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Macro Benthic Assemblage and Temporal Interactions at Palk Strait, Southeast Coast of India

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Abstract: The present study was made to map out the seasonal variation (from March 2007 to Feb 2008) of macro faunal diversity at different depths *viz.* 0mt, 5m, 10m and 20m in Arkattuthurai region of Palk Strait, southeast coast of India. A total of 66 species of macro fauna were recorded. Among them, polychaetes were found to be the dominant group (38 species), followed by bivalves (15 species) and gastropods (13 species). The density of organisms varied from 62 during post monsoon at 10m depth to 126 during summer at 20m depth. Similarly species diversity varied from 4.075 at 10m in the sample collected during pre monsoon to 4.935 at 20m depth during summer. In a nutshell, the distribution of macro fauna was found to increase with increasing depth and the probable reasons for the distribution pattern of organisms is discussed in this paper.

Key words: Biodiversity · Macro fauna · Polychaetes · Bivalves · Gastropods

INTRODUCTION

Marine benthic organisms are valuable as they are ecologically important, numerically abundant, often sessile life style and they also function as integrators of ecological processes and disturbances over long time scales [1,2,3,4]. Benthic assemblages are a direct measure of habitat condition. [5] noted that benthic communities, dominated by deposit-feeding polychaete worms, have been characterized by low species diversity and increased abundances close to sources of organic input. In India, indicator species from the benthic realm of estuarine and marine environments have been reported [6,7].

Adult polychaetes and the other invertebrates provide food for fish and birds that forage on the bottom. Their juveniles and reproductive stages provide food for fish feeding in the water column and at the water surface[8]. Since the polychaetes are the main food supply of many commercial fishes, they also serve as an important factor in the evaluation of fishing grounds.

The present work represents as a preliminary effort to set out the abundance and distribution of benthic polychaete and molluscan communities along the Arkattuthurai (Palk Strait) coastline. The Arkattuthurai (Palk Strait) has great importance within the Bay of Bengal due in part to the abundant invertebrate populations. These infaunal macro fauna are the key benthic link between detritus accumulating on the sediments and higher trophic level organisms. Samples were made in sub littoral sediments of the sea at depths off 0mt, 5mt, 10mt and 20mt and determined the seasonal abundance of polychaetes to quantify their distribution.

MATERIALS AND METHODS

Study Area: In Arkattuthurai, four stations were fixed based on different depth variations at 0m depth, (Lat.10.24'N; Long:;79.53' E,) 5m depth (Lat.10.23' N; Long:79.52' E), 10m depth (Lat.10.12' N; Long:79.50' E) and 20m depth (Lat.10.14'N; Long:080.14'E) Nagapattinam district Tamil Nadu southeast coast of India (Fig. 1). This minor fish landing centre is situated from Nagapattinam about 55 km. There are four tributaries from Cauvery, namely Kaduvaiyaru, Odampochiyar, Vedharanyam Canal and Uppanar. All of them mix together and form the Uppanar estuary which finally joins the Bay of Bengal. In the study site, the local people mainly depend on fishing and its related activities. The tidal amplitude of this region is 0.5 to 2.5 m. water visibility is 1 to 2.5 feet (varies due to seasonal changes). This area is also a cyclone prone zone during the southeast monsoon.

Sample collection: Macro benthos and sediment were sampled season wise from Mar. 2007-Feb.2008, using a Peterson (0.0256 m^2) grab. Samples were sieved through a 1.0mm mesh screen and all fauna retained were relaxed for 30min in $MgSO_4$solution, fixed in 10 % borax-buffered

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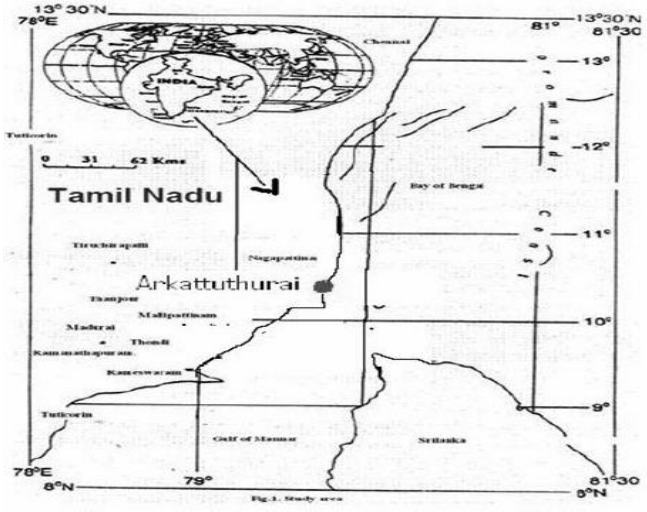

