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European Journal of Experimental Biology, 2012, 2 (3):551-561



Assessment of reef associated biota in the Pirotan Island, Gulf of Kachchh, Gujarat, India

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ABSTRACT

The reef ecosystem is considered to be the richest ecosystem, next to the rain forest. It harbours good species diversity, both in terms of flora and fauna thriving in close association; maintains distinct pattern of biotic assemblages including rare and endangered species. This study aims at understanding the ecological values of the coral reef ecosystem at the Marine National Park in the Gulf of Kachchh, Gujarat State, India. For this, a comprehensive ecological study has been carried out at the Pirotan Island, which is the core area of the Marine National Park. The results of the study indicate that a total of 89 species of fauna and 31 species of flora (seaweeds and seagrasses) were found during the study period. Gastropods were abundant, followed by bivalves and other reef associated fauna. From the study it has been concluded that, the Pirotan Island reef habitat also supports several rare and endangered species. The flora-fauna population and diversity varied from low to moderate levels. Seasonal changes do not seem to have much impact on the floral-faunal abundance and diversity. The study reveals that Pirotan Island ranks first in species diversity in the whole of the Gulf of Kachchh. The reef ecosystem is being threatened from developmental pressures like port activities, crude oil imports and from high natural sedimentation rates occurring in this area.

Key words: Biota, Flora, Fauna, Reef, Coral, Gulf of Kachchh.

INTRODUCTION

Coral reefs are tropical shallow water marine ecosystems restricted in distribution between 30° N and 30° S. They are built up by calcareous organisms with a typical framework and are attached to the sea bottom. The reef contributes about 0.17% of the world's total oceans and about 15% of the total shallow sea floor within 0 to 30 m depth range [1]. Indian Ocean has the second largest reef area, contributing about 24% of the total reef area of the world. Recent remote sensing investigations have shown that reef flats in India extend to an area of 1270 km². These are composed of patch reefs, fringing reefs and atoll reefs. Reefs are distributed in Gulf of Kachchh, Lakshadweep, Andaman, Palk Bay and Gulf of Mannar.

Reef ecosystem is of paramount importance globally for the marine biodiversity it shelters. Reefs support unusually diverse animal communities with distinctive taxonomic structure and geographical distribution patterns. They play a major role in the coastal stability. Due to its surface growth they facilitate breaking of the incoming waves and they provide a buffer to the shoreline erosion. Coral reefs are also economically significant as reef fish make up perhaps 10 percent of the global fish catch. Besides molluscs, sea urchins and other fishery, this ecosystem does sustain the livelihood of over 30 to 40 million people. In addition, recent studies report that some reef-associated organisms are the natural raw material source for many pharmacological products.

Considering the aforesaid significance of reef-associated diversity, the present investigation was focused on the ecology of floral and faunal population of the Pirotan Island reef waters at the Marine National Park in the Gulf of Kachchh.

2. Importance of the Reef Associated Biota

As an ecosystem, coral reefs are quite different from other marine environments and are providing various ecological gradients like large sand patches, small sand filled depressions, sand under coral rock, rubble sand, reef limestone and algal sand on reef limestone. These varieties of gradients provide suitable substratum for a plethora of marine fauna in these systems.

Recent efforts to improve systematic knowledge of reef-associated taxa indicate sharp increase in the number of known species from several groups. There is great fishery diversity in the coral reef and coral reef connected areas. Owing to the exceptional power of skeleton formation possessed by majority of the coral species, massive reefs are being built in the marine environment, which provide suitable shelter and protection for myriad juvenile organisms, which breed in and around the reef area. Besides, tight nutrient cycle [2] and relatively calm back-reef area foster sea grass beds and mangroves forest, which are the two enormous productive habitats. Species richness is related directly to reef diameter, area, volume and topographic complexity.

There is a profusion of various species of commercially and pharmacologically important benthic marine algae in association with the coral reefs [3]. Several seaweed species being commercially utilized are Agarophytes, Alginophytes and Carrageenophytes. Apart from this, several marine algal species such as, *Caulerpa* and *Padina* have potential bioactive substances and can be exploited for industrial implications. Some of the species (*Ulva* sp. *Gracilaria* sp.) that have edible value hold great export potential.

2.1. Corals of the Gulf Of Kachchh

Among the different reef formations, the Gulf of Kachchh reefs are considered to be semi-arid coastal patchy reefs spreading over an area of 458 km², from 22° 20'N to 22° 40'N lat and 69° to 70° E long. The coral reef areas in the Gulf of Kachchh were declared as a Marine National Park in 1982, the first in Indian waters. Located almost at the northern limits of coral formations in the Indian Ocean, it is the only site of reef ecosystem in Gujarat State. It has 42 islands, 34 of which have coral reefs on one side or more. The age of these corals varies from 5240 years at Salaya to 45,000 ± 105 years at Okha [4].

