1.90	24.97	9.15	15.25

Table 4 : Biomass of macrobenthic fauna sampled during September in Chahbahar Bay (g dry wt/m^2)

Stations	Biomass (gdry wt/m^2)			
	Polychaetes	Gastropods	Bivalves	Others
1	2.60	24.80	4.25	7.25
2	0.84	14.19	12.99	2.19
3	----	----	----	----
4	----	----	----	----
5	12.00	111.09	3.00	1.05
6	0.24	12.00	0.90	1.74
7	10.10	5.15	1.05	3.09
8	7.59	5.64	5.15	16.14
9	3.95	18.75	-----	3.54
10	4.10	4.85	25.70	182.55
11	15.35	12.20	3.60	27.30
12	0.84	21.80	9.24	5.15
13	2.00	18.69	0.39	0.84
14	2.00	18.69	0.65	0.84
15	3.90	102.30	-----	2.00
Total	65.48	370.13	66.90	253.67
Average	4.37	24.68	4.46	16.91

Table 5 : Biomass of macrobenthic fauna sampled during November in Chahbahar Bay (g dry wt/m^2)

Stations	Biomass (gdry wt/m^2)			
	Polychaetes	Gastropods	Bivalves	Others
1	1.35	515.49	0.15	5.04
2	1.65	33.99	2.60	8.34
3	0.54	9.65	0.15	2.10
4	6.30	53.45	38.30	89.15
5	0.99	148.71	9.80	257.49
6	------	2.85	------	0.30
7	2.55	33.45	19.71	22.14
8	1.05	17.04	5.00	4.05
9	2.49	8.04	2.04	7.85
10	4.40	22.14	1.85	25.15
11	2.49	44.00	2.30	99.80
12	0.50	0.60	9.65	4.80
13	11.64	20.30	0.30	36.80
14	2.34	4.95	-----	9.95
15	1.35	15.30	-----	9.99
Total	39.63	929.94	91.82	584.93
Average	2.64	62.00	6.12	39.00

Table 6 : Biomass of macrobenthic fauna sampled during January in Chahbahar Bay (g dry wt/m^2)

Stations	Biomass (gdry wt/m^2)			
	Polychaetes	Gastropods	Bivalves	Others
1	8.94	2.04	0.65	18.45
2	8.10	110.19	14.70	265.80
3	1.50	25.89	0.99	0.99
4	12.90	41.85	148.44	34.59
5	2.75	165.95	26.10	31.92
6	0.54	146.40	4.70	28.50
7	6.35	23.60	0.54	60.90
8	2.34	7.74	11.94	42.80
9	0.84	5.40	2.55	12.09
10	2.85	91.59	17.10	106.05
11	2.64	11.60	0.45	44.40
12	0.99	7.40	0.09	1.29
13	16.25	2.90	4.89	10.55
14	12.45	12.50	2.70	4.50
15	5.00	5.30	25.20	54.50
Total	84.42	660.32	261.03	717.32
Average	5.63	44.02	17.40	47.82

Table 7 : Biomass of macrobenthic fauna sampled during March in Chahbahar Bay (g dry wt/m^2)

Stations	Biomass (gdry wt/m^2)			
	Polychaetes	Gastropods	Bivalves	Others
1	10.89	2.15	0.50	12.30
2	0.90	10.10	5.40	493.14
3	0.99	15.24	56.94	7.50
4	9.80	14.30	82.55	286.70
5	4.44	578.19	13.65	42.80
6	0.24	18.20	4.02	41.04
7	4.20	45.00	15.84	105.50
8	6.20	13.89	15.39	29.30
9	4.80	6.65	6.00	67.65
10	3.95	8.55	36.65	21.00
11	11.15	36.20	4.44	98.64
12	1.50	5.45	89.79	16.80
13	4.70	2.94	5.94	134.70
14	16.14	334.31	10.29	14.45
15	10.59	3.84	3.05	3.24
Total	90.47	1094.97	350.43	1374.74
Average	6.03	73.00	23.36	91.65