Fig. 1: Map shown the study area

formalin and stored in 70 % ethyl alcohol. Polychaetes and molluscs were identified to the lowest possible taxonomic level and enumerated.

Data analysis: Data were carried out on transformed data (fourth square root) using the Bray-Curtis index and group average linkage for nonmetric multidimensional scaling (MDS). Population density, species richness, diversity and evenness (J) were calculated using the computation of species diversity by Shannon Weiner diversity index. The data collected were approached to univariate and graphical techniques using PRIMER statistical package [9]. The test was used to determine the differences of assemblages between stations and seasons. Multivariate analyses were used to determine temporary differences in the species composition of the benthic assemblage and to assess which species mainly contributed toward the seasonal differences.

RESULTS

The season wise sampling was done at different depths of 0m, 5m, 10m and 20m and samples yielded was a total of 1, 515 individuals belonging to 66 species representing the major taxa polychaeta (Table 1), bivalvia and gastropoda (Table 2 and 3). Polychaetes were found to be the dominant group (38 sp., representing 57% of the fauna and 46% of the total abundance), followed by 15 species of bivalves (23% of the fauna and 33% of the total abundance) and the gastropoda (20% of the fauna but only 21% of the total abundance). Based on various seasons, the species density, species diversity, species richness and evenness values are shown in Fig. 2-5 and Table 4.

Among polychaetes, the most abundant families were Syllidae (69 ind.), Ophelidae (67 ind.), Nephtyidae (58 ind.), Capitellidae (56ind), Nereidae (52 ind.), Cirratulidae (46 ind.), Spionidae (43 ind.), Eunicidae (40 ind.), Cossucidae (35 ind.), Phyllodocidae (20 ind.), Maldanidae (18 ind.), Teribillidae (9 ind.) and Glyceridae (3 ind.). Families with the highest species were Syllidae (4spp), Ophellidae (4spp), Eunicidae (3spp), Nereidae, Spionidae, Captellidae, Cossucidae, Nephtidae and Phyllodocidae with 2 spp each. Species with great abundance were *Nephtys* sp., (51 ind.), *Nereis* sp. and *Ceratulus* sp., (46 ind.), each. *Armandia* sp., (45 ind.), *Prinospio* sp. and *Chone* sp. were (41 ind.) each and *Syllides longocirrata* were (35 ind.). The minimum of *Glycinde* sp. and *Polydora ciliate* were found in minimum level. 15 species of bivalves and 13 species of gastropods were present in the sampling at different depths.

In 20m depth higher population density occurred as 126nos/ m^2 and 123nos/ m^2 during summer and monsoon respectively. But the lowest density was found as 62nos/ m^2 at the depth and 10m during post monsoon. A general pattern of increasing abundance with increasing depth was observed.

The highest richness was found during the post monsoon season at a depth of 20m (0.975) and the lowest richness was during premonsoon season at a depth of 10m (0.932). While at 0mt and 5m depths, the values ranged between 0.95 and 0.97 in monsoon and summer respectively. In these seasonal variations, the depth of 20m attained the highest abundance, when compared to 0mt, 5m and 10m. At measured depths of 0m, 5m, 10m and 20m, the Shannon-Weiner diversity index was applied on

Table 1: Total numbers of polychaetes found in Arkattuthurai (Palk Strait)

