02

Coastal and Marine Protected Areas in India: Challenges and Way Forward

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Summary

India has an extensive coastline of 7517 km length, of which 5423 km is in peninsular India and 2094 km is in the Andaman & Nicobar and Lakshadweep islands. The EEZ has an extent of 2.02 million km^2. This coastline also supports a huge human population, which is dependent on the rich coastal and marine resources. Despite the tremendous ecological and economic importance and the existence of a policy and regulatory framework, India's coastal and marine ecosystems are under threat. Numerous direct and indirect pressures arising from different types of economic development and associated activities are having adverse impacts on the coastal and marine biodiversity across the country. The marine protected area network in India has been used as a tool to manage natural marine resources for biodiversity conservation and for the well-being of people dependent on it. Scientific monitoring and traditional observations confirm that depleted natural marine resources are getting restored and/or pristine ecological conditions have been sustained in well managed MPAs. There are 24 MPAs in peninsular India and more than 100 MPAs in the country's islands. The 24 MPAs of the mainland have a total area of about 8214 km^2, which is about 5% of the total protected area network of India and represents 0.25% of the total geographic area of the country. Dedicated efforts are required to secure and strengthen community participation in managing the marine protected area network in India.

Keywords : *Aichi target; conservation; India; marine biodiversity; marine protected area.*

Introduction

India represents 2.4% of the world's landmass and supports a population of over one billion people. India is also one of the 17 mega-biodiverse countries in the world, with 7.8% of the recorded species of the world, including 45,500 recorded species of plant and 91,000 recorded species of animal (MoEF 2014). The sea around India is part of the northern Indian Ocean, and the Indian subcontinent forms a major physical feature separating the Arabian Sea and the Bay of Bengal of the Indian Ocean. India has an extensive coastline of length 7517 km, of which 5423 km is in peninsular India and 2094 km is in the Andaman & Nicobar and Lakshadweep islands. The extent of the EEZ is 2.02 million km^2. This coastline also supports a huge human population, which is dependent on the rich coastal and marine resources. It is estimated that nearly 250 million people live within a 50 km wide swathe along the coastline of India (UNISDR/UNDP 2012). Therefore, the ecological services of the marine and coastal ecosystems of India play a vital role in sustaining India's economic growth.

Despite the tremendous ecological and economic importance and the existence of a policy and regulatory framework, India's coastal and marine ecosystems are under threat (Sivakumar et al 2012). Numerous direct and indirect pressures arising from different types of economic development and associated activities are having adverse impacts on coastal and marine biodiversity across the country. Human-driven impacts on coastal ecosystems due to population growth, economic development and urbanization are going to increase in the coming decades . In India, these pressures are major drivers of ecosystem degradation by habitat conversion to other forms of land use, overexploitation of species and associated destructive harvesting practices, the spread of invasive alien species and the impacts of agricultural, domestic and industrial sewage and waste. Mushrooming of ports and harbours all along the coasts is also threatening the coastal biodiversity. Further, natural phenomena such as tsunamis, cyclones, hurricanes and storms alter the habitats. Indirect drivers of ecosystem change include demographic, socio-political, cultural, economic and technological factors.

Direct impacts of human activities have been the major cause of the changes seen in the coastal zones in the world (Lotze et al. 2006), also leading to the observed changes in the climatic regime. These shifts include a likely increase in the

frequency of extreme weather events, a rise in the sea level, increased sea surface temperatures and ocean acidification (IPCC 2014). A rise in the sea level is likely to have significant implications for the coastal populations and productivity. For example, some of the islands in the Sundarbans, Gulf of Mannar and Nicobar Islands have already witnessed these changes. The largest mass nesting ground of the Olive Ridley turtle *Lepidochelys olivacea*, in Odisha, is undergoing dynamic changes probably due to climate change. Apart from this, climate change is also rapidly affecting the socio-economic condition of coastal communities, which in turn is intensifying pressure on the marine bio-resources. Demographic changes are also being witnessed among coastal communities due to a constant inflow of people due to droughts in adjoining coastal habitats. These are probably due to climate change. Therefore, it has become imperative to investigate, quantify and monitor the impacts of climate change on the marine biodiversity in certain sites in India.

Marine protected areas (MPAs) are regarded as one of the most potent conservation tools for protection of marine habitats and their resources (Agardy et al 2011). Studies have shown that designation of areas as MPAs has resulted in a significant increase in the biomass and densities of several species (Halpern 2003; Selig & Bruno 2010) over a short period of time (Halpern & Warner 2002). The Environment (Protection) Act, 1986, Coastal Regulation Zone Notification, 1991 and National Biodiversity Act, 2002 have been enacted in India for conservation of coastal and marine environment, along with the Wildlife (Protection) Act 1972, which also provides for establishment of protected areas (Pas) by state governments (Sivakumar et al 2012). The Gulf of Kachchh Marine National Park, Gulf of Mannar National Park, Sundarbans National Park and Wandoor Marine National Park are some of the important MPAs of India.

