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## Biodiversity of Coastal Islands of India

Anant Pande<sup>1\*</sup>, Yashaswi Singh<sup>1</sup>, Biba  
Jasmine<sup>1</sup>, Anil Rajbhar<sup>2</sup>, Gitanjali Katlam<sup>3</sup> and  
K. Sivakumar<sup>1</sup>

<sup>1</sup> Wildlife Institute of India, Chandrabani,  
Dehradun 248001, Uttarakhand, India

<sup>2</sup>The Blatter Herbarium, Department of Botany,  
St. Xavier's College, Mumbai 400001,  
Maharashtra, India

<sup>3</sup>Department of Biological Sciences, Indian  
Institute of Science, Education and Research -  
Kolkata, Mohanpur Campus, Mohanpur  
741252, India

\*Email: anant@wii.gov.in

## Summary

Several smaller islands are located close to the coastline of peninsular India and are part of the territories of various states and union territories. These islands harbour coral reefs, endangered species such as the dugong, sea turtles and several endemic species of mangrove and seagrass. Many of these coastal islands are also tourist attractions, and are used for fishing purposes. These coastal islands are facing serious threats to their natural habitats, and the diverse animal and plant communities inhabiting them. Threats such as mining, pollution, unsustainable fisheries, the trade in ornamental shells, harvesting of seaweeds, sea cucumbers and sea horses and illegal poaching are threatening the ecological functioning of these islands. This chapter presents a review of studies carried out on 21 islands and 3 groups of islands of peninsular India, their biodiversity and related threats.

**Keywords :-** *Peninsular India; east coast; west coast*

## Introduction

Islands around the world are under tremendous pressure from growing human populations and the resulting exploitation of resources, habitat destruction and introduction of invasive species. Anthropogenic activities in these unique ecosystems have drastic impacts on their biodiversity and distinct habitats. Islands make up only about 5% of the Earth's land surface but constitute areas of high endemism (Whittaker & Fernandez-Palacios 2007; Kreft et al. 2008) supporting over 10% of the world's population (Lutchman et al. 2005). Since 1500, the majority of all recorded species extinctions has happened on islands and represent over 50% of the extinctions in the past 20 years. The primary causes of these extinctions are the introduction of alien species and habitat destruction (Baillie et al 2004). Of the 34 biodiversity hotspots in the world defined by Myers et al (2000), 20 are islands, making it even more important to protect them from the human drivers of change. Considering the importance of islands and raising awareness about the threats faced by them, the United Nations declared 2014 as the International Year of Small Island Developing States. However, the present state of rapid habitat alteration calls for conservation of various coastal natural resources and overall development of such islands to ensure the sustainability of both, the natural resources management and the developmental activities, to maintain the health of marine ecosystems through an integrated approach.

India, the seventh largest country in the world, with a total area of 31,66,414 km<sup>2</sup>, is situated north of the equator, between latitudes 8°4' and 37°6' N and longitudes 68°7' and 97°25' E. The country also has a 7517 km long coastline which extends across nine coastal states and two union territories, namely the Andaman & Nicobar and Lakshadweep islands. According to the bio-geographic classification of India (Rodgers et al 2002), the coasts fall under zones 8A (west coast), 8 B (east coast), 8 C (Lakshadweep), 10A (island-Andamans) and 10B (island-Nicobars). The Lakshadweep and Andaman & Nicobar islands form the major groups of islands in the country, comprising 36 and 572 islands, respectively. The Lakshadweep Islands lie 220 to 440 km off the coast of Kerala in the Arabian Sea, with an area of 32 km<sup>2</sup> (<http://lakshadweep.nic.in/>). The Andaman & Nicobar archipelagos are situated between latitudes 6° and 14° N and longitudes 92° and 94° E, in the Bay of Bengal (<http://www.andamans.gov.in/>). These islands have received much attention in the recent past due to their rich coastal and marine ecosystems, which harbour many critical species and provide a source of livelihood to over 4,00,000 people (Census of India 2011). Several studies in the past have focused on the biodiversity of both the island groups, the Lakshadweep Islands (Murty 2002; Apte 2009; Venkataraman 2004; James 2011; Reddy et al 2013) and the Andaman & Nicobar Islands (Sankaran 1997; Ravindran et al 1999; Davidar et al 2002; Padalia et al 2004; Ramachandran et al 2005; Andrews et al 2006; Hari Krishnan et al 2010; Aul et al 2014).



Apart from these large island groups, several smaller islands dot the coastline of mainland India and are part of the territories of various states and union territories. So far, there has been no comprehensive information about biodiversity of these small islands that are close to mainland peninsular India. These islands, harbour coral reefs, especially in the Gulf of Kachchh (GoK), Gujarat, the Gulf of Mannar (GoM), Tamil Nadu and Malvan, Maharashtra, endangered species such as the dugong, sea turtles and several endemic species of mangrove and seagrass. Many of these islands are protected areas, such as Chorao Island, Goa which is a bird sanctuary, and Lothian Island Wildlife Sanctuary and Haliday Island Wildlife Sanctuary, which are part of Sundarbans Biosphere Reserve. A few of them, like Sagar Island, West Bengal and the Cochin group of islands, Kerala, also support a large human population. Many of these coastal islands are tourist attractions, with Sagar Island, Elephanta Island and Murud-Janzira in Maharashtra and Pirotan Island, in Gujarat, visited by thousands of people every year for observing the islands' historical and natural wealth.

The coastal islands of India are facing several serious threats to their natural habitats, and the diverse animal and plant communities inhabiting them are becoming endangered. Threats such as mining, unsustainable fisheries, the trade in ornamental shells, harvesting of seaweeds, sea cucumbers and sea horses and illegal poaching of threatened marine animals necessitate enhancement of protection and better management of these islands.

Although there are many islands which exist on the entire coastline of India, many of which haven't even been named and need attention. During the literature survey, we found a substantial lack of information on these islands and their biodiversity. Also for some islands like Wellington (Kerala) little information was available and was deficient and unrelated to the topic. We also excluded islands which are located inland esp. in the estuaries of major rivers.

This chapter presents a review of studies carried out on 21 islands and 3 groups of islands of peninsular India, their biodiversity and related threats. Here we attempt to focus on the biodiversity of these coastal islands, which has received less attention compared with the Lakshadweep and Andaman & Nicobar groups of islands. We discuss the biodiversity of these islands, moving from the east coast to the west coast of India, from the state of West Bengal to Gujarat, and highlight the grave threats faced by it due to ever-increasing human presence in and around the islands. The aim of this work is to illustrate the importance of these unique ecosystems in the country and draw the attention of decision makers towards improving their management.

## East Coast of India

The east coast of India stretches from West Bengal in the north to the state of Tamil Nadu in the south. The Ganga-Brahmaputra, Mahanadi, Godavari, Kaveri and Krishna are the major rivers that drain into the Bay of Bengal on the east coast. The width of the eastern coastal plains varies between 100 and 130 km. The three largest mangrove areas in the country, the Sundarbans, Coringa and the Bhitarkanika mangrove forests, are found on the east coast. Other biodiversity-rich areas include Chilika Lagoon (the largest brackish water lagoon in Asia), Gulf of Mannar Biosphere Reserve (GoMBR), Gahirmatha Marine National Park and Pulicat Lake. Many islands dot the eastern coast of India from West Bengal to Tamil Nadu, of which some are discussed below.

### ● WEST BENGAL

The southern boundary of West Bengal state lays in the largest contiguous block of mangrove forest in the world, called the Sundarbans. Over 9000 km<sup>2</sup> of these forests are part of the Sundarbans Biosphere Reserve, part of which is recognized as a World Heritage Site by UNESCO. Several islands exist in this land-ocean interface, of which two, namely Haliday and Lothian islands, were declared as wildlife sanctuaries (WLS) in 1976 and have been identified as marine protected areas (MPAs). These islands were formed through a slow process of deposition of silt at the estuary's mouth by the tidal action of the sea.

- **Haliday Island** is situated to the south of the Sundarbans and covers an area of 5.95 km<sup>2</sup>. The intertidal marshes serve as a suitable habitat for a variety of water birds. Other animals reported from the sanctuary include the Spotted Deer, Wild Boar, Rhesus Macaque, Estuarine Crocodile, Monitor Lizard, Green Turtle, King Cobra, Rat Snake, Russell's Viper, Dog-Faced Water Snake, Common Krait and Python. Fish species such as the Common Carp, Silver Carp, Butter Fish and electric rays have been reported from the island waters, along with invertebrates such as star fishes, and King Crab (Venkataraman et al 2012).

- **Lothian Island** is located where the Saptamukhi River meets the Bay of Bengal. It has an area of 38 km<sup>2</sup>. This mangrove-rich habitat harbours species such as *Acanthus illicifolius* and *Avicennia alba*, *A. marina*, *Ceriops decandra*, *E. agallocha* and *Heritiera fomes* (Mukhopadhyaya et al 2001). A project for captive rearing of crocodiles was started in Bhagabatpur near Lothian Island to supplement the wild populations in the region.

