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Original Research Paper

Present Scenario of Corals in Tsunami Affected Katchal and Teressa Islands of Andaman and Nicobar Archipelago

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ABSTRACT

The density and diversity of corals and their associated faunal communities were investigated by underwater survey in Katchal and Teressa Islands of Andaman and Nicobar Archipelago in order to assess the post-tsunami status of corals. The density of scleractinian corals in Katchal Island is 1-13 colonies/10m^2, and in Teressa Island it ranged from 1 to 18 colonies/10m^2. Fifteen species of scleractinian corals belonging to 13 genera and 6 families with the species diversity of 0.98 were identified during the survey in Katchal Island. Whereas in Teressa Islands 25 species of corals under 14 genera and 7 families with the species diversity of 1.17 have been reported. The density and diversity of coral associated faunal communities such as zooplankton, octocorals, sponges, molluscs and echinoderms were also studied at both the islands.

INTRODUCTION

Appearing as solitary forms in the fossil record more than 400 million years ago, corals are extremely ancient animals that evolved into modern reef-building forms over the last 25 million years. Large wave resistant structures of reef have accumulated from the slow growth of corals. Coral reefs are the largest structures on the earth of biological origin. They are the most diverse and beautiful of all marine habitats. The development of reef is aided by algae that are symbiotic with reef-building corals, known as zooxanthellae. Coralline algae, sponges, and other organisms, combined with a number of cementation processes also contribute to reef growth. Corals and coralline algae precipitate calcium carbonate, whereas the framework-building sponges may also precipitate silica. Most of these organisms are colonial, and the slow process of precipitation moves the living surface layer of the reef upward and seaward. Because of the complexity, thousands of species of fish and invertebrates live in association with reefs, which are by far our richest marine habitats. Of all ocean habitats, reefs seem to have the greatest development of complex symbiotic associations.

Corals are anthozoans, the largest class of organisms within the phylum Cnidaria. Comprising over 6,000 known species, anthozoans also include sea fans, sea pansies and anemones. Scleractinians (stony corals) make up the largest order of anthozoans, and are the group primarily responsible for laying the foundations of, and building up, reef structures. For the most part, scleractinians are colonial organisms composed of hundreds to hundreds of thousands of individuals, called polyps. As per the recent global estimate, shallow water coral reefs occupy 2,84,300/sq. km which is about 1.2% of the world's continental shelf area. As many as 1,00,000 species may have been described from the worldwide reefs, but the total number of coral reef inhabitants in the world may be up to 2 million or

perhaps even more. Large portion of world's coral reefs occur within the Indian Ocean. The total area of coral reefs in India is estimated to be 2,379 sq. km coral reefs. A total of 314 species of corals have been recorded from Indian seas of which 284 species are reported in Andaman & Nicobar Archipelago. However, GOI/UNDP/GEF survey organized by Ministry of Environment and Forests, Government of India in Andaman waters suggested that thorough survey and proper taxonomic identification of coral reefs in Andaman & Nicobar Islands can yield a result of more than 400 species at these islands alone (Turner et al. 2001).

Coral reefs are highly productive marine ecosystems in the world with annual gross production rates in the range of 2000-5000g cm^{-2} through efficient retention and recycling of nutrients (Mann 1982). Coral reefs of the world cover an estimated area of 600,000 km^2 (Smith 1978, Klepays 1997). Over half of this (54%) lies in the Mediterranean Indian Ocean. Of the remaining, Pacific reefs account for 25%, Atlantic reefs for 6%, Caribbean reefs for 9%, Red Sea reefs for 4% and Persian Gulf reefs for 2%. Majority of the coral reef areas are concentrated on western sides of these oceans (Scheer 1985). The growth rate of coral and a coral reef depends on the factor such as light intensity, water temperature, salinity, turbidity, food availability, competition for space, and predation. Upward growth of coral colonies is generally between 1 and 10 cm per year under favourable conditions (Lalli & Parsons 1997).

In India, coral reefs are distributed in Andaman & Nicobar Islands, Lakshadweep Islands, Gulf of Mannar, Gulf of Kachchh and Saurashtra coast; and in patches off Malwan on west and Gopalpur on east coasts. Indian coral reefs together with shelves, lagoon and submerged banks have a fishery potential of 0.2 billion tonnes per year or about 10% of the total production (Wafar 1990, Raghunathan et al. 2004). Reefs around Indian waters also represent all geomorphological forms. Fringing reef occurs in Andaman & Nicobar Islands, Palk Bay, Gulf of Mannar and Gulf of Kachchh. Forms of barrier reefs are also present in Andaman & Nicobar Islands and Gulf of Mannar. Reefs of Lakshadweep are represented by atolls. Besides these prominent reef forms, patchy reefs occur in some submerged banks and intertidal areas along the west and east coasts of India. The total area of various reef features as deduced from the satellite imagery is about 2,300 km^2, but extent of coralline shelves below one optical length (detection limit of satellite-borne sensors) could be several times higher, especially in the shelves of Andaman & Nicobar reefs (Wafar 1999). The 1998 bleaching event affected all the Indian reef areas to varying degrees. The Andaman & Nicobar reefs appear to have suffered the most followed by Lakshadweep, Gulf of Mannar and Gulf of Kachchh reefs (Wafar 1999).

