Integrated Management Plan of the Gulf of Mannar Marine National Park and Biosphere Reserve (2018-2027)

Tamil Nadu Forest Department

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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K. Sivakumar

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PART-I

The Existing Situation

Chapter 1

TheGulf of Mannar Marine National Park and Biosphere Reserve

1.1 Introduction

The Gulf of Mannar, the first Marine Biosphere Reserve in the South and South East Asia, running down south from Rameswaram to Kanyakumari in Tamil Nadu, India, is situated between Longitudes $78^0$08'E to $79^0$30'E and along Latitudes from $8^0$35'N to $9^0$25'N with a total area of 10,500 Km^2. This marine Biosphere Reserve encompasses a chain of 21 islands and adjoining coral reefs off the coasts of the Ramanathapuram and the Tuticorin districts forming the core zone; the Marine National Park. The surrounding seascape of the Marine National Park and a 10 km strip of the coastal landscape covering a total area 10,500 sq. km., in the Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari Districts forms the Gulf of Mannar Biosphere Reserve.

The importance of the Gulf of Mannar region dates back to the 2nd Century AD because of its highly productive pearl banks and other religious significance. The Gulf of Mannar has drawn attention of conservationists even before the initiation of the Man and Biosphere (MAB) program by the UNESCO in 1971. With its rich biodiversity of 3600 species of various flora and fauna of the Gulf of Mannar has been declared as a Marine National Park in 1986 by the Government of Tamil Nadu and later as the first Marine Biosphere Reserve of India in 1989 by the Government of India.

After the concurrence of the Tamil Nadu Government (Telex message NO.75612 / FRV / 88 –3, dated the 24th January 1989) to the proposal of the Government of India for setting of a Marine Biosphere Reserve in Tamil Nadu, the Government of India vide their Notification No. No. 1/6/80-Mannar, dated 4th April 1989, declared the Indian part of the Gulf of Mannar region covering an area of 10500 sq. km as the Gulf of Mannar Biosphere Reserve (GOMBR). It also suggested that the Tamil Nadu Government for preparation of detailed maps of the Biosphere Reserve (BR) and to initiate management of the BR as per the Government of India Guidelines. The last Management Plan of BR that was prepared by WII for the period of 2007-2016 was implemented under the direction of the CWLW, TN and implemented by the Director, GoMBRT and the Wildlife Warden under the supervision of the Southern Regional Wildlife circle at Madurai and later under the supervision of Conservator of Forests, Virudhanagar circle designated as the Director, GOMBR.

Since the GOMBR surrounding the Marine National Park is the area where the local communities are dependent for their livelihood, the Tamil Nadu Government established the Gulf of Mannar Biosphere Reserve Trust (GOMBRT) under the Tamil Nadu Society Registration Act, 1975 vide TN G.O. Ms. No. 263, E&F-FR (V), dated 18.12.2000 as a Special Purposed Vehicle to coordinate and ensure effective inter sectoral coordination and facilitate mainstreaming of biodiversity conservation issues into the productive sector and policy development. Government of Tamil Nadu sought support and assistance of the GEF-UNDP through a project 'Conservation and sustainable use of the Gulf of Mannar BR coastal biodiversity'. The GEF-UNDP approved this seven year project in the year 2002 at the cost of Rupees 140 crores, of which, the GEF-UNDP contribution was tune of Rupees 40 crores and co-funding from the Government of Tamil Nadu, Government of India and others to the tune of Rupees 100 crores. Support of UNDP-GEF was ended in 2012 and then the Tamil Nadu Government has been supporting GOMBRT.

Therefore, in addition to the Wildlife Warden, GOMMNP and the Director, GOMBR, the Director, Gulf of Mannar Biosphere Reserve Trust are jointly responsible for protection, management and development of the GOMBR.

