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Abundance and diversity profile of invertebrate macro benthic faunal components in a coastal ecosystem of Eastern India

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ABSTRACT

The Chandipore beach, situated in Balasore district, Odisha, 21°28´N 87°01´E / 21.47°N and 87.02°E shows an interesting nature of wave action as the water recedes up to an average of 5 kilometres during the ebb and tide, resulting in a vast, dynamic array of coastal biodiversity. It gets exposed to a huge tourism load every year and is faced with multidimensional anthropogenic interactions manifested through a varying gradient of urbanizing parameters like cattle grazing, automobile exhaust, constructions in vicinity of beach area, sewage and solid disposals etc. Present piece of work aims at documenting the premonsoon abundance and diversity of marine invertebrate fauna in this eastern Indian sea beach. *Adamsia palliata, Carcinoscorpius rotundicauda, Diogenes rectimanus*, *Sabella* sp., *Astropecten mauritianas* were found to be few of the prominent faunal representatives. Significant differences in respect of species richness have been observed among different selected ecozones through the coastal landscape based on tidal activity and anthropogenic exposure ($F_{5.73,\ p \leq\ 0.05}$). Such type of field-based observations leads to the scope of further estimation of the ecological status of these native organisms, their intra and inter-specific associations and functional contributions to coastal landscape playing role as a potential bioindicator, which may in turn become instrumental in frame working the future conservation scheme of these natural assets.

***Keywords*:** Bioindicator, Urbanizing parameters, Anthropogenic interactions, Coastal biodiversity, Tourism, Marine invertebrate fauna, Conservation

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1. INTRODUCTION

India is with an extensively dynamic coastal asset possessing a coastline of about 8000 km, with an EEZ of 2.02 million sqkms. On the east coast, it is extended over 0.56 million sq. kms. The coastal landscape has a rich biotic resource with about 40,000 listed species (OBIS - Oceanic Biogeographical Information System) (Venkataraman and Wafer, 2005). Chandipore is a sandy sea beach on the eastern coast, situated at Balasore district, Odisha, fronted by Bay of Bengal. This beach is represented as a spatial strip with fascinating wave characteristics under continuous influence of marine and terrestrial processes and is very popularised destination for tourism activities.

The coastal landscape formed by the dual action of climatic and geophysiological processes, serves as an intermediate biotope leaving provision for huge biodiversity. It presents an ecozone with unique attributes of succession, fragile eco dynamics and definitive ecological niche pattern. Bottom living organisms with > 1 mm body size consisting of various invertebrate groups like cnidarians, crustaceans, molluscs and echinoderms play a vital role in such transitional ecosystem as a significant component of the existing food web (Wafer et al. 2011). Benthic macro organisms, encompassing both the macro benthos (crabs, molluscs, polychaetes) and meio benthos (polychaetes) are vital components of this transitional ecosystem as they are periodically exposed to intertidal flows and at the same time they are at proximity to land surface (Alongi, 1990).

The ecopotential coastal landscape with high productivity levels serves as feeding, nursery and spawning grounds for a considerable number of invertebrate macrobenthic organisms. Those macrobenthic pool plays role as a vital food web component by linking the primary producers with the higher trophic levels as they filter feed upon the phyto planktons and on the other hand, provides nutritional resource for larger organisms. They remain effectively operational as nutrient recyclers by breaking down the organic matter prior to bacterial remineralization.as well as playing significant role in the oxygenation of highly mineralized sediment layer which is exposed to constantly varying wave action and a fluctuating salinity gradient (Gerlach, 1978). Primary productivity gets enriched by constant reconstruction of biogenic structure through the bacterial remineralization upon the organic matter inputs from these macrobenthic community generated in the process of burrowing, defaecation and infaunal secretion. Another ecologically vital role of nutrient recycling is performed through bioturbation, specifically by the burrow dwelling polychaetes (*Sabella* sp.), arthropods (different crabs) and Echinoderms (deposit feeders) (Giere 1993). The coastal economy deals with the exploitation of both the renewable and non-renewable resources viz. food to native people, delicacy to tourists, scope of aesthetic values, supply of aquaria and museum specimen, provision of herbal and cosmetic usage (Quasim and Wafer, 1990).

The coastal ecosystem exhibits an overall balanced ecologically supportive status with its intrinsic resilient nature keeping in tune with hydrologically linked geomorphological parameters to withstand the huge climatic stress, mainly caused by wave and wind action. In recent days, this ecozone is being vulnerable due to the alarming rate of damage and loss of coastal biodiversity imposed by different threat factors including the natural ones like land erosion, rising of sea level, shoreline shifting, global climate change, depletion in the Ozone layer, as well as the risk factors caused by anthropogenic influences in the form of maritime activities, overexploitation of natural resources, destructive fishing techniques, accelerated usage of fishing gear, employment of increased number of fishing trawlers, huge ratio of nontarget catch, considerable volume of discarded by-catch, attainment of commercial values by numerous newer fish and non-fish marine resources, habitat alteration and destruction through different rapidly encroaching urbanising factors like human settlements, runoff or sedimentation from developmental activities or industrial projects, eutrophication through municipality sewage disposal and agricultural run-offs, pollution from land based or other sources, introduction of invasive alien species and last but not the least, the tourism load, ultimately leading to the irreversible geophysical alteration of this Eco potential landscape (Simboura *et al.*, 1995).

The proper maintenance and management of the rich biodiversity related to this ecosystem segment turns out to be challenging to some extent due to the loophole factors like deficiency of holistic information about the systematic profile and autecology of the macrobenthic faunal compositions, encompassing for those with potential commercial values, lack of implementation of legislative control and ultimately the lack of public awareness (Haplern *et al.*, 2008).

Study about coastal fauna in recent years in our country includes- Goswami 1992, Bairagi *et al.* 1995, Talukdar *et al.* 1996, Mitra *et al.* 2002. A baseline information about the macrobenthic faunal assemblage of Chandipore coast with an outline idea about the anthropogenic influences upon the benthic faunal distribution across the intertidal coastal habitats is yet to be reported.

The main objectives of this field observation-based documentation are a comprehensive documentation of overall abundance of coastal macrobenthic invertebrates, extrapolating their assemblage pattern and diversity profile from sampling-based surveys, correlating their distributional pattern of occurrence varying with differential anthropogenic exposure. The present study reveals the scope of establishment of the native macrobenthic fauna as potential bioindicator acting as a determinant for landscape hygiene and providing 'environmental cues' for long-term sustainable management of coastal landscapes.

2. MATERIALS AND METHODS

Study area: Chandipore, district Balasore, Odisha, India (21°28′N 87°01′E / 21.47°N and 87.02 °E).

Figure 1a. Study area.