Coastal and Marine Protected Areas in India

The MPA network in India has been used as a tool to manage natural marine resources for biodiversity conservation and for the well-being of the people dependent on it. Scientific monitoring and traditional observations confirm that depleted natural marine resources are getting restored and/or pristine ecological conditions have been sustained in well managed MPAs (Halpern 2003). India has designated four legal categories of protected areas: National Park, Wildlife Sanctuary, Conservation Reserve and Community Reserve. India has created a network of PAs representing all its 10 biogeographic regions (Rodgers et al 2002). A total of 690 protected areas have been established in India as on 1 April 2014, including 102 national parks, 527 wildlife sanctuaries, 57 conservation reserves and 4 community reserves. Besides, 26 wetlands have been designated as Ramsar sites.

In India, PAs that fall entirely or partially within the swathe of 500 m from the high tide line and the marine environment are considered to be in the MPA network. There are 24 MPAs in peninsular India and more than 100 MPAs in the country's islands (see Table 1 & 2). The 24 MPAs of the mainland have a total area of about 8214 km^2 , which is about 5 % of the total area under the entire PA network of India and less than 0.3% of the total land area of India. The Gulf of Mannar Marine National Park, Sundarbans National Park, Gulf of Kachchh National Park, Gahirmatha Marine Sanctuary, Coringa Wildlife Sanctuary and Chilika Wildlife Sanctuary, on the mainland, have unique marine biodiversity and provide a range of ecological services to the local communities. The total area of the Andaman and Nicobar Islands is 4947 km^2, of which 1510 km^2 is protected under the provisions of India's Wildlife (Protection) Act, 1972. There are 105 PAs in the Andaman and Nicobar Islands, and all are part of the MPA network of India. These MPAs cover about 60% of the terrestrial area of the islands and protect more than 40% of the coastal habitat. Mahatma Gandhi Marine National Park and Rani Jhansi Marine National Park are important MPAs here. In the Lakshadweep group of islands, Pitti Island (0.01 km^2) is the only island having the status of an MPA.

India has also identified 12 protected areas as trans-boundary protected areas under the framework of the IUCN Trans-boundary Protected Area programme. Two of these sites are MPAs (Sundarbans National Park and Gulf of Mannar Biosphere Reserve). India has also designated six UNESCO World Heritage Natural sites, and Sundarbans National Park is one among them.

India has taken several steps towards achieving the Aichi Biodiversity Targets, especially Target No. 11 (at least 10% of coastal and marine areas are conserved in networks of protected areas) and Target No.14 (ecosystems that provide water, health, livelihoods and well-being are restored and safeguarded). Towards achieving these two targets, 106 coastal and marine sites have been identified and prioritized as Important Coastal and Marine Areas (ICMBAs) by the Wildlife Institute of India. Sixty-two ICMBAs have been identified along the west coast of India, and 4 have been identified along the east coast (Table 3). These sites have also been proposed as conservation or communities reserves to increase participation of the local communities in governance. More efforts are required to secure and strengthen community participation in the management of the MPA network in India.

Fig 1 : *Important coastal and marine protected areas of India*

Table 1 : List of Marine Protected Areas in peninsular India

Sl. No.	Name of MPA	State	Category	IUCN category	Area (km^2)	Year of establishment
1.	Coringa	Andhra Pradesh	Sanctuary	IV	235.7	1978
2.	Krishna	Andhra Pradesh	Sanctuary	IV	194.81	1989
3.	Pulicat Lake	Andhra Pradesh	Sanctuary	IV	500	1980
4.	Dadra & Nagar Haveli	Dadra & Nagar Haveli	Sanctuary	IV	92.16	2000
5.	Fudam	Daman & Diu	Sanctuary	IV	2.18	1991
6.	Chorao Island	Goa	Sanctuary	IV	1.78	1988
7.	Marine (Gulf of Kachchh)	Gujarat	National park	II	162.89	1995
8.	Khijadia	Gujarat	Sanctuary	IV	6.05	1981
9.	Marine (Gulf of Kachchh)	Gujarat	Sanctuary	IV	295.03	1980
10.	Kadalundi Vallikkunnu Community Reserve	Kerala	Community reserve	NA	1.50	2007
11.	Malvan Marine	Maharashtra	Sanctuary	IV	29.12	1987
12.	Bhitarkanika	Odisha	National park	II	145	1998
13.	Bhitarkanika	Odisha	Sanctuary	IV	672	1975
14.	Chilika (Nalaban)	Odisha	Sanctuary	IV	15.53	1987
15.	Balukhand Konark	Odisha	Sanctuary	IV	71.72	1984
16.	Gahirmatha	Odisha	Sanctuary	IV	1435	1997
17.	Gulf of Mannar Marine	Tamil Nadu	National park	II	6.23	1980
18.	Point Calimere	Tamil Nadu	Sanctuary	IV	172.6	1967
19.	Pulicat Lake	Tamil Nadu	Sanctuary	IV	153.67	1980
20.	Sundarbans	West Bengal	National park	II	1330.1	1984
21.	Haliday Island	West Bengal	Sanctuary	IV	5.95	1976
22.	Sajnakhali	West Bengal	Sanctuary	IV	2091.12	1976
23.	Lothian Island	West Bengal	Sanctuary	IV	38	1976
24.	West Sundarban	West Bengal	Sanctuary	IV	556.45	2013