The studies on taxonomy of Indian coral reef started in India as early as 1847 by Rink in Nicobar Islands. Alcock (1893) published an account of some ahermatypic corals from the seas around India. Later Alcock (1902) described 25 species of deep sea *Madreporaria* dredged by Royal Indian Marine Survey Ship *Investigator* from depth of more than hundred fathoms, around Andaman Islands. Sewell (1922, 1925) reported on ecology and formation of coral reefs of these islands. Reef ecology and structure in various reef areas of these islands have been studied by several authors (Reddiah 1977, Pillai 1983, Mahadevan & Easterson 1983, Wood 1989, Arthur 1996, Soundararajan 1997, Venkataraman & Rajan 1998, Jayabaskaran 1999, Kulkarni et al. 2001, Turner et al. 2001).

The listing of coral species began since Matthai (1924), who listed coral species from the Andaman based on collections in the Indian Museum in Calcutta. Pillai (1983) listed 135 coral species from this region. Turner et al. (2001) lists 197 species within 58 genera. The latest Status Report (Wilkinson 2004) sources that 203 hard coral species occur in these islands. The faunal studies other than corals

have also been carried out at different reef locations of the Andaman and Nicobar Island. More than 1200 fish species have recorded around Andamans and Nicobars (Rajasuriya et al. 2002).

Quantification of reef areas has been carried out by Space Application Centre (MWRD 2000) using Landsat TM, IRS LISS II and SPOT satellite imagery. The reef area calculated by this study comprised 795.7 km^2 in Andaman Islands, 30.81 km^2 in Great Nicobar, 15.53 km^2 in North Reef, 27.15 km^2 in Rani Jhansi Marine National Park, 6.78 km^2 in Cinque and 58.29 km^2 in Little Andaman. In-depth information on coral reef ecology and community structure is limited to few studies on some specific reef sites only. The percentage cover of live corals has been estimated for the islands of the Mahatma Gandhi Marine National Park (Dorairaj & Soundararjan 1997, Arthur 1996, Kulkarni 2001) and North Reef, Cinque Island, Twin Islands reef, West Rutland Island, Tarmugli Island, Flat Island, South Button, Outram Island, Henry Lawrence, Minerva ledges, and Neil Island (Turner et al. 2001). These studies also listed specieswise distribution for these reef areas. In addition, Kulkarni et al. (2001) addressed several ecological parameters in their study, which include sedimentation, terrestrial zone influence and other anthropogenic factors. Apart from that the post-*tsunami* status of corals have been studied (Saxena et al. 2008 and Raghunathan et al. 2008).

The present study has been carried out in the Katchal and Teressa Islands of Andaman & Nicobar Archipelago which were highly affected region of Nicobar group by December 2004 event of *tsunami* cum earthquake. Katchal Island has an area of 174.4 km^2 and located about 305 km south of Port Blair. Katchal is one of the largest islands in the central group of Nicobar Islands, The highest peak of Katchal is 835 feet high. The hills of Katchal are composed of calcareous sandstone and marble slates and in the tropical forest of Katchal harbours pythons, black monkeys and pigs. Teressa Island is also one of the islands in the archipelago of Nicobar. Its area is 87.04 km^2 and located at 8° 20'N latitude and 93°7'-93°15' E longitude. Mean minimum temperatures on these islands range between 22.97°C in January and 25.44°C in March. Rainfall is heavy from May to November, and is influenced by both the southwest and northeast monsoons. In the other months, rainfall is generally low, while February being the driest month for both the islands.

In the present study, the underwater survey for coral reef has been undertaken in the offshore region an area between latitudes 07°58.952'N & 07°59.118'N and longitudes 93°24.351'E & 93° 24.343'E at Katchal Island and between latitudes 08°13.68'N and 08°17.41'N, and longitudes 93°10.91'E and 93°10.33'E at Teressa Island. (Fig. 1) during April 2009. The prime aim of the study was to assess and quantify the distribution and diversity of corals in and its associated faunal communities.

MATERIALS AND METHODS

The undersea survey has been conducted by SCUBA diving to estimate the coral reef diversity. The corals were videographed/photographed for species level identification. The specieswise assessment of live corals on the subtidal region has been performed by Line Intercept Transect (LIT) method (English et al. 1994) in three different localities at both the islands. The transect area has been standardized depending upon the availability of coral cover on the reefs. Coral associated faunal communities have been quantified specieswise by employing 25 × 25 cm quadrant at 10m interval on the LIT line along the sea bed and the values were calculated for 50m interval. The numerical density and diversity of these communities have also been estimated. The species of corals were identified following Veron (2000).

The data on physicochemical parameters and zooplankton productivity in seawater from the study area were also collected. The temperature was measured by mercury thermometer while salinity was analysed by hand-held refractometer. The seawater pH was measured soon after collection of water sample using portable water quality analyser. Transparency of seawater column was measured by using Secchi disc from surface of sea to assess the depth of light penetration, and the turbidity was measured by a turbidity meter. The data on the coordinates of the survey area were collected by using Global Positioning System, Model GARMIN 12 Channel GPS.

Zooplankton samples were collected by surface haul using Heron-Tranter plankton net with a mesh size of 300µ for 10 minutes at 2 knot. The zooplankton in terms of wet weight, dry weight and volume were calculated. The numerical density of zooplankton was estimated using Sedgwick Rafter Counting Cell, and species were identified following standard manuals.