- **Dhanchi Island** lies between latitudes and 21°36' 21°43' N and longitudes 88°25' and 88°28' E and is located at the confluence of the Thakuran River (in the east) and the Jagdal Ganga (in the west), with the Bay of Bengal in the

south. Dhanchi Island has been mapped at the community level using high-resolution satellite data (Nayak et al 2003). The mangrove ecosystem of the island may be classified into mangrove forests, intertidal mudflats and creeks/channels (FSI 2011). Three distinct physiographic zones are observed from satellite data. Zone 1, the area above the eastern creek (Binidar Creek), is dominated by a *Ceriops-Aegialitis-Excoecaria* and *Phoenix* community. Zone 2 makes up the area between the two creeks and has a dense *Phoenix* community in the eastern and southern parts. The central and western regions have degraded mangroves, a grass community and sparsely distributed *Avicennia*. Zone 3 is the area south of the western creek and has a sparse cover of mangroves. There is prominent degradation towards the end of the creeks, where anthropogenic influence is higher. Most significant is the absence of *Heritiera fomes* on the island. This species does not even occur in isolated or small patches on this island. The largest stretches of the sparse mangrove are in the area above the eastern creek (Binidar Creek) and in the area between the two creeks.

Fig 1 : Mangroves of Sunderbans

Anant Pande



Fig 2 : Pneumatophores, Sunderbans

Anant Pande



- **Sagar Island** (21°42' N and 88°06' E), also known as Gangasagar or Sagardwip, is the biggest island in the Bay of Bengal and is a part of the Sunderban Biosphere Reserve. It lies at the mouth of the Hooghly River (Lakshmi & Edwards 2010; Danda et al 2011). The island has a total population of 1, 85,000 and has a total area of 224.3 km<sup>2</sup> (Danda et al 2011). Though the island forms a part of the Sunderbans, it does not have any mangrove forests that can support Tigers. The island has a mixed coast of sand and mudflats, and the inland areas are good for agriculture. The island's location and topography makes it an excellent bird-watching site. Many species have been recorded here, including the Great Knot (*Calidris tenuirostris*), Sanderling (*Calidris alba*), Pheasant-Tailed Jacana



(*Hydrophasianus chirurgus*), Small Pratincole (*Glareola lactea*), Black-Headed Gull (*Larus ridibundus*), Great Crested Tern (*Sterna bergii*), White-Winged Tern (*Chlidonias leucopterus*), Oriental Honey Buzzard (*Pernis ptilorhynchus*), Booted Eagle (*Hieraaetus pennatus*), Common Kestrel (*Falco tinnunculus*), Amur Falcon (*Falco amurensis*), Ashy-Crowned Sparrow Lark (*Eremopterix grisea*) and Richard's Pipit (*Anthus richardi*) (<http://www.kolkatabirds.com/coastbirdlist.htm>). So far, 46 varieties (37 local variety) of paddy, 112 species/varieties of vegetable, 6 species of pulse, 4 species of oil seed, 256 species of wild plant (including medicinal plants), 41 species of weed, 15 species of aquatic plant, 23 species of fruits plant and 42 species of flowering plant have been recorded (PUPA 2008-2009). A major cause of concern for the island is the erosion of the sandy beaches and mudflats, mainly due to natural processes and to some extent by anthropogenic activities. The net erosion of the island from 1967 to 1999 was 29.8 km<sup>2</sup>. As a result, the mangroves and casuarinas, which form the major coastal vegetation, are under threat (Gopinath & Seralathan 2005). The World Bank-aided 'Integrated Coastal Zone Management Project' has been working in Sagar Island with an objective of improving, strategically managing and preserving the long-term productivity of the region by protecting hazard-prone areas of the coastline from erosion by planting more mangroves, streamlining fishing in and around the island, reducing the dependence on fossil fuels such as diesel of generators by providing grid electricity, improving the livelihoods of coastal communities by generating new afforestation-based livelihoods and promoting small-scale tourism and ecotourism activities. Ecosensitive tourism infrastructure is also being developed, considering the importance of the site for Hindu pilgrimage (<http://www.iczmpwb.org/>). Another project of the Global Environment Facility (GEF), United Nations Development Programme (UNDP) Small Grant Programme (SGP) is also actively working towards conservation of biodiversity in Sagar Island through self-help-groups (SHGs), village coordinators, village clubs and regional clubs (<http://www.sgpindia.org/>).

Fig 3 : Fiddler Crabs, Sundarbans

Anant Pande



## ● ODISHA

Odisha has a 480 km long coastline extending over six coastal districts, from Balasore, in the north, to Ganjam, in the south. The coastline also provides discharge points for six major rivers, the Baitarani, Brahmani, Budhabalanga, Mahanadi, Rushikulya and Subarnarekha, which carry a high load of sediments along with freshwater into the Bay of Bengal. These fluvial deposits are highly fertile and thus make this region one of the highly populated coasts of India. Four protected areas are located in the marine and coastal waters of Odisha, including Gahirmatha Wildlife Sanctuary, the site for Olive Ridley mass nesting, Chilika Lagoon, Asia's largest brackish water lagoon, and Bhitarkanika National Park, India's second largest mangrove forest. The coastline of Odisha is extremely vulnerable to cyclones, storm surges and floods, which contribute considerably to changes in the shoreline and damage ecologically valuable habitats (Mohanty et al 2008).

● **Wheeler Island** is located around 10 km off the coast of Odisha in the Bay of Bengal. The island is about 2 km in length, with an area of 1.6 km<sup>2</sup>. Dhamara is the nearest port. . One of active mass nesting ground of Olive Ridley turtles. About 100 to 200 thousands of ridleys nest here annually. Continuous tidal action leads to sand erosion in

the island, which causes shifts in the nesting area available to the turtles. Apart from its being a turtle nesting site, little information is available on the biodiversity of the island. Gopi and Pandav (2007) observed Black-Bellied Terns on the sand bars of the island.

## ● ANDHRA PRADESH

There are three MPAs, Coringa WLS, Krishna WLS and Pulicat Lake Bird Sanctuary, along the over-1000 km long coastline of Andhra Pradesh. They cover an area of 983.51 km<sup>2</sup> and sustain a rich biodiversity. The Krishna and Godavari deltas provide refuge to many threatened species. Several migratory bird species and mammals, such as otters and fishing cats, take shelter in these habitats.



Fig 4 : Prawn Fishery in Chilika

Gitanjali Katlam

- **Hope Island** is a narrow sand bar bordering Kakinada Bay, with an area of around 146 km<sup>2</sup>, near Coringa WLS (Bouillon et al 2004). The mouth of the bay spreads up to 5 km into the Bay of Bengal on the northern side, bounded on the west by the mainland and on the east side by Hope Island (Dehairs et al 2000). The width of the island ranges from 200 to 1200 m, broadening towards the northwest. This 15 km long natural sand bar provides protection to Kakinada Bay from wave action and acts as a barrier for sediment deposition at the fishing harbour (Raju et al 2004). Coastal erosion in the island has caused a loss of about 1300 ha of land along the southern boundaries. It was noted that the increase in the length of the sand spit towards the west was resulting in the loss of mangrove vegetation at the mouth of the estuary (Ramasubramanian et al 2006). No detailed scientific study on the biodiversity of the island exists except that of Rao (1985), who reported the nesting of Olive Ridley Turtles on Hope Island. Rao also witnessed nest predation by Jackals and collection of eggs by fishermen from the island.

- **Sriharikota Island** is a spindle-shaped barrier island (13°43' N and 80°12' E; area approximately 181 km<sup>2</sup>) in the Bay of Bengal located in the south-eastern part of the coast of Andhra Pradesh (Manakadan 2009). The island is very important from a biodiversity perspective as it has the last remaining, largest and best-preserved tracts of coastal tropical dry evergreen forest in India (Daniels et al 2007). The island is sandwiched in between the Bay of Bengal, in the east, and Pulicat Lake, in the west (Sivakumar et al 2011). Pulicat Lake is an Important Bird Area (IBA) and was declared a sanctuary in October 1980 (ICMAM, no date). The lake spreads over an area of about 720 km<sup>2</sup> and is the second largest brackish water lake in India (Kannan 2013). The is extremely shallow due to deltaic depositions, having an average depth of the lake is 1.5 m. About 53 species of phytoplankton, 29 species of zooplankton, 1 species of macrophyte (Basha et al 2012), 115 species of bird, both aquatic and terrestrial (Sanjeevaraj 2006), 160 species of fish, 25 species of polychaete worm, 12 species of prawn and 19 species of mollusc have been documented, apart from a number of other species of aquatic flora and fauna (Venkatraman et al 2013). The coastal tropical dry evergreen forest is the characteristic feature of Sriharikota Island and is represented by 24 species of plant, namely *Manilkara hexandra*, *Syzigium cumini*, *Albizia amara*, *Albizia lebbbeck*, *Strychnos nux-vomica*, *Drypetes sepiaria*, *Ficus tsilea*, *Sapindus emarginatus*, *Tamarindus indica*, *Azadirachta indica*, *Pterospermum suberifolium*, *Borassus flabellifer*, *Memecylon umbellatum*, *Maba buxifolia*, *Garcinia spicata*, *Crataeva religiosa*, *Atlantia monophylla*,

*Cordia dichotoma*, *Gmelina arborea*, *Phoenix sylvestris*, *Flacourtia indica*, *Glycosmis pentaphylla*, *Randia sp.* and *Calamus viminalis* (Daniels et al 2007). Approximately 440 species of angiosperms, belonging to 115 families, and 212 medicinal plants have been identified from the island (Savithramma & Narayana 2001). Plantations of Eucalyptus (*Eucalyptus sp.*), Casuarina (*Casuarina equisetifolia*) and Cashew (*Anacardium occidentale*) can also be found on the island. Invasive species such as *Prosopis chilensis* and Cane (*Calamus rotang*) are also proliferating along the western edge and along freshwater bodies, respectively. Coconut, Tamarind, Mango and Palmyra patches can also be seen on the southern part of the island. Twenty-eight species of mammal (Manakadan et al 2013), 12 amphibian species, 34 species of reptile, 44 fish species, 51 species of butterfly and 125 species of bird (70 resident bird species, 33 winter migrant species from the Palearctic region/Himalaya, 12 species that migrate seasonally from the Eastern Ghats or other parts of India and 10 species of uncertain status due to a lack of records) have been recorded from this island. There has also been a decline in the population of some birds which include the White-Rumped Vulture (*Gyps bengalensis*) (Manakadan et al 2009). Sriharikota beach has been a regular breeding ground for Olive Ridley Turtles (*Lepidochelys olivacea*), with approximately 500 nests each year. In a study covering a 10 km stretch of the beach from the northern tip of Sriharikota to the mouth of Pedda Wagu during the 2003 and 2006 breeding seasons, 27 nests and 60 nests of Olive Ridley Turtles were recorded, respectively (Sivakumar et al 2011).