While the Gulf of Mannar Marine National Park is managed under the provision of the Wildlife (Protection) Act, 1972, the Indian Forest Act, 1927, Forest (Conservation) Act, 1980, Environmental (Protection) Act, 1986, National Forest Policy, 1988, Coastal Zone Regulation Act, 1992 and Coastal Zone Management Plans of the Tamil Nadu State Government are some of the legal instruments which are supportive and are applicable for protection and management of both the Gulf of Mannar Marine National Park and Biosphere Reserve.

The geographic scope of the Management Plan encompasses the proposed Gulf of Mannar Biosphere Reserve (GOMBR) and the Marine National Park as the core area within the GOMBR. The GOMBR also encompasses a terrestrial area up to 10 km from the coast line from Dhanuskodi Island on the north-east (Ramanathapuram District) to Cape Comorin in South (Kanyakumari District) covering all along the four coastal districts of Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari.

However, due to logistic constraints all management actions with respect to BR was restricted upto Tuticorin. Both GoMBRT and GMBR authorities could not expand their management activities beyond south of Tuticorin that needs to be addressed as early as possible. Though, this Plan is also not recommending any major management interventions beyond Tuticorin but suggest to carry out a detailed feasibility study by GOMBRT to extend this Management Plan up to Kanyakumari.

At present there are two zones exist in BR such as Core Zone (National Park) that is surrounded by Buffer Zone (BR). In this Plan, we introduced one more Zone i.e. Tourism Zone inside the National Park and

entire buffer zone can be declared as multipurpose use zone but in sustainable manner so that there is no harm to biological integrity of the region. Therefore, selective control of activities at different zones is proposed in the plan, including both strict protection and various levels of use.

