Synergizing Traditional Knowledge and Sustainable Local Practices for Enhancing Coastal Resource Education and Management- an Indian Scenario

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The diverse marine and coastal habitats in India harbor a wide range of biodiversity which has not been fully understood due to logistic constraints. The variety of coastal ecosystems along the Indian coastline measuring 8,129 km encompassing nine maritime states and four union territories include estuaries, lagoons, mangroves, backwaters, and coral reefs. The marine floral and faunal diversity is immense that India stands third in fish production and second in aquaculture in the world. This vast coastline, which has such rich coastal resources, has always been under threat, atleast in the recent past due to reasons, viz. nature, anthropogenic factors, and urbanization. These factors have contributed to the loss in biodiversity endangering few species to the brink of extinction. As a part of the conservation campaign for coastal resource management in India, traditional knowledge that helped in sustainable fishery has to be revived through synergizing the activities of the academicians, policy makers, and NGOs to draft a proposal for an effective and successful coastal resource management. Inculcating the need for coastal resource management in the minds of future generation would warrant the introduction of this focal point at different levels of education, and the wealth of traditional knowledge of the fisherfolk of Pulicat Lake in Tamil Nadu would be an added feature on this subject.

Keywords: traditional knowledge, coastal resource education, coastal resource management, India

INTRODUCTION

The coastal stretch of India is made up of diverse ecosystem, which includes a wide range of mangroves, coral reefs, sea grasses, salt marshes, mud flats, estuaries, lagoons, and unique flora and fauna.In India, nearly ten million fishermen depend on coastal resources and seas for their survival. Increasing stress due to development of industries, trade and commerce, tourism and resultant human population growth and migration towards coastal cities and urban centers pose a serious threat to the health of these coastal ecosystems and to lives and livelihoods of coastal communities. Thus, protection, conservation, and rejuvenation of coastal natural resource have become a need of thehour. This paper focuses on the use of traditional fisheries knowledge and indigenous fisheries knowledge for sustainable fisheries,which carry special relevance in the context of resource conservation, reduction of environmental pollution, maximum utilization of locally available resources, and cost effectiveness.

RESOURCE POTENTIAL OF INDIA

India has a vast coastline of about 8,129 km encompassing nine maritime states and four union territories with an Exclusive Economic Zone (EEZ) of 2.02 million km^2, which is home to a diversity of coastal and marine ecosystems, comprising nationally and globally significant biodiversity rich areas. Until today marine diversity is less known than terrestrial biodiversity due to the logistic difficulties of explorations, underwater surveys, and collections. The coastline of Bay of Bengal and Arabian Sea continues to be a rich fishing ground in the South Asian region, and India is one of the world's largest fish producing countries. Indian marine ecosystems are all known for their high biological productivity, thus providing a wide range of habitats for aquatic flora and fauna. They also provide important food resources and other fishery relatedactivity to people.

FISH PRODUCTION IN INDIA

With continuous and sustained increments in fish production since independence, India is considered to be the third largest fish producer in the world (first and second being China and Peru, respectively) and

second largest producer through aquaculture. In the overall production of shrimps, India stands in fifth in the world. India constitutes about 6.3% of the global fish production; the sector contributes to 1.1% of the GDP and 5.15% of the agricultural GDP. Per capita fish consumption in India is 9kg (NFDB, 2016).

CURRENT STATUS OF INDIAN SEAFOOD EXPORT

During the financial year 2014-15, exports of marine products from India reached an all-time high. Exports aggregated to 10,51,243 MT valued at Rs. 33,441.61 crores and USD 5511.12 million. Compared to the previous year, seafood exports recorded a growth of 6.86 % in quantity, 10.69% in rupees and 10.05 % growth in USD earnings.Frozen shrimp continued to be the major export item in terms of quantity and value, accounting for a share of 34.01% in quantity and 67.19% of the total dollar earnings. Fish was the second largest export item, accounting to a share of about 29.44% in quantity and 11.24% in dollar earnings. The US wass the largest market for Indian seafood products with a share of 26.46% followed by South East Asia (25.71%), European Union (20.08%), Japan (9.11%), Middle East (6.04%), China (4.02%) andother countries (8.58%) (MPEDA, 2016).