Table 2 : List of Marine Protected Areas in Islands India

Sl. No.	Name of MPA	Union Territory	Category	IUCN category	Area (km^2)	Year of establishment
1	Arial Island	Andaman & Nicobar	Sanctuary	IV	0.05	1977
2	Bamboo Island	Andaman & Nicobar	Sanctuary	IV	0.05	1977
3	Barren Island	Andaman & Nicobar	Sanctuary	IV	11.99	1977
4	Battimalv Island	Andaman & Nicobar	Sanctuary	IV	5.03	1977
5	Belle Island	Andaman & Nicobar	Sanctuary	IV	0.08	1977
6	Bennett Island	Andaman & Nicobar	Sanctuary	IV	3.46	1977
7	Bingham Island	Andaman & Nicobar	Sanctuary	IV	0.08	1977
8	Blister Island	Andaman & Nicobar	Sanctuary	IV	0.26	1977
9	Bluff Island	Andaman & Nicobar	Sanctuary	IV	1.14	1977
10	Bondoville Island	Andaman & Nicobar	Sanctuary	IV	2.55	1977
11	Brush Island	Andaman & Nicobar	Sanctuary	IV	0.23	1977
12	Buchanan Island	Andaman & Nicobar	Sanctuary	IV	9.33	1977
13	Campbell	Andaman & Nicobar	National park	II	426.23	1992
14	Channel Island	Andaman & Nicobar	Sanctuary	IV	0.13	1977
15	Cinque Islands	Andaman & Nicobar	Sanctuary	IV	9.51	1977
16	Clyde Island	Andaman & Nicobar	Sanctuary	IV	0.54	1977
17	Cone Island	Andaman & Nicobar	Sanctuary	IV	0.65	1977
18	Curlew (B.P.) Island	Andaman & Nicobar	Sanctuary	IV	0.16	1977
19	Curlew Island	Andaman & Nicobar	Sanctuary	IV	0.03	1977
20	Defence Island	Andaman & Nicobar	Sanctuary	IV	10.49	1977
21	Dot Island	Andaman & Nicobar	Sanctuary	IV	0.13	1977
22	Dottrell Island	Andaman & Nicobar	Sanctuary	IV	0.13	1977
23	Duncan Island	Andaman & Nicobar	Sanctuary	IV	0.73	1977
24	East Island	Andaman & Nicobar	Sanctuary	IV	6.11	1977
25	East of Inglis Island	Andaman & Nicobar	Sanctuary	IV	3.55	1977
26	Egg Island	Andaman & Nicobar	Sanctuary	IV	0.05	1977
27	Elat Island	Andaman & Nicobar	Sanctuary	IV	9.36	1977
28	Entrance Island	Andaman & Nicobar	Sanctuary	IV	0.96	1977
29	Galathea	Andaman & Nicobar	National park	II	110	1992
30	Gander Island	Andaman & Nicobar	Sanctuary	IV	0.05	1977
31	Girjan Island	Andaman & Nicobar	Sanctuary	IV	0.16	1977
32	Goose Island	Andaman & Nicobar	Sanctuary	IV	0.01	1977
33	Hump Island	Andaman & Nicobar	Sanctuary	IV	0.47	1977
34	Interview Island	Andaman & Nicobar	Sanctuary	IV	133.87	1977
35	James Island	Andaman & Nicobar	Sanctuary	IV	2.1	1977
36	Jungle Island	Andaman & Nicobar	Sanctuary	IV	0.52	1977
37	Kyd Island	Andaman & Nicobar	Sanctuary	IV	8	1977
38	Landfall Island	Andaman & Nicobar	Sanctuary	IV	29.48	1977
39	Latouche Island	Andaman & Nicobar	Sanctuary	IV	0.96	1977
40	Lohabarrack	Andaman & Nicobar	Sanctuary	IV	22.21	1977
41	Mahatma Gandhi Marine	Andaman & Nicobar	National park	II	281.5	1983
42	Mangrove Island	Andaman & Nicobar	Sanctuary	IV	0.39	1977
43	Mask Island	Andaman & Nicobar	Sanctuary	IV	0.78	1977