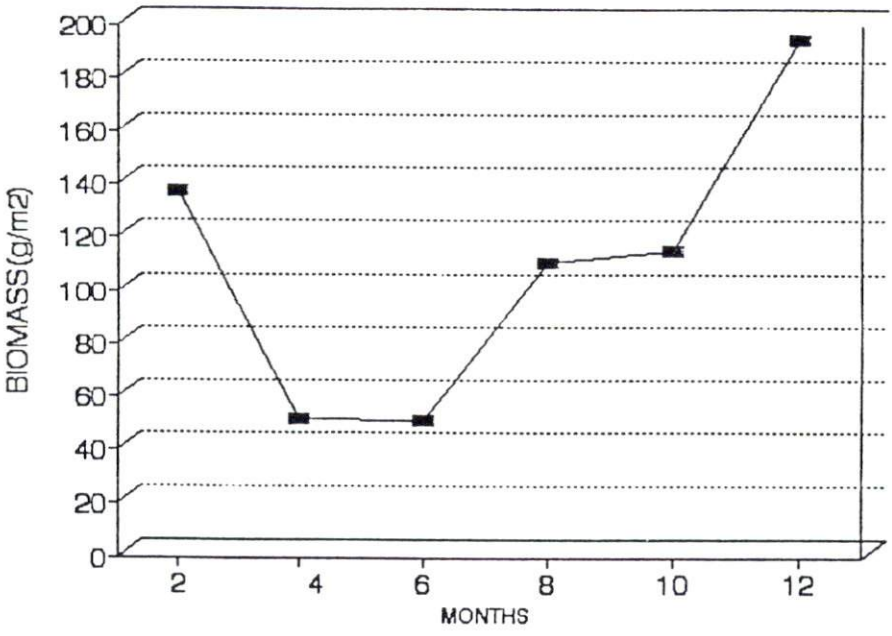

Fig. 6 : Bimonthly variation of macrobenthic biomass (dry weight) in the Chahabahar Bay

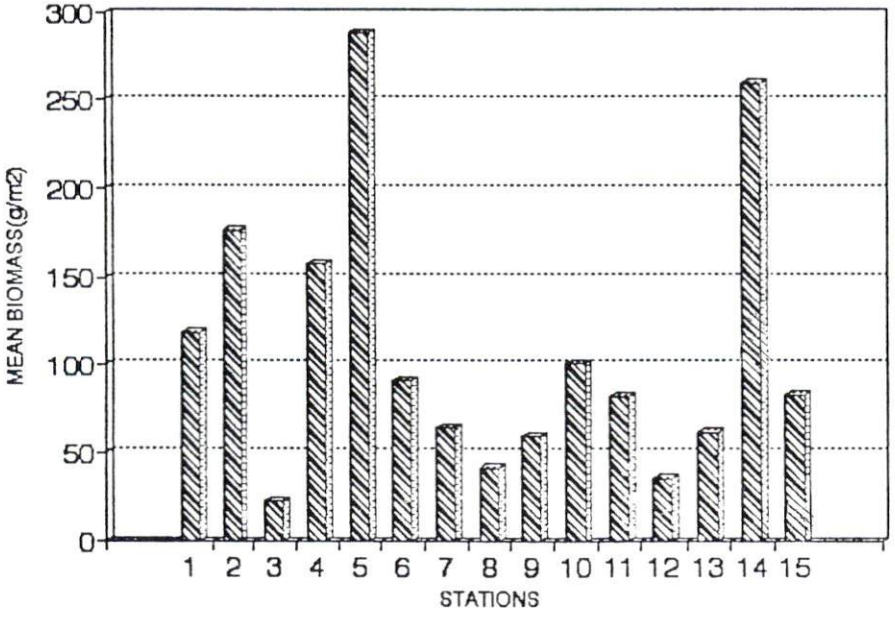

Fig. 7 : Mean macrofauna biomass (dry weight) at different stations in the Chahbahar Bay

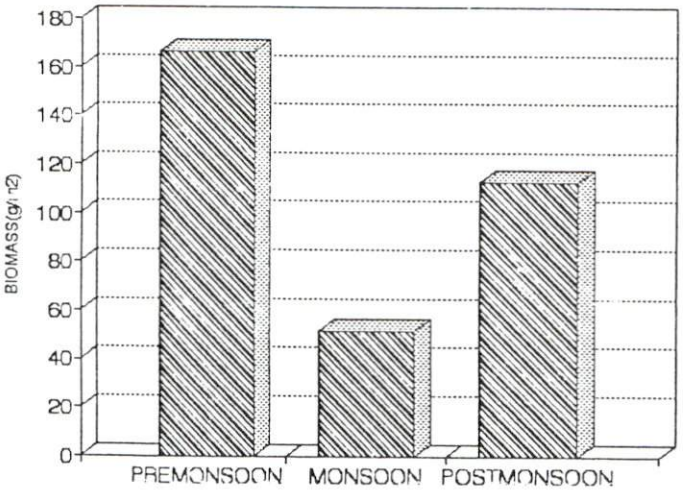

Fig. 8 : Monsoonal variation of macrofauna mean biomass (dry weight) in the Chahbahar Bay

Table 8 : Biomass of macrobenthic fauna according to the sampling period based on wet and dry weight in Chahbahar Bay

Month	Biomass (g/m^2)	
	dry weight	wet weight
May	135.75	298.65
July	51.26	112.77
September	50.41	110.9
November	109.75	241.45
January	114.87	252.71
March	194.04	426.88
Average	109.35	240.56

Table 9 : Results of ANOVA indicating levels of significant between macrofauna density at different sites and various seasons (pre-post and during monsoon) in Chahbahar Bay

	Source of variation	Sum of squares	d.f	Mean square	F-ratio	Sig. level
macrofauna	stations	2132508.2	14	152322	0.826	0.6386
	seasons	2745785.2	2	1372892.6	7.449	** 0.0011
gastropoda	stations	74914.651	14	5351.047	1.305	* 0.2257
	seasons	45641.931	2	22820.966	5.565	** 0.0056
polychaeta	stations	28243.487	12	2353.6239	2.162	* 0.0247
	seasons	8766.692	2	4383.3462	4.26	** 0.0226
Bivalvia	stations	38873.622	14	2776.6873	1.856	** 0.0461
	seasons	1622.022	2	9811.0111	6.558	** 0.0024