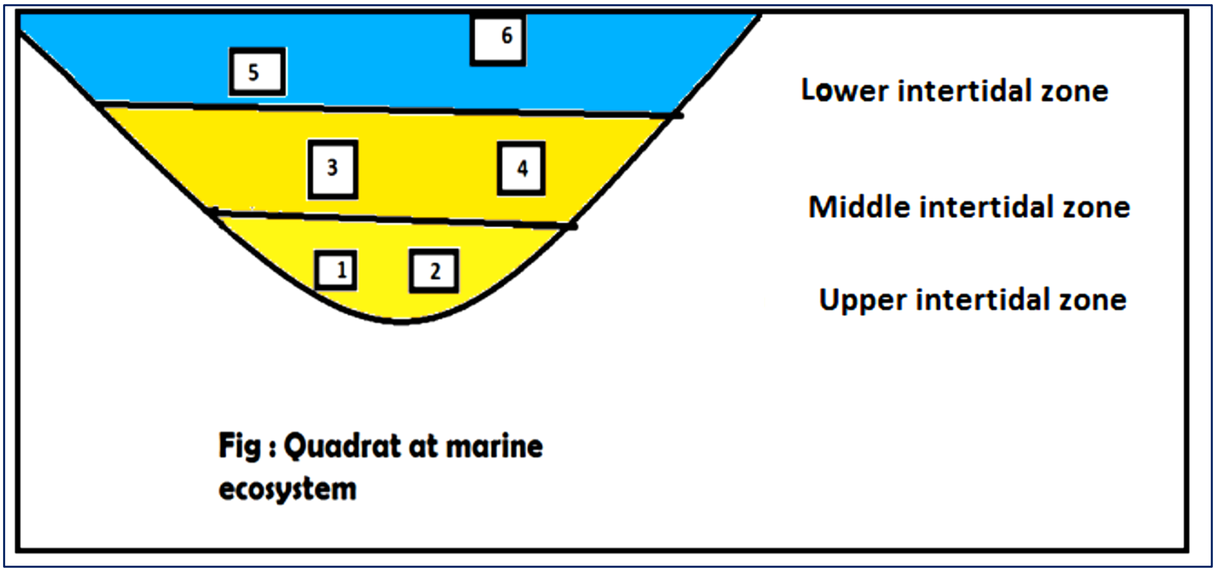

Figure 1b. three different coastal ecozones *viz*. UIZ (quadrat 1, 2), MIZ (quadrat 3, 4), LIZ (quadrat 5, 6)

Physiography of the Coastline - it is characterized by a sandy beach, fronted at the Bay of Bengal, where sand grains are mixed with variable proportion of silt and forms a compact beach basin, scattered with marshes and small lagoons. The slope is almost flat, not much gradual up to the low water mark. Wave action has unique characteristics as water level recedes up to 5 kms during the ebb tide. For the sampling purpose, beach slope was gradually compartmentalized as Upper intertidal zone, **UIZ** (flooded only during high tide, greater exposure to anthropogenic activities), Middle intertidal zone, **MIZ** (covered & uncovered twice a day by tide, moderately exposed to anthropogenic influences), Lower intertidal zone,

LIZ (always remain underwater, lesser anthropogenic exposure).

Climate –average annual temperature ranges between 15-25 °C, wind north east at 3km/h, with 77% humidity; annual rainfall ranges between 800-5500 mm.

Study period: post winter in 2017

Sampling: across and vertical shore area-based surveys during diurnal tide shifts for collection of shore animals occupying different habitats and niches**.** Survey was performed along a potential coastline of about 10 kms starting from Buddhabalanga river mouth.at eastwards to Sonapur at the west. Macrobenthic invertebrates representing various phyla were collected from three different zones (Figure 1b) spread across the intertidal zone *viz*. UIZ (quadrats 1, 2), MIZ (quadrats 3, 4), LIZ (quadrats 5, 6), using quadrats and line transect methods with suitable modifications, following standard sampling protocol (Emery, 1961). Collections were done mostly during low tide, collected specimens were washed, sorted accordingly and preserved in 70% alcohol, mixed with 3% Formalin (Birkett and McIntyre 1971). Catches from fishing gear, bag catch or bagda net were also considered (particularly to collect the comparatively sessile organisms) and the discarded by- catch were also surveyed.

The relative abundance, total abundance, Simpson's Dominance Index (D), Shannon-Weiner Index (*H'*), Pielou's Evenness Index (*J'*), Margalef's Species Richness (R), Berger-Parker Index (BP) of the available species were determined by following standard indexing methods (Shannon and Weiner, 1948; Magurran 1988; Pielou 1969; Simpson1949, Berger and Parker 1970). Dominance status of each species was ascertained on the basis of relative abundance following Engelmann's scale (Engelmann, 1978). The data have been statistically processed and computed with Microsoft Excel 2007 and PAST version 3.02.

3. OBSERVATION

Figure:2. Phylum wise percentage abundance of coastal benthic invertebrate groups

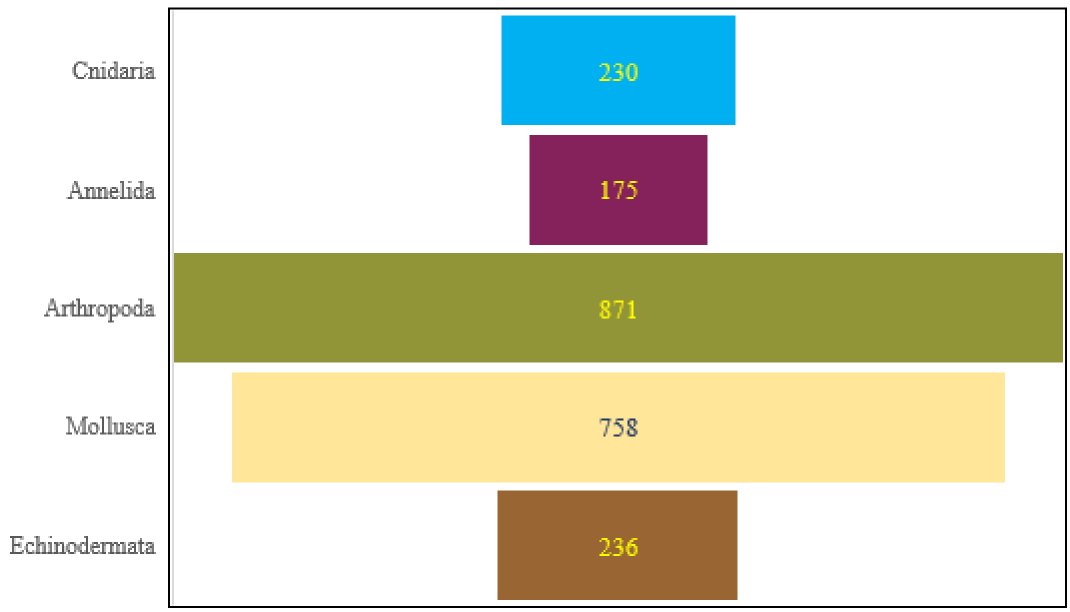

Table 1. Prominent representative invertebrate macrobenthic faunal members of Chandipore coast

