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A comparative study on intertidal faunal biodiversity of selected beaches of Mumbai coast

S.N. Datta*[1], S.K. Chakraborty[1], A.K. Jaiswar[1] and G. Ziauddin[2]

[1]Fisheries Resource Management Division, Central Institute of Fisheries Education (Deemed University), ICAR, Versova, Andheri (West), Mumbai - 400 061, India
[2]Fishery Science Division, Krishi Vigyan Kendra, Central Research Institute for Jute and Allied Fibres (ICAR), Budbud, Burdwan - 713 403, India

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Abstract: *Comparative study has been done to examine the biodiversity and ecological status of the intertidal region of Tata Institute of Fundamental Research (TIFR), Bandstand and National Centre for Performing Arts (NCPA) rocky beaches in Mumbai, West coast of India. A total of 50 species of intertidal organisms were recorded from these shores. Shannon and Simpson's diversity index, Margalef's richness index and Pielou's evenness index indicated different level of ecological state of the shore in different months. Dendrograms and 2-D non metric MDS ordination from Bray-Curtis similarity matrix of occurrence of intertidal organisms from these sites showed highest similarity and combination pattern of occurrence between Nerita oryzarum and Planaxis sulcatus in TIFR and Bandstand shore. Nerita oryzarum and Tactarius malaccanus at NCPA shore. Abundance/ biomass comparison (ABC) method of determining level of disturbance also pointed towards the polluted status of these shores. Study concludes that though these beaches are highly disturbed due to anthropogenic activities, they still support a rich intertidal biodiversity which need immediate attention for protection and conservation.*

Key words: *ABC curve, Abundance, Dendrogram, Diversity, Intertidal, Molluscs, Non metric-MDS, Rocky shore*
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Introduction

Biodiversity essentially reflects ecological quality of the habitats (Vladica and Snezana, 1999). Marine ecosystem particularly the Intertidal zone is one of the most dynamic zone that is the interface between sea and terrestrial environment. The most important physical factor that influences the life and activities of organisms of the intertidal zone is the existence of waves and duration of exposure to sunlight. Indian coast is continuously being threatened by effluent discharges from metropolis and industrial towns. This gives rise to immense environmental problems leading to deterioration of water quality and reduction of flora and fauna. The intertidal ecosystem around Mumbai was environmentally clean and rich in faunal composition (Rai, 1931; Subramanyam *et al.*, 1952), but it has been disturbed and imbalanced due to ever increasing anthropogenic discharges from the city (Govindan and Desai, 1980). Anthropogenic disturbances may affect the physiological state of the animals predicting to changes in growth rate, recruitment and mortality (Tablado *et al.*, 1994; Johnston and Keough, 2002; Ng and Keough, 2003). Coastal waters of Mumbai receives industrial discharges up to 230 million l d^{-1} (MLD) and domestic wastes of around 2,200 MLD of which, 1800 MLD are untreated. This has affected the water and sediment quality that has disturbed the intertidal marine biodiversity (Zingde and Govindan, 2000). Therefore, in view of degraded coastal ecosystem, the present investigation was undertaken to assess the present status of intertidal biodiversity of TIFR, Bandstand and NCPA beaches of Mumbai, India.

* **Corresponding author:** surjya30740@yahoo.co.in

Materials and Methods

Mumbai, the Island city is situated on West Coast of India (between Lat. 18°54' to 19°09' N and Long. 72°47' to 72°56' E). Intertidal areas of TIFR (Tata Institute of Fundamental Research), Bandstand (Bandra) and NCPA (National Centre for Performing Arts) were selected for the present study. Three transects (T_1, T_2, T_3) were marked as a reference point of sampling at all the three shores, and 15 quadrates with 0.1 m^2 area at interval of 5 m were sampled every month from each transects from December 2006 to November 2007 during low tide. Thus, 45 quadrates sampled in this sampling design have covered an area of 4.5 m^2 $month^{-1}$ over the stretch of three transects from all the sites. The intertidal organisms collected were identified by following the key of Hornell (1949), Subramanyam *et al.* (1952), Rao (1982), Apte (1998) and Chhapgar (2005). Doughtful specimens were sent to the laboratory of Zoological Survey of India, Kolkata for proper confirmation of the identification. Among the multivariate analysis dendrograms from Bray-Curtis similarity matrix, 2- D non metric MDS ordination and Abundance biomass comparison (ABC) method of determining level of disturbance (pollution induced or otherwise) described by Warwick (1986) was followed.