		NOS./ 0.0256 M^2																
	Name of the Species	Pre monsoon				Monsoon				Post monsoon				Summer				
Sl. NO.	Polychaetes	0	5mt	10mt	20mt	0mt	5mt	10mt	20mt	0mt	5mt	10mt	20mt	0mt	5mt	10mt	20mt	0mt
1	*Armandia* sp.	1	4	2	5	*	3	3	4	3	4	2	4	2	1	2	5	1
2	*Polydora ciliate*	*	*	*	*	*	*	*	*	*	*	*	2	*	*	*	*	*
3	*Nereis* sp.	2	2	2	*	8	6	6	4	2	3	*	3	2	2	2	2	2
4	*Glvcera alba*	*	1	2	*	*	*	*	3	3	*	2	*	*	*	*	*	*
5	*Capitella* sp.	*	3	1	2	1	2	*	1	2	1	2	4	3	2	2	3	*
6	*Dorvillea* sp.	1	*	1	2	4	7	3	*	3	2	*	*	*	*	*	2	1
7	*Cossura coasta*	2	2	4	4	2	2	1	*	*	3	*	2	*	*	*	*	2
8	*Goniada* sp.	3	*	1	2	*	1	2	2	4	2	*	1	2	2	*	1	3
9	*Chaetopterus* sp.	2	3	*	2	*	*	*	*	*	3	*	*	*	3	2	5	2
10	*Drilonereis* sp.	*	*	*	*	1	1	*	2	*	*	2	1	*	*	*	*	*
11	*Glycinde* sp.	*	*	*	*	*	*	*	*	*	*	*	*	2	1	*	*	*
12	*Cirratulus* sp.	1	2	*	3	3	3	3	6	1	2	3	*	4	2	3	6	1
13	*Nephtys* sp.	2	5	5	5	5	2	4	3	1	2	3	1	4	*	5	4	2
14	*Prionospio* sp.	4	4	1	1	5	2	3	8	2	1	*	4	*	*	3	3	4
15	*Pista* sp.	3	1	*	*	2	1	*	*	*	*	*	2	2	1	2	5	3
16	*Chone* sp.	1	*	1	4	1	3	2	4	2	*	4	4	4	5	3	3	1
17	*Paralacydonia* sp.	*	*	*	*	*	*	*	*	2	1	1	3	3	1	*	4	*
18	*Eunice* sp.	*	*	*	*	*	2	2	1	*	1	*	2	*	*	*	*	*
19	*Notomastus* sp.	5	1	1	*	2	5	4	2	*	*	*	*	3	2	*	2	5
20	*Syllides* sp.	2	4	*	3	*	*	*	*	*	*	*	*	*	*	*	*	2
21	*Exogone* sp.	*	*	*	*	*	*	*	*	*	3	*	1	2	*	2	4	*
22	*Cossura* sp.	*	3	1	*	*	2	1	2	*	2	*	*	*	*	*	2	*
23	*Syllides longocirrata*	2	1	3	4	2	*	6	5	*	*	*	*	5	2	1	4	2
24	*Rhodine gracilior*	2	4	1	2	*	*	*	*	*	*	*	*	*	*	*	*	2
25	*Phyllodoce* sp.	3	1	*	2	*	*	*	*	*	*	*	*	2	2	1	2	3
26	*Maldane glebifex*	5	6	1	3	*	*	*	*	*	*	3	*	*	*	*	*	5
27	*Ophelia capensis*	*	*	*	*	4	2	*	1	*	*	*	*	*	*	*	*	*
28	*Nephtys sphaerocirrata*	*	*	*	*	3	2	*	2	*	*	*	*	*	*	*	*	*
29	*Ophelia* sp.	*	*	*	*	*	*	*	*	*	*	*	*	2	2	1	2	*
30	*Phyllodace longipes*	*	*	*	*	*	*	*	*	3	3	*	1	*	*	*	*	*
31	*Streblosoma Persia*	*	*	*	*	*	*	*	*	4	3	*	2	*	*	*	*	*
32	*Eurythoe* sp.	*	*	*	*	*	*	*	*	2	1	2	4	3	2	2	4	*
33	*Ophelia agulthana*	*	*	*	*	*	*	*	*	5	1	*	2	*	*	*	*	*
34	*Syllis exilis*	*	*	*	*	*	*	*	*	3	5	2	4	*	*	*	*	*
35	*Bhawania goodai*	*	*	*	*	*	*	*	*	*	*	*	*	4	2	*	4	*
36	*Scolopella* sp.	*	*	*	*	*	*	1	*	2	3	*	*	*	*	*	*	*
37	*Lepidasthenia* sp.	*	*	*	*	*	*	*	*	2	*	1	2	*	*	*	3	*
38	*Ceratonereis* sp.	*	*	*	2	*	*	*	*	3	1	*	*	*	*	*	*	*
	Total	41	47	27	46	43	46	41	50	49	47	27	49	49	32	31	70	41