44	Mayo Island	Andaman & Nicobar	Sanctuary	IV	0.1	1977
45	Megapode Island	Andaman & Nicobar	Sanctuary	IV	0.12	1977
46	Middle Button Island	Andaman & Nicobar	National park	II	0.44	1987
47	Montogemery Island	Andaman & Nicobar	Sanctuary	IV	0.21	1977
48	Mount Harriett	Andaman & Nicobar	National park	II	46.62	1987
49	Narcondam Island	Andaman & Nicobar	Sanctuary	IV	6.81	1977
50	North Brother Island	Andaman & Nicobar	Sanctuary	IV	0.75	1977
51	North Button Island	Andaman & Nicobar	National park	II	0.44	1987
52	North Island	Andaman & Nicobar	Sanctuary	IV	0.49	1977
53	North Reef Island	Andaman & Nicobar	Sanctuary	IV	3.48	1977
54	Oliver Island	Andaman & Nicobar	Sanctuary	IV	0.16	1977
55	Orchid Island	Andaman & Nicobar	Sanctuary	IV	0.1	1977
56	Ox Island	Andaman & Nicobar	Sanctuary	IV	0.13	1977
57	Oyster Island-I	Andaman & Nicobar	Sanctuary	IV	0.08	1977
58	Oyster Island-II	Andaman & Nicobar	Sanctuary	IV	0.21	1977
59	Paget Island	Andaman & Nicobar	Sanctuary	IV	7.36	1977
60	Parkinson Island	Andaman & Nicobar	Sanctuary	IV	0.34	1977
61	Passage Island	Andaman & Nicobar	Sanctuary	IV	0.62	1977
62	Patric Island	Andaman & Nicobar	Sanctuary	IV	0.13	1977
63	Peacock Island	Andaman & Nicobar	Sanctuary	IV	0.62	1977
64	Pitman Island	Andaman & Nicobar	Sanctuary	IV	1.37	1977
65	Point Island	Andaman & Nicobar	Sanctuary	IV	3.07	1977
66	Potanma Islands	Andaman & Nicobar	Sanctuary	IV	0.16	1977
67	Ranger Island	Andaman & Nicobar	Sanctuary	IV	4.26	1977
68	Rani Jhansi	Andaman & Nicobar	National park	II	256.14	1996
69	Reef Island	Andaman & Nicobar	Sanctuary	IV	1.74	1977
70	Roper Island	Andaman & Nicobar	Sanctuary	IV	1.46	1977
71	Ross Island	Andaman & Nicobar	Sanctuary	IV	1.01	1977
72	Rowe Island	Andaman & Nicobar	Sanctuary	IV	0.01	1977
73	Saddle Peak	Andaman & Nicobar	National park	II	32.54	1987
74	Sandy Island	Andaman & Nicobar	Sanctuary	IV	1.58	1977
75	Sea Serpent Island	Andaman & Nicobar	Sanctuary	IV	0.78	1977
76	Shark Island	Andaman & Nicobar	Sanctuary	IV	0.6	1977
77	Shearme Island	Andaman & Nicobar	Sanctuary	IV	7.85	1977
78	Sir Hugh Rose Island	Andaman & Nicobar	Sanctuary	IV	1.06	1977
79	Sisters Island	Andaman & Nicobar	Sanctuary	IV	0.36	1977
80	Snake Island-I	Andaman & Nicobar	Sanctuary	IV	0.73	1977
81	Snake Island-II	Andaman & Nicobar	Sanctuary	IV	0.03	1977
82	South Brother Island	Andaman & Nicobar	Sanctuary	IV	1.24	1977
83	South Button Island	Andaman & Nicobar	National park	II	0.03	1987
84	South Reef Island	Andaman & Nicobar	Sanctuary	IV	1.17	1977
85	South Sentinel Island	Andaman & Nicobar	Sanctuary	IV	1.61	1977
86	Spike Island-I	Andaman & Nicobar	Sanctuary	IV	0.42	1977
87	Spike Island-II	Andaman & Nicobar	Sanctuary	IV	11.7	1977
88	Stoat Island	Andaman & Nicobar	Sanctuary	IV	0.44	1977
89	Surat Island	Andaman & Nicobar	Sanctuary	IV	0.31	1977