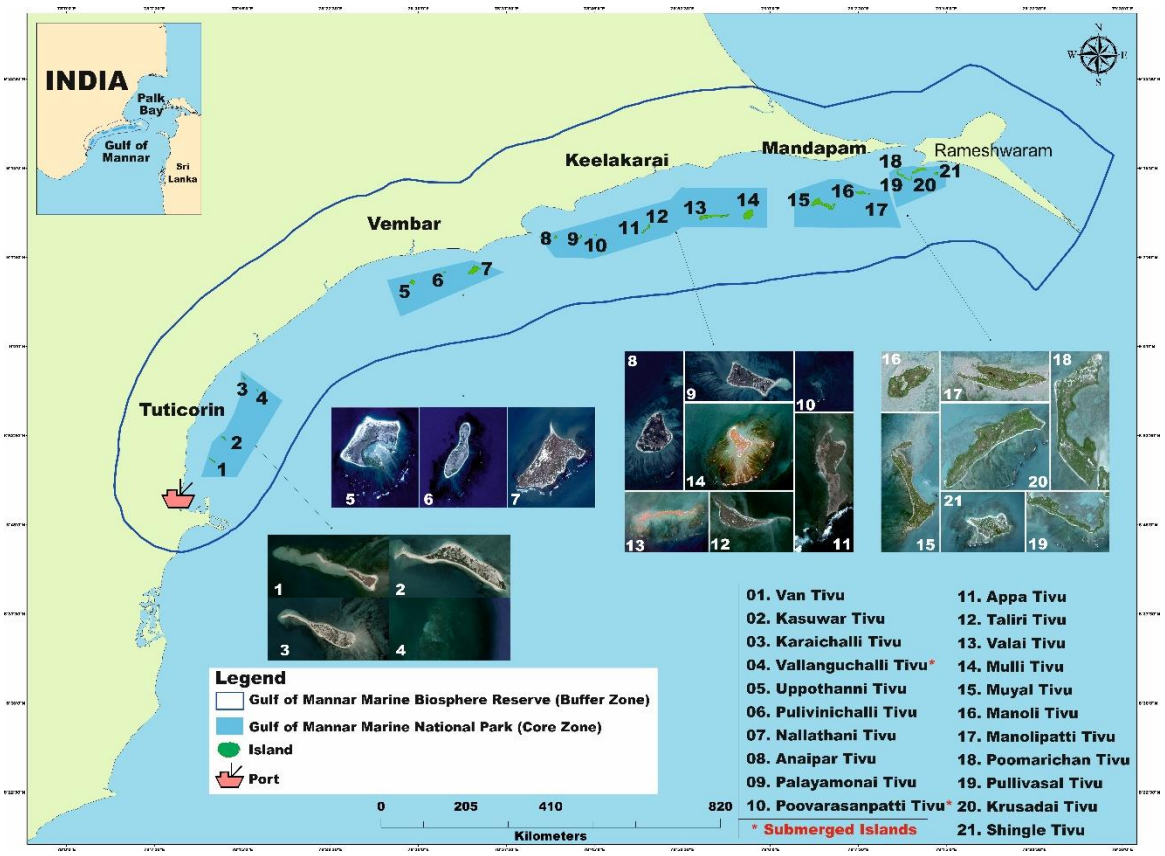

Figure 1.1: Gulf of Mannar Marine National Park

The Core zone (Gulf of Mannar Marine National Park)

Core conservation areas (sites of high diversity, critical habitats of threatened species, and special research areas) in which disturbing/destructive uses are strictly prohibited. This zone can also protect breeding populations of fishes and other organisms for the natural replenishment of neighboring fishing areas such as buffer zone where resource utilization is allowed. Kurusadai Island with buffer of 1 km of its surroundings has been identified for tourism inside the National Park has been recommanded. Based on a study on impact of tourism on this zone would determine the further course of action related to opening up newer islands for tourism or completely closing tourism inside the National Park. This impact assessment study may be carried out after 5 years from now.

All the 19 islands and 2 submerged island and the sea portions surrounding the islands up to 6.405m (3.5 fathoms) on the bayside and 9.5m (5 fathoms) depth toward the seaward side, which is the National

Park area is the Core Zone and the rest of the area of the seascape i.e. up to 20 m depth and the coastal terrestrial areas (10 km from the high tide mark to landward side) will be the Biosphere Reserve and forms the buffer zone for the Marine National Park.

It is observed that by a hindsight, the boundary of the Tuticorin cluster of islands based on quadrates mentioned in the National Park Notification has omitted Karaichalli Island, which has been included into the Marine National Park, accordingly the boundary line was redrawn during the earlier Plan and the same boundary line retained in this Management Plan too. Partitioning of the Marine National Park into five clusters of core zones provides options for providing and planning navigation routes, better policing and protection and opportunities for sustainable migration and harvest of resources from the core to the buffer. The total area of the Marine National Park constitutes about 10% of the northern half of the Biosphere Reserve and may only be 4% of the total Biosphere Reserve as a undisturbed, closed and no take area.

Except research, monitoring and restoration of biodiversity, no other activities is proposed to be permitted in the core zone, except Kurusadai Island and its surroundings for tourism. The strict protection given to the core zone will result in spillover and migration of the faunal wealth to the buffer zone and will be available and can be harvested in sustainable manner by people who directly depend on these resources for their livelihood especially those who live in the buffer zone. It will also help in the economic development and a source of revenue to these coastal districts.

Core zone at present have a good representation of the various marine ecosystems component and are fairly in good condition, which need to be strictly protected without major management activities. Research and monitoring, habitat restoration (mangrove restoration, coral reef restoration, seagrass beds restoration, stock enhancement of critically endangered species such as sea horse, holothurians etc., removal of invasive species) and protection are the only three activities proposed to be taken up inside the National Park. Plantation of exotic species is to be strictly prohibited on the islands and removal of existing exotic species is also prescribed with proper planning.