The species diversity of all the organisms were calculated according to the Shannon-Weiner formula.

$H' = pi.\log pi$

Where pi = proportion of the *i*th species in the collection and H' = diversity of a theoretically infinite population.

RESULTS

The physicochemical parameters of the seawater are the prime factors indicating quality of coastal waters which directly influence the primary, secondary and tertiary producers in marine environment. The data on these parameters obtained from seawater samples collected from Katchal and Teressa islands are depicted in Table 1.

The atmospheric temperature was recorded from 32.2 to 33.0ºC at Katchal Island and 30.1 to 31.3º at Teressa Island whereas the surface seawater temperature for these stations showed lower values during high tides, i.e. 28.2 and 27.0ºC for these islands respectively. No difference in the values of salinity was observed in both the tides at both the places of study. However, the salinity was recorded as 33.8ppt at Katchal and 34.2ppt at Teressa islands. The concentration of hydrogen ions (pH) did not show significant variation between tides as well as stations and varied from 7.3-7.4. The transparency in terms of penetration of light in the seawater column was also measured at both the places, and ranged from 6.5 to 7.0 m in Katchal Island and 8.0 to 10.5 m at Teressa Island. The quintessence of the results acquired for seawater transparency indicated that both the stations have

Table 1: Physicochemical characteristics of seawater.

Sl. No.	Parameters	Katchal Island		Teressa Island	
		Low Tide	High Tide	Low Tide	High Tide
1.	Atmospheric Temperature (°C)	32.2	33.0	30.1	31.3
2.	Surface Seawater Temperature (°C)	28.6	28.2	27.3	27.0
3.	Salinity (ppt)	33.8	33.8	34.2	34.2
4.	pH	7.4	7.4	7.3	7.4
5.	Transparency (m)	6.5	7.0	8.0	10.5
6.	Turbidity (NTU)	735	725	686	680
7.	Depth (m)	3-12	5-15	4-12	5-17
8.	Intertidal exposure (m)	35	-	20	-
9.	Nature of shore	Rocky		Sandy	

Table 2: Quantitative estimation of zooplankton at Katchal and Teressa Islands.

Sl. No.	Parameter	Katchal Island	Teressa Island
1.	Numerical density (No./100m^3)	12428	9432
2.	Fresh weight (mg/100m^3)	2186	1076
3.	Dry weight (mg/100m^3)	836	362
4.	Volume (mL/100m^3)	5.6	4.1
5.	Species diversity (H')	2.58	2.08

high light penetration. The turbidity of seawater was measured by Nudson Turbidity Unit (NTU) and it varied from 725 to 735 for former and 680-686 for latter stations. The depth of the study area has also been recorded as 3-15m at Katchal Island and 4-17m at Teressa Island. The intertidal exposure during low tide at Katchal Island was 35 m and 20 m at Teressa Island, and the nature of shore was rocky and sandy at these stations respectively.

Zooplankton: The zooplankton are the secondary producers or primary consumers and their productivity is highly responsible for the fishery potential of the given area. The data for the quantitative estimation of zooplankton and its diversity and distribution are shown in Tables 2 and 3.

Altogether 62 species of zooplankton belonging to 14 groups were recorded from the study area. However, total number of species recorded at Katchal Island was 49 while at Teressa Island it was 51. Results of zooplankton study clearly indicated that the Foraminiferans were the predominant group as they were represented by 23 species followed by Copepods which wee comprised of 16 species. A total of 38 species were commonly found in both the stations, and they were larval forms of annelids, chaetognaths, most species of copepods, crustacean larvae viz., megalopa, nauplii and zoea, ostracods, fish eggs and veliger larvae and gastropods.

The biomass of zooplankton in terms of fresh weight, dry weight and volume were estimated. The values for these variables were generally high in the zooplankton samples collected from Katchal Island than Teressa Island. The productivity of zooplankton is directly correlated with the primary producers, i.e. phytoplankton in the marine environment. However, the lower values of zooplankton productivity, observed at Teressa Island, might be attributed to the poor phytoplankton productivity in the particular region coupled with diel vertical migration of zooplankton.

Density of corals: Apart from harbouring several species of invertebrates and vertebrates, it is an established fact that the corals serve as a barrier for continental shelves and resist the high tidal waves resulting in protection of shores. The results obtained through line intercept transect (LIT), employed by SCUBA diving at Katchal and Teressa Islands to evaluate the density of corals corresponding to water depth, are presented in Tables 4-5.

Katchal Island: In Katchal Island the depth of the surveyed area ranged from 5.0 to 6.0m with an average of 5.5m, 7.0 to 8.0m with an average of 7.58m, and 10.0 to 15.0m with an average of 11.08m at LIT-1, LIT-2 and LIT-3 respectively. The mean value for the number of coral colonies was noticed at the site as 4 colonies/10m^2 at both LIT-1 and LIT-3, and 3 colonies/10m^2 at LIT-2. In general, the scleractinian corals in the study area are distributed as 1-13 colonies/10m^2 (Table 4). Furthermore, the coral colonies observed in the transect area were mostly of new recruits and their colony size ranged from 12 to 40cm diameter. The uneven topography of sea-bed with uneven depths having rocky and dead coral reefs has been observed in the transect area at Katchal Island.

Table 3: Distribution of zooplankton at Katchal and Teressa Islands.