Table 2: Total numbers of gastropods found in Arkattuthurai (Palk Strait)

		Nos./0.0256 m^2															
	Name of the species	Pre monsoon				Monsoon				Post monsoon				Summer			
Sl. No.	Gastropods	0mt	5mt	10mt	20mt	0mt	5mt	10mt	20mt	0mt	5mt	10mt	20mt	0mt	5mt	10mt	20mt
1	*Cerithedia cingulata*	2	*	4	3	3	7	*	1	2	3	2	2	4	3	*	*
2	*Littorina* sp.	*	4	*	1	8	2	8	4	*	*	*	*	*	*	*	*
3	*Littorina scabra.*	1	*	*	*	*	*	*	*	*	*	*	*	*	*	3	2
4	*Littorina* sp Veligers	*	*	*	*	*	*	*	*	4	5	4	5	2	1	*	13
5	*Umbonium vestiarium*	7	2	8	*	4	2	10	10	*	*	*	*	2	*	7	3
6	*Umbonium* sp.	3	2	*	1	*	*	*	*	8	9	1	5	*	*	*	*
7	*Oliva* sp.	*	*	2	3	*	*	*	*	*	1	4	3	*	*	*	*
8	*Turritella attenuata*	*	1	*	*	1	*	12	9	*	*	*	*	*	*	*	2
9	*Turritella* sp.	*	*	*	*	*	2	3	10	9	6	5	2	*	2	3	*
10	*Bullia vitata*	*	*	*	*	*	1	2	*	*	4	3	*	*	*	*	*
11	*Natica* sp.	*	*	*	*	*	*	*	*	2	1	*	3	3	*	5	1
12	*Natica* sp. Velligers	*	*	*	*	*	*	*	*	3	2	2	2	*	*	*	*
13	*Bursa* sp.	2	*	*	3	*	*	*	*	*	*	*	*	3	*	4	1
	Total	15	9	14	11	16	14	35	34	28	31	21	22	14	6	22	22

Table 3: Total numbers of bivalves found in Arkattuthurai (Palk Strait).

		Nos./0.0256 m^2															
	Name of the species	Pre monsoon				Monsoon				Post monsoon				Summer			
Sl. No.	Bivalves	0mt	5mt	10mt	20mt	0mt	5mt	10mt	20mt	0mt	5mt	10mt	20mt	0mt	5mt	10mt	20mt
1	*Meretrix* sp.	*	*	*	*	2	*	3	*	3	1	1	3	*	*	*	*
2	*Meretrix meretrix*	4	7	14	6	10	*	9	10	*	*	*	*	*	5	9	8
3	*Meretrix* sp. Veligers	12	10	12	10	11	9	10	13	10	9	4	5	*	*	*	*
4	*Donax* sp. Veligers	*	*	*	*	*	*	*	*	*	*	*	*	3	*	1*	5
5	*Donax scortum*	7	4	6	*	*	*	4	*	1	2	2	1	*	4	2	5
6	*Donax* sp.	2	*	1	*	5	4	*	3	2	*	2	3	*	3	1	3
7	*Anadara* sp.	*	*	*	*	5	3	2	*	6	3	*	4	1	2	1	4
8	*Anadara granosa*	3	2	3	*	*	*	*	*	*	*	*	*	*	*	2	1
9	*Anadara inequelis*	*	*	4	5	*	*	*	*	*	*	*	*	*	1	5	*
10	*Anadara* sp. Veligers	*	*	*	*	*	3	4	1	*	*	*	*	*	*	*	*
11	*Arca* sp. Veligers	8	11	9	12	6	11	7	10	*	4	1	2	4	5	6	4
12	*Arca* sp.	*	4	*	3	*	*	*	*	*	*	*	*	*	*	*	*
13	*Cardium* sp.	*	*	*	*	*	*	*	*	2	4	4	3	2	4	*	3
14	*Cardium setosum*	*	*	*	*	1	2	3	*	*	*	*	*	*	*	*	*
15	*Cardium* sp. Veligers	*	*	*	*	*	*	3	2	*	*	*	*	*	2	3	1
	Total	36	38	49	36	40	32	45	39	24	23	14	21	10	26	39	34