Most of the islands of the Gulf support fringing reefs. The reefs are generally restricted to areas exposed to the strongest tidal currents and live corals are confined to the northern and western sides of the islands [5]. The diversity of coral species in the Gulf is the lowest of all Indian reefs. A total of 44 species of Scleractinian corals and 12 species of soft corals have been reported from the Gulf [6]. Most of these corals are hermatypes (reef forming) while only a few are ahermatypes. Satellite imagery over the Intertidal zone of the Gulf indicated that the extent of the coral reefs is reduced from 116 km² in 1975 to 83 km² in 1982. Further reduction of area was reported in 1985 (53 km²). Recent remote sensing data supported by ground-truth data collection revealed that between 1985 and 1991 a net improvement of live coral cover of 20-30 % within the Marine National Park has taken place [7]. In fact, even in areas normally referred to as coral reefs or patches, live coral covers rarely exceed 20-30%. Vast areas with dead corals are rather a rule than an exception, and an indication that the mortalities are of recent origin. Some of the hard stony corals encountered in some reefs indicate that these could not have been dead for more than a couple of decades [7].

3. Description of Study Area

Corals of the Pirotan Island

Pirotan Island has well-developed fringing reefs, though nothing comparable to a lagoon (figure 2). This island has been identified as the eastern limit of major coral formation in the Gulf and is also the core area of the Marine National Park. During 1999 the research team from Gujarat Ecological Society carried out SCUBA diving and underwater video graph along the deep waters of the Pirotan Island. This was the first coral reef video exploration in the Gulf of Kachchh. The survey was conducted at water depths between 5 and 10 metres. The observations made it clear that varieties of live coral both soft and stony at various stages of growth— are abundantly present in the sub-tidal regions of the reefs. The abundance of live corals decreased from inner to the outer reefs from 75-80% to around 50 % by visual approximation [8]. The intertidal zone also has isolated coral patches. These include *Favia fava* and *Favites complanata*.

MATERIALS AND METHODS

Seasonal field surveys have been conducted from various habitats viz. inter-tidal, dead reef and live coral reef regions. The survey includes, intertidal macro benthic fauna, flora and reef associated forms. Special attention has been given to the rare and endangered species in the reef environs. Intertidal faunal and floral information were collected during low tide period from the exposed substratum on rock, muddy, sandy, dead coralline beds, sea grass and algal beds, etc.

Reef Associates

Plate - 1



Coral - Platygyra sinesis



Coral - Tubastrea aurea



Coral - Symphyllia radians



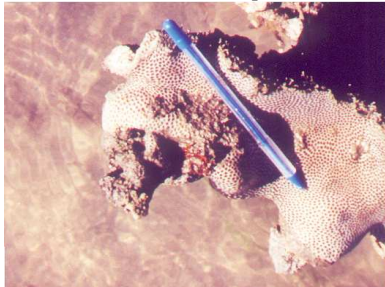
Coral - Turbinaria peltata



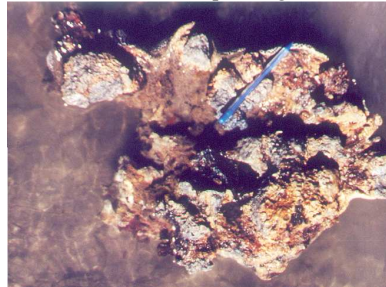
Coral - Goniopora nigra



Coral - Cyphastrea serailia



Exposed live coral - Favia sp.



Exposed dead coral



Exposed coral with sponges



Soft coral - Dendronephthya brevirama



Soft coral - Lobophytum pauciflorum



Soft Coral -Dendronephthya dendrophyta



Sponges - Unidentified



Sponges - Unidentified



Dead coral and Sponges



Tube worm - *Sabella* sp.



Gorgonians - *Leptogorgia* sp.



Soft coral - *Alcyonium* sp.



Membranopora sp.



Sea anemone - *Discosoma* sp.



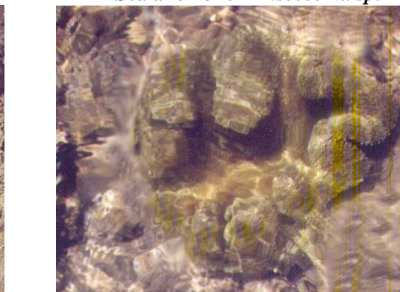
Sea anemone - *Discosoma* sp.