Sl No.	Species	Katchal Island	Teressa Island
	Annelid		
1	Setiger larva	P	P
2	Spirorbis larva	P	P
	Appendicularian		
3	*Oikopleura dioica*	P	
	Bivalve		
4	*Anadara granosa*	P	P
5	*Crassostrea cuculata*	P	P
6	*Sunetta effosa*	P	P
7	*Tellina tellina*	P	P
	Chaetognath		
8	*Sagitta enflata*	P	P
9	*Sagitta maxima*	P	P
	Cladoceran		
10	*Evadne tergestina*	P	P
	Copepod		
11	*Acartia spinicauda*	P	P
12	*Corycaeus danae*	P	P
13	*Euterpina acutifrons*	P	P
14	*Labidocera pavo*		P
15	*Longipedia coronata*		P
16	*Lucicutia flavicornis*		P
17	*Macrosetella gracilis*	P	P
18	*Metis jousseamei*	P	P
19	*Microsetella gracilis*	P	P
20	*Miracea efferata*	P	P
21	*Nannocalanus minor*	P	P
22	*Oithona brevicornis*	P	P
23	*Paracalanus parvus*	P	P
24	*Pontella danae*	P	P
25	*Pontellina pulmata*	P	P
26	*Rhincalanus cornutus*		P
27	*Temora discaudata*		P
	Cruastacean		
28	Megalopa larva	P	P
29	Nauplii	P	P
30	Zoea	P	P
	Euphausid		
31	*Euphausia diomediae*	P	
	Foraminiferan		
32	*Amhistegina lessonii*	P	
33	*Bolivinita quadrilatera*	P	P
34	*Bolivinita rhomboidatis*	P	P
35	*Calcarina calcar*	P	P
36	*Ctyclogyra involvens*	P	P
37	*Elphidium jensoni*	P	P
38	*Elphidium rapandus*	P	P
39	*Globigerinoides rubber*	P	
40	*Globigerinoides sacculifer*	P	P
41	*Loxostomum limbatum*	P	P
42	*Nonion depressulum*	P	P

Table cont....

Cont. Table...

43	*Peneroplis pertusus*		P
44	*Quinqueloculina crassa subcuneata*		P
45	*Quinqueloculina curta*		P
46	*Quinqueloculina laevigata*		P
47	*Quinqueloculina polygona*	P	
48	*Quinqueloculina rhodiensis*	P	
49	*Quinqueloculina seminulum*	P	
50	*Rosalina bradyi*	P	
51	*Rosalina globularis*	P	
52	*Spirillina limbata* var. *decorata*		P
53	*Spiroloculina antillarum*		P
54	*Triculina irregularis*		P
	Gastropod		
55	*Janthina janthina*	P	
56	*Umbonium vestarium*		P
57	*Veliger larvae*	P	P
	Ostrocod		
58	*Conchoecia indica*	P	P
	Pisces		
59	Fish eggs	P	P
	Salpid		
60	*Salpa maxima*	P	P
	Tintinnid		
61	*Tintinnopsis cylindra*	P	P
62	*Tintinnopsis tubulosa*	P	
	Total no. of species	**49**	**51**

P-present

Teressa Island: In Teressa Island the length of the LIT survey was made up to 800m at all the three LIT survey lines. The depth of water column at the survey was 5.0 to 7.0m with an average of 6.4m at LIT-1, 8.0 to 9.5m with an average of 8.9m at LIT-2, and 12.0 to 17.0m with an average of 14.6m at LIT-3. The mean coral colonies recorded from the study area were 0.2 colonies/10m^2, 7 colonies/10m^2, and 3 colonies/10m^2 for LIT-1, LIT-2 and LIT-3 respectively. However, number of scleractinian corals in the study area ranged from 1 to 18 colonies/10m^2. No coral colonies were observed till 500m along LIT. This particular zone of the sea bed is covered by sporadic distribution of sea-grasses and sea-weeds. However, beyond the length of 550m of LIT line the existence of luxuriant growth of coral reef formations with an area of about 2 km^2 has been observed at latitude 08°13.966'N and longitude 93°10.624'E.

Diversity of corals: The diversity of corals has been assessed and the specimens were identified up to species level at both the study sites. A total of 35 species of scleractinian corals under 17 genera and 8 families were recorded. Among them the representatives of the Family Faviidae were the dominant group as they have 14 species in the areas surveyed (Table 6).

In Katchal Island, 15 species of scleractinian corals belonging to 13 genera and 6 families with the species diversity of 0.98 were identified during the survey (Table 6). Among them the species *Porites lutea, Porites solida, Pocillopora damicornis* and *Pocillopora eydouxi* were dominant in the study area while other forms showed very few numbers of colonies.

In Teressa Island, 25 species of corals under 14 genera and 7 families with the species diversity of 1.17 have been identified (Table 6). The species belonging to *Acropora, Favites, Favia* and *Pocillopora* were predominantly occurred with moderate size colonies.

Table 4. Density of coral colonies at Katchal Island.