(*)-absent of species

Table 4: Diversity of macro fauna

	Depths	Population Density (N)	Species Diversity (d)	Species Richness (J´)	Species Evenness H'(log2)
Pre monsoon	0mt	92	4.466	0.954	0.929
	5mt	94	4.424	0.954	0.93
	10mt	90	4.075	0.932	0.878
	20mt	93	4.412	0.953	0.939
Monsoon	0mt	99	4.311	0.95	0.928
	5mt	92	4.472	0.954	0.93
	10mt	121	4.5	0.944	0.936
	20mt	123	4.35	0.949	0.915
Post monsoon	0mt	101	4.689	0.963	0.946
	5mt	101	4.831	0.967	0.942
	10mt	62	4.492	0.967	0.967
	20mt	92	4.935	0.975	0.97
Summer	0mt	73	4.616	0.97	0.982
	5mt	64	4.577	0.968	0.963
	10mt	92	4.499	0.957	0.936
	20mt	126	4.922	0.969	0.952

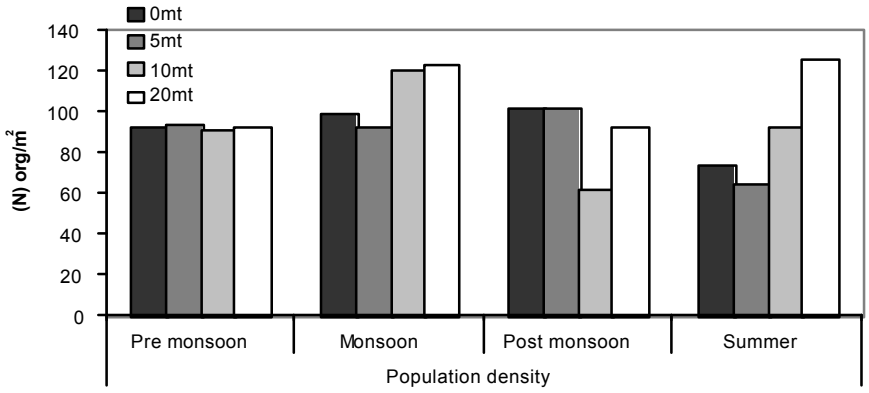

Fig. 2: Mean abundance of the macro faunal communities found along the Palk Strait