**P<0.01
* P<0.05

Discussion

Chahbahar Bay is influenced by open sea waters and periodic exposure to waves, known as monsoon. The results of the present study have clearly demonstrated the effects of monsoon on density, abundance and biodiversity of macrobenthic fauna of Chahbahar Bay. It is also revealed that the density of the macrofauna is relatively higher than that reported for other areas of the Indian Ocean. The density of macro-benthic fauna here was recorded to be between 4600 to 13000 individuals per m^2 in Chahbahar Bay while in coastal waters of Gangolli (western Indaian Ocean) it is 900 to 3700 per m^2 (Prabhu *et al.*, 1993), in Marmugao Bay (central western Indian Ocean) it is 498 to 1107 per m^2 (Ansari *et al.*, 1994), and in north eastern Bay of Bengal (eastern Indian Ocean) maximum density of benthic fauna is recorded as 12572 per m^2 (Harkantra *et al.*, 1982). The similarity of density between Bay of Bengal and Chahbahar Bay does not persist when one looks at abundant species. Harkantra *et al.*, 1982, reported a high abundance of polychaetes with 68.5% of the total population followed by molluscs (11.7%). In Chahbahar Bay amphipods recorded as the most dominant group followed by polychaetes and molluscs.

Amphipods, polychaetes, gastropods and bivalves were most abundant taxa in Chahbahar Bay. These groups make almost 70% of the total macrofauna in this region. The results of the present study indicate clearly the effect of the Indian Ocean summer monsoon on the quantity and distribution pattern of macrofauna of Chahbahar Bay. A two way analysis of variance showed that there is a significant difference between sites and between seasons (pre-post and during monsoon) for total number of gastropods, polychaetes and bivalves. Taking the whole number of macrofauna individuals into account, ANOVA results indicated that there is a high significant ($P<0.01$) difference between seasons. This difference between sites was non-significant. Remarkable reduction in population density of benthic invertebrates is also reported from several studies in the Indian Ocean during monsoon (Parulekar *et al.*, 1982 ; Harkantra *et al.*, 1982 ; Prabhu *et al.*, 1993 and Ansari *et al.*, 1994).

During monsoon period wind speed usually rises up to 35 to 40 knotical miles per hours which causes a very rough condition in the water column. This condition consequently disturbs and dislocates sediments and as a result the physical stability of the bottom sediment as well as the population density of macrofauna reduce to great extent. The reduction of benthic population may be due to

mortality or migration to deeper sediment or they may be washed and transfered into open and deeper waters. This may increase their susceptibility to perdation (Suresh *et al.*, 1992). Monsoon can therefore be regarded as an important tool for seasonal changes in distribution and abundance of benthic fauna in the Chahbahar Bay. During postmonsoon period (November-January), the population density of benthic invertebrates increase. This may occur because of improved settled condition of bottom sediments and provision of food items in the sediments by water movement during monsoon. This increase in benthic population continues from November to March as it can be found in Fig. 3.

Biomass of the macrobenthic fauna in Chahbahar Bay range between a minimum of 51.5 g/m^2 in July to a maximum of 194 g/m^2 dry weight. An average biomass of 109.3g/m^2 dry wt. in the present study is higher than other benthic studies in the Indian Ocean region. Average biomass of macrobenthos in the Bay of Bengal is reported to be 10.61 g/m^2 (Harkantra *et al.*, 1982). Biomass of benthos in other region of the Indian Ocean ranges between 0.01 to 601 g/m^2 at different station (Parulekar *et al.*, 1982). Biomass of Macrobenthic fauna present in Swansea Bay in the United Kingdom were amounted to a 116.65 g/m^2 wet weight (Harkantra , 1982). Harkantra indicated that the biomass of benthos in Swansea Bay is smaller than that of tropical parts of the world. He believes that is why benthic animals in the tropics are generally larger in size. In Rajapur Bay in the central western coasts of India, the biomass of macrofauna is reported to be between 102 to 206.5 g/m^2 wet weight with an average of 60.01 g/m^2 (Harkantra *et al.*, 1982). In a similar study in Marmugao in central west coast of India, the biomass of macrofauna was ranged between 2.54 to 46.02 g/m^2 wet weight (Ansari *et al.*, 1994).This comparison shows that the density and biomass of benthic fauna in the Chahbahar Bay is relatively high which can consequently be supported a very good resource of demersal fish.

Spatial distribution of macrofauna in Chahbahar Bay in the present study showed that eastern parts of the Bay have a greater biomass. Sites 5, 14, 2 and 4 had the greatest amount of biomass while the control station (15) right at the mouth of the estuary (outside the Bay) represente the smallest amount of macrofauna biomass.

Since the studies of benthic fauna such as the present work can provide vital information regarding the presence of pollution and its impact on the ecosystem, it is recommended to continue such studies on a long term basis. At the moment,

Chahbahar Bay as a non-polluted place provides a good and healthy environment for benthic animals. Monitoring benthic assemblages may help detecting environmental hazards and protecting this diversified water body from defecting.

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