COASTAL BIODIVERSITY

India's coastline holds many biological treasures.The rich mangrove forests of Sundarbans (Plate 1a), the world's largest congregations of nesting turtles in Odisha, beautiful seagrass beds in Palk Bay, enigmatic sea cows in the Gulf of Mannar, majestic yet gentle whale sharks in the Gulf of Kutch and some of the world's most beautiful and striking coral reefs (Plate 1b) are examples of some of the biological treasures of India's coastal and marine biodiversity. Besides being store houses of biological diversity, coastal regions are also home to a large human population. Indian coastal ecosystems consist of sandy and rocky beaches (Plate 1c&d),backwaters (Plate 1e), estuaries, creeks, mangroves, coral reefs, Mudflats (Plate 1f) marshes, lagoon, and seagrass.

IMPACT OF NATURAL CALAMITY ON FISHERIES AND COASTAL COMMUNITIES – POST TSUNAMI

The tsunami, which also attacked Indian Ocean on the 26th December 2004, caused considerable destruction and casualties in the coastal regions of the states including Tamil Nadu, Pondicherry, Kerala, Andhra Pradesh, and Andaman and Nicobar Islands. There was a considerable reduction in the fishing trips and decline in catch rates, which was mainly due to loss of fishing equipment, fear of recurrence of tsunami, and displacement from their original place of inhabitance to relief camps. Fishermen restricted their activities near the shore. Hence, there was drastic reduction in the per capita landings of all types of fishing units. The prices of marine fish also faced great setback immediately after the tsunami. This was mainly due to low demand for fishes in the market, as result of people's apprehension, that fishes might have consumed carcasses of humans and animals floating in the sea after the tsunami.

The income levels of owners of mechanized and non-mechanized boats as well as the crew members showed a steep decline. Fishing labourers, who share one third of the total revenue of the catch, suffered heavily with substantial wage losses due to decrease in catch after tsunami. The tsunami also caused widespread damage to houses that were either completely destroyed or damaged (Plate 2 a b c & d).

Employment opportunities apart from capture fisheries, which includes net mending and weaving, supply and repair of fishing equipment and gear, boat building, ice plants, marketing, processing and transporting of fish, and fish exports, among others seem to have been affected very badly (Sathiadas & Prathap, 2008).

THREATS TO MARINE BIODIVERSITY

India's rapid population, economic, and industrial growth had created pressures on the coastal resources. Some coastal stretches in India were highly polluted with municipal waste deriving from urbanization and tourism, waste generated from industry, and toxic chemicals from fertilizers and pesticide application. Untreated sewage and other non-industrial waste accounted for more pollution than industrial effluents. Mining of sand from the sea-bed resulted in an increase in turbidity in the ambient water, which affects benthic organisms and primary productivity by limiting the availability of

light. Aquaculture activity in some parts of India had also placed considerable pressure on coastal resources. Construction of breakwaters (Plate 3a), which forms part of the port development, alters the sediment transport mechanisms in the coastal areas, thereby causing erosion (Plate 3b) or accretion.

Major anthropogenic activities that cause ecosystem degradation and destruction include habitat conversion into the other forms of land use, overexploitation of species, associated destructive fishing practices, spread of invasive alien species, and the impacts of pollution from agricultural, domestic, and industrial effluents.The marine biodiversity has to counter a wide range of challenges that threaten their very existence. These challenges include the impact of climate change, overexploitation of fishery, habitat damage, urbanization, and pollution.

The rise in sea level, due to the melting of the glaciers, inundates coastal areas and in some cases would drown an island completely. The overexploitation of fishery resource through commercial fishing, recreational fishing, illegal unregulated or unreported fishing (IUU) causes a decline in the fishery resource of the sea (Plate 3c). The increase in oceanic temperature due to global warming results in coral bleaching (Plate 3d).The unsteady water cycle increases the rainfall causing floods and changes the patterns of water movement, displacing the usual path of biodiversity.

Destructive fishing gear, especially bottom trawling, damages the habitat to a large extent. The coral reefs are ripped off when the nets that entangle them are removed. The dredgers have a drastic effect on the benthic organisms as they disturb or in most cases remove the soil, which is the habitat of a variety of encrusting organisms, biofoulers and epibenthic organisms. The marine environment is being polluted by an array of pollutants that include, sediments from mining or rigging, plastic litter (Plate 3e) usually from the navigating ships, discharge of effluents (Plate 3f), hazardous and radioactive substances from industries along the coast, discarded fishing gear in the sea (Plate 3g) that accounts for ghost fishing, microbial pollution and trace chemicals which become carcinogens, endocrine-disruptors, etc.They cause a serious threat to the life of many aquatic organisms.