Various diversity indices including Shannon's diversity index (1949), Simpson's diversity index (1949), Margalef's richness index (1958) and Pielou's evenness index (1975) were calculated. The statistical analysis of the collected data was performed by using software, primer Ver.6 (developed by Plymouth Research Lab. U.K.).

Results and Discussion

During the present study a total 50 species of intertidal organisms (41 Gastropoda, 5 Pelecypoda, 1 Crustracea, 1 Anthozoa, 1 Cephalopoda and 1 Ophiuroidea) were recorded from TIFR, Bandstand and NCPA shores. TIFR shore harboured a total 48 species (43 Gastropoda, 3 Pelecypoda, 1 Crustracea, 1 Anthozoa), Bandstand shore 42 species (37 Gastropoda, 3 Pelecypoda, 1 Crustracea, 1 Anthozoa,) and NCPA shore 49 species (41 Gastropoda, 4 Pelecypoda, 1 Crustracea, 1 Anthozoa,

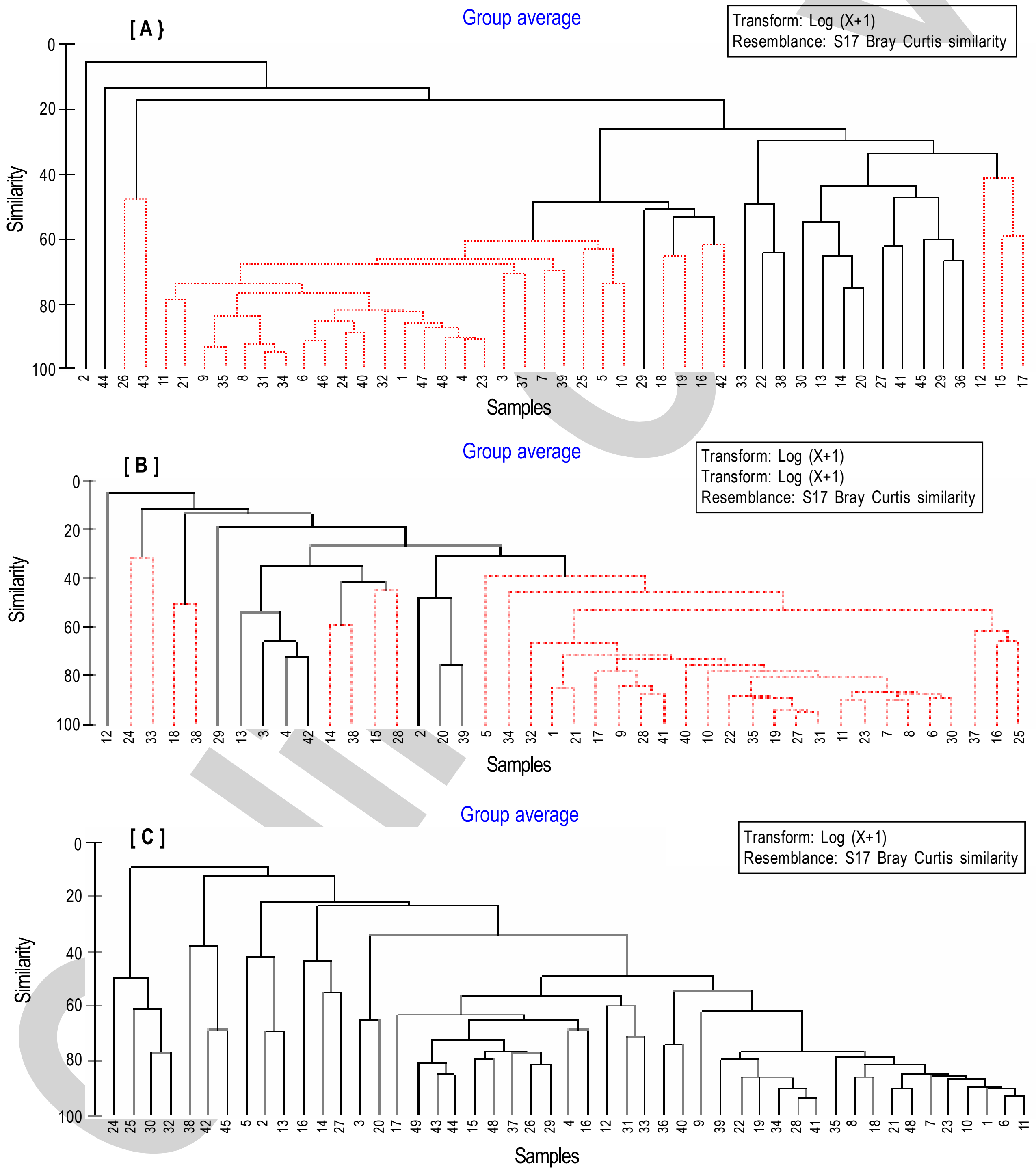

Fig. 1: Dendrogram from Bray – Curtis similarity matrix of intertidal species abundance data [log (X+ 1) transformed], with group average linking for the organisms as TIFR (A), Bandstand (B) and NCPA (C) shore with their samples name depicted on Appendix 1

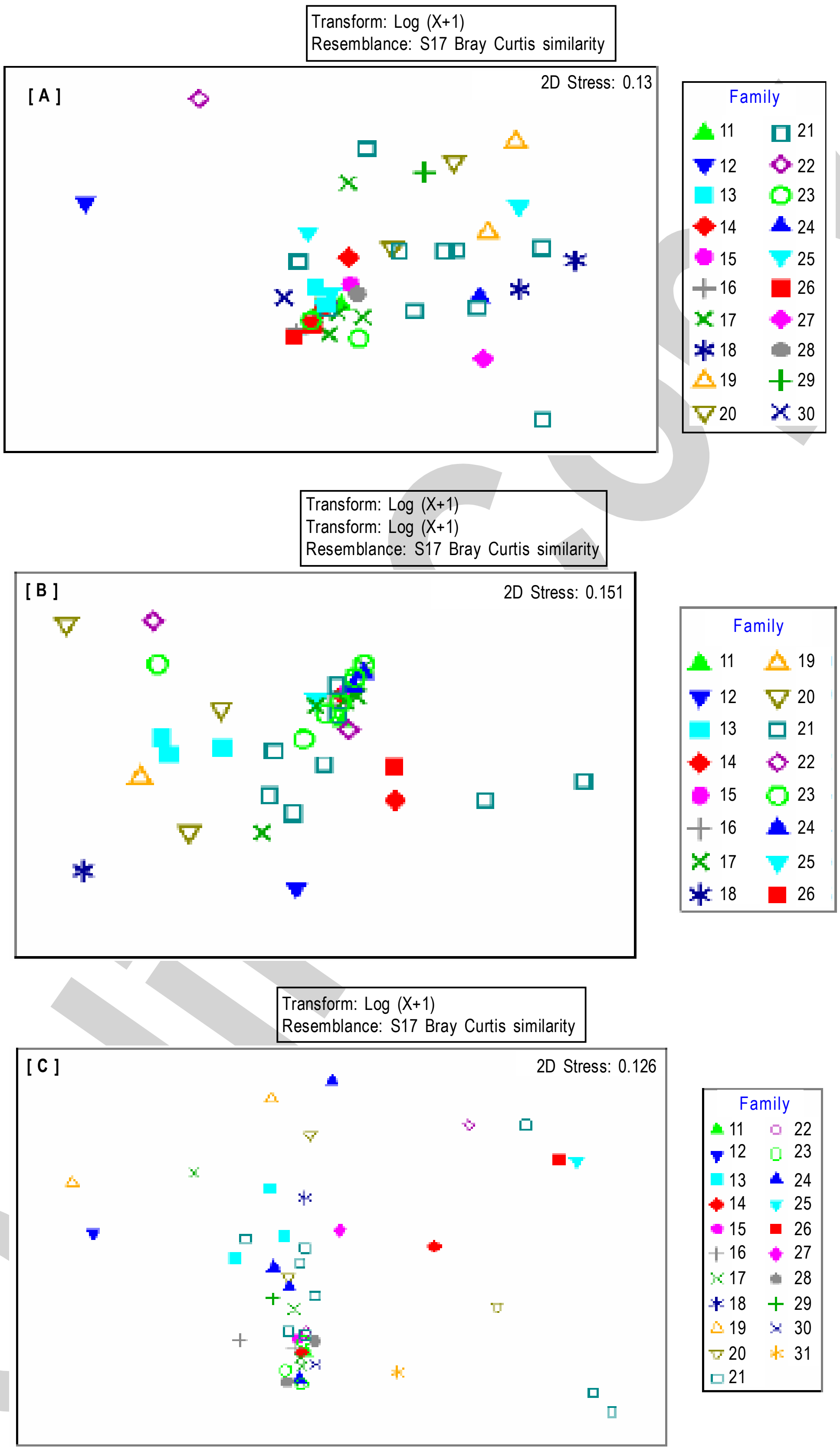

Fig. 2: Non metric MDS ordination of intertidal abundance data [log (X+ 1) transformed] for the family wise at TIFR (A), Bandstand (B) and NCPA (C) shore with their families name depicted on Appendix