Phylum-Cnidaria				Relative abundance (RA)%	Dominance Satatus
	Scientific name	Common name	Class		
1	*Porpita porpita* (Linnaeus)	Blue disc/ Blue dollar	Hydrozoa	0.93	SR
2	*Physalia physalis* (Linnaeus)	Portuguese man-o-war	Hydrozoa	1.63	R
3	*Obelia spinulosa* (Bell)	Sea fir	Scyphozoa	2.69	R
4	*Adamsia palliata* (Fabricius)	Sea anemone	Anthozoa	4.89	SD

Phylum-Annelida					
5	*Glycera alba* (Muller)	Rag worm/ Sand worm	Polychaeta	2.38	R
6	*Lumbrinereis polydesma* (Southern)	Rag worm/ Sand worm	Polychaeta	0.93	SR
7	*Perinereis nuntia* (Savigny)	Rag worm/ Sand worm	Polychaeta	0.62	SR
8	*Nereis indica* Kinberg	Rag worm/ Sand worm	Polychaeta	0.84	SR
9	*Sabella* sp.		Polychaeta	3	R
Phylum-Arthropoda					
10	*Balanus amphitrite* Darwin	Acorn barnacle	Crustacea	10.35	D
11	*Lepas anatifera indica* Annandale	Goose barnacle	Crustacea	3.92	SD
12	*Squilla nepa Laterille*	Mantis shrimp	Crustacea	2.86	R
13	*Macrobrachium rosenbergii* De Mann	Prawn	Crustacea	1.01	R
14	*Diogenes rectimanus* Meirs.	Hermit crab	Crustacea	6.48	SD
15	*Scylla serrata* De Hann	Giant mud crab	Crustacea	4.27	SD
16	*Ocypoda macrocera* Edwards	Red crab	Crustacea	3.48	SD
17	*Ocypoda ceratopthalma* Palas	Ghost crab	Crustacea	2.47	R
18	*Uca triangularis bengali* Crane	Fiddler crab	Crustacea	2.03	R
19	*Carciniscorpius rotundicauda* (Latreille, 1802)	Horse shoe crab	Crustacea	1.50	R
Phylum-Mollusca					
20	*Dentalium variable* Deshayes	Tooth shell	Scaphopoda	0.62	SR
21	*Dentalium octangulatum* Donovan	Tooth shell	Scaphopoda	0.35	SR
1. Family- Trochiidae					
22	*Umbonium vesitarium* (Linnaeus)	Button top	Gastropoda	3.83	SD
2. Family- Turbinidae					
23	*Tarbo bruneus* (Roding)	Brown Dwarf Turban	Gastropoda	1.15	R
3. Family- Neritidae					
24	*Nerita chamaeleon* Linnaeus	Chamaeleon Nerite	Gastropoda	0.84	SR

	4. Family- Littorinidae				
25	*Littoraria articulata* (Philippi)	Articulated littorina	Gastropoda	1.01	R
26	*Littoraria scabra* (Linnaeus)	Mangrove periwinkle	Gastropoda	0.84	SR
	5. Family- Potamididae				
27	*Certhideopsilla cingulata* (Gmelin)	Girdled Horn Shell	Gastropoda	0.93	SR
28	*Telescopium telescopium (Linnaeus)*	Telescoipium shell/ Creeper	Gastropoda	1.59	R
	6. Family- Turritellidae				
29	*Turritella terebra* (Linnaeus)	Great screw shell	Gastropoda	1.94	R
	7. Family- Cypraeidae				
30	*Monetaria annulus* (Linnaeus)	Gold ringer	Gastropoda	1.06	R
31	*Monetaria moneta* (Linnaeus)	Money cowrie	Gastropoda	1.45	R
	8. Family-Naticidae				
32	*Natica picta* Recluz	Moon snails	Gastropoda	1.19	R
33	*Natica maculosa* Lamarck	Spotted moon snail	Gastropoda	1.59	R
	9. Family-Tonnidae				
34	*Tonna sulcosa* (Born)	Banded Tun	Gastropoda	0.35	SR
	10. Family- Muricidae				
35	*Ergalatax contracta* Reeve	Contracted Rock Shell	Gastropoda	0.62	SR
			Class- Bivalvia		
36	*Perna viridis* Linnaeus	Green mussel	Gastropoda	0.48	SR
37	*Donax scortum* Linnaeus	Wedge clam	Gastropoda	8.85	SD
38	*Sepiella aculeata* Orbigny	Cuttlefish	Cephalopoda	2.78	R
39	*Loligo duvauceli* Orbigny	Squid	Cephalopoda	1.94	R
			Phylum-Echinodermata		
40	*Astropecten mauritianus* Gray	Sea star	Asteroidea	7.27	SD
41	*Temnopleurus toreumaticus* Leske	Small Sea urchin	Echinoidea	3.13	R

RA<1 = SUBRECEDENT (SR); 1.1-3.1 = RECEDENT (R); 3.2-10 = SUBDOMINANT (SD); >10.1 31.6 = DOMINANT (D)

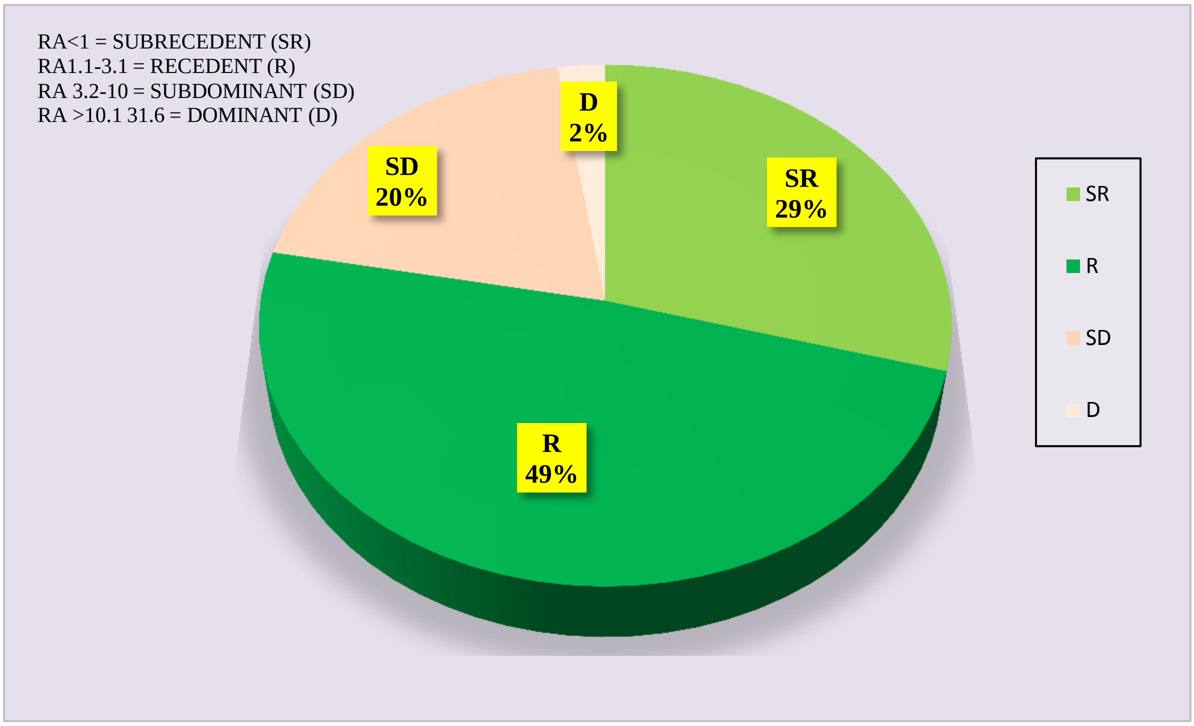

Figure 3. Dominance status of non chordate macrobenthic species documented from Chandipore coast

