

Review Article

**REVIEW OF CORAL REEFS OF INDIA: DISTRIBUTION, STATUS,
RESEARCH AND MANAGEMENT**

Jyoti Saroj; Ravi Kumar Gautam; Arti Joshi and Panja Tehseen
College of Fisheries, Junagadh Agricultural University, Veraval-362265
E-mail: jyotisaroj31@gmail.com

Abstract: Coral reefs are some of the most diverse and valuable ecosystems of India. The coral reefs not only provide a sanctuary to a myriad of marine life but also play a key role in protecting the coastline from erosion. India has around 8,000 km of coastline. The major reef formations in India are restricted to the Gulf of Mannar, Palk bay, Gulf of Kutch, Andaman and Nicobar Islands and the Lakshadweep islands. Three major reef types (atoll, fringing and barrier) occur in India. While the Lakshadweep reefs are atolls, the others are all fringing reefs. This article reviews that the status, distribution, research and management of coral reefs in India. In India coral reefs are being damaged and destroyed at an increasing rate. They face a number of worsening anthropogenic threats, including bleaching, destructive fishing practices, pollution and climate change. The Reef condition is generally poor and declining in near shore waters and areas of high population density. Sedimentation, dredging and coral mining are damaging near shore reefs, while the use of explosives and bottom nets in fishing are damaging offshore reefs in specific sites. Although institutions and laws are sufficient in theory to manage and protect the reefs in India, authorities in the field have taken little effective action in implementing these laws.

Keywords: Coral reefs, India, Oceans.

Introduction

Coral reefs are a vital natural resource found in tropical waters throughout the world (Spalding *et al.* 2001). They are important not only to adjacent coastal communities, where they are often a source of livelihood, but also to national and international communities, where they contribute in various ways to oceanic production and deliver other significant benefits related to their role in tourism, recreation and coastal protection, and as indicators for climate change and waste treatment. As more research findings indicate that the species richness and biodiversity contained in reef ecosystems may not regenerate once destroyed, the conservation of coral reefs has become a major concern. Further, people dependent on coral reefs are some of the most vulnerable groups in many coastal and island communities, because reef and reef-based resources are often their primary means of food production, source of income and livelihood (Alcala, 1988; Gomez *et al.* 1994; White, 1987). Coral reefs

*Received Aug 26, 2016 * Published Oct 2, 2016 * www.ijset.net*

are known to be among the most biologically productive and diverse ecosystems in the world, home to thousands of species of plants and animals, less than one tenth of which have been identified (Birkeland, 1997; Serageldin, 1998). The reef ecosystem provides habitat and food sources for a variety of marine organisms. Coral reef fisheries are a vital source of food, income and livelihood to coastal populations, and are also critical to the economic health of many coastal nations (Burke *et al.* 2002).

The structure of a reef is formed by the calcareous skeleton that houses corals, a type of soft-bodied, radially symmetrical, marine invertebrates of the phylum coelenterate. Individuals of a colony are called polyps or hydroids. Millions of coral skeletons cemented together over a period ranging from a few thousand to millions of years give rise to such reefs (WWF1992). There are mainly four types of coral reefs found in India.

1. Platform Reefs: These are almost flat reefs without any lagoon. They rest on the shallower part of the continental shelves and they may present associated with atolls and also between a coast and a barrier reef. These types of reefs are mainly found in Gulf of Kutch of India.

2. Fringing Reefs: These types of reefs are directly attached to a shore, or borders it with an intervening shallow channel or lagoon. Fringing reefs are found in Gulf of Mannar, Palk bay and in Andaman & Nicobar islands of India.

3. Barrier Reefs: These reefs are separated from a mainland or island shore by a deep channel or lagoon. Barrier reefs are mainly found in Andaman & Nicobar islands of India. Outside India the Great Barrier Reef is located in Australia. Barrier reefs separated from the land by wide expanses of water and follow the coastline.