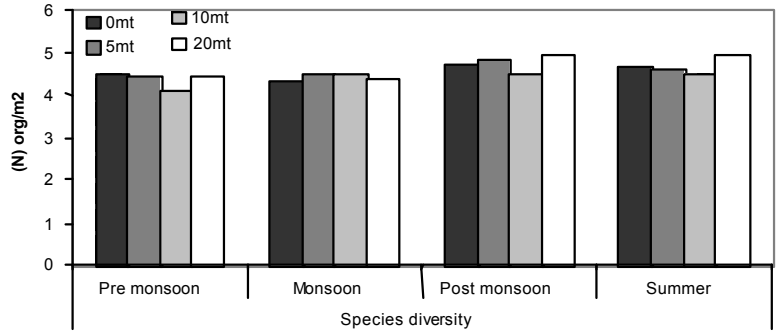

Fig. 3: Species diversity of macro faunal communities found in the Palk Strait

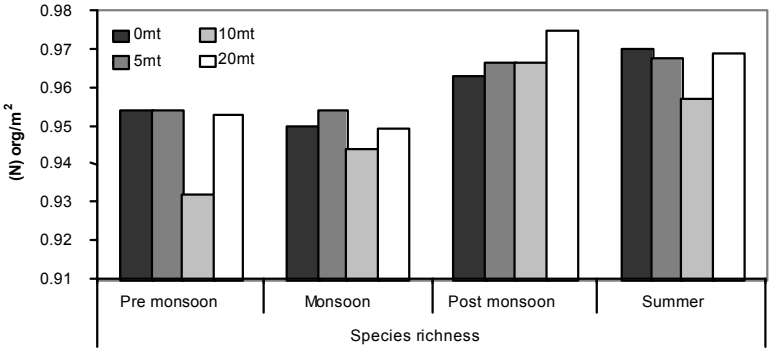

Fig. 4: Species richness of macro faunal communities found along the Palk Strait

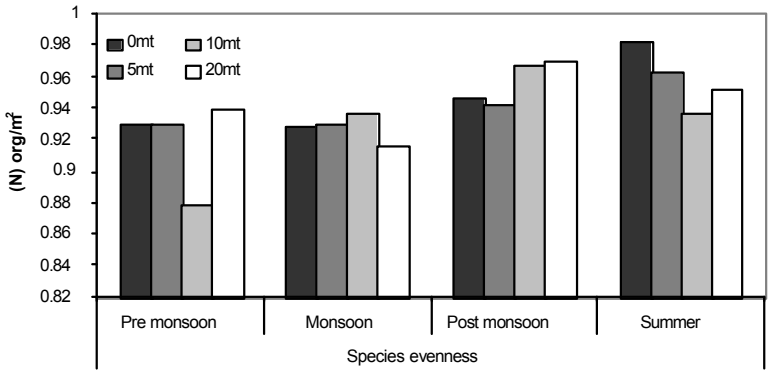

Fig. 5: Species evenness of the macro faunal communities found along the Palk Strait

the general pattern of seasonal variation of polychaete diversity. In that, species diversity was found to be higher at post monsoon at the depth of 20m (4.935). The minimum species diversity was found during premonsoon season at the depth of 10m (4.075). The range of species diversity during monsoon was (4.311 to 4.5) and during the summer season it was around (4.499 to 4.922) at the depth of 0m to 20m.

The cluster analysis showed the maximum similarity (78.2%) between 0m to 5m depths in post monsoon season and these two stations joined with 20m depths at 75.5% level and formed depths, where as the premonsoon and monsoon season was appeared from this depth indicating lower level of similarity with other seasons. The result observed in cluster was evident in the MDS. It was evident that the monsoon shows the lowest diversity and was not similar to all the other seasons and maximum diversity was recorded in post monsoon season as shown in Fig. 6.

In the case of MDS, the average taxonomic distinctness and variation in taxonomic distinctness were calculated for all seasons according to different depths

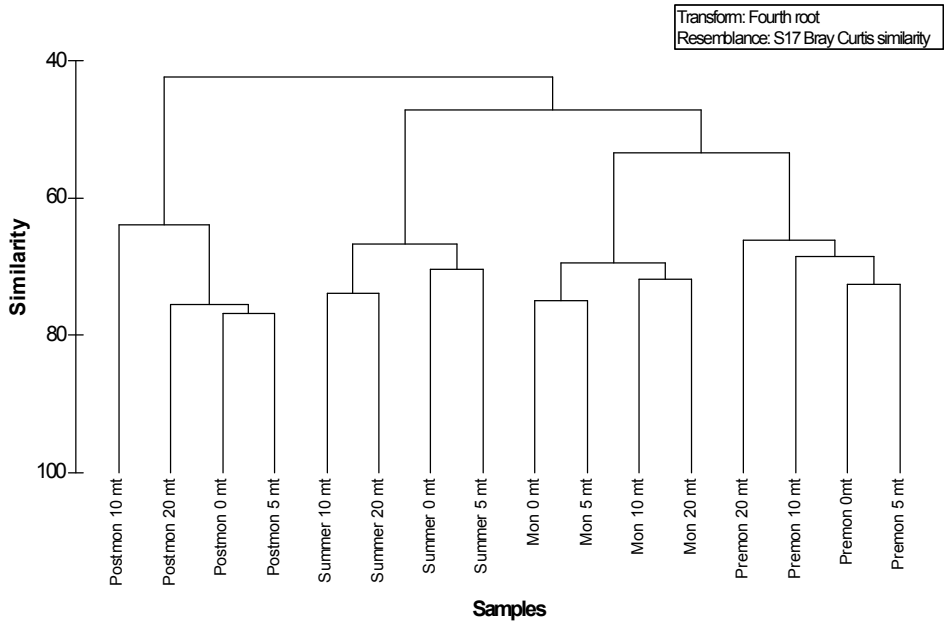

Fig. 6: Dendrogram of benthic fauna recorded in various seasons of Arkattuthurai region. (Samples depth wise). Showing grouping of seasons from Arkattuthurai (Palk Strait)