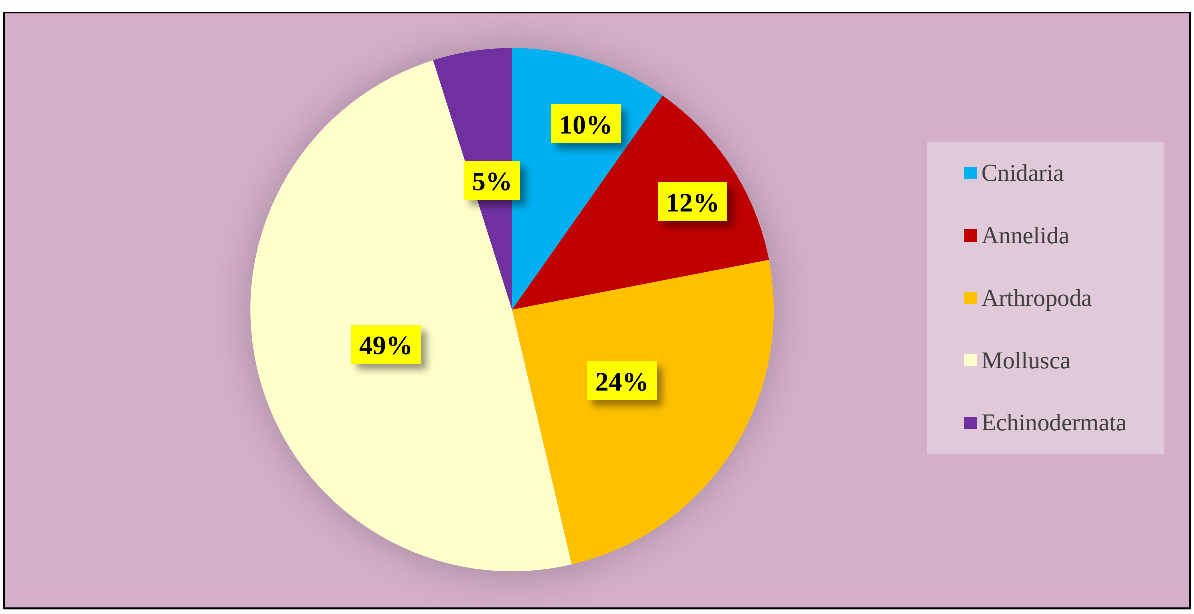

Figure 4. Phylum wise species-composition of coastal benthic invertebrate groups (percentage abundance

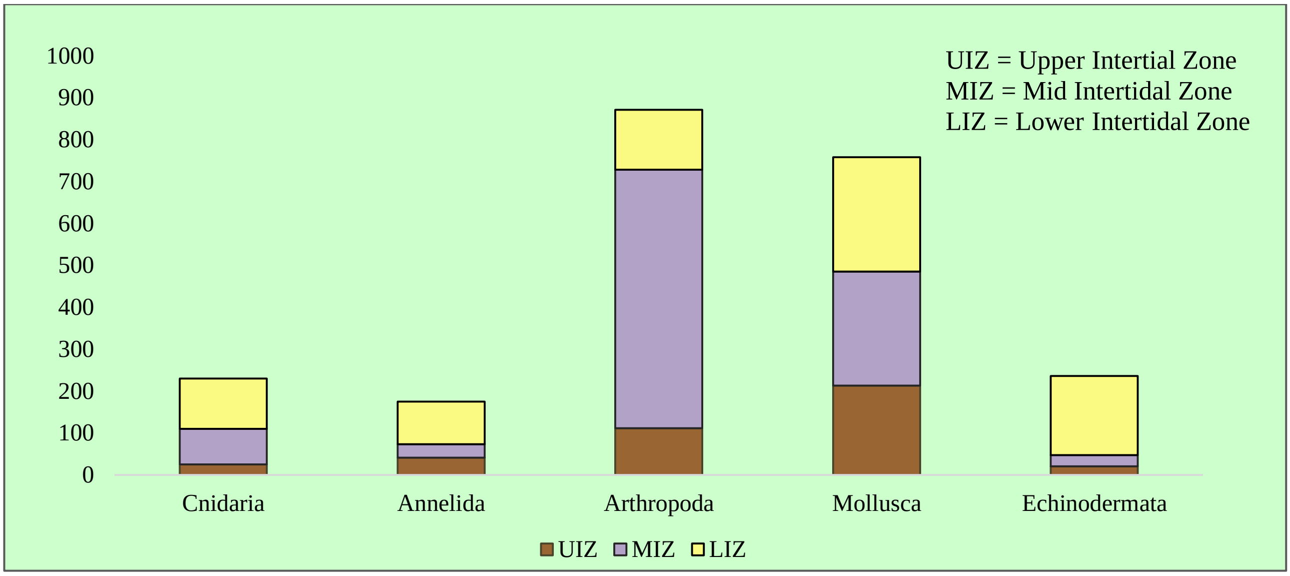

Figure 5. Differential preference for intertidal zones displayed by coastal invertebrate macrobenthos