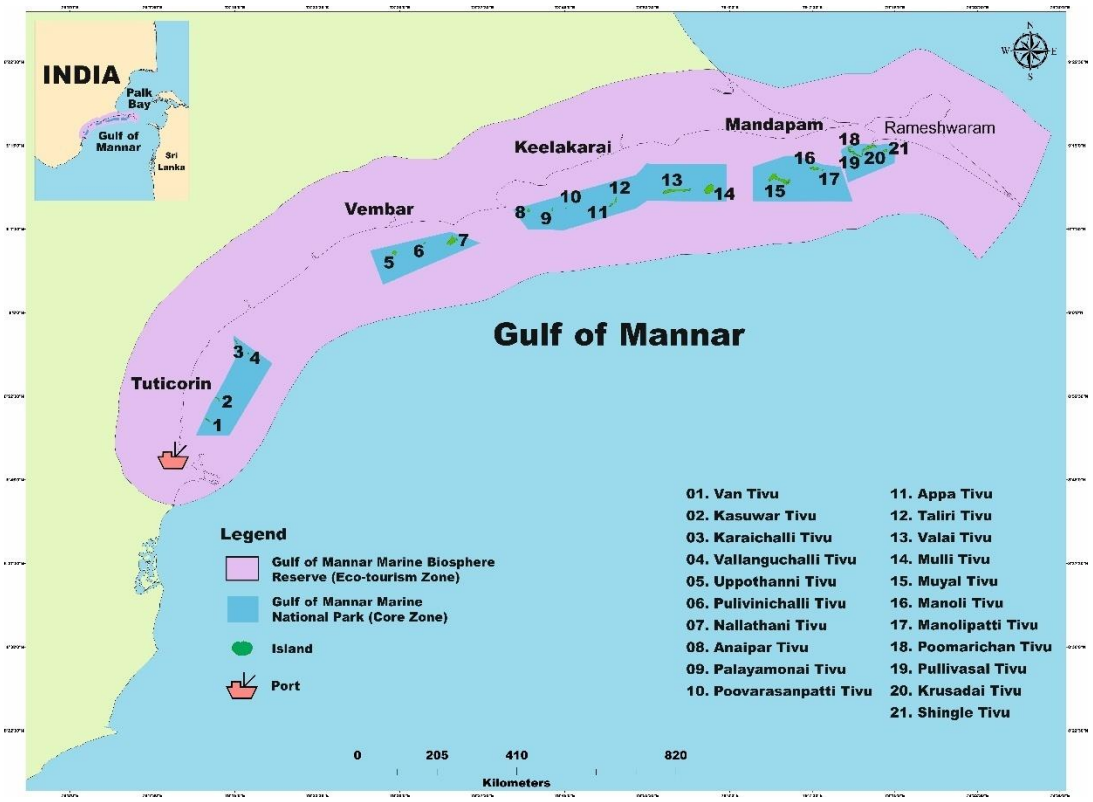

Figure 1.2: Gulf of Mannar Marine National Park: Core and Buffer Zone

The Buffer zone - Gulf of Mannar Biosphere Reserve (The utilisation/Manipulation/Experimental zone)

This zone is proposed to be permitted for local people's use such as fishing and fisheries related activities, tourism and tourism related activities. The seascape surroundings the islands beyond the limits of the National Park will form the buffer zone i.e. up to 20 m depth in seascape around the National Park and the coastal areas (10 km from the high tide mark to landward side) will form the buffer zone of the Biosphere Reserve. As per the Notification of the Gulf of Mannar Biosphere Reserve the total area of the Reserve is reported to be 10500 sq. km which extend from Dhanuskodi Island to Cape Comorin.