1 Cephalopoda and 1 Ophiuroidea). Numerically, 48 species belonging to 21 families and 28 genera, 42 species belonging to 17 families and 25 genera and 49 species belonging to 22 families and 29 genera were recorded from TIFR, bandstand and NCPA shore, respectively (Table 1). A variation in number of species and their composition was noticed among all the three sites.

Melvill and Abercrombie (1893) recorded 322 species, Hornell (1949) 414 species, recorded 99 species of molluscs which are higher in number as compared to the present study where only 50 species of intertidal organisms including other groups were recorded. The reason may be the anthropogenic activities in the coastal area that have increased tremendously leading to degradation of the coastal water. Decline of the biodiversity of benthic fauna along with changing of community structure under pollution stress has also been reported by Simboura *et al.* (1995) and Young *et al*. (1995). Secondly, the earlier investigators have surveyed the larger areas and included dead shells also in their record, while in the present study, only live animals were recorded.

Generally, in a healthy environment Margalef richness index is higher in the range of 2.5-3.5 (Khan *et al.,* 2004). In the present study, margalef richness index ranged from 2.93-5.71 from different sites indicating the rich diversity of these shores. Pielou's evenness Index reveals the evenness of distribution of various species in the sample. Maximum values of Pielou's evenness index was recorded in July at TIFR (0.83) and in April at bandstand (0.81) and NCPA (0.81), respectively indicating the evenness of species in these months from three respective sites. Both Shannon's and Brillouin indices have given similar and often correlated estimates of diversity. When the two indices were used to measure the diversity of present work, the Brillouin index always produced the lower value. This is because the Brillouin index describes a known collection about which there is no uncertainty. Shannon index by contrast estimated the diversity of the unsampled as well as the sampled portion of the community (Magurran, 2004).

A scale of pollution in terms of Shannon's species diversity (3.0-4.5 slight, 2.0-3.0 light and 1.0-2.0 moderate and 0.1-1 heavy pollution). In present study, Shannon's index (1949) was highest in January (2.99) and lowest in August (2.10) at TIFR, it was highest in July (2.81) and lowest in August (2.14) at Bandstand ecosystem and in NCPA highest and lowest values were observed in April (2.91) and in August (1.98) indicates light polluted nature of TIFR and Bandstand ecosystem whereas light to moderate polluted nature of NCPA ecosystem. Overall low values of H' is indicator of pollution. The evenness index reveals the evenness of distribution of various species in a sample and Shannon index is maximum when all the species in a sample are equally abundant, decrease towards zero as the relative abundance of species diverse away from the evenness due to environmental disturbances (Ismail and Dorggham, 2003). A community becomes more dissimilar as the stress increases and accordingly species diversity decreases with decreasing water quality. Hence community dominated by relatively few species would indicate environmental stress (Plafkin *et al*. 1989). Dendrogram from Bray-Curtis similarity matrix of intertidal species abundance data with group average linking for the organisms from three sites shows similarity and combination pattern of occurrence was highest for *Nerita oryzarum* and *Planaxis sulcatus* in TIFR and Bandstand shore. *Nerita oryzarum* and *Tactarius malaccanus* at NCPA shore (Fig. 1). 2 D-non metric-MDS indicates (Fig. 2) that Planaxidae, Neritidae and Littorinidae are dominant group assemblages in the intertidal rocky shores in Mumbai which is also supported by Parulekar (1973) and Sreerammurthi (1980).