## ● TAMIL NADU

Tamil Nadu is the southernmost state of the country on the east coast of India, with an area of 130,058 km<sup>2</sup>. It has a coastline of about 910 km, which is the third longest in India, harbouring three important MPAs. These are Pulicat Lake Sanctuary, Gulf of Mannar Marine National Park and Point Calimere Sanctuary. A number of rivers drain into the sea on the coast of Tamil Nadu, including major rivers such as the Kaveri, Polar and Ponnaiyar. The Gulf of Mannar is also recognized as a Biosphere Reserve under UNESCO's Man and Biosphere (MAB) programme.

● **Pamban Island** is also sometimes referred to as Rameshwaram Island due to the presence of the famous Hindu temple. Pamban Island is situated between latitudes 9°11' N and 9°19' N and longitudes 79°12' E to 79°23' E. A chain formed by Pamban Island, the shoals of Adam's Bridge and Mannar Island, of Sri Lanka, separate Palk Bay and the Palk Strait, in the northeast, from the Gulf of Mannar, in the southwest. Pamban Island is about 30 km wide and 2 km long at the Dhanushkodi promontory, 7 km from Rameshwaram. The area of the island is around 67 km<sup>2</sup>. Forty-five angiosperm plant species were recorded and identified by Balakrishnan et al (2012) during a survey in Pamban. Eighty-seven percent of the plant species recorded in the study were indigenous species. Earlier, Blasco (1975) recorded mangroves such as *Excoecaria agallocha* and *Ceriops tagal* in the island. Magdoom et al (2009) studied macrobenthic fauna from the backwaters of the island. The study highlighted the dominance of gastropods and polychaetes in the Pamban and Rameshwaram backwaters, respectively. Five species of angel fish belonging to three genera, namely *Apolemichthys xanthurus* (Smoke Angel), *Centropyge nox* (Midnight Angel), *Pomacanthus semicirculatus* (Koran Angel), *P. annularis* (Blue Ring Angel) and *P. imperator* (Emperor Angel) were recorded from Rameshwaram Island during a recent study (Rajeshwari & Thangavel 2014). Fishing capture of threatened species such as the Olive Ridley (Kasinathan 1988) and Leatherback (Pillai et al 1995) turtles has also been reported from the island.



Fig 5 : Rameshwaram

Neeraj Khera

- **Gulf of Mannar Group of Islands** most of the coastal islands of Tamil Nadu belong to the Gulf of Mannar region, which is one of the world's richest regions in terms of marine biodiversity. In 1989, the Gulf of Mannar was declared as the first marine biosphere reserve in Southeast Asia, with an area of 10,500 km<sup>2</sup>. A part of it was designated as a protected area, the Gulf of Mannar Marine National Park, which lies between latitudes 8°47' and 9°15' N and longitudes 78°12' and 79°14' E. Gulf of Mannar Marine National Park (GoMMNP) comprises 21 islets that harbour diverse ecosystems such as mudflats, beaches, algal beds, sea grasses, coral reefs, salt marshes and mangroves. These 21 islands, with areas ranging from 0.25 ha to 130 ha, are 1-10 km away from the mainland coast of Tamil Nadu. Over 3600 species have been recorded from the region, including many endemic mangrove species, corals and the globally endangered Sea Cow (*Dugong dugon*).
- The sandy shores of these islands are visited by several migratory birds, nesting sea turtles (Chacko 1942) and numerous invertebrate species, including *Balanoglossus* sp. These islands form a stopover between Chilika Lagoon, Point Calimere and Sri Lanka for migratory birds. The nearly 180 birds found here include the Lesser Sandpiper, Curlew Sandpiper, Little Stint, Red Knot, Eastern Knot, Crab Plover, Bar-Tailed Godwit, Broad-Billed Sandpiper, Dunlin, Long-Toed Stint, Red-Necked Phalarope, Little Tern, Kentish Plover, Stone Plover, Stone Curlew and Lesser Crested Stern. Many Greater Flamingoes breed here, during winter, before returning to the Rann of Kachchh (<http://www.forests.tn.nic.in/>).
- About 20 mangrove species have been recorded from these areas, with *A. marina* as the dominant species (Untawale 2006). Blasco (1975) recorded mangroves such as *Excoecaria agallocha* and *Ceriops tagal* from the Rameshwaram and Gulf of Mannar islands. In addition, Jeganathan et al (2006) reported 10 true mangroves and 24 mangrove-associated species from the islands in the GoMBR. Over 180 species and 99 genera of marine algae (Rao 1972) and 12 species and 7 genera of sea grass (Jagtap 1991) have also been reported from the Gulf of Mannar and Palk Bay. A region of high fish diversity, the GoM alone accounts for 450 of the 2200 fish species recorded from Indian waters. Moreover, up to 79 species of crustacean, 108 species of sponge, 260 species of mollusc and 100 species of echinoderm also occur in the region, including the islands (UNDP 2001).
- About 91 species of coral belonging to 37 genera have been identified from the fringing coral reefs, which are discontinuously distributed along the islands. Sukumaran and George (2010) investigated the coral reef cover around the GoM islands. Their study revealed that the highest and lowest average coral cover percentages were 60.8% and 13.9%, around Shingle and Pullivasal islands, respectively. Krusadai Island was reported to harbour the greatest number of hard coral species (35 species), among which *Acropora formosa* was most abundant. The species richness of the other islands are Manauli, 30; Hare, 25; Shingle, 23; and Pullivasal, 11. Referred to as a biologist's paradise, Krusadai Island is one of the most biologically rich islands of the region, harbouring three species of sea grass that are endemic to it. It also serves as a habitat of the only living connecting link between vertebrates and invertebrates, *Balanoglossus (Ptychodera flava)*, UNDP 2001).
- Among the other invertebrates, the molluscs have been relatively better studied in and around the GoM Islands. Hameed and Somasundaram (1998) identified 55 species of bivalve belonging to 2 subclasses, 4 orders and 18 families. A recent survey of the molluscan diversity of the islands carried out by Deepak and Patterson (2004) revealed the presence of 5 species of polyplacophoran, 5 species of scaphopod (first records), 174 species of bivalve, 271 species of gastropod and 16 species of cephalopod. Meenakshi & Senthamarai (2013) surveyed the diversity of ascidians in the GoM and reported the presence of 10 families. Twelve new genera and 303 new species were added to the inventory of the GoM, taking the total species diversity in the region to 372, including 170 ascidian species new to science. A study on the macrobenthic diversity of the islands in the GoM revealed higher abundances of bivalves and polychaetes in Shingle Island and Krusadai Island, respectively (Magdoom et al 2009).
- Jeyabaskaran and Khan (2007), who investigated the brachyuran crab diversity in the GoM islands, reported the greatest abundance, of 32 species, in Manauli Island, and the lowest abundance in Karaichalli Island (18 species). Seventeen species of porcellanid are also known from the intertidal-to-shallow-subtidal waters of the GoM (Prakash et al 2013).
- Venkatraman et al (2013) reported 44 echinoderm species from the GoMBR, of which species such as *Astropecten monacanthus*, *Anthenea pentagonula*, *Pentaceraster mammillatus*, *Protoreaster lincki*, *Stomopneustes variolaris*, *Salmacis bicolor*, *Salmacis virgulata*, *Temnopleurus alexandri*, *Brissus latecarinatus*, *Holothuria (Halodeima) atra*, *Holothuria (Metriatyla) scabra* and *Stichopus hermanni* were evenly distributed all over the GoMBR. Species such as *Clypeaster rarispinus* were found only in the Vembar group of islands, and *Astropecten indicus*, *Echinaster purpureus* and *Toxopneustes pileolus* were restricted to the Thoothukudi group of islands. This study also reported some new species from the GoM, such as *Pentaceraster mammillatus*, *Echinothrix diadema*, *Temnopleurus alexandri*, *Clypeaster rarispinus*, *C. reticulatus*, *Brissus latecarinatus* and *Stichopus hermanni*.