Feather star



Barnacles - *Balanus tintinnabulum*



Sea anemone - *Paracondylactis* sp.



Bonilia- *Ikedellidae misakiensis*



Reef fish (*Epinephelus* sp.)



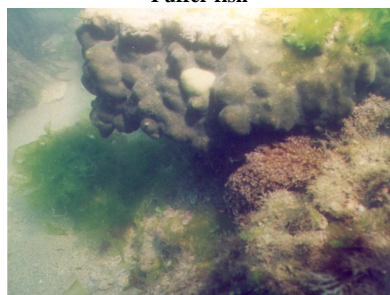
Grouper fish



Puffer fish



Reef fishes - Unidentified

Hermit crab - *Clibanarius* sp. & *Uca* sp.Algae - *Halimnria venusta*Algae - *Caulerpa racemosa*Algae - *Sargassum tenerrimum*

For the qualitative study, the fauna were hand picked, scooped out of sand bottom, dead coral substratum, washed out of the sea grass and algal beds. Specimens were identified on-the spot using standard field identification manuals [9], [10], [11]. For quantitative analysis, Random Quadrat Method was adapted [12].

Associated faunal and floral distribution data were collected along the shallow water region around the coral reef formations. Faunal and floral photographs were taken during the reef underwater photographic study.

RESULTS AND DISCUSSION

A total number of 89 faunal and 31 floral (seaweeds and seagrasses) species were recorded during the study period from the various reef habitats. Annexure 1 gives the species recorded in the Pirotan Island. Some international reef biota studies [13] recorded over 7,000 marine species from Hawaiian Islands, 3,800 from French Polynesia and 3,400 from Guam. Further, majority of faunal species were recorded from the inter-tidal shallow region than the sub-tidal reef areas.

Gastropods

The present study was conducted at five stations and the results of relative species composition indicate the dominance of gastropods both on the inter-tidal and reef areas. Next to the gastropods, bivalves and other associated species were recorded. Seasonal variations were also observed in gastropod diversity and it varied between 26 and 36 during the pre-monsoon and post monsoon seasons respectively (Table 1)

As compared to the other groups, the population of gastropods was high at lower inter-tidal region during the post monsoon sampling. Within the intertidal region the distribution of gastropods was higher beneath the reef rocky substratum. The phenomenon recorded in the present study is a common trend occurring with tropical reef environs [14], [15] conducted a detailed study at the Heron reef Island on *Conus* spp. The result indicates that high population density in inter-tidal region, whereas low density in sub tidal reef crest. [16] Collected 37 species of molluscs from the live and dead coral part of the Karachalli Island in the Gulf of Mannar thereby signifying the wealth of molluscan resources in the reef area

Thais, *Umbonium*, *Cerithium*, *Oliva* and *Nassarius* are the common gastropods collected in good number during each sampling season, therefore indicating its abundance. Species such as *Telescopium*, *Babylonia spirata*, *Babylonia canaliculata* and *Murex poppei* were rare and sporadically collected in small numbers in all the seasons. The presence of few species in good numbers compared to others, hints towards the specific habitat preferred by these species. Earlier studies also recorded abundance of species in reef habitat representing few families of Gastropods like Mitridea, Cypraeidae and Conidea [17].

Table 1: Seasonal occurrence and density of major Inter tidal benthic fauna diversity