90	Swamp Island	Andaman & Nicobar	Sanctuary	IV	4.09	1977
91	Table (Delgarno) Island	Andaman & Nicobar	Sanctuary	IV	2.29	1977
92	Table (Excelsior) Island	Andaman & Nicobar	Sanctuary	IV	1.69	1977
93	Talabaicha Island	Andaman & Nicobar	Sanctuary	IV	3.21	1977
94	Temple Island	Andaman & Nicobar	Sanctuary	IV	1.04	1977
95	Tillongchang Island	Andaman & Nicobar	Sanctuary	IV	36.43	1977
96	Tree Island	Andaman & Nicobar	Sanctuary	IV	0.03	1977
97	Trilby Island	Andaman & Nicobar	Sanctuary	IV	0.96	1977
98	Tuft Island	Andaman & Nicobar	Sanctuary	IV	0.29	1977
99	Turtle Island	Andaman & Nicobar	Sanctuary	IV	0.39	1977
100	Kwangtung Island	Andaman & Nicobar	Sanctuary	IV	0.57	1987
101	West Island	Andaman & Nicobar	Sanctuary	IV	6.4	1977
102	Wharf Island	Andaman & Nicobar	Sanctuary	IV	0.11	1977
103	White Cliff Island	Andaman & Nicobar	Sanctuary	IV	0.47	1977
104	Galathea Bay	Andaman & Nicobar	Sanctuary	IV	11.44	1997
105	Cuthbert Bay	Andaman & Nicobar	Sanctuary	IV	5.82	1997
106	Pitti	Lakshadweep	Sanctuary	IV	0.01	2002

Table 3 : Important coastal and marine biodiversity areas of peninsular India

State (number of sites)	District	Identified Sites	Coordinates North	Coordinates East	Area (Km^2)	Suggested Category
Gujarat (14)	Kachchh	1. Koteshwar	23°40.363	68°33.614	146	Conservation/ community reserve
	Kachchh	2. Jacau	23°14.245	68°36.602	403	Conservation/ community reserve
	Kachchh	3. Gasabara	22°57.305	69°00.121	19	Conservation/ community reserve
	Porbandar	4. Porbandar	21°39.150	69°36.629	261	Wildlife sanctuary
	Porbandar	5. Madhavpur	21°15.717	69°57.057	19.6	Conservation/ community reserve
	Diu-Daman	6. Diu	20°23.034	70°57.613	179	Conservation/ community reserve
	Junagad	7. Gopnath	21°26.090	72°06.531	87	Conservation/ community reserve
	Bhavnagar	8. Bhavnagar	21°45.678	72°11.502	816	Conservation/ community reserve
	Anand	9. Wadgham	22°16.414	72°27.661	927	Conservation/ community reserve
	Surat	10. Aliabet	21°38.294	72°42.909	647	Conservation/ community reserve
	Surat	11. Purna	20°56.254	72°48.201	147	Conservation/ community reserve
	Valsad	12. Ambika	20°45.348	72°51.202	105	Conservation/ community reserve
	Valsad	13. Damnganga	20°24.654	72°51.019	9	Conservation/ community reserve
	Valsad	14. Umergaon	20°12.265	72°44.976	22.5	Conservation/ community reserve

State (number of sites)	District	Identified Sites	Coordinates North	Coordinates East	Area (Km^2)	Suggested Category
Maharashtra (16)	Thane	15. Vaiterna Creek	19°31.623	72°51.116	132.4	Conservation/ community reserve
	Thane	16. Bassein/ Vasai Creek	19°19.111	72°51.203	150	Conservation/ community reserve
	Thane	17. Thane Creek	19°09.256	72°58.671	152	Conservation reserve
	Raigad	18. Dharamtar	18°41.865	73°01.625	340	Conservation/ community reserve
	Raigad	19. Kundalika	18°32.690	72°55.915	98	Conservation/ community reserve
	Raigad	20. Murud-Janjira/Mhasala	18°18.366	72°57.990	141.7	Conservation/ community reserve
	Raigad	21. Shrivardhan	18°02.102	73°01.037	9.6	Conservation/ community reserve
	Ratnagiri	22. Harihareshwar -Savitri	17°59.455	73°01.136	21.77	Conservation/ community reserve
	Ratnagiri	23. Dabhol/Vasishti	17°34.799	73°10'910	23	Conservation/ community reserve
	Ratnagiri	24. Jaigad	17°17.545	73°13.402	40.75	Conservation/ community reserve
	Ratnagiri	25. Purnagad	16°48.503	73°19.349	9.4	Conservation/ community reserve
	Ratnagiri	26. Vijayadurgh	16°33.592	73°20.116	48.45	Conservation/ community reserve
	Sindhudurg	27. Devgad	16°22.475	73°22.278	14.4	Conservation/ community reserve
	Sindhudurg	28. Angria Bank	16°21.323	72°08.083	400	Conservation reserve
	Sindhudurg	29. Achra-Malvan	16°12'326	73°26'518	62.74	Conservation/ community reserve
	Sindhudurg	30. Terekhol	15°43.411	73°41.306	7.5	Conservation/ community reserve
Goa (3)	North Goa	31. Morjim-Anjuna	15°37.019	73°44.007	11	Conservation/ community reserve
	North Goa	32. Zuari-Mandovi Estuary	15°27.989	73°48.297	84.5	Conservation/ community reservey
	South Goa	33. Galgibagh	14°57.877	74°03.201	3.5	Conservation/ community reserve
Karnataka (10)	Uttara Kannada	34. Kali Estuary	14°51.206	74°06.712	25.3	Conservation/ community reserve
	Uttara Kannada	35. Gokarna/Tadri	14°50.521	74°08.503	46	Conservation/ community reserve
	Uttara Kannada	36. Sharavati/ Hanovar	14°16.581	74°27.958	13.6	Conservation/ community reserve
	Uttara Kannada	37. Murudeshwar	14°05.709	74°29.149	30	Conservation/ community reserve
	Udupi	38. Netrani Island	14°01.048	74°19.559	5	Conservation reserve
	Udupi	39. Kundapur/ Haladi	13°38.865	74°42.317	16.7	Conservation/ community reserve
	Udupi	40. Kodi Bengre/ Swarna-Sita	13°23.334	74°44.704	15	Conservation/ community reserve