4. Atolls: These are more or less circular or continuous barrier reef extends all the way around a lagoon without a central island. Atolls in India are mainly found in Lakshadweep islands: a roughly circular ring of reefs surrounding a lagoon, a low lying island, common in the Indian and South pacific oceans.

Distribution of coral reefs in India

India has a coast line of nearly 8129 km but the reef formation is restricted to four major centres, viz. Gulf of Kutch. Gulf of Mannar, Lakshadweep and Andaman and Nicobar Islands. In India, the reefs are distributed along the east and west coasts at restricted places. Fringing reefs are found in Gulf of Mannar and Palk Bay. Platform reefs are seen along the Gulf of Kachchh. Patchy reefs are present near Ratnagiri and Malvan coasts. Fringing and barrier reefs are found in Andaman and Nicobar Islands. The Lakshadweep is the only atoll

formation of our waters. The total area of coral reefs in India is estimated to be 2,375 sq. km (DOD and SAC, 1997).

Coral reefs of the Indian Ocean were built up during the tertiary and quaternary periods. Coral reefs are restricted mainly in seven regions of India, such as:

1. Coral reefs in Goa coast,
2. Coral reefs in Kerala coast,
3. Coral reefs in Palk Bay,
4. Coral reefs in Gulf of Kutch,
5. Coral reefs in Gulf of Manner.
6. Coral reefs in Lakshadweep islands,
7. Coral reefs in Andaman and Nicobar islands.



Figure 1. Major coral reef areas in India

Gulf of Mannar

The Gulf of Mannar reefs on the other hand are developed around a chain of 21 islands that lie along the 140 km stretch between Tuticorin and Rameswaram (Krishnamurthy, 1987). These islands are located between latitude 8°47' N and 9° 15' N and

longitude 78° 12' E and 79° 14'E on southeast coast of India 21 islands running parallel to a coastline at an average of 8 km from shore. Different types of reef forms such as shore platform, patch, coral pinnacles and atoll type are also observed in the Gulf of Mannar. The islands have fringing coral reefs and patch reefs around them. Narrow fringing reefs are located mostly at a distance of 50 to 100 m from the islands. On the other hand patch reefs arise from depths of 2 to 9 m and extend to 1 to 2 km in length with width as much as 50 meters. Reef flat is extensive in almost all the reefs in the Gulf of Mannar. Reef vegetation is richly distributed on these reefs. The total area occupied by reef and its associated features is 94.3 sq. km. Reef flat and reef vegetation including algae occupies 64.9 and 13.7 sq. km, respectively. (DOD and SAC, 1997). Visibility is affected by monsoons, coral mining and high sedimentation load. The reefs are more luxuriant and richer than the reefs of Palk bay.

Palk Bay

Coral reefs on the Tamil Nadu coast are located in Palk Bay near Rameswaram and in the Gulf of Mannar. Palk Bay is separated from the gulf of Mannar by Mandapam peninsula and Rameswaram Island. The reef is centered on 9 °17'N and 79° 15'. There is only one fringing reef in the Palk bay, which lies in an east-west direction along the mainland from the Pamban channel at the Pamban end of the bridge to Rameshwaram Island. This reef is 25-30 km long and generally less than 200 m wide. Visibility is poor around 1 meter and it is badly affected by the north east monsoon. The reef flat is relatively broad from Pamban channel to the southern end near Ramnad and narrow from Pamban to south of Rameshwaram. The present day reef growth is poor and it is not in a pristine condition since it was quarried in the sixties (Pillai, 1996). Satellite data shows that the reef flat is barren and is followed by sandy beach on the landward side. A small patch of reef fringes at the Dhanushkodi tip (Bahuguna and Nayak, 1994).

Gulf of Kutch

The Gulf of Kutch located at 22°15'-23°40' N Latitude and 68°20'-70°40' East Longitude, is one of the indentations found on the northern side of the Saurashtra Peninsula. The beaches are sandy or muddy with occasional large sandstone formation. There are about 40 islands with patchy coral formations of which the largest is Pirotan Island. Corals are found on sand stones substrate in patches. The coral fauna of Gulf of Kutch is comparatively less diverse compared to other parts of India (Pillai, 1996). Total Area of Reefs in Gulf of Kutch is about 352.5 sq. km. (Jayaprakas and Radhakrishnan, 2014).