Abundance Biomass Comparison Curve (ABC curve) is widely used for determining level of disturbance (pollution induced or otherwise) on macrobenthos (Warwick *et al.*, 1987). According to Warwick (1986), in undisturbed communities, the ABC curve for biomass lies above that for numbers. In moderately disturbed communities both curves roughly coincide and in grossly disturbed communities the numbers curve lies above the biomass curve. In the present study, the ABC curves for both, the dominance and abundance curve roughly coincided for TIFR and bandstand indicating the moderately disturbed condition. Whereas, for NCPA beach the abundance curve lies above the biomass curve in some of the portion indicating grossly disturbed communities (Fig. 3). The Warwick (W) statistics values observed for Bandstand, TIFR and NCPA are 0.085, 0.019 and 0.001, respectively also indicated the very same situation of these shores. This polluted condition of these shores could be attributed to human interference and anthropogenic stress. The TIFR and NCPA beaches are close to the Mumbai port, thus suffered to some degree of oil pollution due to sea transport. However, in bandstand, the disturbances could be attributed mainly to anthropogenic stress. Thus variations in the pollution on the three shores can be justified.

Khan (2004) found the abundance curve to fall over the biomass curve throughout its length suggesting polluted nature of Uppanar estuary. He also found Warwick (W) values to fall on the negative side, ranging from -0.084 to -0.112, showing the highly disturbed nature. In the present study, the value of Warwick (W) ranged from 0.001-0.085, thus indicating moderate to slightly higher range of pollution level at all the three sites. Ismael and Dorgham (2003) observed the curve for numerical abundance to lie partially above the biomass curve for El-Dekhaila Harbour which he described as moderately polluted conditions.

Increasing level of oil pollution from Mumbai port and anthropogenic stresses have already been restricted the number of intertidal fauna in a critical level in Mumbai. As the bandstand and NCPA shores are important recreation spots of the city, number of plastic bottles, polyethylene bags, cans etc were observed during the study period. Presence of these materials are not only disturbing intertidal community but also during high tide these are floating into the nearshore water and disturbing the plankton community too. Thus the disposal of these materials should be taken to maintain the healthy environment. Harvesting the edible clam (*Gafrarium divaricatum*) which is going on in an uncontrolled manner from

Table - 1: Species found as intertidal organisms at different shores

	TIFR		Band stand		NCPA
1	*Alpheus spp*	1	*Alpheus spp*	1	*Alpheus spp*
2	*Aplysia benedicti*	2	*Aplysia benedicti*	2	*Aplysia benedicti*
3	*Astrea semicostata*	3	*Astrea semicostata*	3	*Astrea semicostata*
4	*Astrea stellata*	4	*Astrea stellata*	4	*Astrea stellata*
5	*Bursa granularis*	5	*Bursa granularis*	5	*Bursa granularis*
6	*Bursa tuberculata*	6	*Bursa tuberculata*	6	*Bursa tuberculata*
7	*Cellana radiata*	7	*Cellana radiata*	7	*Celina radiata*
8	*Cerithium morus*	8	*Cerithium morus*	8	*Cerithium morus*
9	*Cerithium rubus*	9	*Cerithium rubus*	9	*Cerithium rubus*
10	*Clanculus ceylanicus*	10	*Clanculus ceylanicus*	10	*Clanculus ceylanicus*
11	*Clanculus depictus*	11	*Clanculus depictus*	11	*Clanculus depictus*
12	*Conus figulinus*	12	*Conus figulinus*	12	*Conus figulinus*
13	*Conus piperatus*	13	*Cyprea arabica*	13	*Cyprea arabica*
14	*Cyprea arabica*	14	*Diodora bombayana*	14	*Cyprea pallida*
15	*Cyprea pallida*	15	*Diodora lima*	15	*Diodora bombayana*
16	*Diodora bombayana*	16	*Drupa contracta*	16	*Diodora lima*
17	*Diodora lima*	17	*Drupa konkanensis*	17	*Drupa contracta*
18	*Drupa contracta*	18	*Drupa tuberculata*	18	*Drupa konkanensis*
19	*Drupa konkanensis*	19	*Euchelus asper*	19	*Euchelus asper*
20	*Drupa tuberculata*	20	*Euchelus indicus*	20	*Euchelus indicus*
21	*Euchelus asper*	21	*Gafrarium divaricatum*	21	*Gafrarium divaricatum*
22	*Euchelus indicum*	22	*Littorina intermedia*	22	*Littorina intermedia*
23	*Gafrarium divaricatum*	23	*Littorina ventrucosa*	23	*Littorina ventrucosa*
24	*Littorina intermedia*	24	*Meretrix meretrix*	24	*Meretrix meretrix*
25	*Littorina ventrcosa*	25	*Nerita albicilla*	25	*Murex adustus*
26	*Meretrix meretrix*	26	*Nerita chameleon*	26	*Nerita albicilla*
27	*Murex adustus*	27	*Nerita oryzarum*	27	*Nerita chamelian*
28	*Nassarius spp*	28	*Nerita polita*	28	*Nerita oryzarum*
29	*Nerita albicilla*	29	*Onchidium spp*	29	*Nerita polita*
30	*Nerita chameleon*	30	*Planaxis similis*	30	*Octopus spp*
31	*Nerita oryzarum*	31	*Planaxis sulcatus*	31	*Onchidium spp*
32	*Nerita polita*	32	*Pyrene atrata*	32	*Perna viridis*
33	*Onchidium spp*	33	*Scutus unguis*	33	*Placenta placenta*
34	*Planaxis sulcatus*	34	*Sea anemone*	34	*Planaxis sulcatus*
35	*Planaxis similis*	35	*Tectarius malaccanus*	35	*Planaxis similis*
36	*Potamides cingulatus*	36	*Thais blanfordi*	36	*Polychaete*
37	*Pyrene atrata*	37	*Thais bufo*	37	*Pyrene atrata*
38	*Scutus unguis*	38	*Thais carnifera*	38	*Scutus unguis*
39	*Sea anemone*	39	*Thais rudolphi*	39	*Sea anemone*
40	*Tectarius malaccanus*	40	*Thais tissoti*	40	*Star fish*
41	*Thais blanfordi*	41	*Trochus radiatus*	41	*Tectarius malaccanus*
42	*Thais bufo*	42	*Turbo brunneus*	42	*Thais blanfordi*
43	*Thais carnifera*			43	*Thais bufo*
44	*Thais echinulata*			44	*Thais carnifera*
45	*Thais rudolphi*			45	*Thais echinulata*
46	*Thais tissoti*			46	*Thais rudolphi*
47	*Trochus radiatus*			47	*Thais tissoti*
48	*Turbo brunneus*			48	*Trochus radiatus*
				49	*Turbo brunnous*