State (number of sites)	District	Identified Sites	Coordinates North	Coordinates East	Area (Km^2)	Suggested Category
	Udupi	41. Malpe	13°21.624	74°41.874	38	Conservation/ community reserve
	Dakshin Kannada	42. Mulki-Pavanje	13°05.835	74°47.267	3.5	Conservation/ community reserve
	Dakshin Kannada	43. Gurpur-Netravati	12°51.254	74°50.058	13.8	Conservation/ community reserve
Kerala (18)	Kasargod	44. Kumbala Estuary	12°35.876	74°56.457	4.7	Conservation/ community reserve
	Kasargod	45. Mongrol	12°32.945	74°57.304	4.5	Conservation/ community reserve
	Kasargod	46. Kasargod/ Chandragiri	12°29.244	74°59.372	8	Conservation/ community reserve
	Kasargod	47. Edayilakadu	12°08.144	75°09.391	38	Conservation/ community reserve
	Kannur	48. Azhikkal	11°56.199	75°28.277	25	conservation/ community reserve
	Kannur	49. Kadakavu/ Dharmadom	11°46.835	75°27.649	9.5	Conservation/ community reserve
	Kozhikode	50. Kolavipalem	11°33.812	75°35.481	4.5	Conservation reserve
	Kozhikode	51. Beypore	11°09.713	75°48.065	8	Conservation/ community reserve
	Malapuram	52. Kadalundi	11°07.592	75°49.951	4	Community reserve
	Thrissur	53. Edakazhiyur beach	10°36.580	75°59.435	3.2	Conservation/ Community reserve
	Thrissur	54. Kole wetlands	10°32.527	76°06.449	175	Community reserve
	Ernakulam	55. Vypin-Fort Kochi	09°58.381	76°14.394	110	Conservation/ community reserve
	Alapuzha	56. Kumbalanghi	09°51.502	76°16.795	59.5	Conservation/ community reserve
	Alapuzha	57. Vembanad/ Kumarakom	09°37.882	76°25.125	230	Conservation/ community reserve
	Alapuzha	58. Kayamkulam/ Ayiram	09°07.496	76°28.756	21	Conservation/ community reserve
	Kollam	59. Ashtamudi	08°56.306	76°32.384	75	Conservation/ community reserve
	Tiruvanand-apuram	60. Paravur Kayal	08°48.762	76°38.924	12	Conservation/ community reserve
	Tiruvanand-apuram	61. Kadinamkulam	08°38.150	76°47.722	9.5	Conservation/ community reserve
West Bengal (3)	24 Pargnas	62. Jambudweep	21°35.126	88°11.152	5.12	Conservation/ community reserve
	Midnapur	63. Jambuchar	21°59.976	88°07.025	130	Conservation/ community reserve
	Midnapur	64. Junput	21°45.596	87°51.816	57.6	Conservation/ community reserve
Orissa (12)	Balasore	65. Talseri-Udaipur	21°36.340	87°28.842	3.5	Conservation/ community reserve
	Balasore	66. Subarnarekha	21°33.720	87°24.281	38	Conservation/ community reserve