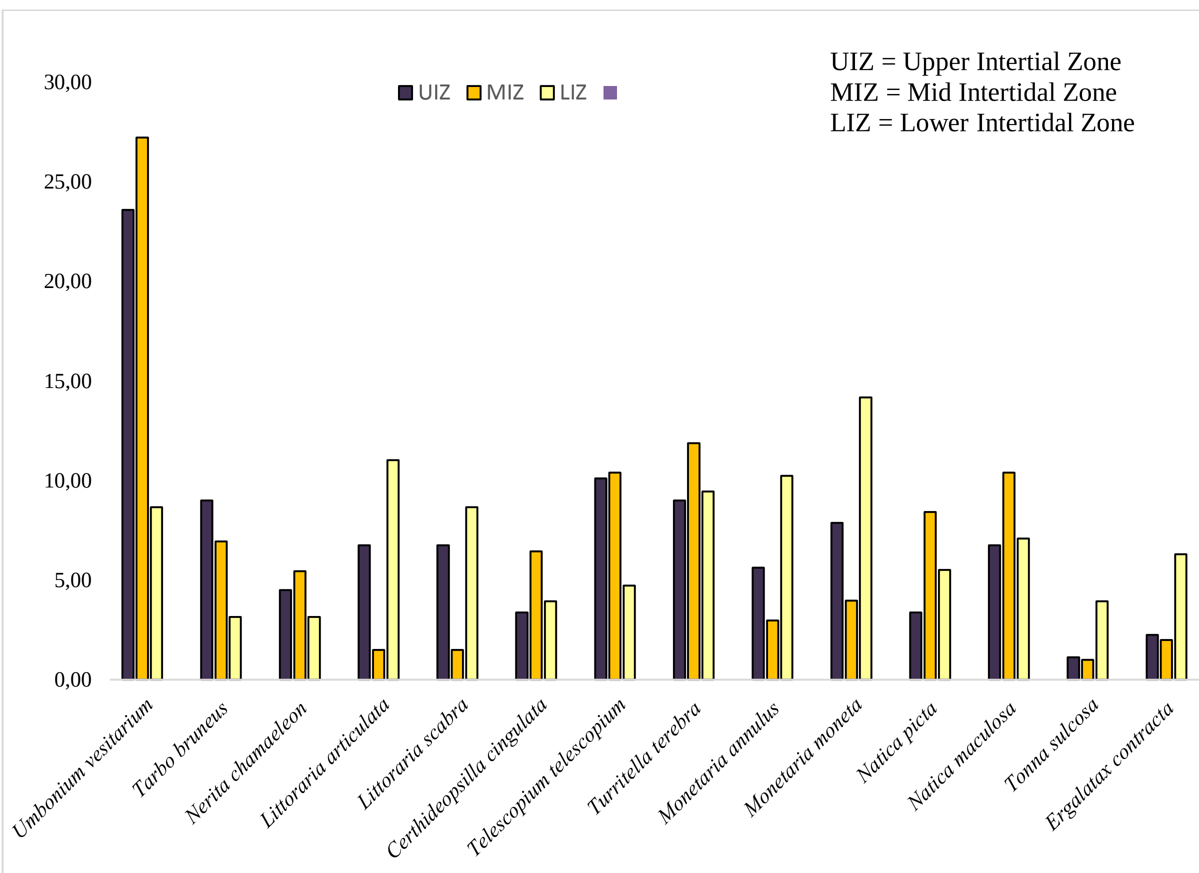

Figure 6. Differential relative abundance profile of prominent gastropods throughout three different ecozones at Chandipore coast

Table 2. Diversity indices for coastal ecozone wise community analysis
[UIZ = Upper Intertial Zone; MIZ = Mid Intertidal Zone; LIZ= Lower Intertidal Zone]

Community analysis indices	UIZ	MIZ	LIZ
Total Abundance (N)	52	**260**	107
Dominance_D	**0.10**	0.14	0.14
Simpson(1-D)	**0.90**	0.86	0.86
Shannon_H′	**2.46**	2.27	2.27
Evenness_e^H/S	**0.84**	0.69	0.69
Margalef (R)	**3.3**	2.3	2.8
Equitability_J	**0.93**	0.86	0.86
Berger-Parker (BP)	**0.17**	**0.30**	0.26