Andaman and Nicobar Islands

The Andaman and Nicobar group of Islands are located in the SE of the Bay of Bengal, between 6°-14° N latitude and 91 °-94° E longitude. They consist of 350 islands. Almost all the islands of the Andaman and Nicobar groups exhibit narrow, linear and extensively well-developed fringing reefs (Vineeta Hoon, 1997). A total of 135 species divided among 59 genera is known to both Andaman and Nicobar (Pillai 1983). The total area occupied by reef is 1021.46 sq.km (SAC, 2010). There is not enough recent information about the reefs around North Andaman and the Nicobar islands to provide a true picture of the current status of the reefs.

The Lakshadweep Islands

The Lakshadweep islands lie scattered in the Arabian Sea about 225 to 450 km from the Kerala coast. Geographically, the islands lie between 8°N - 12°3'N latitude and 71 °E-74°E longitude. The islands consist of coral formations built up on the Laccadive-Chagos submarine ridge rising steeply from a depth of about 1500 m to 4000 m off the west coast of India. The U.T of Lakshadweep along with the Maldives and the Chagos Archipelagoes form an interrupted chain of coral atolls and reefs on a contiguous submarine bank covering a distance of over 2000 km. This ridge is supposed to be a continuation of the Arravali Mountains and the islands are believed to be remnants of the submerged mountain cliffs (James *et al.*1986). There are 36 tiny islands, 12 atolls, 3 reefs and 5 submerged banks, covering an area of 32 km² with lagoons occupying about 4200 km². Only 11 of the 36 islands are inhabited (Vineeta Hoon, 1997). Coral reefs of the islands are mainly atoll except one platform reef at Androth. The total area occupied by reef is 933.7 sq.km including lagoon area of 510 sq. km (SAC, 2010).

West Coast of India

The west coast of India between Bombay and Goa is reported to have submerged banks with isolated coral formations (Nair and Qasim, 1978). Coral patches have been recorded in the intertidal regions of Ratnagiri, Malvan and Redi, south of Bombay (Qasim and Wafer, 1979) and at the Gaveshani Bank, 100 Km west of Mangalore (Nair and Qasim, 1978). *Ponies*, *Coscinarares*, *Turbinaria*, some favids and *Pseudosiderastrea* are reported. Down south from Quilon along the Kerala coast to Enayam in TamilNadu coast hermatypic corals are reported along the shore. *Pocilipora* spp is the most common genus in this area. *Accropora* is found with representation of three species. *Pseudosiderastrea* and *Ponies* spp

are also found. A recent investigation has shown that 29 species in 17 genera of scleractinians occur in this area (Pillai, 1996).

Diversity of scleractinian corals in the Indian Ocean

Pillai (1996) reported on a total of 199 species of scleractinian corals from the reefs of India that are divided among 37 genera. The total species number may be around 225 from the Indian region. The list of species and genera is as follows.

Table 1

Sr. no.	Locality	Genera	Species	Sources
1	Lakshadweep	27	105	(Pillai and Jasmine, 1989)
2	Gulf of Kutch	24	37	(Pillai and Patel, 1988)
3	S.E. coast of India	37	94	(Pillai, 1986)
4	Andaman and Nicobar	59	135	(Pillai, 1983)
5	West coast of Kerala and Tamil nadu	17	29	(Pillai and Jasmine, 1989)
6	Total for India	37	199	