State (number of sites)	District	Identified Sites	Coordinates North	Coordinates East	Area (Km^2)	Suggested Category
	Balasore	67. Chandipur	21°27.071	87°02.413	81.56	Conservation/ community reserve
	Bhadrak	68. Dhamra/ Karanjmal	20°51.152	86°56.835	90	Conservation/ community reserve
	Kendrapara	69. Bhopal	20°29.600	86°44.584	30	Cconservation/ community reserve
	Kendrapara	70. Jambudweep	20°24.075	86°43.260	95	Conservation/ community reserve
	Jagatsinghpur	71. Paradip	20°15.530	86°40.736	260	Conservation/ community reserve
	Puri	72. Devi	19°58.810	86°19.528	88.38	Conservation/ community reserve
	Puri	73. Chilika/ Nalabana Isle	19°41.336	85°17.659	1095	Wildlife sanctuary
	Ganjam	74. Rushikulya	19°22.799	85°04.355	18.85	Conservation/ community reserve
	Ganjam	75. Gopalpur	19°15.426	84°58.326	5.4	Conservation/ community reserve
	Ganjam	76. Bahuda swamp	19°13.720	84°50.458	18.55	Conservation/ community reserve
Andhra Pradesh (17)	Srikakulam	77. Sunapur/ Nilarevu/Ichchap	19°05.342	84°44.235	34.54	Conservation/ community reserve
	Srikakulam	78. Nuvularevu	18°40.754	84°26.460	10.32	Conservation/ community reserve
	Srikakulam	79. Naupada	18°33.740	84°20.875	28.98	Conservation/ community reserve
	Srikakulam	80. Kalinga-patnam	18°20.535	84°07.449	10	Conservation/ community reserve
	Vishakapatnam	81. Gangavaram	17°38.770	83°11.945	3	Conservation/ community reserve
	Vishakapatnam	82. Pudimadka	17°28.531	82°59.599	2	Conservation/ community reserve
	Vishakapatnam	83. Bangaram-palem	17°25'186	82°51'718	4.2	Conservation/ community reserve
	Puducherry	84. Yenam	16°43.513	82°12.565	8.4	Conservation reserve
	East Godavari	85. Vashisti/ Kothapalem	16°35.605	82°17.885	148	Conservation/ reserve
	Krishna	86. Bantumeli	16°20.628	81°20.410	28.44	Conservation reserve
	Krishna	87. Machilipatnam	16°07.919	81°10.827	26.38	Conservation reserve
	Krishna	88. Hamasaladevi	15°58.627	81°06.035	42	Conservation/ community reserve
	Guntur	89. Nizamapatnam	15°53.711	80°38.584	45.64	Conservation/ community reserve
	Guntur	90. Chinna Ganjam	15°40.120	80°15.331	14.85	Community reserve
	Prakasam	91. Pennar	14°34.881	80°10.155	23.5	Conservation/ community reserve
	Nellore	92. Krishnapatnam	14°15.341	80°75.182	48.6	Conservation/ community reserve

State (number of sites)	District	Identified Sites	Coordinates North	Coordinates East	Area (Km^2)	Suggested Category
	Nellore	93. Pulicat	13°34.080	80°08.454	383	Wildlife sanctuary
Tamil Nadu & Puducherry (14)	Thiruvallur	94. Pulicat	13°26.311	80°19.516	82.4	Conservation/ community reserve
	Kanchipuram	95. Muttukad/ Kovalam	12°48.343	80°14.576	32.42	Conservation/ community reserve
	Villupuram	96. Kaliveli	12°14.115	79°58.326	101.4	Conservation/ community reserve
	Puducherry	97. Ariyankuppam	11°54.308	79°49.553	4	Conservation/ community reserve
	Cuddalore	98. Cuddalore	11°41.490	79°46.215	9.567	Conservation/ community reserve
	Cuddalore	99. Vellar	11°30.103	79°46.332	8.2	Community reserve
	Cuddalore	100. Pichavaram	11°25.835	79°47.601	20	Wildlife sanctuary
	Cuddalore	101. Pazhayaar	11°21.220	79°49.531	10.5	Conservation/ community reserve
	Nagapatnam	102. Talaingnayar	10°31.060	79°43.634	37	Conservation reserve
	Nagapatnam	103. Vedaranyam swamp	10°18.993	79°44.737	210	Community reserve
	Thiruvarur	104. Muthupet	10°20.301	79°32.417	70	Wildlife sanctuary
	Thanjavur	105. Adiramapatnam	10°18.260	79°22.364	32.25	Conservation reserve
	Pudukotai-Ramnad	106. Palk Bay	09°38.813	78°56.373	725	Wildlife sanctuary
	Kanyakumari	107. Manakudy	08°06.129	77°29.019	4.41	Conservation/ community reserve

Challenges and Way forward

Considering the importance of coastal areas in India with respect to the prevailing socio-economic perspectives, it will be difficult to add further habitats of coastal and marine biodiversity in the existing MPA network as national parks or sanctuaries.

So far, there has been no systematic assessment of the conservation status of coastal and marine species of India using the IUCN Regional Red Listing Guidelines. This is largely due to a lack of required data on the status and distribution of most of the marine species in India. Currently, according to expert opinion, 10 species of shark and ray, including the Whale Shark, all species of sea horse, the Giant Grouper, all cetaceans, the Dugong, 9 species of shell, 5 species of sea turtle, one species of otter, all species of coral, all species of sponge and all holothurians that occur in the coastal and marine areas of India are considered to be under threat. Therefore, they have been protected under the Wildlife (Protection) Act, 1972 by being listed in Schedule I.