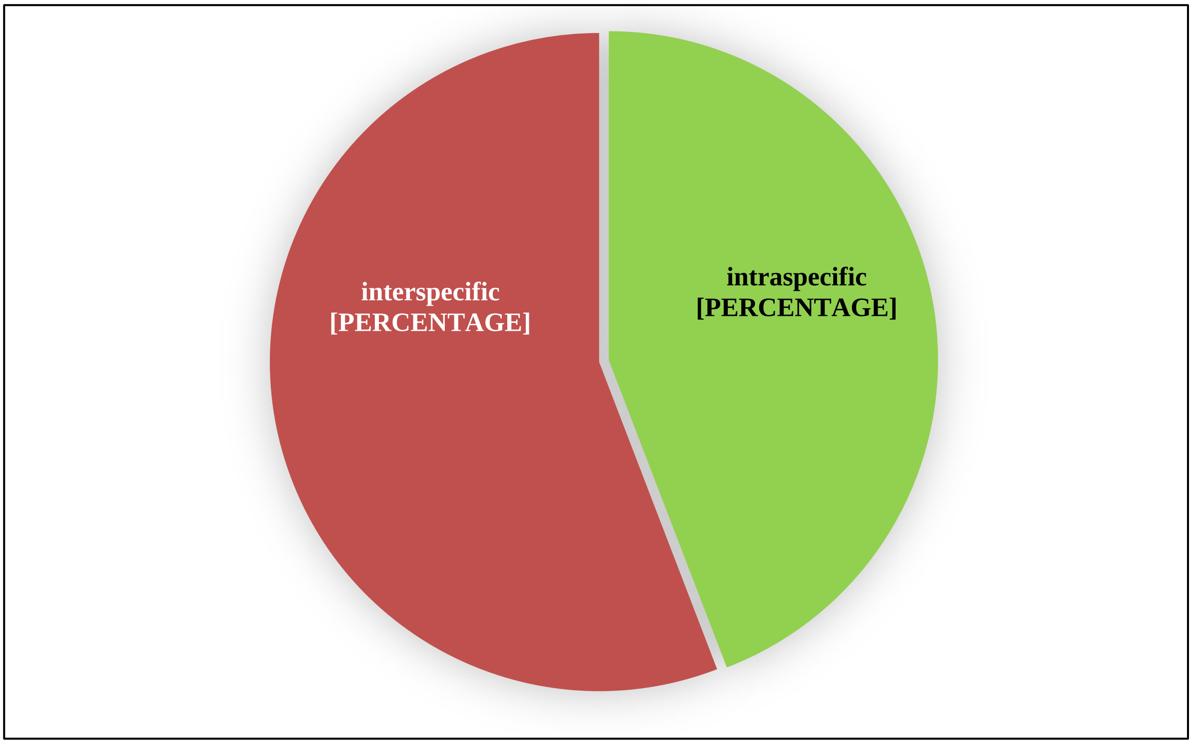

Figure 7. Biotic association profile of the coastal invertebrate macrobenthos

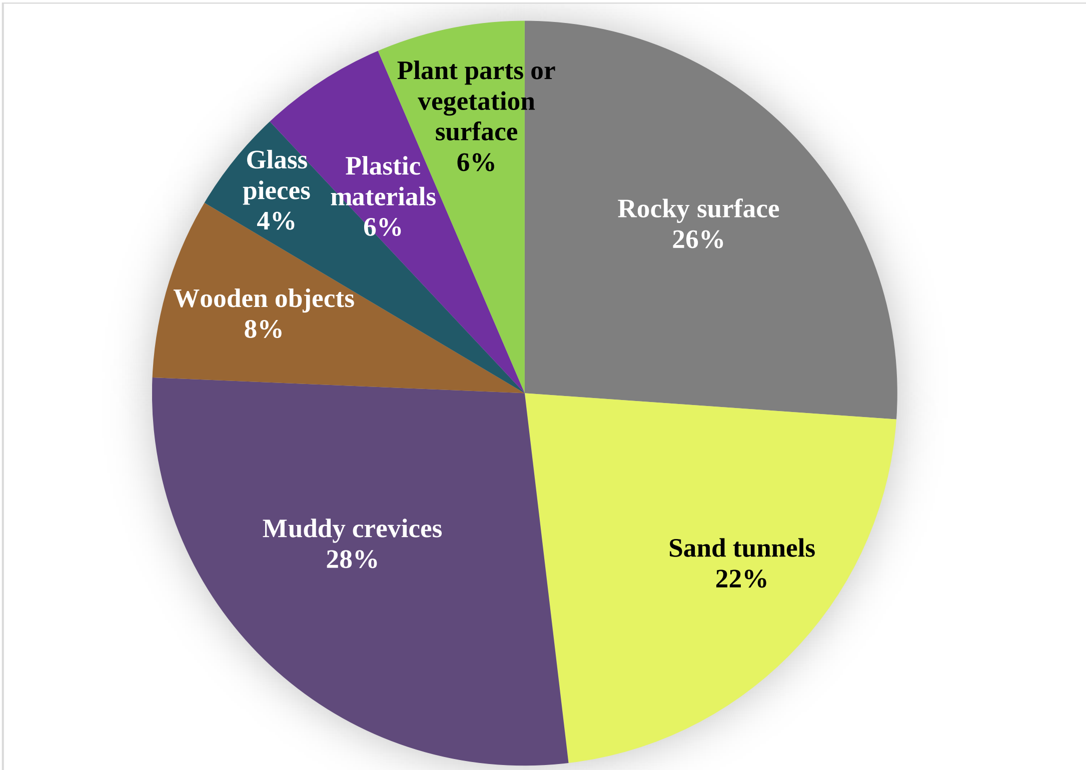

Figure 8. Utilization ratio (% value) showing the attachment profile of the benthic coastal macroinvertebrates to the available substratum (natual or introduced)

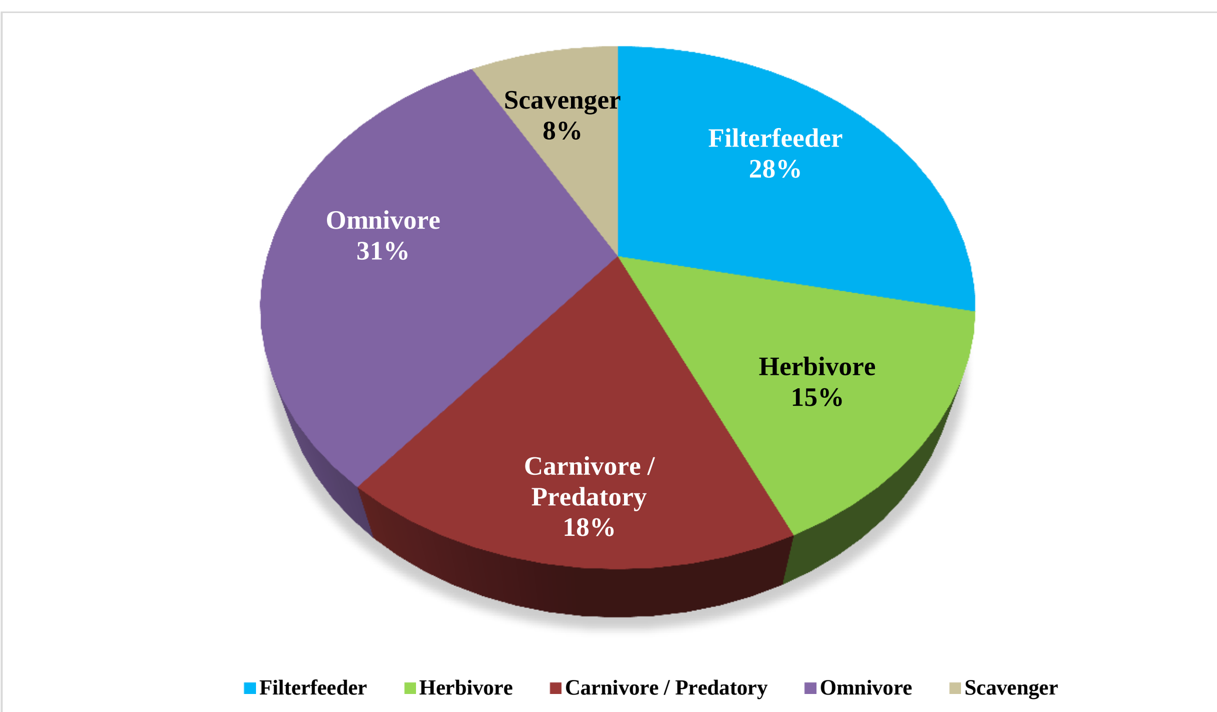

Figure 9. Dietary preference marine invertebrate macrobenthos

4. DISCUSSION & CONCLUSIONS

A total of 41 species under 36 genera, 10 classes and 5 phyla were reported from the short term coastal survey during post winter at this unique ecological landscape characterized by the prominence of few gastropod species belonging to 10 different families.

The comprehensive documentation established Arthropoda (871) as the most abundant phylum, followed by the Mollusca (758) and Annelida (175) whereas Cnidaria (230) were with lesser abundance (Figure 2).

Table 1 depicts the invertebrate macrobenthic faunal composition of Chandipore coast, Odisha. Considering their relative abundance profile *Balanus amphitrite* showed highest abundance (10.35), followed by that of *Donax scortum* (8.85) and *Astropecten mauritianus* (7.27), contrastingly, minimum value was represented by the scaphopod *Dentalium octangulatum* (0.35), *Adamsia palliata* (4.89), *Scylla serrata* (4.28), *Lepas anatifera indica* (3.92), *Ocypoda macrocera* (3.48), *Umbonium vesitarium* (3.83) were few of the other prominent representatives.

Among all the species, higher dominance status was shown by *Physalia physalis*, *Obelia spinulosa*, *Sabella* sp., *Glycera alba*, *Ocypoda* spp., *Uca* spp., *Tarbo bruneas*, *Littoraria articulata*, *Telescopium telescopium*, *Natica picta*, *Loligo duvauceli* and few others, whereas the least rank of dominance status was found to be attained by *Balanas Amphitrite* (Figure3). A considerable number of castings of *Arenicola* sp., the marine polychaete worm is reported to be present in the beach during low tide. In the year 2015, a full-grown worm was reported for the first time, in this particular coastal zone of the Bay of Bengal (Chakrabarti and Ray, 2017).