- Recently Rajeswari and Thangavel (2014) recorded a high abundance of marine angel fishes from the Kilakkarai and Tuticorin areas compared with other regions along the Tamil Nadu coast. Five species belonging to three genera, namely *Apolemichthys xanthurus* (Smoke Angel), *Centropyge nox* (Midnight Angel), *Pomacanthus semicirculatus* (Koran Angel), *Pomacanthus annularis* (Blue-Ring Angel) and *Pomacanthus imperator* (Emperor Angel) were recorded from these islands during the study. Four fish species, namely *Rhinobatos variegatus*, *Enchelycore tamarae* (Mandapam coral reef, Krusadai Island), *Leiognathus striatus* (Pamban, Mandapam and Kilakarai) and *Lalmohania velutina*, found in the GoM region are endemic to the east coast of India (Sekhar 2013). Kumar et al (2013a) recorded 117 species of reef fish under 79 genera and 42 families from the Thoothukudi and Vembar groups of islands. Of these, 41 species were from Vaan Island, 38 species from Koswari Island, 73 species from Kariyachalli island, 84 from Upputhanni Island, 52 species from Pulivinichalli Island and 57 species from Nallathanni Island.
- After a pioneering study, Lobo (2006) reported 11 species of sea snake (*Hydrophis cyanocinctus*, *Hydrophis (Microcephalophis) gracilis*, *Hydrophis fasciatus fasciatus*, *Hydrophis lapemoides*, *Hydrophis ornatus ornatus*, *Hydrophis spiralis*, *Lapemis curtus* and *Thallasophina viperina* (family Elapidae); *Acrochordus granulatus* (family Acrochordidae); Dog-Faced Water Snake *Cerberus rynchops* (family Colubridae); and *Pelamis platurus* (family Elapidae). All these were first records from the area in and around these islands. Sea turtles have also been reported to nest in the islands of the GoM. During the 1960s, over 3000-4000 turtles were caught every year in the area between Pamban and Kanyakumari. The islands of Pamban and Kilakarai were some of the main fishing centres, and the catch consisted primarily of Green Turtle *Chelonia mydas*, Olive Ridley Turtle *Lepidochelys olivaceae* and Loggerhead Turtle *Caretta caretta* (Rajagopalan 1996).
- Among the marine mammals, the Sea Cow *Dugong dugon* is the most threatened species found in the region. GEER Foundation estimated its population to be between 77 and 158 individuals in the GoM (Pandey et al 2010). Cetaceans have also been reported from the waters around the islands, including stranded individuals (Kasim & Balasubramanian 1989; Lipton et al 1995) and opportunistic sightings (Afsal et al 2008).
- **West Coast of India** The western coastal plain is a 50-100 km wide strip of land sandwiched between the Western Ghats and the Arabian Sea. It extends from Gujarat, in the north, through Maharashtra, Goa and Karnataka to Kerala. Numerous perennial rivers, such as the Narmada, Tapi and Mandovi, originating in the Western Ghats inundate the region and meet the sea at estuaries. The northern part of the coast is known as Konkan and extends from Maharashtra to Goa. The central stretch is called the Kannada Plain (Karnataka), while the southern part is referred to as the Malabar coast. The Gulf of Khambat and the Gulf of Kachchh are located in the northernmost state, Gujarat. Important protected areas on the coast include the Gulf of Kachchh Marine National Park, in Gujarat, and Malvan Sanctuary, in Maharashtra.

## ● GUJARAT

Gujarat, a state in the northwestern part of India, has a coastline of 1650 km (21.9% of the Indian coastline), which is the longest among all the maritime states of India. Its continental shelf occupies 1,65,000 km<sup>2</sup>, or 35.3% of the area of the Indian continental shelf (4,68,000 km<sup>2</sup>). The coastline has two indentions, the Gulf of Khambhat and the GoK (FSI 1999). The major ecosystems of the coastal wetlands in Gujarat include mangroves (1031 km<sup>2</sup>), coral reefs (130.2 km<sup>2</sup>), mudflats (21,913.7 km<sup>2</sup>), beaches (106.1 km<sup>2</sup>), rocky areas (20.7 km<sup>2</sup>) and salt pans (459.5 km<sup>2</sup>) (Garg et al 1998).

- **Gulf of Kachchh group of islands** The (GoK, about 170 km long and 75 km wide at its mouth, is an indentation on the northwest coast of India, oriented in the east-west direction, covering an area of about 7350 km<sup>2</sup> and having a volume of 220,000 million m<sup>3</sup>. It has one of the four major reef systems of the country on its southern shoreline. This area, which extends from Okha (22°30' N, 69°00' E), in the west, to Navlakhi (22°30' N, 70°40' E), in the east, is rich in marine wealth and biodiversity. Therefore, in 1980, the Government of Gujarat declared part of the GoK as the first marine national park of India to protect the marine biota of the area (Chhaya & Patel 1997). Bordering the GoK, at its head, is the Little Rann of Kachchh, a dry, saline, flat region. The GoK represents a complex setup in a macro-tidal region, marked by the presence of shoals, channels, inlets, creeks and islands (Kunte et al 2005). The spectacular biodiversity in this area is attributed to the availability of different types of habitats in the demarcated area. The ecosystem of the GoK, consisting of fringing reefs, patch reefs, mud and mangrove swamps, corals, shallow muddy banks and mangroves, serves as nurseries for fishes (Patel 1988). A chain of islands and islets (an islet is a small island), are clustered in the southern Gulf, near the Saurashtra coast, and provide a uniquely productive habitat for a diverse and colourful variety of life forms (Biswas, no date). According to official records, there are 42 islands and some islets in the GoK, covering a total area of about 410.6 km<sup>2</sup>. These islands and islets are varied in their size, with many of these partially submerged in the water and quite a few being fully submerged during the normal period. These submerged islands (e.g. Dona, Boria, Pashu islands) are, however, exposed during

the 'minus tide'. Among all the islands, only two have human habitations, namely Beyt and Ajad. And out of 42 islands, coral is present in 25 islands and mangrove cover is found on 16 islands. Bural-Chank, Kalumbhar, Paga, Chindri, Narara and Pirotan are the islands with rich coral reefs. The habitat diversity supports a rich biological diversity including 174 species of alga, 10 species of mangrove, 365 species of fish, 129 species of aquatic bird, 8 species of reptile, 5 species of marine mammal, 69 species of sponge, 102 species of coelentrate (including 68 species of coral), 357 species of mollusc, 115 species of arthropod (including 71 species of crab and 33 species of prawn), 35 species of echinoderm (including 10 species of sea cucumber and 6 species of star fish and 58 species belonging to minor phyla (Dixit et al 2010b).

- Pirotan Island (also known as Pirothan), is located at 22°34' 40.4" N, 69° 59' 07.3" E. It has an area of 504.18 ha. It is located in the core area of the Gulf of Kachchh Marine National Park and Sanctuary (MNPS), in Jamnagar District. It is located 12 nautical miles (22 km) off the coast and has an area of 3 km<sup>2</sup>. It consists of mangroves and low-tide beaches. A study conducted by Maria and Sridhar (2002) revealed that Pirotan Island consist of mixed wood and core group fungi like *Aigialusparvus* (11.3%) and *J. avicenniae* (13.3%) out of sample size of 150. A comprehensive study by Singh et al (2004) indicates that sea grasses are abundant at Pirotan Island. According to a case study (Biswas, no date), Pirotan's corals are suffering heavy damage as they often get crushed under the feet of visitors. A study conducted by the Gujarat Ecological Education Research Foundation by (Singh et al. 2006) found that as far back as 1992-1993, the mangrove areas of Pirotan Island (under the MNPS) were covered with oil, which destroyed over 3 ha of mangroves. The study also pointed out that, oil covering the surfaces of other islands in the park indicate the occurrence of spills because of inadequate monitoring. Sea grass meadows in the island waters (Kamboj 2014) support herbivorous marine megafauna and may be important feeding sites for some critically threatened species such as the Dugong and Green Turtle (Pandey et al. 2010; Kumar et al 2013). *Thalassia hermprichii* and algae have also been mapped on the coastal reef flats of Pirotan.

- The natural species diversity of the island, which is rich with fringing coral reefs and mangroves, attracts several thousand tourists each year. About 7000 tourists visited Pirotan Island in 2006-2007. The 1994 MNPS management plan had proposed that Pirotan be designated a Zone 1A Area, that is, an area under the highest protection within the MNPS, closed to all activity except scientific research, visits for religious reasons, fishing and afforestation. Unfortunately, this zoning plan was never implemented, whereas the island was opened to tourism. Park authorities believe that only environmentally aware tourists will take the effort to visit the remote island of Pirotan (Biswas, no date) and that the chances of environmental degradation were therefore minimal.

- **Diu (Union Territory of Daman & Diu)** The Diu island (20° 44' - 20° 42' N and 71°00' - 70°52' E), a part of the Union Territory of Daman and Diu, lies off the coast of Kathiawad near the Port of Veraval in southern coast of Saurashtra (Gujarat) with a coastline of 21 km. It is a tiny island, situated just 6 m above sea level, spread over an area of about 37 sq. km, geologically composed of sand, silt, limestone deposits and back-waters of the sea (Mathur & Verma 1979). It is separated from the mainland by a narrow creek of about 250 meters width. Diu is bordered by Junagadh and Amreli districts of Gujarat in the North and by the Arabian Sea in the south (<http://diu.gov.in>).