The introduction of alien species into an ecosystem can alter the entire composition of the biodiversity in that biome. The absence of natural predators, conducive environment, and easy prey can help establish the population of the alien species causing huge damage to the ecosystem as the native species are pushed to a state of mere survival.

Marine debris, mineral exploration, oil rigging, and laying of pipelines and cables in the sea cause habitat destruction and biodiversity loss. The fine silt that is inevitable during mineral exploration alters the turbidity of the water column forcing the fishery to move away from the place. The silt that settle down would bury the encrusting and the epibenthic organisms, which form the major attractants of biodiversity. The oil pipelines that are in deep sea also threatens the life of many organisms. Leakage in the pipeline would wipe out the biodiversity in a very short span of time (Tewari & Bisht, 2010).

ENDANGERED MARINE SPECIES

International Union for the Conservation of Nature(IUCN) has listed approximately 342 marine species in India (Table 1, Plate 4),that fall under different categories, viz.Critically Endangered, Endangered, Near Threatened and Vulnerable (IUCN, 2016). Steps have to be taken for the conservation of these species.

CONSERVATION

In situ conservation of species is the process of protecting an endangered or threatened marine animals in its natural habitat by protecting them from predators and anthropogenic activities.

Sea Ranching: It is a culture method whereby juvenile animals, generally produced in hatcheries but could also be wild-caught, are introduced into the natural environment and allowed to grow without containment structures.

Marine Reserve/protected areas: A marine reserve is a defined space within the sea in which fishing is banned or restricted to protect the habitat and ultimately conserve the associated biodiversity. Marine reserves are also very similar to marine protected areas, fishery reserves, sanctuaries, and parks (Table 2). Declaration of certain protected areas/biosphere reserves for *in situ* conservation of resources appears to be a pragmatic approach. The important biosphere reserves in India (Table 3) are Gulf of Mannar Biosphere Reserve (Tamil Nadu): Sunderbans Biosphere Reserve (West Bengal), Great Nicobar Biosphere Reserve (Andaman and Nicobar Islands), North Andaman Biosphere Reserve (Andaman and Nicobar Islands) (Plate 5a) and Little Rann of Kutch Biosphere Reserve (Gujarat).

Bioregional management: It is the total ecosystem strategy, which regulates factors affecting aquatic biodiversity by balancing conservation, economic, and social needs within an area. In these bio-conservation units, activities such as fishing, hunting, harvesting, and development activities are strictly limited.

Threatened or endangered species designations: Threatened species include organisms likely to become endangered if not properly protected. Endangered species are plants and animals that need protection in order to survive as they are in immediate danger of becoming extinct. Once species are listed, they become subject to national recovery programs and will be placed under international protection.

Restoration/Mitigation efforts: Aquatic areas that have been damaged or suffered habitat loss or degradation can be restored. Even species populations that have suffered a decline can be included for restoration.

Ex situ conservation is "off-site" protection of species by removing the threatened species from their existing habitat and placing them in protected environments. This includes live gene bank, where the endangered species are reared in captivity, bred, and genetically managed avoiding inbreeding, domestication, and unintended selection. Cryopreservation of gametes in liquid nitrogen and gene banks can help in long-term conservation.

Increasing public awareness is one of the most important ways to conserve aquatic biodiversity. This can be accomplished through educational programs, incentive programs, and volunteer monitoring programs. Several initiatives were taken by the Government of India focusing on the conservation and management through implementation of laws and continuous monitoring. The Wildlife Protection Act of India (1972) provides legal protection to many marine animals. The Environment Protection Act, 1986 declare mangrove and coral reef areas as ecologically sensitive areas. The Coastal Regulation Zone (CRZ) prohibit the developmental activities and disposal of wastes in the fragile coastal ecosystems that facilitates the mass nesting of sea turtles at Gahirmatha, Odhisa (Plate 5b). The National Biodiversity Authority also focuses on matters related to the protection and conservation of biodiversity.

INDIGENOUS FISHERIESKNOWLEDGE/ TRADITIONAL FISHERIES KNOWLEDGE – PULICAT PERSPECTIVE

The normal practices of the fisherfolk always had concern for the environment or more so conformed to the norms of the ecosystem. Due to factors like over population, export demand, technological advancement, ecosystems slowly

withered and are now facing the after effects of negligence. It is now pertinent that academicians promote to the current generation of fishermen these, an indigenous fishing practice, which isin tune with nature. By highlighting what the yesteryear fishermen practiced to maintain sustainability, negligence would not grow to ignorance.