As the phylum wise species composition is concerned, as in Figure 4, Mollusca had shown highest species richness (49%), followed by that of Arthropods (24%) and Echinodermata contained least ratio of species richness (5%).

Figure 4 presents the differential preference for intertidal zones shown by the coastal invertebrate macro benthos. The mid intertidal zone (MIZ) is most preferentially occupied by the arthropod community, followed by those of the molluscan components. Echinoderms were found to show least preference for MIZ. Upper intertidal zone (UIZ) was noted to be mostly availed by the Molluscan species and next by the arthropods. Lower intertidal zone(LIZ) mainly sheltered the Molluscan and Echinoderm species and moderate number of Arthropods, Annelids and Cnidarians. Minimum preference for UIZ were shown by Cnidarians, Annelids and Echinoderms. Differential population distribution, both on spatial and temporal scales, of a species through different habitat zones is caused due to differential response to varying levels of multiple stress factors (Lee 1985). Productivity level of the concerned ecosystem plays role as the effector for the maintenance of essential life processes providing the basic energy requirement (Yennawar and Tudu 2014).

Interestingly, a notable pattern of differential distribution of gastropod community was observed throughout the three different coastal ecozones *viz.* UIZ, MIZ, LIZ (Figure 5), presenting the highest abundance of *Umbonium vesitarium* at UIZ and MIZ. MIZ is least availed by the gastropod *Tonna sulcosa and Littoraria* sp. At UIZ, *Tonna sulcosa* was least abundant. At LIZ, *Monetaria moneta* was most prevalent and the species like *Turbo bruneus* and *Nerita chameleon* were least abundant. The major factors influencing the molluscan distribution pattern across the intertidal and subtidal zone of coastal regions encompass the ecobiological attributes like resource availability, reproductive phases, interactions with associated species, juvenile survival rate, seasonally variable eutrophication status at the substratum level and annual temperature profile (Peterson and Fegley, 1986).

In Table 2, The community analysis parameters for the gastropod community at the three selected ecozones were listed. MIZ and LIZ had shown the highest Dominance value (0.14). UIZ was found to be represented with maximum Simpson index value (0.9). Shannon value (H´) calculated was highest for UIZ. Maximum evenness was reported at UIZ (0.84), MIZ and LIZ were with similar values (0.69). Margalef's index (R) and equitability (J) were highest for UIZ (0.84 and 0.93) respectively. Berger-Parker index (BP) was highest for MIZ (0.3), followed by that at LIZ (0.26) and least at UIZ (0.17).

A wide and diverse array of organismal association, particularly commensalism was interestingly marked in this natural habitat. The biotic association was more prominent at interspecific level (56%) than those of intraspecific ones (44%) (Figure7). Intraspecific congregations are commonly found in gastropods, particularly at the layers of regular and moderate salinity (Dame, 1972). Interspecific association was very prominently found for hermit crabs sheltered within gastropod snails, whose surfaces are often infested with sea anemones. Attachment of *Balanas* sp. upon gastropod snails represented another commensal unit.

This field observation-based study helped to point out some attachment surface or substratum commonly utilized by these marine benthic faunal group for attachment or as shelter. Those surfaces either may be naturally occurring on this coastal landscape or sometimes they may be introduced there through different anthropogenic influences (particularly fishing, grazing and tourism activities) or as outcome of resource utilization factors oriented by urbanised land usage extensions. Muddy crevices (28%) appeared to be most frequently utilized substratum level in this depositional coast line followed by patches of rocky surface (26%) and sand tunnels and burrows (22%). Polychaete annelids represent the major group among the soft bodied macroinvertebrates embedded in the muddy substratum. Few molluscs and cnidarians were often found to be attached to the floating plant parts or vegetation surfaces (6%). Besides these natural objects, few of the introduced materials like parts of fishing nets, rubber pieces, plastic items (6%), broken glass pieces (4%), wooden particles (8%) were found to become able to get established themselves as potential microhabitats for foraging, mobility and other ecobiological attributes of these native invertebrate macrobenthic creatures.

The macrobenthic invertebrate coastal substratum community are significant food web components forming a functional channel between the sediment system and higher predators (Gray and Elliot 2009). In the present study, they represent diverse foraging guilds (Figure:8), with omnivores (31%) topping the list, followed by the filter feeders (28%) whereas the scavengers comprise comparatively a lesser ratio (8%). Shifting of nutritional requirements through different phases of lifecycle is also to be considered. The production level gets enriched by the secondary production provided by planktonic oozes particularly nourishing the native organisms both in adult and developmental stages.

Based on the extensive beach study, some of the considerable threat factors responsible for the deterioration of the basic hygiene of this native ecosystem were made possible to be noted like uncontrolled exposure to polluting agents, overexploitation of living marine resources by the activities of different local economic groups like fishermen, sea shell harvesters, fish spawn collectors, prawn collectors, cattle grazers, almost on daily basis. Habitat degradation by artificial establishment at the coastal zone, habitat alteration or modification by multifaceted tourism activities, almost on yearlong basis are some of the recent alteration agents of such coastal ecosystems. Sustainability of the coastal fauna is directly correlated to the levels of anthropogenically employed urbanizing factors (Dauer and Corner 1980). The common damaging effects of urbanisation encroachment upon coastal life forms are- decline in fecundity, hampered fertilization, stunted larval metamorphosis, ultimately inducing mortality. A potential loss of biodiversity occurs through the wastage from by catch, particularly the damage of egg capsules, larval and post larval stages of different invertebrates cause a shifting or alteration of the reproductive guild pattern and successional profile of the native communities of this ecozone (Butler *et al*., 2010). Few species like *Adamsia palliata*, *Diogenes rectimanus*, *Ocypoda macrocera*, *Carcinoscorpius rotundicauda*, *Astropecten mauritianus* become vulnerable by the threats of asymmetric collection pressure imposed by the overenthusiastic consumers and tourist groups and through the repeated exposure to various academic parties with dynamic interests and collection tendencies.

The multidirectional sampling-based analysis comprehensively extrapolates the observations onto a number of hypothesis related to the diversity and distribution and to some extent the behavioural manifestations of these marine macrobenthic faunal community of the present study site. First hypothesis elucidates that an overall satisfactory estimate of these organisms throughout all the selected ecozones might be attributed by their higher tolerance to the environmental stress factors like alternating tidal volume, fluctuating salinity level, pollution load originated from various anthropogenic activities *viz.* discharge from fishing boat, sewage and land drainage. Moreover, the coastal substratum is with the intrinsic functional role as ecological buffer system by manipulating the rate of land released -pollutant- dispersion into the coastal bed to a relatively slower one in comparison to that of the open ocean. Thus, the level of pollutant exposure to the macrobenthic population inhabiting the coastal habitat gets limited at least to some extent (Pethic, 1992).