Activities in this zone suggested are:

1. Eco-developmental activities
2. Tourism
3. Permitted eco-compatible fishing
4. Maritime navigation
5. Artisanal fisheries
6. Sea weed collection
7. Shell collection using traditional methods
8. Restoration of habitats/species
9. Mariculture using native species
10. Research and monitoring

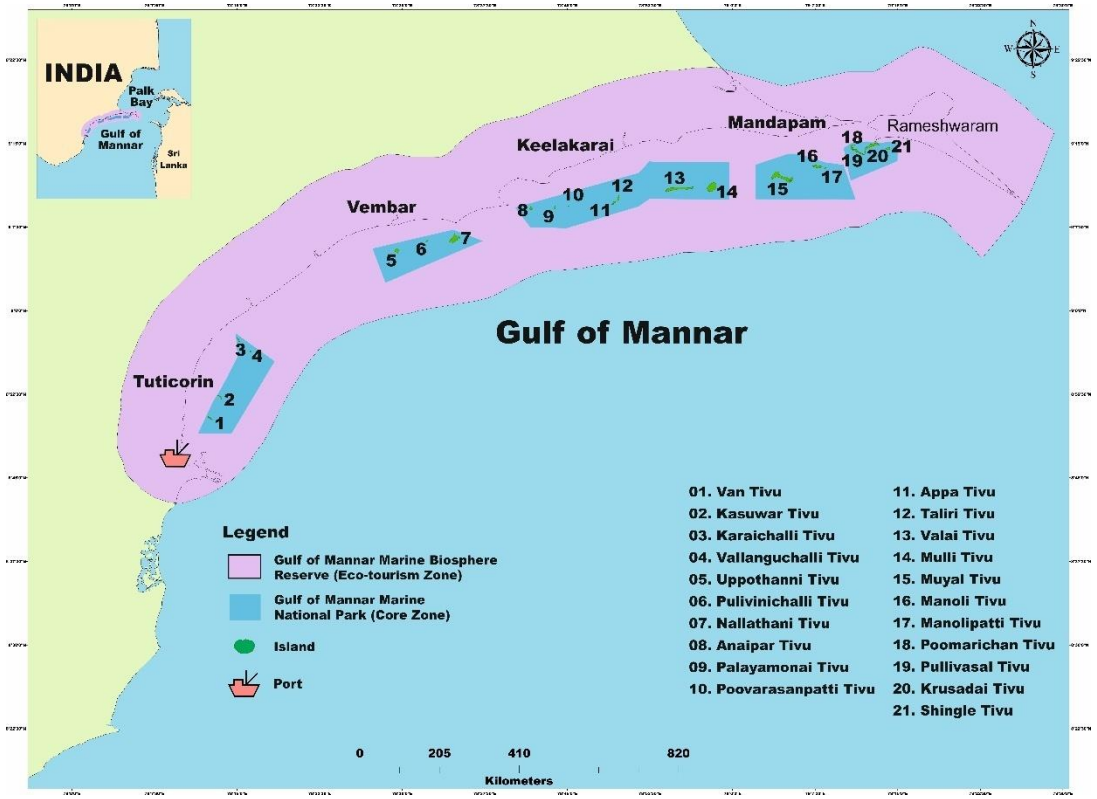

Figure 1.3: Gulf of Mannar Marine National Park: Core and Buffer Zone

Eco-developmental Zone (Terrestrial)

Ten kilometer stretch of coastal land starting from the sea shore all along the Biosphere Reserve are identified as the Eco-developmental (terrestrial) zone. This zone is also to be utilised for multiple use as like the Uilization zone. Drought resistant crops should be promoted in this zone so that extra pressure on marine resources would be minimised becuase of horti and agriculture activities.

Restoration zone

Restoration zone– enable damaged areas to be set aside to recover. Both core zone and buffer zone can be used for restoration of habitat/species. All the islands are infested with invasive species. These islands need to be restored to their original state by eradicating invasive species from these islands. Northern group of islands such as Mandapam and Kilakarai groups are proposed to be used for restortation of mangrove habitat during this Management Plan period. Degraded coral reefs in the Southern group of islands need to be restored. Detailed prescriptions are available in the concerned chapters. Efforts were put in this regard during the previous Management Plan period but it should be continued till the last plants of exotics removed.