Distance	LIT-1		LIT-2		LIT-3	
	No. of Colonies/10m^2	Depth (m)	No. of Colonies/10m^2	Depth (m)	No. of Colonies/10m^2	Depth (m)
0m (Starting point of LIT)	4	5.0	-	7.5	2	10.0
50m	6	5.0	5	7.5	1	10.0
100m	8	5.0	3	7.5	3	11.0
150m	12	5.5	6	8.0	2	11.0
200m	3	5.0	9	8.0	5	11.0
250m	6	6.0	-	8.0	13	11.0
300m	-	6.0	-	8.0	-	15.0
350m	-	6.0	-	8.0	-	12.0
400m	-	6.0	1	7.5	8	11.0
500m	4	5.5	3	7.0	2	10.5
550m	3	5.5	6	7.0	5	10.5
600m	8	5.5	-	7.0	2	10.0
Mean value	**4**	**5.50**	**3**	**7.58**	**4**	**11.08**

LIT-1: 100m away from the infra-littoral zone, LIT-2: 400m away from infra-littoral zone, LIT-3: 700m away from infra-littoral zone

Table 5: Density of coral colonies at Teressa Island.

Distance	LIT-1		LIT-2		LIT-3	
	No. of Colonies/10m^2	Depth (m)	No. of Colonies/10m^2	Depth (m)	No. of Colonies/10m^2	Depth (m)
0m (Starting point of LIT)	-	5.0	-	8.0	-	12.0
50m	-	5.0	-	8.0	-	12.0
100m	-	5.0	-	8.0	-	13.0
150m	-	5.5	-	8.5	-	13.0
200m	-	5.5	-	8.5	-	13.5
250m	-	5.5	-	9.0	-	17.0
300m	-	6.0	-	9.0	-	17.0
350m	-	6.0	-	9.0	-	14.0
400m	-	6.0	-	9.0	-	13.0
500m	2	6.0	-	9.0	-	13.0
550m	-	6.0	6	9.0	-	13.0
600m	-	6.5	15	9.0	-	13.0
650m	-	7.0	18	9.5	12	14.0
700m	-	7.0	16	9.5	8	14.0
750m	1	7.0	18	9.5	10	14.0
800m	-	7.0	20	9.5	12	14.0
Mean value	0.2	6.4	7	8.9	3	14.6

LIT-1: 100m away from the infra-littoral zone, LIT-2: 400m away from infra-littoral zone, LIT-3: 700m away from infra-littoral zone

Coral associated fauna: As the coral reef ecosystem harbours several faunal communities, the coral associated faunal components and their density has also been assessed in the study area at both the islands. The results are depicted in Table 7. A total of 35 species of coral associates under Octocorallia (soft corals), sponges, echinoderms and molluscs were encountered during the course of survey.

Table 6: List of Sleractinian coral species recorded at Katchal and Teressa Islands.

Sl. No.	Species	Katchal Island	Teressa Island
	Family**: Acroporidae** Verill 1902		
	Genus: ***Acropora*** Oken 1815		
1.	*Acropora aspera* (Dana 1846)	+	
2.	*Acropora gemmifera* (Brook 1892)	+	
3.	*Acropora humilis* (Dana 1846)		+
4.	*Acropora monticulosa* (Bruggemann 1879)		+
5.	*Acropora muricata* (Linnaeus 1758)		+
6.	*Acropora palifera* (Lamarck 1816)		+
	Genus: ***Astreopora*** de Blainville 1830		
7.	*Astreopora microphthalma* (Verrill 1869)		+
	Family: **Faviidae** Gregory 1900		
	Genus: ***Cyphastrea*** Milne Edwards and Haime 1846		
8.	*Cyphastrea microphthalma* (Lamarck 1816)	+	
9.	*Cyphastrea serailia* (Forskal 1775)		+
	Genus: ***Favia*** Oken 1815		
10.	*Favia favus* (Forskal 1775)	+	
11.	*Favia pallida* (Dana 1846)		+
12.	*Favia stelligera* (Dana 1846)		+
	Genus: ***Favites*** Link 1807		
13.	*Favites abdita* (Ellis & Solander 1786)	+	+
14.	*Favites complanata* (Ehrnberg 1834)	+	+
15.	*Favites helicora* (Ehrenberg 1834)		+
16.	*Favites pentagona* (Esper 1794)		+
	Genus: ***Goniastrea*** Milne Edwards & Haime 1848		
17.	*Goniastrea pectinata* (Ehrenberg 1834)	+	
18.	*Goniastrea retiformis* (Lamarck 1816)		+
	Genus: ***Galaxea*** Oken 1815		
19.	*Galaxea fascicularis* (Linnaeus 1767)	+	
	Genus: ***Leptoria*** Milne Edwards & Haime 1848		
20.	*Leptoria phyrgia* (Ellis & Solander 1786)		+
	Genus: ***Platygyra*** Ehrenberg, 1834		
21.	*Platygyra daedalea* (Ellis & Solander 1786)		+
	Family: **Merulinidae** Verrill 1866		
	Genus: ***Hydnophora*** Fisher de Waldheim 1807		
22.	*Hydnophora microconos* (Lamarck 1816)	+	+
	Family: **Agariciidae** Gray 1847		
	Genus: ***Pachyseris*** Milne Edwards & Haime 1849		
23.	*Pachyseris rugosa* (Lamarck 1801)		+
	Family: **Euphyllidae** Veron 2000		
	Genus: ***Physogyra*** Quelch 1884		
24.	*Physogyra litchentsteini* Milne Edwards & Haime 1786	+	
	Family: **Pocilloporidae** Gray 1842		
	Genus: ***Pocillopora*** Lamarck 1816		
25.	*Pocillopora damicornis* (Linnaeus 1758)		+
26.	*Pocillopora eydouxi* Milne Edwards & Haime 1860	+	+
	Genus: ***Seriatopora*** Lamarck 1816		
27.	*Seriatopora hystrix* Dana 1846	+	
	Family: **Poritidae** Gray 1842		
	Genus: ***Goniopora*** de Balinville 1830		
28.	*Goniopora edwarsi* (Quelch 1886)	+	+
	Genus: ***Porites*** Link 1807		

Table cont...