- Diu forest range is spread over 516.7 Ha area classified as a reserve forest, planted with Casuarina trees which prevent coastal erosion. Vegetation cover of the island is dominated by Hoka *Hyphaene Dichotoma* tree, an endemic species in Daman & Diu (<http://diu.gov.in>). About 219 Ha of marshy area in Diu has been declared as a protected area known as Fudam Wildlife Sanctuary (or Fudam Bird Sanctuary). The mangrove regions of the sanctuary are feeding and spawning grounds for many bird, fish, mollusc and crustacean species. The site experiences dry and arid climate with regular high and low tidal inundation flushing entire mudflat and mangrove area. The monospecific mangroves of *Avicennia marina*, the salt marsh vegetation covering at fringes of the mudflat and creeks and algal mat are the important saline tolerant flora besides other dry tropical tree species.

- Fishing and fishery related processing are one of the important economic activity in Diu coastal area. However, coastal tourism operation is the main industry which supports the island inhabitants. The mangrove and rocky shoreline is open for tourism operation and related activities and thus is under pressure. Tourism related activities and illegal hunting are the two important observed threats around this site.

## ● MAHARASHTRA

Maharashtra's coastline, also called Konkan, stretches over a length of 720 km along the Arabian Sea. The Konkan coastal plains vary in width from 50 to 80 km and lie between the Arabian Sea and the Sahyadri Range. Their elevation is less than 200 m. Malvan Marine Sanctuary lies at the southern tip of the coast and is an MPA. Most of the islands in the state belong to Raigad District. They are discussed below.

- **Elephanta Island** has an area of 16 km<sup>2</sup>, and it is located approximately at 18°57' N, 72°56' E (18.95° N, 72.93° E). The area comes under the jurisdiction of Raigad District. Elephanta Island (also called Gharapuri Island, 'place of



caves') is one of the islands in Mumbai Harbour, east of Mumbai, India. The name *Elephanta* was given by 17th century Portuguese explorers, after they saw a monolithic basalt sculpture of an elephant near the entrance (Pradhan 1957). It is a protected island, with a buffer zone according to a notification issued in 1985, which also includes "a prohibited area' that stretches 1 km from the shoreline. The island has a population of about 1200, and the main occupations are rice farming, fishing and repairing boats (Pradhan 1957). The foreshore is made up of sand and mud, with mangrove bushes on the fringe. The vegetation of this island was studied by John Graham, who wrote the first catalogue of plants of Bombay Presidency, in 1839 (Almeida 1996). There were about 359 species of plants (Rajbhar, unpublished data). The forest vegetation is of a mixed type. Forest growth and clusters of Mango, Tamarind and Karanj trees covered the hills. There were scattered palm trees. Rice fields were seen in the valley (Pradhan 1957). The flora of Elephanta Island is rich and diverse. Yet it is constantly under threat since the place is a tourist spot. Species such as *Litsea* spp., *Crataeva tapia* Linn. and *Aerides praemorsum* Willd. are found on Elephanta Island (Rajbhar, unpublished data).

Fig 6 : Fishermen in Chilika Lake

Thameem Ansari



- **Murud-Janjira Island** is spread over around 22 acres. It is located approximately at 18°17' N, 72°57' E. It is located in Raigad District. Murud-Janjira Island is actually a fort situated on an oval-shaped rock off the Arabian Sea coast near the port town of Murud. It was built by Siddhis during 1567-1571. Despite several attempts made by the Portuguese, the British and the Maratha kings, no one could wrest this fort from the Siddhis. This fort has all facilities in it, such as a king's palace and two freshwater ponds. Now this around 400 year old fort is in bad shape but still intact, with lots of plants growing on it. During a visit to this island, around 50 species of angiosperms were recorded. Also a few species of *Ficus* could be seen growing on the wall of the fort, such as *Ficus asperima* Roxb. *Ficus parasitica* Koen ex Willd. and *Ficus virens*. The forest vegetation is dry and of the scrub type (Rajbhar, unpublished data).

- **Padamdurg Island** has an extent of 16 acres. It is located at approximately 18°19' N, 72°55' E. It is located within Raigad District. Padamdurg is actually an incomplete fort built by Shambhaji to keep an eye on Murud-Janjira as he had a desire to annexe it. But he had to go to Raigad to save his main fort from the enemy. This island is around 5 km from the Murud coast. Around 57 species of angiosperms could be recorded here on a visit (Rajbhar, unpublished data). Some of the interesting species that were recorded here were *Enicostemma littorale* Blum., which is a plant with many medicinal uses, tree species such as *Azadirachta indica* L., *Manilkara hexandra* (Roxb.) Dubard, *Lannea coromandelica* (Houtt.) Merr. and *Bombax ceiba* L. (Rajbhar, unpublished data). Many herbaceous species such as *Indigofera cordifolia* Heyne ex Roth. and *Tridax procumbens* Linn. were also found (Rajbhar, unpublished data).

- **Khanderi** is spread over approximately 32 acre. Khanderi Island falls within Raigad District. Khanderi Island is located at approximately 18°42'227" N, 72°49'799" E. It is accessible from Thal village, of Alibaug, by boat. Khanderi is famous for an old lighthouse of the navy and the first lighthouse of Mumbai Harbour in the Arabian Sea. Khanderi Island is frequently visited by local fishermen because they have their deity in Viataleshwar Temple (Rajbhar,

Fig 7 : Murud-Janjira Island

 Anil Rajbhar


Fig 8 : Padamdurg Island

 Anil Rajbhar


unpublished data). Khanderi fort is around 2 km away from Underi fort. Khanderi Island has around 52 species of angiosperm (Rajbhar, unpublished data). The most common among them are *Ficus* species and *Sauromantum venosum* (Dryand. ex Aiton) Kunth. Dried remains of *Curcuma* spp. was also recorded from here (Rajbhar, unpublished data).

- **Underi Island** has an area of approximately 20 acres. It is located in Raigad District. Underi Island is located at approximately 18°42'384" N, 72°50'491" E. Underi is accessible from Thal village, of Alibaug, by boat. Underi Island is around 5 km from Thal village in the Arabian Sea. It has around 36 species of angiosperm and 1 species of pteridophyte (Rajbhar, unpublished data). Most of this fort comes under water during the rainy season, and so plants are seen only at the boundaries. The pteridophyte *Ceratopteris thalictroides* (L.) Brongrn. and the smallest angiosperm, *Wolfia* species, were found in a freshwater pond.

- **Islands at Vengurla Rocks.** An archipelago of 20 islands is located around 14 km west to northwest of Vengurla town in Sindhudurg district, Burnt Island being the largest island. Sea grasses such as *Cymbopogon species*, *Celosia argentea* and *Mollugo sperbula* have been recorded. These islands support a colony of over 18,000 Indian Edible-Nest Swiftlets or Indian Swiftlets *Collocalia unicolor* and a breeding congregation of eight tern species (Common Tern *Sterna hirundo*, Roseate Tern *S. dougallii*, White-Cheeked Tern *S. repressa*, Bridled Tern *S.*



*anaethetus*, Sooty Tern *S. fuscata*, Large Crested Tern *S. bergii*, Lesser Crested Tern *S. bengalensis* and Indian River Tern *S. aurantia* (Pande 2002). This archipelago is inhabited, but there are reports of large-scale poaching of the Indian Edible-Nest Swiftlets (Pande 2002).

## ● GOA

Goa is the smallest state in the country, with a geographical area of 3702 km<sup>2</sup>. The coastline of Goa is 105 km long, comprising several major tourist destinations, visited by thousands of tourists from India and abroad every year. Since there are no notified MPAs in the state, the main emphasis is on sea turtle conservation activities along the coast (D'Souza, 2014).

- **Chorao Island** (15°32'17.22" N, 73°52'58.73" E) is located in between the Mandovi and Mapusa rivers in Ilhas, northern Goa (Nagi 2008). In 1985, a mangrove nursery was established on the western part of the island. In 1988, an area of extent 1.78 km<sup>2</sup> in the nursery was declared a bird sanctuary and called the Dr. Sálim Ali Bird Sanctuary after the famous ornithologist (SAC 2012). The area has naturally regenerated mangrove vegetation, which is over 30-40 years old, in a criss-cross network of water channels having tidal variations (SAC 2012). It is a suitable habitat for estuarine fishes, other marine fauna and birds. The mangrove swamps produce exceptional cover, vegetation and food in the form of numerous small insects and fish for many different breeds of local coastal birds and are a perfect resting ground for migrating birds from all around the world. Fourteen different species of mangrove have been reported from the island. These are *Rhizophora mucronata*, *Rhizophora apiculata*, *Avicennia officinalis*, *Avicennia alba*, *Avicennia marina*, *Bruguiera gymnorrhiza*, *Bruguiera cylindrica*, *Kandelia candel*, *Ceriops tagal*, *Sonneratia alba*, *Sonneratia caseolaris*, *Aegiceras corniculatum*, *Excoecaria agallocha* and *Acanthus ilicifolius* (SAC 2012). There are also 6 species of alga, 13 species of fish (Nagi 2008), 115 species of bird, of which 59 are terrestrial, 56 aquatic, 64 resident (including herons, drongos, eagles, kites, kingfishers, the Baya (weaver birds), Purple Sunbird, egrets, the Tailorbird, the Grey-Headed Myna, the Red-Wattled Lapwing, the Common Redshank, the Common Sandpiper, the Green Bee-eater and the Pheasant-Tailed Jacana), 39 long-distance migrants (Northern Pintail, cormorants, Mallard, Purple Moorhen and storks) and 11 local migrants. Threatened avifauna of the island include *Anastomus oscitans* (Asian Openbill), *Leptoptilus dubius* (Lesser Adjutant) and *Aythya nyroca* (Ferruginous Pochard) (Borges 2002). In addition, some reptiles (Indian Rock Python and crocodiles) and mammals (Smooth Indian Otter, Flying Fox and Jackal) have also been reported from the island. One species of nematode, 18 species of polychaete, 7 species of crustacean and 6 species of mollusc have also been documented. The benthic vegetation of the island includes two algal species, *Dicotomosiphon salinas* and *Enteromorpha flexuosa*, and a single angiosperm, *Halophila beckerri* (Borges 2002).