Name of the species	Seasons					
	Pre monsoon		Post monsoon		Summer	
	Density	Occurrence	Density	Occurrence	Density	Occurrence
Gastropods						
Trochus coranatus	1	F	2	F	-	O
<i>Trochus</i> sp.	1	F	2	F	-	O
<i>Clanculus</i> sp.	-	X	-	X	-	R
<i>Umbonium vestiarium</i>	4	F	4	F	5	F
<i>Umbonium</i> sp.	6	F	3	F	4	F
<i>Cellana radiata</i>	-	R	-	R	-	X
<i>Mitra cardinalis</i>	-	X	-	X	-	O
<i>Mitra</i> sp.	-	X	-	O	-	O
<i>Thais bufo</i>	3	F	2	F	2	F
<i>Thais rugosa</i>	-	O	-	O	-	F
<i>Thais lacera</i>	-	X	-	R	-	X
<i>Murex poppei</i>	-	X	-	R	-	R
<i>Nassa stolata</i>	-	X	-	X	-	O
<i>Nassarius stolatus</i>	-	O	-	X	-	X
<i>Nassarius pullus</i>	-	R	-	R	-	X
<i>Nassarius coronatus</i>	-	X	-	R	-	R
<i>Phalium</i> sp.	-	X	-	R	-	R
<i>Symbium</i> sp.	-	R	-	R	-	X
<i>Cypraea arabica</i>	-	O	-	R	-	X
<i>Cypraea ocellata</i>	-	X	-	R	-	R
<i>Cypraea</i> sp.	-	R	-	R	-	R
<i>Cerithium fluvatilis</i>	5	F	3	F	5	F
<i>Cerithium</i> sp.	8	F	9	F	11	F
<i>Nerita tigrina</i>	-	X	-	X	-	O
<i>Nerita</i> sp.	-	O	2	F	-	O
<i>Telescopium telescopium</i>	-	X	-	X	-	R
<i>Natica vitellus</i>	-	X	-	O	-	O
<i>Natica rubromaculata</i>	-	X	-	R	-	X
<i>Natica stellata</i>	-	R	-	O	-	R
<i>Littorina scabra</i>	-	R	-	O	-	R
<i>Littorina littorea</i>	-	X	-	R	-	X
<i>Bulla ampulla</i>	-	R	-	X	-	R
<i>Babylonia spirata</i>	-	X	-	R	-	X
<i>Babylonia canaliculata</i>	-	R	-	X	-	R
<i>Bursa rana</i>	-	X	-	O	-	X
<i>Bursa spinosa</i>	-	X	-	R	-	O
<i>Bursa granularis</i>	-	X	-	R	-	X
<i>Oliva nebulosa</i>	-	O	-	O	-	X
<i>Oliva oliva</i>	-	O	-	R	-	O
<i>Oliva</i> sp.	-	F	-	O	-	O
<i>Turritella terebra</i>	-	X	-	X	-	R
<i>Turritella</i> sp.	-	O	-	O	-	X
<i>Pyrene flava</i>	-	O	1	F	-	X
PYRENE ZEBRA	-	O	-	R	-	O
<i>Turbo intercostalis</i>	1	F	1	F	2	F
Scaphopoda						
DENTALIUM OCTANGULATUM	1	F	-	O	-	O
Bivalves						
<i>Area bistricata</i>	2	F	1	F	1	F
<i>Arca complanata</i>	1	F	2	F	1	F
<i>Anadara rhombea</i>	-	O	-	O	2	F
<i>Pinctada</i> sp.	-	X	-	X	-	R
<i>Crassostrea cristagalli</i>	-	O	-	O	-	O
<i>Crassostrea</i> sp.	-	O	1	F	1	F
<i>Placenta placenta</i>	-	X	-	R	-	X
<i>Paphia malabarica</i>	-	X	-	X	-	R
<i>Paphia textile</i>	-	R	-	R	-	X
<i>Pitra</i> sp.	-	O	-	R	-	R
<i>Tellina angulata</i>	2	F	3	F	2	F
<i>Tellina</i> sp.	2	F	2	F	2	F
<i>Solen lamarckii</i>	1	F	-	O	-	O

Note: F- Denotes Frequent; O- Occasional; R- Rare; (-) not quantified; (X) absence of species; Density Unit [Individuals \ M²]

Bivalves

A total of 13 bivalve species has been recorded from the Intertidal and sub tidal regions (Table 1). Among the bivalves commonly encountered species are *Arca bistricata*, *Arca complanata*, *Tellina angulata* and *Tellina* sp. in all the study sites. Most of the bivalve species are restricted along the Intertidal regions only, which might be due to their preference for sandy substratum. Generally, bivalves were found to be less in number than gastropods in both Intertidal and sub-tidal regions. A similar trend of molluscan occurrence has been observed in the intertidal and offshore waters of Gulf of Kachchh [18].

Crustaceans

Among the crustaceans, the dominant species in the study area are barnacles such as *Balanus balanus*, hermit crabs (*Clibanarius* sp. and *Diogenes* sp.) and *Uca* sp. which are predominantly present in the mid and lower Intertidal zone in the clayey substrata.

Coral fish

Coral fish community shows marked variation in species diversity at all levels. In general, most of the reef species are restricted geographically and locally rare throughout their range. Present study, noticed that reef fishes are being represented by very few individuals within the assemblages. Similarly, [19] reported the rarity in reef fish assemblages at Madagascar and French Polynesia. She found that over 85 % of species each were represented by less than 1% of the total sample and 25% of species were represented by only a single individual per reef habitat. Several large fish families, including many rare species have reef residential behaviors. For example, families like Scaridae, Chaetodontidae, Pomacanthidae, Acanthuridae entirely, are restricted within the reef inhabitants.