Fishing in Pulicat is an example of sustainable fishing. The regulation on the fishing rights and fishing grounds, which is monitored and implemented strictly through a system called "P*aadu* system," is an example of sustainable fishing. According to this system, a village is allotted a particular fishing ground to fish only on certain days using only certain craft and gears. This prevents overcrowding, allows equal distribution of productive fishing grounds, and reduces fishing pressure in the lake by providing fishing rights in the sea. The use of non-mechanized boats helps prevent oil pollution and noise pollution, and reduces damage to the nets.

The fishermen had a unique knowledge on fish aggregation through the onset of wind direction. They were able to project the aggregation or movement of shoals of specific fishes at the advent of a specific wind from a specific direction. By this, they were able to forecast fish catch, thereby increasing their catch per unit effort (CPUE) and income per unit effort (IPUE). They were able to take specific nets for specific shoals of fishes having specific mesh size, thereby, reducing the quantum of trash fish or bycatch.

The complexity in the pattern of installation of shrimp nets in the lake was done in full knowledge of the movement of the shrimp based on the impact of any obstruction. The use of specific baits for the hook and line fishing was also based on the behavior of the fishes. Live prawn was used as bait for fishing seabass not because of visual stimulus of the twitching of the prawn but because of the olfactory stimulus of the body fluids that ooze out of the prawn while twitching. Another traditional practice was the crab fattening where the unproductive crab, after a moult was transformed into commercially potent crab. This type of culture was more prevalent in small fishing hamlets.

Jamilabad, a village in Pulicat, maintained their traditional knowledge of building boats (Plate 6 a & b) for the entire fishing community in and around Pulicat. The boat builders never went to any institute to learn the art, but the indigenous knowledge was transferred from one generation to the other for so many years till recently when fibre boats came into play. The choice of wood, adhesive, nails, paint, and sail are all custom-made

from locally available indigenous products. The introduction of the fiber boats had distorted their livelihood and their art was in the verge of a mere memory.

Neelankarai, a fishing village in the east coast of India near Mamallapuram, practiced a unique method to attract fish to their area. The bark of a tree, *Delonixelata,* was cut and anchored in the sea. The bark would start to purify slowly and the smell from the bark would attract many fishes to the vicinity. This was used as a fish aggregating device. Fishermen could easily forecast the weather and help in effective fishing. With the help of the colour and proximity of the cloud and the direction of the wind, they were able to predict the presence of the shoals in the vicinity.

In a shallow water body like Pulicat Lake, the depth of the lake was not uniform and this could result in the boats getting grounded. The colour of the water gave a clue to the fishermen whether the depth was adequate to wade through.

INDIGENOUS FISHERIES KNOWLEDGE/ TRADITIONAL FISHERIES KNOWLEDGE – KERALAPERSPECTIVE

Traditional knowledge on selection of wood for making crafts helped them to have better quality boats with strong and long durability in salt water. The use of sardine oil was the most common practice to safe guard the wooden boats. Cotton and jute threads were used for making gears with the mesh size suitable for catching only the targeted size and for reducing juvenile fishing. Traditional knowledge of boiling the nets in cow dung slurry and drying it in the sun helped them to maintain the nets.The other method of boiling the nets with dried seeds of tamarind gave strength and colour to the gears.A mixture of powdered ghee and charcoal were used as an antifouling agent in their traditional crafts. Hence, a wide variety of materials and indigenous techniques were used in making crafts and gears and also for their maintenance.

Based on the water movement and colouration, fishers were able to tell the availability of fish. The appearance of seagulls would indicate the presence of fish. Sardine shoals was characterized by the presence of small bubbles and oily appearance on the top of water. The presence of silver bellies was indicated by a white colouration of water. Muddy water in some

seasons indicated good shoals on the next day.The traditionally practiced shoal identification techniques showed the sound knowledge and close association of the older generation with the nature.

Traditional knowledge was used even for the post-harvest techniques. Fresh fish sprinkled with wet sand was believed to preserve the fish, day long.The fishes like sharks and rays were kept in pits dug on beach helped prevent easy decay.The common practice of salting fish in earthenvessels and keeping them for two days and drying them for 3-4 days in the hot sun was practiced as a common preservation technique.Many of the indigenous preservation methods were cheaper and free from harmful chemicals (Ashaleetha & Immanuel, 2008).