Biodiversity of Coral Reefs in India

All coral reefs are very rich in biodiversity. There is an accumulation of various types of biotic factors in each ecosystem of coral reefs. The composition of coral reefs in India is unique and it includes near about 180 species of biotic algae, 20 species of sea weeds, 20 species sea grasses, 115 species of Poriferans, 5 species of Crustaceans, 110 species of Echinoderms, and 600 species of bony fishes. Besides, it should be noted that different species of crabs, gastropods, bivalves, cephalopods are also found in Indian coral reefs. Coral reefs are hard limestone forms constructed by continuous cementing process and depositional activities of class Anthozoa, Scyphozoa and Hydrozoa and also a group of calcifying algae. In different coral reefs of India 25 species of ammonifying bacteria, 12 species of nitrifying bacteria, 3 species of nitrogen fixing bacteria, 25 species of phosphate producing bacteria were also noted. About 55 species of Diatoms and 50 species of phytoplanktons were also found in different reefs of India. Both stony and soft corals were found in the sub-tidal regions of reefs. The genera of stony corals noted in the Indian reefs are *Favia*, *Goniopora*, *Favites*, *Sinularia*, *Montipora* etc. and soft coral genera were found such as *Nephthya*, *Dendronephthya* (Saxena, 2015).

Threats

Coral reefs are dying around the world. In particular, coral mining, agricultural and urban runoff, pollution (organic and inorganic), overfishing, blast fishing, disease, and the

digging of canals and access into islands and bays are localized threats to coral ecosystems. Broader threats are sea temperature rise, sea level rise and pH changes from ocean acidification, all associated with greenhouse gas emissions. Another cause for the death of coral reefs is bioerosion. Various fishes graze corals, dead or alive and change the morphology of coral reefs making them more susceptible to other physical and chemical threats. General estimates show approximately 10% of the world's coral reefs are dead. About 60% of the world's reefs are at risk due to destructive, human-related activities.

Status of Coral Reef research in India

The major institutions involved in research of Coral reefs and management are: Department of Ocean Development, The Space Applications Centre, Ahmedabad, The Zoological survey of India, Central Marine Fisheries Research Institute, Madurai-Kamaraj University, CAS, at Parangipettai, Annamalai University, Centre for Earth Studies, Trivandrum, Institute for ocean Management, Madras, National Institute of Oceanography, Goa and the World Wide fund for Nature-India. The Space Applications Centre at Ahmedabad has used remote sensing data to assess the area under coral reefs and prepare a coral reef atlas of India.

The Department of Ocean Development has recently received a grant from the World Bank, to prepare a CIS based information system for critical habitats for coastal ecosystems. This will include all the coral reefs ecosystems in India including the patches and submerged banks found along the West coast of India.

Current coral reef research and achievements

The knowledge of scleractinian corals has considerably increased. All the major reefs are reasonably studied. Formulation and partial implementation of conservation laws have considerably reduced the destruction of reefs. An attempt is made to capacity building in various sectors including training to coral taxonomists. Tourism is restricted to selected areas. Effluent discharge to reefs has been considerably controlled. Continuous monitoring of the reefs in Gulf of Mannar and some parts of Andaman and Nicobar Islands and Lakshadweep enabled us to understand present status of reefs so also recolonization of scleractinians after mortality. Awareness to the value of reefs and need for conservation of this ecosystem has increased particularly among the coastal people and Island inhabitants. Some attempts are being made to transplant corals for eco development Marine Parks and biosphere established (Pillai, 2010).

Ongoing research activities

Zoological Survey of India, National Institute of Oceanography and Central Marine Fisheries Research Institute are the major national centres of current reef research. The Suganthi Devadason Marine Research Institute at Tuticorin Tamil Nadu is a private organization that is very actively engaged in reef research in Gulf of Mannar. The major ongoing research activities at various centres are mainly on various aspects covering Biodiversity of coral reef, Biophysical monitoring of coral reefs, coral reef restoration and coral transplantation, Reproductive biology of corals, Studies on the physical and biological impact on coral reefs GIS based mapping of coral reefs, Livelihood programmes on coastal population to reduce anthropogenic pressure, Awareness creation on the value of coral reefs and need for conservation, Capacity building in the taxonomy of corals and reef dwelling organisms to assess biodiversity (Pillai, 2010).