...Cont Table

29.	*Porites lobata* Dana 1846		+
30.	*Porites lutea* Milne Edwards & Haime 1860	+	+
31.	*Porites solida* (Forskal 1775)		+
	Family: **Mussidae** Ortmann 1890		
32.	Genus: ***Symphyllia*** Milne Edwards & Haime 1848		
33.	*Symphyllia radians* Milne Edwards & Haime 1849	+	+
34.	*Symphyllia recta* (Dana 1846)		+
	Total number of Families	6	7
	Total number of Genera	13	14
	Total number of Species	15	25
	Species diversity (H')	0.98	1.17

Katchal Island: In Katchal Island there were 28 species of coral reef inhabitant fauna, of which 2 species of octocorals, 2 species of sponges, 12 species of echinoderms and 12 species of molluscs with density of 2-6, 3-8, 7-13 and 10-22 individuals/10m^2 respectively were observed. It is pertinent to note that the sea cucumbers *Actinopyga mauritiana, Bahadschia argus* and *Holothuria atra,* recorded from study area at Katchal Island, fall under the Schedule-I category of Wildlife Protection Act 1972.

Teressa Island: Twenty four species of coral associated faunal communities were recorded during the study period with density of 2-4, 5-7, 8-16 and 12-28 individuals/10m^2 belonging to octocorals, sponges, echinoderms and molluscs respectively. Among these groups octocorals were represented by 4 species, sponges by 3 species, echinoderms by 11 species and molluscs by 6 species. Like Katchal Island, scheduled species of sea cucumbers (*Bahadschia margus, Holothuria atra, Holothuria edulis and Holothuria pyxis*) and molluscs (*Trochus niloticus, Strombus marginatus and Tridacna gigas*) were observed in the study site at Teressa Island.

DISCUSSION

Coral reefs are ecologically important fragile ecosystems restricted to warm seas, essentially between the tropics of Cancer and Capricorn, where minimum water temperature does not fall below 20°C. Although coral reefs are geographically restricted to tropical seas and their occurrence limited to 0.2% of the ocean areas (Smith 1978), have globally important implication for their amazing marine biodiversity. There has been a growing concern in recent years, over the status of reefs for the sustenance and survival of living corals associated with them. As a result, there is an increasing awareness nowadays, for coral reef conservation and management along with long term research monitoring programmes at the national and international levels. A number of threats have caused serious declines in the distribution and condition of the coral reefs during recent decades. In particular, the El-Nino event of 1997-98 produced extremely high water temperature that caused bleaching and mortality of corals on a global scale. The Indian Ocean was said to be particularly badly affected by this event and most of the corals of East Africa and in central and northern Indian Ocean corals bleached and died due to this effect (Linden et al. 2002).

A massive earthquake cum *tsunami* struck Andaman and Nicobar Islands posed geomorphological changes which caused irreparable devastation to coral reefs of these islands. The damages were extensive in north Andaman and Nicobar group islands. In consequent upon earthquake, the land mass of north and middle Andaman was uplifted more than 1 m and submergence of land by 1.9m in Nicobar group of islands. This leads permanent exposure of coral reefs in north and middle Andaman

Table 7: Density and diversity of coral associated fauna in the construction site at Katchal and Teressa Islands.

Sl. No.	Group/Species	Katchal Island	Teressa Island
1.	**Octocorallia**		
1.	*Heliopora coerulea*	+	+
2.	*Pumbellula monocephalus*	+	
3.	*Sarcophyton* sp.		+
4.	*Sinularia* sp.		+
5.	*Lobophytoum* sp.		+
	Total	2	4
	Density (No. of colonies/10m^2)	2-6	2-4
2.	**Sponges**		
6.	*Phyllospongia foliascens*	+	
6.	*Spirastrella inconstans*	+	+
7.	*Clathria(Microciona) atrasanguinea*		+
8.	*Aphrocallistes beatrix*		+
	Total	2	3
	Density (No. of colonies/10m^2)	3-8	5-7
3.	**Echinoderms**		
	Sea Star		
9.	*Culcita schmideliana* (Retzius)	+	
10.	*Lickia laevigata* (Linnaeus)	+	+
11.	*Linckia guildingi* (Gray)	+	+
	Sea cucumber		
12.	*Actinopyga mauritiana* (Quoy and Gaimard)	+	
13.	*Bahadschia argus* (Jager)	+	+
14.	*Holothuria atra* (Jager)	+	+
15.	*Holothuria eduilis* (Lesson)		+
16.	*Holothuria pyxis* (Selenka)		+
	Feather stars		
17.	*Heterometra crenulata* (P.H. Carpenter)	+	+
18.	*Capillaster multiradiatus* (Linnaeus)		+
19.	*Cenometra emendatrix* (Bell)	+	
	Sea urchin		
20.	*Diadema savignyi* (Michelin)	+	
21.	*Echinometra mathaei* (de Blainville)	+	+
22.	*Laganum laganum* (Klein)	+	+
23.	*Stomopneustes variolaris*	+	+
	Total	12	11
	Density (No. of individuals/10m^2)	7-13	8-16
4.	**Molluscs**		
	Gastropods		
24.	*Trochus niloticus* (Linnaeus, 1758)	+	
25.	*Cypraea (Mauritia) arabica* (Linnaeus, 1758)	+	
26.	*Cypraea (Mauritia) mauritiana regina* (Linnaeus, 1758)	+	+
27.	*Lambis (Harpago) chgiragra chiragra* (Linnaeus, 1758)	+	+
28.	*Conus mutabilis* (Reeve, 1844)	+	+
29.	*Conus ebraeus* (Linnaues, 1758)	+	+
30.	*Conus nussatella* (Linnaeus, 1758)	+	+
31.	*Turbo (Marmarostoma) crassus* (Wood, 1828)	+	
32.	*Strombus (Canarium) marginatus succinctus* (Linnaeus, 1758)	+	
	Bivalves		
33.	*Tridacna gigas*	+	+
34.	*Mentellum hians* (Gmelin)	+	