Eco-Tourism zone

Eco-tourism zone is proposed to be used for various recreational activities (bird watching snorkeling, coral watching, aquatic sports,

diving, sea walk, etc) to increase the enjoyment and safety of the each pursuit. Eco-tourism is proposed to be allowed in the Biosphere Reserve. As a part of the value addition to the Eco-tourism in the Gulf of Mannar Biosphere Reserve, around 50 km stretches of land areas around the Biosphere Reserve has also been identified and proposed as 'Tourism Zone for Value Addition' with community participation. All the tourist centers in this area have been assessed and included as potential tourism resources in the Eco-tourism sub plan in this Management Plan. Kurusadai Island and its surrounding areas has been identified for eco-tourism inside the National Park.

1.2 Approach and access

Eight classes of tourists (according to the classification of tourists given by the Department of Tourism, Tamil Nadu) visit this region for several purposes and access different parts of the Reserve by air, rail and road. The Gulf of Mannar Biosphere Reserve is easily accessed through road, railway and air from Chennai/Trivandrum or any other major cities of India. The closest airports are located in Tuticorin. Madurain and Thiruchirapalli. Railway lines reach many tourist regions in the Reserve; however, road travel is convenient, with the East Coast road flanking the state's coastline and providing access to remote areas of the reserve. The islands, that form the core area of the reserve can be accessed by boats. Nearest railway stations are Rameshwaram, Mandapam, Tiruchendur, Tuticorin and Kanyakumari.

1.3 Statement of significance

Rich marine biodiversity of the Gulf of Mannar Biosphere Reserve include 104 species of hard corals, more than 450 species of fishes, 4 species of sea turtles, 38 species crabs, 2 species of lobsters, 14 species of sea grasses, 147 species of marine algae, 160 species of birds, 79 species of crustaceans, 108 species of sponges, 260 species of molluscs, 99 species of echinoderms, 4 (5) species of sea horses, 12 species of sea snakes besides 12 species of mangroves. So far, about 3600 species of fauna and flora recorded from this region. The Gulf of Mannar Biosphere Reserve also supports several globally important species such as the highly threatened Dugong, whale shark, sea horses, balanoglossus, green and hawksbill sea turtles, dolphins and sacred chunks including several endemic species such as the Balanoglossus, sea grass, crabs and mangroves. The swamp near the Kodandaraman Temple near Rameswaram gives shelter to a flock of about 10,000 Flamingos every year, during the months of December to March along with various other species of waders and wetland birds.

Fishery resources in the inshore waters had been the sole occupations and livelihoods for several thousand families living along the coast of Gulf of Mannar for centuries. About 1,10,000 families from 268 fishing villages have been fishing in the BR. Of these, 55, 000 families live from

Rameshwarm to Tuticorin. These fishermen have been in such close intimacy with the coastal and marine environment that their life-style, culture and social life all centres around the sea.

Further, Gulf of Mannar National Park has been identified as the Important Bird Areas by BNHS-Birdlife International because of rich avian fauna consist of 187 species and the Gulf of Mannar Biosphere Reserve has recently been identified as an Important Marine Mammals Areas of the World by IUCN due to its dugong population and other marine mammals presence here.

1.4 Ecosystem service provided by Gulf of Mannar Marine NP and BR

a. Provisioning services

i. **Food:** Habitats such as corals, seagrasses, mangroves etc here are permanent and temporary habitats for many aquatic organisms like fish, crabs, catfish, prawns, etc. They also provide hatching and nursery grounds for many marine fishes. It is estimated that most of the local fish catch are directly dependent on this region. Biosphere Reserve supports minimum 1,10,000 families from 268 fishing villages.