COASTAL RESOURCE EDUCATION

India has a vast coastline and a wealth of coastal resources; thus,its fishing potential and the need for its coastal management have to be made known to all people through proper education. Like Environmental Studies which was introduced into the curriculum after the government deemed it important for people to know their part in the degradation of the environment, Coastal Resource Management should also be part of the curriculum for the people to know the need for proper management of the coastal resource. This education can be started even from school as a chapter in Biology and in under graduation as a paper and in post-graduation as an interdisciplinary optional paper.

Fishing holidays (61 days in east and west coasts) introduced by the government is a step towards conservation. The overexploitation following the fishing holidays has to be checked to taste the fruits of such endeavor. This can be done with the cooperation of NGOs, self-help groups, and entrepreneurs. The fishing pressure should be neutralized with aquaculture.

Workshops and training programs can be organized to highlight the importance of coastal resource and its management through schools, colleges, and NGOs, to make people aware of the latest research and potential in fisheries. Awareness campaigns on conservation and management is the need of the hour.

Extension education in the form of out of school education can target specific groups based on their understanding. Different methodologies can be adopted for different target groups like pamphlets, street plays, movies, short plays, meetings, demonstrations, onsite programs, newsletter; participatory rural appraisal techniques can be used for effective transfer of information.

Lab to land programs should be quick, transparent, and replicable. The successful techniques from the institutes should be brought to the people and educate them to maximize the potential utilization of research findings.

Joint efforts from all units related to the coastal resource like the state fishery departments, forest department, coast guard, fisher folk, boat builders, entrepreneurs, businessmen, NGOs, scientists, researchers, and academicians should join hands in coastal resource education and management. Central fisheries institutes in India like, CMFRI, CIBA, CIFT, CIFRI, CIFE and others play a very important role in educating the farmers/communities by providing technical support and consultancies as well as monetary help in the form of loans, credits, and subsidies.People's awareness, participation, and support are pivotal to the implementation of any project concerning the resource management. More than management and conservation, it is the concern that is very important.

The population of India has grown exponentially and is likely to touch 1.6 billion in 2050. Conservation of coastal resource is pivotal to sustenance in meeting the growing need for food and nutritional requirements of the country. Innovation in hatchery technology and farming, feed technology, diversification, and introduction of more cultivable organisms in aquaculture could help reduce the fishing pressure on capture fisheries.

The indigenous fisheries knowledge and traditional knowledge of the fishermen cannot be ignored these days as they could stabilize the balance between need and greed. Coastal resource management / education will surely transform the coastal resource into an unending resource for the future. The coastal resource concern is more important than coastal resource conservation.

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Plate – 1. Few Coastal Ecosystems in India

(a) Mangroves in Sunderbans, West Bengal; (b) Coral Reefs of Andaman Islands;
(c) Sandy Beaches of Goa; (d) Rocky Shores of Mammallapuram;
(e) Backwater of Kerala; (f) Mudflats of Muthupet, Tamilnadu