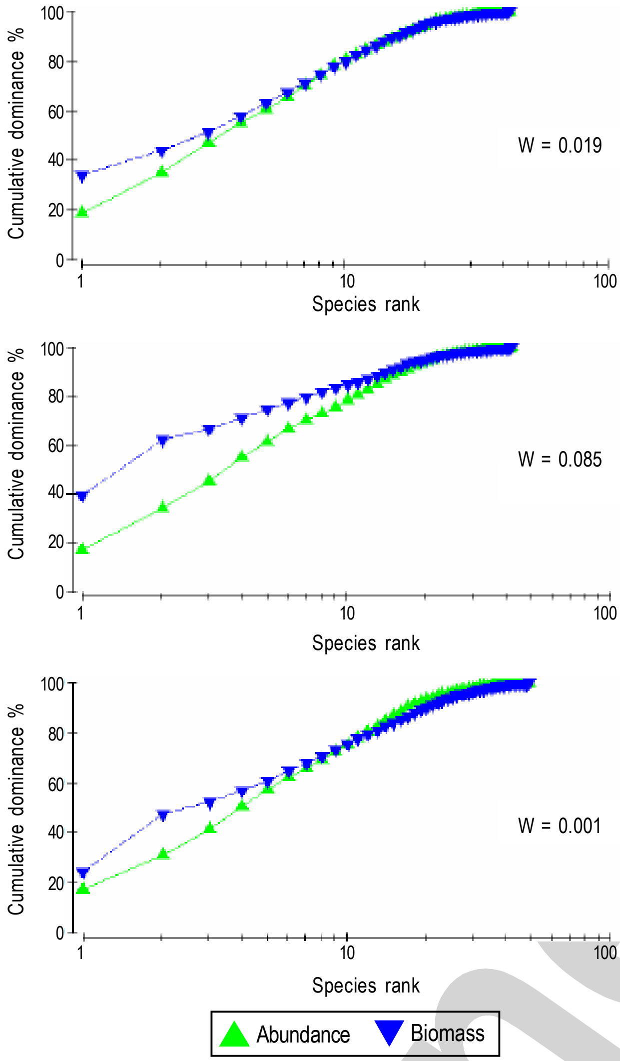

Fig. 3: Abundance biomass comparison (ABC) Curve of TIFR (A), Bandstand (B) and NCPA (C) shore

Bandstand and NCPA shore should be properly regulated. Thus, immediate attention is required to preserve the present biodiversity and to protect it from the further deterioration.

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