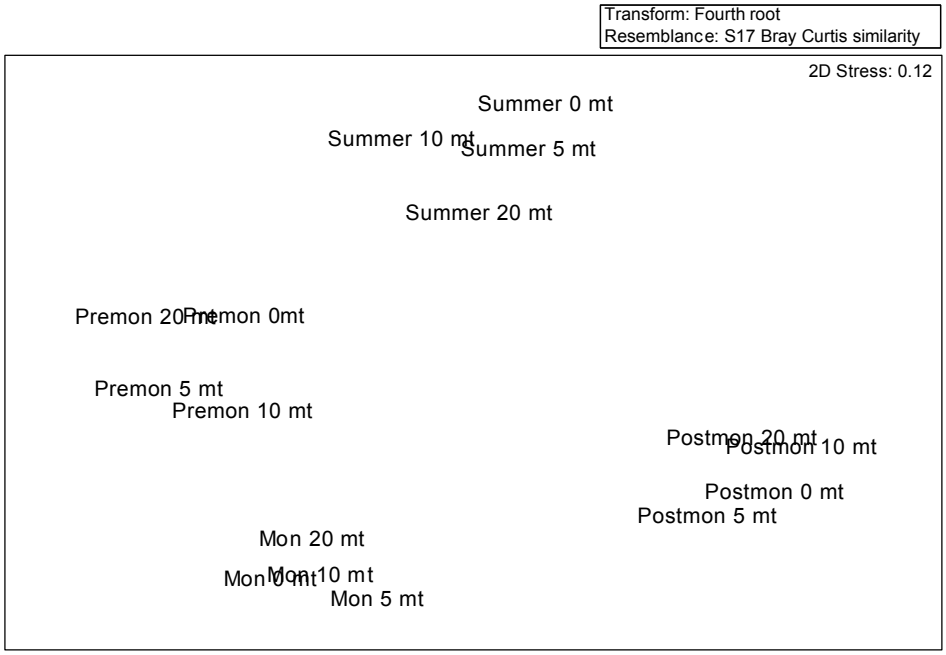

Fig. 7: MDS for benthic fauna recorded in various seasons of Arkattuthurai region. (Samples depth wise). Showing grouping of seasons from Arkattuthurai (Palk Strait)

from the study area. For all depths the MDS value were found distributed within the 95% confidence limit of probability. But the monsoon and premonsoon seasons was departed from others showing minimum similarity and diversity than other seasons as shown in Fig. 7.

The polychaetes *Nereis* sp. and *Nephtys* sp. were the dominant (7%) followed by *Armandia* sp., *Cirratulus* sp. and *Prinospio* sp. (6%) the total of 38 species recorded. In the case of bivalves the most dominant species was *Meretrix* sp. Veligers (22%) followed by 15 species of bivalves *Arca* sp. Veligers was around 20% of the total bivalves. Among the gastropods the most abundant species *Umbonium vestiarium* was 18% of the total 13 species, followed by *Turritella* sp., with around 13% of the total gastropods.

DISCUSSION

A detailed quantitative survey of the benthic polychaete macro fauna was carried out on Palk Strait region in southeast coast of India. The data were collected to map out abundance and seasonal variations of benthic macro fauna in depth wise transition 0m, 5m, 10m and 20m. Establishing baseline data on the number of species and the relative abundance of each species allow us to define benthic communities in this study. Distributions of soft-bottom polychaetes and molluscan fauna in general have been related to different depths.