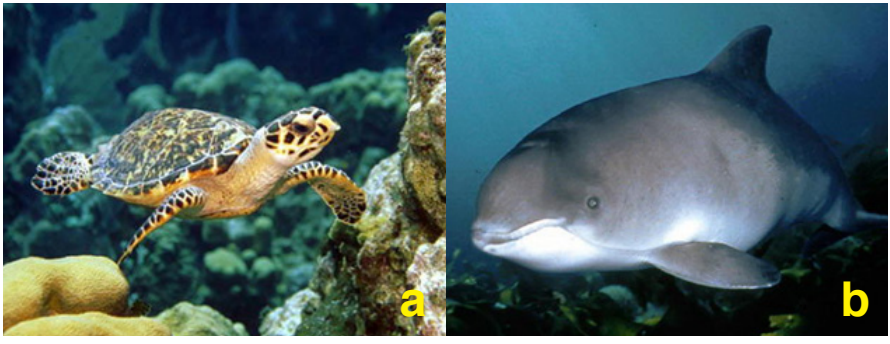
Plate – 2. Effects of Tsunami

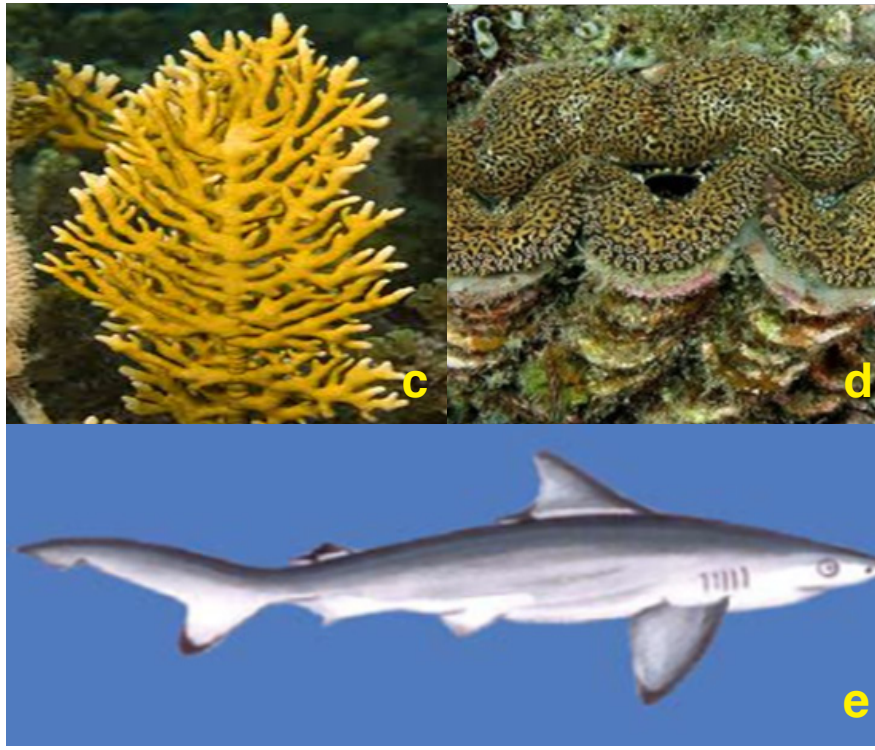
(a) Tsunami damages in Cudalore; (b) Erosion in Pondicherry;
(c)Houses damaged in Nagapatinam; (d) Boats damaged in Cudalore

Plate – 3. Threats to Marine Biodiversity

(a) Construction of Breakwater; (b) Beach Erosion;
(c) Overexploitation of Fishery Resource; (d) Coral Bleaching;
(e) Plastic litter; (f) E**ffl**uent discharge; (g) Discarded nets

Plate - 4. Endangered Marine Species of India





(a) Hawksbill Sea Turtle; (b) Sei Whale; (c) Fire Coral;
(d) Giant Clam; (e)Pondicherry Shark

Plate - 5. Marine Protected Areas in India

(a) National Park in Andaman Islands; (b) Turtle nesting at Gahirmatha, Odisha

Plate - 6. Boat-building in Jamilabad, Pulicat

(a) Choice of wood; (b) Boat-building in Jamilabad, Pulicat

Table 1. Endangered Marine Species in India

S.No.	Group	No.of species
1	Anthozoa	28
2	Hydrozoa	182
3	Bivalvia	25
4	Holothuroidea	2
5	Chondrichthyes	70
6	Actinopterygii	9
7	Reptilia	3
8	Aves	10
9	Mammalia	4
10	Liliopsida (seaweed)	2
11	Magnoliopsida (seaweed)	5

Table 2. Marine Sanctuaries and Marine National Parks in India

S.No.	Name of Marine Sanctuaries and Marine National Parks	State of India
1.	Gulf of Kutch Marine National Park	Gujarat
2.	Mahatma Gandhi Marine National Park	Andaman Islands
3.	Gulf of Mannar Marine National Park.	Tamil Nadu
4.	Rani Jhansi Marine National Park	Andaman and Nicobar Islands

5.	Gahirmatha Marine Wildlife Sanctuary	Odisha
6.	Malvan Marine Wildlife Sanctuary	Maharashtra

Table 3. Marine Biosphere Reserves in India

S.No.	Name of the Marine Biosphere Reserve	State of India
1.	Gulf of MannarBiosphere Reserve	Tamil Nadu
2.	Sunderbans Biosphere Reserve	West Bengal
3.	Great Nicobar Biosphere Reserve	Andaman and Nicobar islands
4.	North Andaman Biosphere Reserve	Andaman and Nicobar islands
5.	Little Rann of Kutch Biosphere Reserve	Gujarat