- **Divar Island** (15°31'40.08" N, 73°54'23.12" E) is an estuarine island located in the Mandovi River. It divides the river in two, the smaller Narve River and the bigger Mandovi River, in northern Goa. It spreads over an area of 0.57 ha and has a mudflat area of 1.28 km<sup>2</sup>. Beds of *Meretrix casta*, *M. ovum* and *Crassostrea edulis* have been recorded on the banks of the Narve River. The island is fringed by mangroves along its entire length. *Avicennia marina* and *Sonneratia alba* are the dominant mangrove species and can be seen bordering the sandflats. *A. officinalis*, *A. ilicifolius*, *S. caseolaris*, *Kandelia candel* and *Excoecaria agallocha* have also been documented from the island. *Acanthus ilicifolius* can also be seen growing with the mangrove bushes. *Clerodendron inerme*, *Caesalpinia nuga* and the grasses *Cyperus malaccensis*, *Cyperus rotundus* and *Cyperus quinquesetica* are found in the inner, dryer parts of the island. The benthic vegetation of the island includes two algal species, *Dicotomosiphon salinas* and *Enteromorpha flexuosa*, and a single angiosperm, *Halophila beckerri*. One species of nematode, 23 species of polychaete, 15 species of crustacean and 9 species of mollusc have been recorded from the island. There are 93 species of bird, of which 41 are terrestrial, 52 are aquatic, 47 are resident, 36 are migratory and 9 are locally migratory. *Anastomus oscitans* (Asian Openbill), *Leptoptilus dubius* (Lesser Adjutant), *Threskiornis melanocephalus* (Oriental White Ibis), *Haliaeetus leucoryphus* (Pallas's Fish-Eagle) and *Sterna acuticauda* (Black-Bellied Tern) are the threatened avifauna of the island (Borges 2002).

- **Jacinto Island** (Juer) is situated near Vasco city of Goa. It is 1.5 km inside from the coast (15°24'15" N, 73°51'53" E) and has an area of about 15 acres. Jacinto Island was named after St. Jacinto Church. Its population is about 1000. Fishing is the occupation. Previously, people used to walk across to Jacinto Island during low tide, but a new bridge was constructed in 2009. A total of 440 plant species have been recorded (Rajbhar, unpublished data). Though it is an island, no mangroves grow on the periphery of the island. This may be due to the rocky shore and the lack of marshy soil. The flora of this island resembles the inland flora of the Konkan coast. Some of the plant species belonging to the evergreen forests of higher altitudes are also found growing on Jacinto Island, e.g. *Alseodaphne semicarpifolia* Nees (Almeida 1996).

- **Cumbarjua** (15°30'36"N, 73°57'3"E) is an island town in the middle of the Mandovi River. It is situated 20 km to the east of Panaji and has an area of 2.4 km<sup>2</sup>. Crocodile sightings are a common feature along the Cumbarjua canal

but these animals are an absolute rarity in the rest of the state. The vegetation of this island is of a mixed type. The island is surrounded by many species of mangrove, in contrast to Jacinto Island. About 413 species of plant have been recorded from here (Rajbhar, unpublished data). The vegetation is thick in patches due to a high population density. Mangrove species such as *Rhizophora mucronata* Poir and *Bruguiera gymnorrhiza* Lamk. are present here (Rajbhar, unpublished data). Due to loss of habitat, the flora of Cumberjua Island remains restricted to small patches of rich vegetation. The greatest number of mangrove species among all the islands of Goa is found in Cumberjua Island.

## ● KARNATAKA

Karnataka is situated between latitudes 11°31' and 18°45' N and longitudes 74°12' and 78°40' E and lies in the west-central part of peninsular India. It has a coastline of about 300 km from Talapadi, in the south, to Karwar, in the north. There are five islands along the coastline, namely, Devgad, Kukre, Kurmagad, Netrani and St. Mary's. We describe here only two of these islands, Netrani and St. Mary's, owing to a lack of information on the others.

- **Netrani Island** is a tiny island in the Arabian Sea (14°01'667" N, 74°31'667" E) located 10 nautical miles (19 km) from the coast of Murudeshwar, Karnataka. The island is uninhabited. It emerges straight from the sea, with rocky edges and without any sandy beaches around it. Also known as Pigeon Island, it has wild goats as inhabitants, besides pigeons. It is home to endangered coral reefs, varieties of shrimps and fishes such as the Butterfly Fish, Trigger Fish and Parrot Fish apart from eels. There are also reports of divers sighting Killer Whales and Whale Sharks near the island waters ([www.daijworld.com/news](http://www.daijworld.com/news)).

- A study conducted by Central Marine Fisheries Research Institute (Zacharia et al 2006) found the benthic coverage by hard coral on Netrani Island to be 14.7%, by algae 63.2%, by boring polychaetes 13.3% and by mussels 0.3%. This study first reported the existence of giant clams from the west coast of India. Twelve species of coral (*Porites* sp., *Favia favus*, *Pocillopora* sp., *Pocillopora verrucosa*, *Goniastrea pectinata*, *G. retiformes*, *Goniopora* sp., *Plesiastrea versipora*, *Coscinaraea monile*, *Turbinaria* sp., *Leptastrea* sp. and *Dendrophyllia* sp.) were also identified from the island. The coral reef habitat was rich in nudibranchs, Blue Trigger Fish, groupers, Parrot Fish, gobies, Lion Fish and Scorpion Fish. Another threatened fish species, the Napoleon Wrasse (*Cheilinus undulatus*) was reported from the island. Several grouper species such as *Aetheloper caroga*, *Cephalopholis sonnerati* and *Epinephelus longispinis* were recorded for the first time from the island. Dineshababu and Zacharia (2007) reported a significant assemblage of marine ornamental shrimps, *Rhynchocinetes durbanensis*, known as Dancing Shrimp, associate fauna of giant clams, from the island along with many rare ornamental fishes.

- A study conducted by Sujitha et al (2011) found a total of 69 fish species belonging to 39 genera, 19 families and 3 orders in the waters of Netrani. The family Balistidae dominated the fish fauna (22%), followed by Pomacentridae (12.5%), Caesionidae (9.7%), Labridae (7.8%), Acanthuridae (7.3%), Haemulidae (6.7%), and Scaridae (6.1%). The other major groups of fish species were Siganidae (4.2%), Chaetodontidae (3.2%), Lutjanidae (2.9%), Gobiidae (2.8%), Pomacanthidae (2.6%) and Zanclidae (2.5%). The minor groups included Carangidae (1.8%), Serranidae (1.8%), Holocentridae (1.5%), Synodontidae (1.1%), Muraenidae (1.0%), Mullidae (0.9%) and Tetraodontidae (0.8%).

- Zacharia et al (2008) found the existence of a patchy reef surrounding this island in which there were 14 coral species belonging to 11 genera. The other flora and fauna comprised fishes (92), seaweeds (7), sponges (6), jellyfish (2), holothurian (1), nudibranchs (7), zooplankton (25), bivalves (15), phytoplankton (16), gastropods (48), cephalopods (3), crabs (17), shrimps (2), lobsters (4), etc. Twenty-six species of fishes recorded from this island reef area were found to be new records from the Indian coast. Two IUCN Red Listed fish species, the Humphead Wrasse (*Cheilinus undulatus*) and the Whale Shark (*Rhincodon typus*) and a mollusc, the Giant Clam (*Tridacna maxima*), were reported from the reef. The report of the Giant Clam was the first report on its occurrence in peninsular Indian waters. Netrani is also internationally acclaimed as a recreational diving site. The Indian Navy also uses the island as a practice ground for shooting and shelling (Zacharia et al 2008), which may be damaging the coral reef patches.

- **St. Mary's Island** is a group of four small islands, located at 13°38' N, 74°68' E and spread over a distance of 4 km from north to south. The northernmost island, Coconut Island, is about a square mile in area and about 230 m in width. It is composed of basalt rocks that have crystallized into 10 m high columns of 10 m and split into hexagonal mosaic (Naganna 1966). The continental shelf off Karnataka, where these group of islands are located, has on average a width of 80 km. The coastline at Honnavar and Malpe is inclined 17° to the west from the true north, with the depth contours aligned approximately parallel to the coastline. In a study conducted by Kaladharan et al (2011), 12 locations from the island eco-systems along the Karnataka coast were assessed during low tide to understand the seasonal distribution of planktonic algae (phytoplankton), macroalgae (seaweeds) and submerged flowering plants (seagrasses). It was found that the islands have 76 species of seaweeds and 60 species of phytoplankton, while seagrasses were absent from the islands. The coast is exposed to seasonally reversing monsoon winds, with



winds from the southwest direction during the southwest (summer) monsoon and from the northeast during the northeast (winter) monsoon period. The tides in the region are mixed and are predominantly semidiurnal. The tidal range increases slightly from south to north (Kumar et al 2011). St. Mary's Island is uninhabited by humans. The local fishermen and fishermen from Kerala exploit large-sized mussels for human consumption.