Table cont...

...Cont Table

35.	*Haliotis asinina* (Linnaeus, 1758)	+	
	Total	12	6
	Density (No. of individuals/10m^2)	10-22	12-28
	Total number of species	**28**	**24**

resulting in 30% loss of coral cover while in south Andaman loss was about 20%. According to the remote sensing data carried out by Space Application Centre during 2005, it was revealed that a total loss of coral reefs in Andaman Islands was 22978 ha, and in Nicobar Islands 17180 ha.

Post-*tsunami* surveys have been conducted by Zoological Survey of India (ZSI) in the selected islands of Andaman groups and Nicobar groups during 2007-2008 in order to find out the present status of live coral cover, and the study revealed that loss of coral reef covers in 7 islands of Mahatma Gandhi Marine National Park ranged from 27.27 to 71.43% due to the impact of *tsunami*. The estimated loss of live coral cover in selected islands ranged from 13% in Noncowry Island to 90% in Little Nicobar Islands. The species belonging to the genera *Acropora, Montipora, Pocillopora, Porites, Platygyra, Goniastrea,* etc. are the most affected corals. It is also noted that in Car Nicobar Island reefs were damaged up to the depth of 20m (Saxena et al. 2008, Raghunathan et al. 2009).

The mortality of corals in Andaman group of islands is mainly due to the exposure of reefs while in Nicobar groups the damage was caused by severe wave action. Most of the massive corals were uprooted and turned upside down, while branching type corals were broken in wider extent. Deposition of sand, mud and detritus on reefs in Nicobar Islands has been observed as these islands are in the proximity of epicentre of the earthquake which generated heavy siltation and spread across by oceanic currents. ZSI's recent survey, conducted during February 2008 in Nicobar Islands, revealed the abundant growth of soft coral *Sinularia* overgrown on the corals, especially in Trinket and Nancowry Islands. However, the new recruits of corals found in Katchal and Teressa islands in the present survey, indicated recuperation process of coral reefs in the severely affected reefs of Nicobar Islands. The coral colonies (1-13 colonies/10m^2 and 1-18 colonies/10m^2 at Teressa Island) recorded over here are healthy and distributed with moderate diversity as well as density. The rate of recuperation was quite low in these Islands while compared to the density up to 152 colonies/10m^2 reported at Pongibalu and Rangachang region of south Andaman during the post-tsunami surveys (Raghunathan & Sivaperuman 2009). Relatively less density of corals in Katchal and Teressa islands might be due to high turbidity of the water column coupled with strong wave action.

Periodic monitoring of coral reefs is a prerequisite by setting up a permanent monitoring station at each reef site which will provide the useful information about the health, morphological changes, bleaching, disease outbreak of the reef and its associated organisms. Organized monitoring of water quality parameters and primary and secondary productivities will give the health of ambient environment for monitoring corals in better perspectives.

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REFERENCES

Alcock, A. 1893. On some newly recorded corals from Indian Seas. J. Asiatic Soc. Bengal, 62(2): 138-149.

Alcock, A. 1902. Report on the deep-sea *Madreporaria* of the Siboga expedition. Siboga Exped., 16A: 1-51.

Arthur, R. 1996. A survey of the coral reefs of the Mahatma Gandhi Marine National Park, Wandoor, Andaman Islands. A Report submitted to ANET, 47 pp.

Dorairaj, K. and Sundararjan, R. 1997. Status of coral reefs of Mahatma Gandhi Marine National Park, Wandoor, Andamans. In: Background Papers (ed. V. Hoon). Regional Workshop on Conservation and Sustainable Management of Coral Reefs, pp. 52-63.

English, S., Wilkinson, C. and Baker, V. (eds.) 1994. Survey Manual for Tropical Marine Resources. ASEAN-Australian Marine Science Project: Living Coastal Resources. Australian Institute of Marine Sciences, Tonsville, 368p.

Jeyabaskaran, R. 1999. Report on Rapaid Assessment of Coral Reefs of Andaman & Nicobar Islands. GOI/UNDP/GEF Project on Management of Coral Reef Ecosystem of Andaman & Nicobar Islands. Published by Zoological Survey of India, Port Blair, 110p.