Protection Status of Coral reef areas
Table 2

Locality	Protection	
	established	proposed
Gulf of Kutch	Marine National Park (110 Sq Km-1982)	Nil
Lakshadweep Islands	Collection of corals is banned.	Sanctuary proposed at Malwan - South of Bombay
West Coast Patches	Nil	Nil
Palk bay	Nil	Nil
Gulf of Mannar	Gulf of Mannar Biosphere reserve.	
Andaman Islands	Mahatma Gandhi Marine national Park at Wandoor - 234 sq km. of islands and reefs.	Ritchies Archipelago
Nicobar Islands	Nil	Nil

Source: Vineeta Hoon, 1997.

Status of Coral reefs in India
Table 3

	Bio-physical	Research	Perceived threats
Palk Bay	Slow recovery from 60's coral mining	Mainly on Bio-physical aspects	Population Pressure and associated effects
Gulf of Mannar	Slow recovery from 60's coral mining	Bio-physical aspects; associated fauna and Human activities damaging the reefs.	Population Pressure and associated effects
Andaman &	Fair Excellent, Problems	Bio-physical	Siltation due to

Nicobar	around south island	aspects; associated fauna and Human activities damaging the reefs	logging, Sand mining
Lakshadweep	Excellent off uninhabited islands and endangered along habited islands	Bio-physical aspects; associated fauna and Human activities damaging the reefs	Population Pressure and associated effects
Gulf of Kutch	30% of the reefs are living	Bio-physical aspects; associated fauna and Human activities damaging the reefs	Sedimentation and siltation due to cutting of mangrove forests, sand mining for industrial use. Population pressure
West Coast	Unknown	Limited	Unknown

Source: Vineeta Hoon, 1997.

Conservation and management of coral reef areas in India

The protection of coral reef has been stressed under Wildlife Protection act, 1972 and Environmental Protection Act, 1986 and Coastal Regulation Zone Notification (CRZN) of 1991 coming under it. Other acts like Indian Forests Act, 1927, Forest Conservation Act, 1980 and Indian Fisheries Act also offer a sort of relief in the conservation of Coral reefs of India. But there is no separate legal status for coral conservation even under Wildlife Protection Act. The State forest department, fisheries departments and recently the state coastal management authority at the state level are taking up the responsibilities for coral reef conservations in India. Wildlife Protection Act include the protection of major ecosystems, there is no direct stress on coral reef conservations. So the recommendation for law reform and policy making for coral reef conservation and management in the country essentially concern amending the Wildlife (Protection) Act 1972 to include species of coral in the schedules and specifically state that the extraction of coral is prohibited under the provisions of Chapter VA of WPA. Moreover, the CRZ notification essentially covers coastal areas extending 500 metres from High tide line and the land lying between the Low tide line and High tide line in the landward side, the areas extending beyond the coral and coral reefs on seaward side remain unprotected. The major coral reef areas could be declared ecologically sensitive under EPA 1986 and strict restrictions could be imposed on dangerous industries.

Conclusions

Coral reef research in India is still at a preliminary stage. Enormous data exists on coral reefs. However very little information exists on population density of corals and reef

associated species in relation to abundance. Little information is available on the coral reef ecosystem and the ecological resources of coral reefs. This makes development of realistic management plans for coral reef areas involving local community participation especially difficult. The main problem is that each institute has its own research agenda and special focus. Coral reef research has been more incidental than a main stream programme in nearly all these institutes. This has to change if we are serious about developing management plans for conserving and managing our coral reef heritage.