## ● KERALA

Kerala extends from 8°18' N to 12°48' N latitude and from 74°52' E to 77°22' E, with an area of 38,863 km<sup>2</sup>. It has a coastline of 590 km lying wedged between the Western Ghats, in the east and the Lakshadweep Archipelago, in the west. The width of the coastal belt ranges from 11 to 121 km. Kerala's coastal belt is inundated by many small rivers and interconnected brackish water canals, lakes and estuaries. All the backwater islands in Kerala have been brought under the CRZ in order to protect the unique coastal system of backwaters and backwater islands (CRZ 2011).

- **Cochin Group of Islands** is a coastal city located on the southwestern coast of India in Kerala. 'Cochin Islands' (9°59'09.42" N, 76°15'12.78" E) refers to the islands off Cochin, namely Vypeen, Vallarapadam, Bolghatty and many smaller islands. The total area of these three islands is 56.95 km<sup>2</sup>. Vypeen is the biggest island, with a total area of about 51.49 km<sup>2</sup>. It is bounded by the Arabian Sea on the western side and the Cochin backwaters on the eastern side. Bolghatty Island has a total area of 2.61 km<sup>2</sup>, and Vallarapadam Island, which lies between Vypeen and Bolghatty, has an area of about 2.8 km<sup>2</sup> (ICMAM 2002). The Cochin backwaters, which surround Bolghatty and Vallarapadam on all sides and Vypeen Island on the eastern side, are a chain of lakes and canals with a total area of about 157 km<sup>2</sup>. Two rivers, the Periyar and Muvattupuzha, discharge themselves into these backwaters. The Cochin backwaters have been notified as an Ecologically Sensitive Zone by the Government of India (ICMAM 2002). The flora and fauna of the Cochin backwaters are both very rich in species diversity. About 685 species have been recorded in total, comprising 194 species of phytoplankton, 135 species of zooplankton, 199 species of benthos and 150 species of fishes (ICMAM 2002). Twenty-three species of mangrove have been recorded from an area of approximately 7 km<sup>2</sup> on these islands. The dominant species of the islands are *Avicennia marina*, *A. officinalis*, *Excoecaria agallocha*, *Clerodentron* spp., *Aegiceras corniculatum*, *Rhizophora appiculata* and *Acanthus ilicifolius* (ICMAM 2002). Fifty-seven species of bird were recorded from the area. The House Crow (*Corvus splendens*), Little Cormorant (*Phalacrocorax niger*), Darter (*Anhinga melanogaster*), Black Kite (*Milvus migrans*), Brahminy Kite (*Haliastur indus*), Common Myna (*Acridotheres tristis*), Indian Pond Heron (*Ardeola grayii*), Indian Cormorant (*Phalacrocorax fuscicollis*), Little Egret (*Egretta garzetta*) and Intermediate Egret (*Mesophoyx intermedia*) were the most common species. The Ashy Drongo (*Dicrurus leucophaeus*), Chestnut-Tailed Starling (*Sturnus malabaricus*), Common Sandpiper (*Actitis hypoleucos*), Common Redshank (*Tringa totanus*), Grey Heron (*Ardea cinerea*), Marsh Sandpiper (*Tringa stagnatilis*), Greenish Warbler (*Phylloscopus trochiloides*), Blyth's Reed-Warbler (*Acrocephalus dumetorum*), Wood Sandpiper (*Tringa glareola*), Common Greenshank (*Tringa nebularia*) and Marsh Sandpiper (*Tringa stagnatilis*) were the seasonal visitors to the area. There were 14 species of reptile, with the Indian Black Turtle (*Melanochelys trijuga*), Indian Flapshell Turtle (*Lissemys punctata*) and Checkered Keelback or Asiatic Water Snake (*Xenochrophis piscator*) were common. The Dwarf Gecko (*Cnemaspis* sp.), Dussumier's Little Skink (*Sphenomorphous dussumieri*) and Cat Skink (*Ristella* sp.) are endemic to the region. Four species of amphibian including the Bush Frog (*Philautus* sp.) are endemic to the region. Six species of mammal and 49 species of butterfly have also been recorded. Many of the butterflies are endemic and protected under various schedules of the Indian Wildlife Protection Act 1972. The Crimson Rose (*Pachlioptera hector*) and Danaid Eggfly (*Hypolimnas missippus*) are protected under Schedule-I, while Common Pierrot (*Castalius rosimon*), Malabar Banded Peacock (*Papilio buddha*), Southern Birdwing (*Troides minos*) and Common Gull (*Cepora nerissa*) are protected under Schedule-II. Another species, the Common Crow (*Euploea core*), is included under Schedule-IV. Twenty-nine food-/fruit-yielding plant species, 30 ornamental plant species, 29 medicinal plant species and 6 endemic plant species (*Artocarpus hirsutus*, *Hardwickia binata*, *Lagerstroemia microcarpa*, *Phyllanthus rotundifolius*, *Terminalia paniculata*, *Vateria indica*) have also been documented from the Cochin Islands (Azeez et al 2011).

## Discussion

Islands that are close to mainland India are critical in many ways to human beings. These islands are breeding grounds for several fishes, protect the sea shore from natural calamities such as cyclones and Tsunamis and provide livelihoods to thousands of coastal communities. Despite their tremendous ecological values, they have been ignored for several years. Gadgil (2004) reported widespread damage to corals in Netrani Island, an important habitat for seabirds, as it is used for target practice by the Indian Navy. Sriharikota Island has the last remaining tracts of tropical dry evergreen forest on the western coast due to the high security in the region, the government establishments may lead to cutting down the forest for construction of buildings and other facilities. Therefore, judicious steps are needed to conserve the forest and its



**Fig 9 :** Dead Tree

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wildlife in view of the proposed future expansions and development plans (Manakadan et al 2013). Sagar Island also faces severe threats from anthropogenic pressures such as pollution, tourism, agriculture, aquaculture, collection of wood for timber and firewood and fishing (Lakshmi and Edwards 2010). The Cochin Islands and the backwaters also face severe threats due to various anthropogenic pressures such as agriculture, fishing, intensive shrimp culturing, pollution from sewage and industry effluents, construction along the banks, reclamation of wetlands for various purposes, overexploitation of natural resources and construction of human-made structures such as bunds to prevent seawater intrusion (ICMAM 2002, SACON 2011). Most of the islands in the GoK face threats due to intense tourist activity. In 2006-2007, about 7000 tourists visited Pirotan Island, which is rich with fringing coral reefs and mangroves and is part of the national park's core area (Gujarat Forest Department 2008), leading to immense pressure on the island's biodiversity. The mangroves in Kori Creek of Kachchh and in various islands near the Jamnagar coast and adjoining mainland areas are quite stunted and poor in growth, mainly due to exposure to various levels of anthropogenic pressures (Dixit et al 2010).

Illegal capture and hunting of turtles has been reported from the GoM from very early times. Specially designed nets called *pachu valai* and *kattuvai* were used to catch turtles, and there was a regular trade in live turtles, turtle meat and turtle shell between India and Sri Lanka (Rajagopalan 1996). Though there has been a decrease in the illegal hunting of turtles with most of the area having come under protection, the status of turtles in the waters has reached a critical level. Habitat degradation, overfishing and turtle egg collection have exacerbated the threats posed to these large marine species (Chacko 1942; Bhupathy & Saravanan 2001; Murugan & Naganathan 2006) in the islands of the GoM, which once provided excellent nesting habitats. Similarly, Silas and Fernando (1985) mention the illegal hunting of about 250 Dugong individuals between 1983 and 1984 in Kilakarai and Periyapattinum villages. Indiscriminate poaching of the Dugong has also led to severe depletion of its population in the region (Sivakumar 2013). Sriharikota Island is a high-security area due to the presence of the satellite launching facility of ISRO, and because of this the island is an ideal refuge for nesting Olive Ridley Turtles. But predation by animals such as Jackals and Wild Boar and human activity such as egg collection by tribals, planting *Casuarina* and *trawling* along the coast are the major problems being faced by sea turtles, especially the Olive Ridley (Sivakumar et al 2011).

Overfishing in the areas of high marine biodiversity, especially around islands with coral reefs, is also a major threat, as evident from the fast declining fish catch in the GoM (Rajasuriya et al 2000; Bavinck & Vivekanandan 2011). Many forms of fishery exist in the GoM, such as reef fishery, pearl fishery, collection of ornamental shells and illegal mining of corals (Kumar et al 2013). Fishermen also harvest sea cucumbers, sea horses and pipe fish. Harvesting of turtles and Dugongs has also been reported quite often. Moreover, fish mortality has also been reported in the GoM, which has been attributed to industrial pollution (Asha et al 2009) and climatic change (Badrudeen et al 1987). Seaweed farming, a common occupation in the region, providing livelihoods to several coastal communities (Bhatt & Vivekanandan 2013), is also a disturbance to coastal habitats. According to a survey carried out by Dixit et al (2010), the major threats faced by the



islands in the GoK are commercial fishing within reef areas (close to a few sites near islands such as Pirotan and Kalumbhar, commercial fishing in offshore waters (excessive and unsustainable catch) and subsistence fishing in reef areas (physical damage to coral reef habitats, mostly caused by Pagadia fishermen, who sometimes use poison for fishing purposes).