Gorgonids

Near the dead and live coral regions, bottom substratum comprised of rocks, coralline sand and dead coral pieces. In the sub-tidal region, seabed area was covered with rich live corals having diverse associate faunal inhabitants. Several places along this zone are rich in three species of gorgonids i.e., *Leptogorgia australiensis*, *Juncella juncea* and *Subergorgia* sp. The gorgonids have economical value and around 74 bioactive compounds and various chemicals have been isolated from different species [20].

Soft coral

There are three species of soft corals recorded during the study. They occur all along the sub-tidal regions in the depth of 2-3 meters and are in close association with Scleractinian species (GES, 1999). In regions like Indo-west Pacific reefs (Charles, 1997), soft coral acts as keystone species with high abundance and diversity (over 700 species), but in other regions soft corals were virtually absent from reef community. Many soft corals have been reported to contain four PGF (Isomers) derivatives, which is responsible for inflammation pain and swelling [3]. However, commercial exploitation of gorgonids and soft corals has yet to be initiated in Gujarat.

Algae

An area of ~ 50 m² has been studied during each of the sampling periods. All quadrates were used to estimate total coverage of algae species. The algae coverage varies between 5 and 62 % of the total surface. A total number 31 seaweed and seagrass species were identified during the study period (Table 2). *Ulva* and *Sargassum* were noticed as dominant species throughout the study period. Higher algae coverage has been found in the clay bottom regions and it reduced towards sandy and rocky substratum. The occurrence of low algal diversity in the present study is due to difference in distribution of algal species within the Gulf ecosystem.

Bahuguna *et al.* (1992) reported a total number of 120 algae species with dominance of *Sargassum*, *Ulva*, *Enteromorpha* and *Cladophora* species in the Gulf of Kachchh. Several observations have revealed that the algae constitute the dominant and diverse group of reef waters. At least 180 species of benthic algae have been reported from the Gulf of Mannar [21]. Minicoy reef islands (Lakshadweep) have known species of benthic algae [22].

Mangroves

Four mangrove species are documented in and around the island. *Avicenia marin* trees are dominant at most of the places followed by *Rhizophora mucronata*, *Ceriops tagal* and *Avicenia officinalis*. The average height of the trees is 1 to 3 meters; *Avicenia marina* plantation has been carried out by State Forest Department in these islands. Mangroves are extremely important both ecologically and economically. They also serve as breeding and feeding grounds for several marine species. Many avian faunal nesting have been observed on the mangrove trees but no documentation of breeding of birds exists in the Gulf of Kachchh.

Other forms

Among the different groups, quantification and seasonal occurrence are documented for gastropods, bivalves and algae species only, which are common in distribution in the study area (Table 1 & 2). Individuals of remaining groups are quite rare in the survey and so they have not been categorized season wise. A status report has been prepared for all the identified species (Table 3).

Table 2: Seasonal occurrence and biomass of seaweed and sea grasses

Species name	Pre monsoon		Post monsoon		Summer	
	Biomass	Occurrence	Biomass	Occurrence	Biomass	Occurrence
<i>Gelidiella acerosa</i>	-	X	-	R	-	X
<i>Gelidium pusillum</i>	-	X	-	X	-	O
<i>Gracilaria</i> sp.	-	X	-	O	-	R
<i>Acanthophora delilei</i>	-	R	-	X	-	O
<i>Ceramium rubrum</i>	-	X	-	R	-	X
<i>Laurencia papillosa</i>	-	X	-	O	-	O
<i>Amphitroa</i> sp.	-	R	-	O	-	R
<i>Soleria rubusta</i>	-	X	-	R	-	X
<i>Hypnea musciformis</i>	-	O	-	R	-	O
<i>Hypnea valentiae</i>	0.8	F	-	O	-	O
<i>Dictyota dichotoma</i>	-	X	-	O	-	X
<i>Padina tetrastromatica</i>	-	X	0.3	F	-	O
<i>Padina gymnospora</i>	-	X	-	R	-	X
<i>Cystoseira rubrum</i>	-	R	-	R	-	R
<i>Cystoseira</i> sp.	-	R	-	O	-	R
<i>Sargassum tenerrimum</i>	1.6	F	0.6	F	-	O
<i>Sargassum Johnstonii</i>	-	O	-	O	-	X
<i>Turbinaria ornate</i>	-	X	0.4	F	-	O
<i>Ulva lactuca</i>	5.3	F	8.0	F	4.5	F
<i>Ulva reticulata</i>	-	O	-	O	-	O
<i>Ulva beytensis</i>	-	R	0.8	F	-	R
<i>Enteromorpha tubulosa</i>	2.1	F	1.5	F	-	O
<i>Monostroma</i> sp.	-	R	-	X	-	X
<i>Caulerpa racemosa</i>	-	O	-	O	-	O
<i>Caulerpa scalpelliformis</i>	-	O	-	O	0.3	F
<i>Caulerpa taxifolia</i>	-	O	-	O	-	R
<i>Codium dwarkens</i>	-	X	-	R	-	O
<i>Codium decorticatum</i>	-	X	-	O	-	O
<i>Halimeda</i> sp.	-	O	-	R	-	O
Seagrasses						
<i>Halophila ovalis</i>	-	X	-	O	-	O
<i>Halophila beccarii</i>	-	X	-	O	-	X