Kleypas, J. 1977. Modeled estimates of global reef habitat and carbonate production since last glacial maximum. Palaeoceanography, 12: 535-545.

Kulkarni, S., Saxena, A., Choudhury, B.C. and Sawarkar, V.B. 2001. Ecological Assessment of Coral Reefs in Mahatma Gandhi Marine National Park, Wandoor, Andaman & Nicobar Islands: Conservation Implications.

Lalli, C.M. and Parsons, T.R. 1997. Biological Oceanography, and Introduction. 2nd Edition, Butterworth Heinmann, Oxford, 314p.

Linden, O., Souter, D., Wilhelmson, D. and Obura, D. (Eds.) 2002. Coral Reef Degradation in Indian Ocean. CORDIO Status Report, 284p.

Mann, K.H. 1982. Ecology of coastal waters: A systems approach. Studies on Ecology, 8: 160-182.

Mahadevan, S. and Easterson, D.C.V. 1983. Topographical features of areas surveyed. In: Mariculture Potential of Andaman and Nicobar Islands - An Indicative Survey. Bull. Cent. Mar. Fish. Res. Inst., 34:

Matthai, G. 1924. Report on the Madreporina corals in the collection of Indian Museum, Calcutta. Mem. Indian Mus., 8: 1-52.

MWRD 2000. Coral Reefs of the Andaman and Nicobar group of Islands. Report prepared for the Zoological Survey of India. Marine and Water Resources Division (MWRD) RESA/SAC, Ahmedabad, February, 2000.

Pillai, C.S.G. 1983. Coral reefs and their environs. In: Mariculture Potential of Andaman and Nicobar Islands - An Indicative Survey. Bull. Cent. Mar. Fish. Res. Inst., 34: 36-43.

Raghunathan, C., R. Sen Gupta, Wangikar, U. and Lakhmapurkar, J. 2004. New record of corals along the Saurashtra coast, Arabian Sea. Current Science, 87(8): 1131-1138.

Raghunathan, C. and Sivaperuman, C. 2008. Littoral diversity of corals and their associated molluscs and echinoderms of Andaman Sea, South Andaman. Recent Trends in Biodiversity of Andaman and Nicobar Islands, ZSI Publication.

Raghunathan, C., Rajkumar, R. and Ramakrishna, 2008. Current Scenario of Coral Reefs of Andaman and Nicobar Islands. Proceedings of National Brainstorming Workshop on the Currents Status, Threats and Conservation Measures of Coral Reefs in India. Organized by Ministry of Environment and Forests and SDMRI at Tuticorin, 29th-30th December 2008.

Rajasuriya, A., Venkataraman, K., Muley, E.V., Zahir, H. and Cattermoul, B. 2002. Status of coral reefs in South Asia: Bangladesh, India, Maldives, Sri Lanka.

Reddiah, K. 1977. The coral reefs of Andaman and Nicobar Islands. Records of the Zoological Survey of India, 72: 315-324.

Saxena, A., Rajan, R. and Choudhury, S.S. 2008. Status of coral reefs in post-tsunami period in Andaman and Nicobar Islands. Proc. of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, 7-11 July, 2008.

Scheer, G. 1985. The distribution of coral reefs in Indian Ocean with a historical review of its investigation. Deep-Sea Research, Part A, 31: 885-900.

Sewell, R.B.S. 1922. A survey season in the Nicobar Islands on the RIMS Investigator, October 1921 to March 1922. J. Bombay Nat. Hist. Soc., 28: 970-989.

Sewell, R.B.S. 1925. The geography of the Andaman Sea Basin. Mem. Asiatic Soc. Bengal, 9(10): 1-26.

Smith, S.V. 1978. Coral reef area and the contribution of reefs to processes and resources of the world Oceans. Nature, 273: 225-226.

Soundararajan, R. 1997. Biophysical status of reefs - Andaman and Nicobar Island Group (India). Central Agricultural Research Institute, Port Blair.

Turner, J.R., Vousden, D., Klaus, R., Satyanarayana, C., Fenner, D., Venkataraman, K., Rajan, P.T. and Subba Rao, N.V. 2001. GOI/UNDP GEF Coral reef Ecosystems of the Andaman Islands.

Venkataraman, K. and Rajan, P.T. 1998. Coral reefs of Mahatma Gandhi Marine National Park and Crown-of-thorn phenomenon. In: Sym. Proc. Islands Ecosystem & Sustainable Development. Eds. B. Gangwar and K. Chandra, published by Andaman Sci. Ass. and Dept. of Sci. & Tech., Andaman and Nicobar Administration, Port Blair, 124-132.

Veron, J.E.N. 2000. Corals of the World. Vol 3, Australian Institute of Marine Sciences and CRR Qld Pty Ltd.

Wafar, M.V.M. 1990. Coral reefs-Specialized Ecosystem. Current Trends in Coastal Marine Science: A special collection of papers to felicitate Prof. R. Natarajan on his 60th birthday, pp.156-162.

Wafar, M.V.M. 1999. Status Report India. In: CORDIO Status Report. (Linden, O and N. Sprong, eds.), pp. 24025.
Wilkinson, C. (eds.) 2004. Status of coral reefs of the world. Australian Institute of Marine Sciences, Townsville, 557p.
Wood, E. 1989. Corals: Wandoor Marine National Park. SANE awareness series, INTACH, A&N 14 pp.