Fig 10 : Fishing boats

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Earlier, illegal mining of corals for construction material was a serious hazard to the fringing reefs in the islands of the GoM. Islands such as Vilanguchalli, in the Thoothukudi group, and Poovarasanpatti Island, in the Kilakarai group, have been submerged in the past due to extensive quarrying for corals (Venkataraman 2000). Similar impacts are expected to be seen in the GoK area (Rajasuriya et al 2000). Other threats include proposed infrastructural activities such as construction of the Sethusamudram canal project for navigation of ships between the west and east coasts of India (Tripathy 2005). If cleared, this will involve large-scale dredging operations in the GoM that may result in smothering of corals (Rodriguez et al 2007). Sedimentation is also very high in the GoK area due to increasing discharges from the land (Rajasuriya et al 2000). Commercial coral collection (loss of live coral cover, habitat destruction), commercial oyster collection (overexploitation and failure of pearl oyster fishery), mangrove cutting, seaweed harvesting and extraction of construction material (habitat destruction) are also posing threats to the island coral diversity in the GoK (Dixit et al 2010). Increased sedimentation will also cause decreased water transparency, affecting the seagrass meadows, apart from the direct impacts of dredging. However, in the GoK, several reefs, including Pirotan Island, have been severely damaged by the extraction of limestone for cement and the associated siltation. Mining activity was legally banned in 1986 after the creation of the Marine National Park, but small-scale mining continued up to 1988 (Singh 2002). Due to these developmental impacts, there is a possibility of substantial damage to the reef ecosystem and consequently to the habitat of corals in the GoK. Although, there is no information on coral bleaching in the GoK (Rajasuriya et al 2000), those in the islands of the GoM have witnessed bleaching caused by several abiotic and biotic factors. Only 25% of the corals in GoM were reported to have survived the bleaching event of 1998 (Venkataraman 2000). Coral reefs in the GoM are also under stress due to overexploitation of algae and collection of shells by fishermen. Other than these, disturbances such as crab fishing, siltation from infrastructural activities, agricultural runoff, sewage discharge and chemical pollution are the major problems faced by the marine biodiversity of the islands in the GoM.

A climate change-driven sea level rise is expected to aggravate inundation, storm surges, erosion and other coastal hazards, threatening vital infrastructure in small islands. Over 2000 km<sup>2</sup> of coastal wetlands on the West Bengal coast are likely to be submerged, with islands such as Lothian experiencing over 50% inundation as the result of a less-than-1 m sea level rise (Islam et al 2013). Warming seas contributed to coral bleaching globally, including in the GoK. In 1998-1999 and 2005, the GoK suffered from coral bleaching, which resulted in widespread degradation of coral reefs and an estimated decline in the live coral cover of over 50% between 1982 and 2002. Gardner et al (2003) suggested that the average live coral cover has declined from between 25% and 30% percent of the area to about 10% in the GoK.

.Invasive species such as the Snowflake Coral *Carijoa riisei*, Crown-of-Thorns Starfish (*Acanthaster planci*) and *Kappaphycus alvarezii* (Red Alga) are also a problem in the coral reefs of the GoM (Chandrasekaran et al 2008;

Padmakumar et al 2011). These exotic species are carried in the ballast water of the ships using the two major ports in the region (Padmakumar et al 2011; Raghunathan et al 2013). Invasive species such as the Chilean Mesquite (*Prosopis chilensis*), Cane (*Calamus rotang*) and *Lantana camara* are the major invasive plant species of Sriharikota Island (Manakadan et al 2009).

Pollution due to heavy metal contamination (Rao et al 2009; Asha et al 2010), natural calamities such as tsunamis (Kumaraguru et al 2005), the illegal curio trade (John et al 2013), diseases (Kumaraguru et al 2005), harmful algal blooms or red tides (Kumar et al 2011) and bio-fouling (Babu et al 2012) are some of the other threats affecting the marine biodiversity of the islands in the GoM. The GoK also suffers heavy pollution, due to its proximity to the oil-exporting countries of the Middle East and due to the natural advantages of its calm ports, which are emerging as a major oil-importing base and refinery site. Seventy percent of India's total crude import is expected to take place through the GoK (Vethamony et al 2007). There are many environmental problems associated with the increased port development and maritime activity, including tanker spills and accidents, as well as sediment deposition on corals due to deep-sea dredging activities. The major urban centres, such as Jamnagar, Sikka, Salaya and Okha, and the townships of Reliance, ESSAR, GSFC, etc. produce domestic waste and sewage, which are released into the waters of the GoK and thus into the MNPS, without any treatment and recycling. These waste materials pollute the water and cause serious disturbances to the flora and fauna of the GoK (Nair 2002).

The mangrove cover on Sriharikota Island and the adjoining Pulicat Lake is declining due to various anthropogenic pressures such as agriculture and fishing. Only a few patches of mangroves are left in Pulicat (Kannan 2013). The mangrove cover on Chorao Island is on the decline due to various anthropogenic pressures such as fishing, construction, agriculture, conversion of the mangrove habitat into salt pans and cutting of mangroves for timber and fuel. Measures such as restoration of mangrove habitats by re-plantation and declaring a part of the island as Dr. Sálim Ali Bird Sanctuary are protecting some of the mangrove habitats, but constant measures need to be taken to prevent deforestation (Nagi 2008).

Natural hazards such as coastal erosion and loss of landmass are severe threats to Sagar Island (Gopinath & Saralathan 2005; Lakshmi and Edwards 2010)

## Way Forward

The Coastal Regulation Zone Notification of the Ministry of Environment and Forests covers all the coastal stretches and islands of the country in its territorial waters (CRZ 2011). The CRZ Notification, 2011 calls for special provisions for the states of Goa and Kerala and seeks to identify critically vulnerable coastal areas (CVCA), imposing strict restrictions on shore development within 200 m from the high tide line and pollution in coastal areas of islands as well. According to Biswas (no date) and Singh et al (2006), the accessibility of the various coastal islands and the links between them need to be enhanced. As the majority of these islands have found tourism to be an indispensable factor for the survival of the local population, augmenting the economic growth, creating more jobs and bringing diversification to their economic foundations through tourism-related services is of prime importance (Dixit et al 2010). The National Centre for Sustainable Coastal Management (NCSCM), Ministry of Environment and Forests has prepared an integrated island management plan to ensure the future socio-ecological sustainability of the Indian islands (<http://ncscm.org/iim>). This plan devises scientific strategies, coupled with indigenous knowledge, for better management of the islands and their resources. Specific tools will be developed for disaster risk reduction based on the experiences of other island countries to improve the resilience of the island communities.

Some of the islands, such as Netrani Island, with rich natural wealth should also be declared as MPAs to conserve their ecosystems (Gadgil 2004). Likewise, designation of parts of the inhabited islands as Critical Vulnerable Coastal Areas (CVCA) according to CRZ 2011 or Ecologically Sensitive Areas (ESAs) will help them recover from damage. There is a dire need for evaluating welfare economics (encompassing total economic value), in terms of how optimal allocation of resources among the competing uses for maximization of human welfare and for understanding and quantifying the social, cultural, economic and political aspects of individuals, organizations and communities in and around the coastal islands (Dixit et al 2010).

Practices such as dynamite fishing, mechanized fishing, use of destructive types of fishing nets, untargeted catching of marine animals, coral mining and overharvesting of fish resources are major challenges to the conservation of biodiversity in the islands. Effective implementation of management plans for the islands under protection such as those in the GoK and GoM and Chorao, Lothian, Haliday and Dhanchi has to gather momentum to prevent any further degradation of these habitats. Better enforcement of laws for recovery of damaged corals by checking mangrove cutting and coral mining in the GoK (Rajasuriya et al 2000) are some good examples that should be replicated in the protected islands of the country. Inventorization of marine fauna and flora, carried out by organizations such as the Zoological Survey of India (ZSI) and Central Marine Fisheries Research Institute (CMFRI), has to assist the planning processes of the



forest departments for better management of the islands (Gadgil 2004). Coordinated research activities by governmental and non-governmental organizations are needed to contribute to the conservation of biodiversity in the islands. Research programmes should be designed for development of appropriate technologies for seaweed farming and pearl oyster farming, along with ecotourism development, to provide alternate livelihoods to the communities dependent on the islands. Additionally, the expertise needed to transfer this technology to the local people must also be integrated in the mandates of the research institutions (Rajasuriya et al 2000).

In the islands such as Netrani, Wheeler and Sriharikota where there is restricted access due to defence-related activities, the respective state governments should develop joint plans with the Indian defence forces and organizations such as Indian Space Research Organization (ISRO) to protect the coral reefs, seabird colonies and other characteristic biodiversity of these island ecosystems. An integrated project on the lines of the Integrated Coastal Zone Management (ICZM) plan needs to be developed to manage the unique resources of the coastal islands of India. A GIS-based information system for critical coastal island habitats has to be prepared to help understand any potential impacts of a sea level rise on the islands. Guidelines and mitigation strategies for dealing with natural hazards and climate change in the islands should be incorporated in the ICZM plan. However, there is also an acute need for creating better national policies, development plans and plans for adaptation to climate change and for resourceful technical capacity for coordination and management of the coastal islands. Long-term monitoring of the islands to understand changing environmental variables and to check pollution from various human-linked sources is the need of the hour. An integrated island management plan, in agreement with island inhabitants, will help build regional capacity in risk management and preparing long-term policies for protection of the coastal islands of India. Concerted efforts are required to find solutions that will ensure a brighter future for generations to come and that will ensure that the islands will thrive, by adopting a suitable strategy for tackling the needs of the islands under discussion.

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