Note: F- Denotes Frequent; O- Occasional; R- Rare; (-) Not quantified; Biomass unit [g fresh wt. M²]; (X) absence of species

Table 3. Status Report of Biota along the Pirotan Island

Name of the species	C	R	Endg	Vul.	Thr.
Gastropods					
<i>Trochus coranatus</i>	✓				
<i>Trochus</i> sp.	✓				
<i>Clanculus</i> sp.	✓				
<i>Umbonium vestiarius</i>	✓	✓			
<i>Umbonium</i> sp.	✓				
<i>Cellana radiata</i>		✓			
<i>Mitra cardinalis</i>	✓				
<i>Mitra</i> sp.	✓				
<i>Thais bufo</i>	✓				
<i>Thais rugosa</i>		✓			
<i>Thais lacera</i>		✓			
<i>Murex poppei</i>				✓	
<i>Nassa stolata</i>		✓			
<i>Nassarius stolatus</i>		✓			
<i>Nassarius pullus</i>		✓			
<i>Nassarius coronatus</i>		✓			
<i>Phalium</i> sp.		✓			
<i>Symbium</i> sp.		✓			

<i>Cypraea arabica</i>		✓			
<i>Cypraea ocellata</i>		✓			
<i>Cypraea</i> sp.		✓			
<i>Cerithium fluvatilis</i>	✓	✓			
<i>Cerithium</i> sp.	✓				
<i>Nerita tigrina</i>					
<i>Nerita</i> sp.	✓				
<i>Telescopium telescopium</i>		✓			
<i>Natica vitellus</i>		✓			
<i>Natica rubromaculata</i>		✓			
<i>Natica stellata</i>		✓			
<i>Littorina scabra</i>		✓			
<i>Littorina littorea</i>		✓			
<i>Bulla ampulla</i>		✓			
<i>Babylonia spirata</i>		✓	✓		
<i>Babylonia canaliculata</i>		✓			
<i>Bursa rana</i>		✓			
<i>Bursa spinosa</i>		✓			
<i>Bursa granularis</i>		✓			
<i>Oliva nebulosa</i>		✓			
<i>Oliva oliva</i>		✓			
<i>Oliva</i> sp.	✓	✓			
<i>Turritella terebra</i>		✓			
<i>Turritella</i> sp.		✓			
<i>Pyrene flava</i>		✓			
PYRENE ZEBRA		✓			
<i>Turbo intercostalis</i>		✓			
Scaphopoda					
<i>Dentalium octangulatum</i>		✓			
Bivalves					
<i>Arca bistricata</i>	✓				
<i>Arca complanata</i>	✓				
<i>Anadara rhombea</i>		✓			
<i>Pinctada</i> sp.		✓			✓
<i>Crassostrea cristagalli</i>	✓	✓			
<i>Crassostrea</i> sp.	✓				
<i>Placenta placenta</i>		✓			
<i>Paphia malabarica</i>		✓			
<i>Paphia textile</i>		✓			
<i>Pitra</i> sp.	✓	✓			
<i>Tellina angulata</i>	✓				
<i>Tellina</i> sp.	✓				
<i>Solen lamarckii</i>	✓				
Crustaceans					
<i>Balanus tintinnabulum</i>	✓	✓			
<i>Uca anaulipes</i>	✓	✓			
<i>Uca</i> sp.	✓				
<i>Scylla serrata</i>	✓				
<i>Clibanarius</i> sp.	✓				
<i>Dardanus</i> sp.	✓				
Stony Corals					
<i>Favia favius</i>		✓	✓		
<i>Favites melicerm</i>		✓	✓		
<i>Platygyra sinensis</i>		✓	✓		
<i>Platygyra compressa</i>		✓	✓		
<i>Cyphastrea serailia</i>		✓	✓		
<i>Goniopora nigra</i>		✓	✓		
<i>Goniopora planulata</i>		✓	✓		
<i>Montipora</i> sp.		✓	✓		
<i>Tubastrea aurea</i>		✓	✓		
<i>Symphyllia radians</i>		✓	✓		
<i>Turbinaria</i> sp.		✓	✓		
Soft Corals					
<i>Alcyonium</i> sp.		✓	✓		
<i>Lobopython</i> sp.	✓	✓	✓		
<i>Nepthea</i> sp.		✓	✓		
<i>Dendronephthya dendrophyta</i>		✓	✓		
<i>Dendronephthya brevirama</i>		✓	✓		
Sponges					