Benthic polychaetes help in recycling of nutrients between pelagic and benthic realm and also remove the organic wastes from aquaculture systems [10]. This is mainly in the case of many invertebrate taxa, especially those from benthic sediments which contain species rich communities such as polychaetes, crustaceans, nematodes and mollusks. Benthic invertebrates are especially relevant as test organisms because of strong pelagic-benthic coupling of biological processes in these regions [11]. Numerous sponges, gorgonians, holothurians and other large sessile suspension feeders serve as biogenic substrata for other animals thereby creating the typical Antarctic multi-stored assemblages [12].

Analysis of the obtained data has displayed that bottom communities at depth 0 m to 20 m of seasonal fluctuations of biomass and population density in major groups of macro benthos. During summer season, the species density was maximum at the depth of 20 m when compared to 0 m, 5 m and 10m. In post monsoon, the species density was minimum at the depth of 10 m and the species diversity was maximum during post monsoon at the depth of 20 m and the minimum was recorded during the pre monsoon at the depth of 10 m. The species richness was maximum during the post monsoon at the depth of 20 m and the minimum during the pre monsoon at the depth of 10 m. in the case of evenness maximum was found during the summer the depth of 0 m and the minimum during the monsoon at the depth of 20 m. The variations were caused by seasonal consumption of detritus from the water column by benthic fish and by periodic bottom supply against a background of varying temperature parameters of water and of mass settling of benthic larvae.

The results of the affinity between diversity and seasonal distribution of polychaetes and molluscs showed a higher percentage of the total variance was explained by variables measured in terms of density, diversity, species richness and evenness.

The abundance of polychaetes followed seasonal variations in Palk Strait at different depths 0m, 5m, 10m and 20m. Seasonal variations may be an important controlling factor of polychaete fauna. In contrast, abundance values for the 0m to 20m were comparable to each other and tend to increase gradually. The ranges of depth were from 0m to 20m in Palk Strait, 10m depth had low numbers of polychaetes in all the seasons. These patterns may differ with the organic enrichment hypothesis.

[13], reported that the presence of large spionid communities was previously interpreted as an indication of polluted environments. [14], indicated that biomass and abundance of the benthic fauna decrease exponentially with depth as a result of abatement in nutrient flux. The assemblage of macro fauna has a constituent member of the family Spionidae and spionid worms accounted for the total polychaete abundance. These lower diversity values were located near points of disturbance and may be an indication of ambient stress for the adjacent communities, [5]. Based on diversity, there is evidence for faunal gradient of decreasing stress away from the shore.

Polychaetes and molluscs occurred mainly at the intertidal level and crustaceans tend to occur higher on the shore as they are less susceptible to desiccation. Abundance, biomass and number of species were negatively related to sediment depth. Difference in depth distribution of organisms could be related to difference in sediment characteristics that conditioned an organism's ability to burrow. Most of the species inhabiting the intertidal level belonged to the deposit feeders group, favored by organic-rich supply on the sediment surface during winter and spring. Deposit feeders able to exploit food resources rapidly and conspicuous abundance of this trophic group has been related to a marked increase in proteins [15]. Several works suggested that further control of the structure and dynamics of the macro

infauna community from the intertidal zones could be related to fluctuations in the availability of food resources [15]. Some benthic animals may indeed benefit from drifting algal mats as a key resource, i.e., food and/or refuge and its availability can affect diversity and abundance of intertidal animals including shorebirds[16,19].

Investigation similar to this was carried out by [20], who made a comparative study of the structure of some tropical and temperate macrobenthic communities using cluster analysis and found major dichotomy between these two communities which is mainly due to sediment pattern and water depth. These two parameters were found to exert major influences on benthic community. To study the robustness of multivariate analysis and cluster analysis in particular, [21] made a study on the community structure of macrobenthos in the UK waters and found them quite suitable.

Further, [22,23] and [24] studied the benthic biodiversity employing multivariate techniques in the Southern Irish Sea. Cluster analysis of different depths based on a Bray-Curtis similarity of abundance and species composition, yielded four seasons between the 40-80% levels of similarity. So, the dendrograms derived in their investigations revealed three main faunal assemblages based on sediment particle size and also depth. Similarity analysis indicated a high level of dissimilarity among stations. Based on polychaete and molluscan assemblages, there was no sign of similar densities in the Palk Strait. Four stations at different depths revealed the constituent assemblages with depth.

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