Second hypothesis emerges from the minute and detailed observation of the ecozone wise faunal distribution pattern. Arthropods were found to avail the MIZ most, probably due to their compatible foraging activities and prey-predator interrelationships synchronized with wave periodicity. At LIZ, most abundant were the echinoderms and the molluscs, whose sustainability gets directly correlated to their osmoregulatory mechanism which becomes operational to withstand the constant wave actions. *Adamsia palliata* were represented with almost a uniform distribution pattern throughout all the three zones, leading to the hypothesis that they may play role as the stress tolerant potential flagship species. At UIZ, quite prominently distributed are the molluscs, being covered with hard shells they are capable to withstand the alternating wave actions, characteristic to this zone. Being protected under the calcareous shell they become much protected against the periodic threats of desiccation and are significantly tolerant to counter the pollution stress imposed by urbanising parameters and anthropogenic interactions, to which the UIZ is most exposed among all the three zones.

Thus, the hard-shelled molluscans are potentially suitable to act as bioindicators. Third hypothesis is based on the frequent occurrence of faunal associations, particularly commensalisms indicating the probability of persistence of an almost conducible ecobiological status for the sustainability of native organisms (Rhoads and Boyer 1982).

The abundance, population density and diversity pattern of coastal macrobenthic invertebrates are faithful reflector of environmental conditions through their sensitivity towards ecological alterations. They act as effective "indicator" species playing role as an integrated environmental signal over a longer course of habitat loss, fragmentation or overexploitation of natural resources. Environmental regulation and habitat management are urgent for the conservation of these natural assets. Sustainable usage of marine resources and prevention of the loss of biotic resources can be promoted by the controlled rate of consumption of fish and non-fish resources by adopting a permissible limit of mesh size of capture nets, as well as, prevention of damaging capture techniques like net dragging through the intertidal areas. Immediate release of bycatch is advisable for minimizing the unwanted loss of biodiversity (Talukdar *et al.*, 1996). The overall ecosystem integrity can be maintained through long term socioeconomic improvement. Sustainable land form maintenance through the application of remote sensing techniques, development of eco-friendly tourism schemes (Ramkrishna *et al.*, 2003) and a comprehensive eco health assessment encompassing the geophysiological, chemical, environmental and ecobiological aspects of this dynamic and ecopotential coastal stretch is highly recommended for their protection and conservation.

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References

[1] Alongi D M. The ecology of tropical soft-bottom benthic ecosystems. *Oceanography and Marine Biological Annual Review* 28 (1990) 381-496

[2] Berger W H and Parker F L. Diversity of planktonic foraminifera in deep-sea sediments. *Science* 168 (1970) 1345–1347.

[3] Birkett L, McIntyre A D. Treatment and sorting of samples. Methods for the study of marine benthos, *IBP Handbook No. 16*: Blackwell Sci. Publ. Oxford and Edinburgh (1971) p. 157.

[4] Butler A J, Rees T, Beesley P and Bax N J. Marine biodiversity in the Australian region. *PLoS ONE* (2010), 5(8): e11831. doi: 10.1371/journal. pone.0011831

[5] Chakrabarti S and Ray R. Coastal Eutrophication as a Cause of Elimination of Lugworms: First record of Arenicola (Linn., 1758) from coastal areas of Bay of Bengal at Chandipur, Odisha, India. Biodiversity: Exploration, Exploitation, Conservation and Management – Vision and Mission" Proceedings of the UGC Sponsored National Seminar, Kolkata, India, 19-20th November 2016. *World Scientific News* 71 (2017) 53-57

[6] Dame R F. The ecological energies of growth, respiration and assimilation in intertidal American oyster, Crassostrea virginica. *Marine Biology* 17 (1972) 243-250

[7] Dauer D M, Corner W G. Effect of moderate sewage input on benthic polychaetes population. *Estuarine Coastal and Shelf Science* 10 (1980) 335-362.

[8] Emery K.O. A Simple method of measuring beach profile. *Limnology and Oceanography* 6(1) (1961) 90-93

[9] Engelmann H D. Zur Dominanz klassifizierung von Boden arthropoden. *Pedobiologia* 18 (1978) 378-380

[10] Gerlach S A. Food chain relationship in subtidal silty sand marine sediment and the role of meiofauna in stimulating bacterial productivity. *Oecologia* 33(1978) 55-69.

[11] Giere O. Meiobenthology, the microscopic fauna in aquatic sediments, Springer–Verlag, Ber vol 328 (1993) 1-273.

[12] Gray J S and Elloitt M. Ecology of Marine Sediments. *From Science to Management*. Oxford Univ. Press, Oxford (2009) 225.

[13] Haplern, B S, Walbridge S, Selkoe K A, Kappal C V, Micheli F A global map of human impact on marine ecosystems. *Science* 319 (2008) 948–952.

[14] Lee S Y. The population dynamics of the green mussel *Perna viridis* (L.) in Victoria harbour, Hong Kong – dominance in a polluted environment. *Asian Marine Biology* 2 (1985) 107-118

[15] Magurran, A.E. Diversity indices and species abundance models. Ecological diversity and its measurement. Princeton University Press, Princeton, NJ (1988) 7–45.

[16] Peterson C H and Fegley S R. Seasonal allocation of resources to growth of shell, soma and gonads in *Merceneria merceneria*. *Biological Bulletin* 171 (1986) 597-610.

[17] Pethic J. Natural change in coastal zone and management. Thomas Telford, London, pp. 49–63 (1992)

[18] Pielou, E. C. An Introduction to Mathematical Ecology. Publ. John Wiley, New York. 286 (1969) 1-286 pp.

[19] Qasim S Z, Wafar M V M. Marine resources. *Resource Management Optimization* 7 (1990) 141–169.

[20] Ramakrishna, Sarkar J, Talukdar, S. Marine invertebrates of Digha coast and some recommendations on their conservation. *Records of Zoological Survey of India*, 101 (2003) 1-23.

[21] Rhoads D C, Boyer L F. The effects of marine benthos on physical properties of sediments: a successional perspective. In: McCall PL, Tevesz MJS (eds) *Animal-sediment relations*. Plenum, Springer Science and Bisuness Media, New York (1982) 3–52

[22] Shannon, C E and Weiner W. *A mathematical theory of communication.* Publ. University of Illinois Press, Urbana (1948) 117

[23] Simboura N, Zenetus A, Panayotides P, Makra A. Changes in benthic community structure along an environmental pollution gradient. *Marine Pollution Bulletin* 30 (1995) 470-474.

[24] Talukdar, Sarkar S and Ramkrishna, New Fishing gear at Digha (West Bengal) threatens biodiversity. *Journal of Andamans Scientific Associations* 12(1&2) (1996) 94-96

[25] Yennawar P, Tudu P. Study of Macrobenthic (invertebrate) fauna around Digha coast. *Records of Zoological Survey of India* 114(2) (2014) 341-356

[26] Simpson, E.H. Measurement of diversity. *Nature* (1949) 163: 688.

[27] Venkataraman K, Wafar M. Coastal and marine biodiversity of India. *Indian Journal Marine Science* 34 (2005) 57–75