<i>Haliclona</i> sp.		✓			
<i>Cribrorchalina</i> sp.		✓			
Gorgonians					
<i>Leptogorgia australiensis</i>		✓	✓		
<i>Juncella juncea</i>		✓	✓		
<i>Subergorgia</i> sp.		✓	✓		
Other					
<i>Sabella</i> sp.		✓			✓
<i>Triphyllozoon</i> sp. [Bryozonas]		✓	✓		
<i>Paracondylactis</i> sp.			✓		✓
<i>Rubricetatus pirotansts</i> [Bonilia]		✓	✓		✓
<i>Ikedella misakiensis</i> [Bonilia]		✓	✓		✓
Fishes					
<i>Epinepelens</i> sp.		✓			
Puffer fish		✓			
Crabs	✓				
Algae					
<i>Gelidiella acerosa</i>		✓			
<i>Gelidium pusillum</i>		✓			
<i>Gracilaria</i> sp.		✓			
<i>Acanthophora delilei</i>		✓			
<i>Soloeria rubusta</i>		✓			
<i>Hypnea musciformis</i>		✓			
<i>Hypnea valentiae</i>	✓				
<i>Dictyota dichotoma</i>		✓			
<i>Amphiroa</i> sp.	✓				
<i>Ceramium rubrum</i>		✓			
<i>Laurencia papillosa</i>		✓			
<i>Padina tetrastromatica</i>		✓			
<i>Padina gymnospora</i>		✓			
<i>Cystoseira indica</i>		✓			
<i>Cystoseira</i> sp.		✓			
<i>Sargassum tenerrimum</i>	✓				
<i>Sargassum johnstonii</i>		✓			
<i>Turbinaria ornate</i>		✓			
<i>Ulva lactuca</i>	✓				
<i>Ulva reticulata</i>		✓			
<i>Ulva beytensis</i>		✓			
<i>Enteromorpha tubulosa</i>	✓				
<i>Monostroma</i> sp.		✓			
<i>Caulerpa racemosa</i>		✓			
<i>Caulerpa scalpelliformis</i>	✓				
<i>Caulerpa taxifolia</i>		✓			
<i>Codium dwarkens</i>		✓			
<i>Codium decorticatum</i>		✓			
<i>Halimeda</i> sp.		✓			
Seagrasses					
<i>Halophila ovalis</i>	✓				
<i>Halophila beccarii</i>		✓			
Mangroves					
<i>Avicennia marina</i>	✓				
<i>Avicennia officinalis</i>	✓				
<i>Ceriops tagal</i>		✓			
<i>Rhizophora mucronata</i>		✓			

Note: C – Common; R – Rare; Endg – Endangered; Vul – Vulnerable; Thr - Threatened
GP - Grazing Pressure; FW - Firewood

CONCLUSION

The present study shows that Pirotan Island reef habitat is supporting several rare and endangered species (Table 3). The faunal and floral population diversity varies from low to moderate diversity, when compared to other Indian reefs. Seasonal changes on floral and faunal abundance and diversity were not significant, but during the post monsoon season the values were slightly higher compared to other seasons. The remarkable observation recorded was the occurrence of more number of species with good abundance in Pirotan Island as compared to the rest of the Gulf. When the reef diversity of Pirotan is compared to any reef at National level, the occurrence of lower diversity could be due to anthropogenic and natural pressures in the Gulf.

The anthropogenic pressures include port activities like dredging; industrial disposal etc. [23] leads to high sedimentation. Sedimentation levels are high due to coastal development, mangrove degradation and high water current, during most of the months the water visibility observed was typically less than 1 m. In addition, the most serious threat to the Indian reefs is the excessive and indiscriminate exploitation of corals, coral debris and sands, which leads to irreversible ecological damage. In the Gulf of Kachchh, several reefs, including Pirotan Island have been severely damaged by the extraction of limestone for cement, and associated siltation. Mining activity was legally banned in 1986 after the creation of Marine National Park area, but small-scale mining continued up to 1988 [6]. Due to these developmental impacts, there is possibility of substantial damage to the reef ecosystem and consequently to the habitat of corals in Gulf of Kachchh.