The highly threatened marine species of India need to be conserved on priority basis using special 'Species Recovery Plans'. In this connection, seven threatened marine taxa were selected for preparation of recovery plans: the Dugong, the Whale Shark, marine turtles (two species), giant clams, holothurians (sea cucumbers), horseshoe crabs and sea horses. The Ministry of Environment, Forests and Climate Change, Government of India has already chosen the threatened dugong, marine turtles, coral reefs and mangroves under its 'Integrated Development of Wildlife Habitats' programme on a priority basis (Anon 2009). Necessary conservation actions in this regard have already been initiated.

Coastal ecosystems are mongst some of the most vulnerable ecosystems to climate change. Therefore, it is of the greatest importance to have a climate change adaptation plan for the coastal and marine protected areas in the country. Coordination among all the organizations/institutions that work for conservation of threatened marine species and the welfare of coastal communities is required. Moreover, documentation and databases of information obtained through research on threatened marine species are also urgently required. It is also important to develop a specialized field-based

programme in marine ecosystem ecology at the higher education level with an emphasis on rigorous scientific research, hypothesis testing, taxonomy and conservation, based on the models established by the M.Sc. course in wildlife science at the Wildlife Institute of India and at the National Centre for Biological Science. Development of human resources to manage the MPAs of India is also essential.

Fisheries, aquaculture, seaweeds and mangroves are among the major areas of scientific research into coastal and marine biodiversity in India. Research on the culture of organisms of export value such as sea cucumbers, sea horses and ornamental fishes has also been carried out by institutions such as state and central fisheries departments and academic institutions. Research on corals, mangroves, sea grasses and certain threatened fauna has also been carried out, but in a sporadic manner and only in selected sites. So far, most of the research carried out in India has considered marine biodiversity as commercial products and largely failed to appreciate their ecological role. Moreover, recent threats such as climate change, invasive species and faster economic development are posing major challenges to conservation of marine biodiversity. These need to be addressed immediately through scientific research. Addressing these lacunae through long-term scientific research and generation of ecological information on the habitat and resource requirements of marine species are needed for successful management of MPAs in the country.

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References

AGARDY, T., DI SCIARA, G.N. & CHRISTIE, P. 2011. Mind the gap: Addressing the shortcomings of marine protected areas through large scale marine spatial planning. Marine Policy 35(2): 226-232.

FUNG, I.Y., DONEY, S.C., LINDSAY, K. & JOHN, J. 2005. Evolution of carbon sinks in a changing climate. Proceedings of National Academy of Science 102: 11201-11206.

GOES, J., THOPPIL, P.G., GOMES, H. do R. & FASULLO, J.T. 2005. Warming of the Eurasian landmass is making the Arabian Sea more productive. Science 308(5721): 545-547.

HALPERN, B.S. 2003. The impact of marine reserves: Do reserves work and does reserve size matter? Ecological Applications 13(sp1): 117-137.

HALPERN, B.S. & WARNER, R.R. 2002. Marine reserves have rapid and lasting effects. Ecology Letters 5(3): 361-366.

IPCC. 2014. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

LOTZE, H.K., HUNTER, S.L., BRUCE, J.B., ROGER, H.B., RICHARD, G.C., MATTHEW, C.K., SUSAN, M.K., MICHAEL, X.K, PETERSON, C.H. & JACKSON, J.B.C. 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas. Science 312(5781): 1806-1809.

MADHUPRATAP, M., MANGESH, G., RAMAIAH, N., PRASANNA KUMAR, S., MURALEEDHARAN, P.M., DE SOUSA, S.N., SARDESSAI, S. & MURALEEDHARAN, U. 2003. Biogeochemistry of the Bay of Bengal: Physical, chemical and primary productivity characteristics of the central and western Bay of Bengal during summer monsoon 2001. Deep-Sea Research II 50(5): 881-896.

MoEF. 2014. India's Fifth National Report to Convention on Biological Diversity. New Delhi: Ministry of Environment and Forests, Government of India. 100 pp.

RODGERS, A.W., PANWAR, H.S. & MATHUR, V.B. 2002. Wildlife Protected Area Network in India: A Review. Dehradun: Wildlife Institute of India. 51 pp.

SELIG, E.R. & BRUNO, J.F. 2010. A global analysis of the effectiveness of marine protected areas in preventing coral loss. PLoS One 5(2): e9278. doi:10.1371/journal.pone.0009278.

SIVAKUMAR, K., MATHUR, V.B. & CHOUDHURY, B.C. 2012. Marine protected areas network in India: Progress in achieving Aichi targets. Abstracts of the 16th Meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, 30 April-5 May 2012, Montreal, Canada. Pp. 78-79.

UNISDR/UNDP. 2012. Status of Coastal and Marine Ecosystem Management in South Asia. Inputs of the South Asian consultative Workshop on 'Integration of Disaster Risk Reduction and Climate Change Adaptation into Biodiversity and Ecosystem Management of Coastal and Marine Areas in South Asia', held in New Delhi on 6 and 7 March 2012. New Delhi: UNDP. 173 pp.