References

- [1] Alcalá, A.C. 1988. Effects of protective management of marine reserves on fish abundances and fish yields in the Philippines. *Ambio*. **17**: 194-199.
- [2] Bahuguna, A. and Nayak, S. 1994. Coral reef Mapping of Tamil Nadu using satellite data. SAC (ISRO), Ahmedabad, India.
- [3] Birkeland, C. 1997. (eds.) Life and death of coral reefs. International Thomson Publishing.
- [4] Burke, L., Selig, E. and Spalding, M. 2002. Reefs at risk in Southeast Asia. Washington DC.
- [5] DOD & SAC .1997. "Coral reef maps of India," Department of Ocean Development and Space Application Centre, Ahmedabad, India.
- [6] Gomez, E.D., Alino, P.M. Yap, H.T. and Licuanan, W.Y. 1994. A review of the status of Philippines reefs. *Marine Pollution Bulletin*. **29(1-3)**: 62-68.
- [7] James, P.S.B.R., Pillai, C.S.G., Pillai, P.P., Livingston, P. and Mohan, M. 1986. Marine Fisheries Research in Lakshadweep" -A Historical resume in MFIS, Special issue on Lakshadweep, technical and extension series, CMFRI, Cochin, India, ICAR.
- [8] Jayaprakas, V. and Radhakrishnan, R. 2014. Indian coral reefs: diversity, anthropogenic influences and conservation measures. *International Journal of Humanities, Arts, Medicine and Sciences*. **2(4)**: 25-36.
- [9] Krishnamurthy, K. 1987. "The Gulf of Mannar Biosphere Reserve: Project document-5, Ministry of Environment & Forests, Government of India.
- [10] Nair, R. R and Qasim, S.V., 1978. Occurrence of a bank with living corals of the South West coast of India. *Indian journal of Marine Sciences*. **7**:55-58.
- [11] Pillai, C.S.G. 1983. Coral Reef and their Environs. Bulletin NO. 34, CMFRI, Cochin, India.

- [12] Pillai, C.S.G. 2010. A review of the status of corals and coral reefs of India. *Indian Journal of Animal Sciences*. **80 (4)**: 53–56.
- [13] Pillai, C.S.G. and Jasmine, S. 1989. The coral Fauna of Lakshadweep. *Bull 43, CMFRI, Cochin, India*.
- [14] Pillai, C.S.G. And Patel, M.J. 1988. Scleractinian corals from the gulp of Kutch. *Journal of Marine biology Assessment of India*.**30 (1 & 2)**: 54-74.
- [15] Pillai, C.S.G. (1996) "Coral reefs of India: Their Conservation and Management, in (Pillai CSG and Menon N.G. eds) "*Marine Biodiversity, Conservation and Management*," CMFRI, Cochin, India. Pillai, C.S.G., Jasmine, S. 1989. The coral fauna. *Central Marine Fisheries Research Institute Bulletin* **43**: 179- 194.
- [16] Pillai, C.S.G. 1986. Recent Corals from South-East Coast of India in PSBR James (ed "*Recent Advances in Marine Biology*," Today and Tomorrow Printers and Publishers, India.
- [17] Qasim, S.Z and Wafer, W.M.W. 1979. Occurrences of living corals at several places along the west coast of India. *Mahasagar Bulletin, NIO, Goa*. **12**: 53-58.
- [18] SAC. 2010. Coral Reef Atlas of the World, Central Indian Ocean. Space Application Centre, Indian Space Research Organization, Ahmedabad, India. **1**: 281.
- [19] Saxena, A. 2015. Coral Reefs and Their Conservation-A Review. Biological and Chemical Research. 187-206.
- [20] Serageldin, I. 1998. Coral reef conservation: Science, economics, and law in Hatzios. World Bank, Washington DC.
- [21] Spalding, M.D., Ravilious, C. and Green, E.P. 2001. World atlas of coral reefs. UNEP World Conservation Monitoring Center, University of California Press, Berkeley, USA, 424 p.
- [22] Vineeta Hoon, 1997. Coral reef of India: review of their extent, condition research and management status. In: *Proc. Regional Workshop on the Conser. Sustain. Manag. Coral Reefs* (Vineeta Hoon, ed.), organised by M.S. Swaminathan Research Foundation and BOBP of FAO/UN, 1-27.
- [23] White, A.T. 1987. Coral reefs: Valuable resources of Southeast Asia. ICLARM Education Series 1, 36 p.
- [24] WWF. 1992. "*India's Wetlands, Mangroves and Coral Reefs*," WWF-India.