This collection of data (Reef associates), from the perspective of gathering information, may help towards the use of conservation measures in the Gulf of Kachchh Marine National Park.

REFERENCES

- [1] Smith, S.V., *Nature*. **1978**, 273: 225-226.
- [2] Jonathan Erez., *On the importance of food sources in coral- reef ecosystem*. *Coral Reef*, Ed. Z . Elsevier, New York, **1990**, 49-73.
- [3] Solimabi Wahidullah, *In: The Indian Ocean – A perspective*, eds. R. Sen Gupta and Ehrlich Desa, Oxford & IBH Publishing, 2001, pp 373-396.
- [4] Gupta, S.K., *Journal Geology*. **1972**, 80, 357-361.
- [5] Pillai, C.S.G and M.I. Patel, *Journal of Marine Biological Association, India.*, **1988**, 30, 54-74.
- [6] Patel, M.I., Patchy Coral of the Gulf of Kachchh. *Proc. of Symp. on Endangered Marine Animal and Marine parks*, Ed. Silas, E.G. **1988**. pp. 411-413. .Cochin: Marine Biology Association of India.
- [7] Bahuguna Anjali, A. Ghosh, S. Nayak, A. Patel and J.P. Aggarwal, Ecological status of the coral reef of the Gulf of Kachchh and Lakshadweep In: *Proc. Nat. Symp. Rem. Sens. for Sustainable Development*, Lucknow, **1992**, 57-61.
- [8] GES, Coral Reefs of the Gulf of Kachchh – Present States, *Technical Report*, Gujarat Ecological Society, **1999**, pp. 35.
- [9] Patricia, M., and B. Isobel, *A coral reef handbook – A guide to the fauna, flora and ecology of Heron Island and adjacent reefs and cays*, The Australian Coral Reef Society, **1984**, pp. 144.
- [10] Kenneth, R. W., *The encyclopedia of shells*, Grange book, London. **1996**, pp. 288.
- [11] ZSI, *Animal Resources of India – Protozoa to Mammalia*, Ed. .Director Zoological Survey of India. **1991**, pp.695.
- [12] ICMAM, *Manual on Methodology for Biological Parameters*, Eds. Integrated Coastal and Marine Area Management (ICMAM), Anna University and Annamalai University; Govt. of India, Department of Ocean Development Publishing, **1998**, pp.161.
- [13] Charles Birkeland, *Life and Death of Coral Reefs*. International Thomson Publishing, Florence. **1997**, pp. 536.
- [14] Rupert, F. G. Ormond and Callum, M., *Marine Biodiversity – Pattern and Processes*, (The biodiversity of coral reef fishes) Eds. Rupert F.G. Ormond, John D. Gage and Martin V. Angel, Cambridge University Press, **1997**, pp. 216-257.
- [15] Kohn, A. J., *Ecology*, **1968**, 49, 1046-62.
- [16] Jayabaskaran, R., D. Asir Remesh and A.L. Paul Pandian, distribution and abundance of molluscan Cryptofauna from Karaichalli Island (Gulf of Mannar), South east coast of India. *Phuket Marine Biological Centre Special Publication no.* **1996**, 16: 215-219.
- [17] ICMAM, Development of Geographical Information system for Gulf of Kachchh and Gulf of Khambhat, *project Technical report*, Integrated Coastal and Marine Area Management (ICMAM), **2000**, pp.156.
- [18] Harmelin, V. M.L., Reef fish community structure, An Indo- Pacific comparison, In *vertebrates in Complex Tropical Systems*, ed. M.L. Harmelin - Vivien & F. Bourliere, **1989**, pp. 21- 60, New York: Springer – Verlag.
- [19] Thomas P.A. and Rani Mary George, Gorgonid resources of India, *Marine Fisheries Information Service*, Central Marine Fisheries Institute, Cochin . India. **1987**, pp. 17.
- [20] Umamaheswara Rao, M., The seaweed potential of the seas around India. In: *Proceeding of the Symposium on Coral and Coral Reefs*. 1969, eds. Mukundan D., Pillai, C.S.G.. **1972**, pp 217 – 230: *Marine Biological Association of India*
- [21] Bakus G., Rohan Arthur, Suki Ekaratne, and S.S Jinendradasa, *Coral reefs of the Indian Ocean, their Ecology and Conservation*. Eds. Mc Clanahan, T.R., C.R.C. Sheppard, D.O. Obura, 2000, Oxford University Press. **2000**, pp. 295-324.
- [22] Sen Gupta, R., Geetanjali Deshmukhe, *Coastal and marine environments of Gujarat- Ecology and Economics*, Gujarat Ecological Society, Vadodara, **2000**, pp. 148.