Table 1.1. Details of fishermen communities who depend on marine resources of Biosphere Reserve

District	Landing centres	Fishing villages	Fishermen Families	Traditional fishermen families	BPL families	Fisherfolk Population
Ramanathapuram	90	178	41,048	37,680	33,429	193,413
Tuticorin	27	32	19,998	18,828	13,212	82,560
Tirunelveli	9	9	6,132	6,125	2,399	24,639
Kanyakumari	46	47	40,266	39,941	7,601	156,595
Total	**172**	**266**	**107,444**	**102,574**	**56,641**	**457,207**

Table 1.2. Details of fishermen communities who engaged in aquaculture activities along Biosphere Reserve

District	Type of aquaculture						Acquired training
	Fish	Prawn	Crab	Lobster	Seaweed	Total	
Ramanathapuram	61	0	0	1	149	211	130
Tuticorin	3	2	1	2	0	8	508
Tirunelveli	8	1	0	0	0	9	16
Kanyakumari	2	2	0	0	0	4	61
Total	**74**	**5**	**1**	**3**	**149**	**232**	**715**

ii. **Enrichment of Coastal Habitats:** The coastal vegetation like Algae, seagrasses, sea weeds, corals and mangroves play a significant roles in enriching the region with respect to biodiversity. They transport the dissolved organic matter, nutrients etc., besides serving as a nursery area for marine organism and residential and migratory birds, mammals and fishes.

iii. **Fawning Ground**: National Park and Biosphere Reserve are the home to a variety of commercially important fishes, crabs, prawn,

etc. thereby providing economic sources to the local fisherman communities and to the State. There are more than 50 fishermen villages along the coasts near the National Park and dependency of these villages is more than 90% on the Biosphere Reserve for their livelihood. The abundance of fish larvae in the seagrass bed reported at 198 individuals/100m^2, was higher than in open sandy areas, with 112 individuals/100m^2 in Gulf of Mannar Marine National Park in 2008 that revealed the importance of this habitat in fisheries. Further, a study by ZSI shows that the abundance of sea cucumbers was higher in seagrass beds than other habitats in Andamans. Economically important fish larvae found in this area were include Carangidae, Nemipteridae, Engraulidae and Mullidae.

b. Relating Services

i. **Protecting the shoreline:** Corals and seagrasses in this region act as physical buffers between the elements and the shore and can absorb 70-90% of the tidal and wave energy, depending on their ecological condition.

ii. **Carbon Sequestration:** Seagrasses, seaweeds, mangroves etc are important carbon sinks. They sequester about millions of tonnes of carbon per year globally. In Gulf of Mannar, NCSCM has estimated that an acre of seagrass habitat can sequester 3,350 kg of carbon per year (Rs. 1,100,000/acre/year). A 20-year-old mangrove plant has a carbon burial rate of 580 grams per square meter per year.

iii. **Promoting accretion:** Seagrasses, corals and mangroves are function much like a living groove to build up sediment, stabilizing the ground and fixing mud banks. Therefore, they prevent erosion.

iv. **Trapping pollutants:** Seagrasses help trap sediments thereby function as filters to sift out pollutants reaching the sea from inland waters.

v. **Support for fauna:** Rich diversity of marine fauna in the region is due to availability of diverse habitats such as corals, seagrasses, lagoons, mangroves, etc. For example, the canopy of mangrove trees provides an essential terrestrial habitat for fauna which prefers arboreal life. Mangrove soils are soft; mud mixed with sand and contains fauna which is not found in sandy and rocky shores. Apart from these residential species a number of birds are attached to these forests since they provide food for them in the form of fishes, crabs, micro-organism, algae, and mud-skippers. They also provide a good canopy for building heronries. BR has been identified as an Important Marine Mammals Areas of the World and also an Important Bird Areas by IUCN.

c. Supporting Services:

i. **Primary production:** Seagrasses are one of the most productive ecosystems in the World and being one of the crucial primary producers, they are rightly known as the 'Prairies of the Ocean'. Although their direct commercial evaluation is not much, seagrasses provide immense indirect ecosystem services to

commercially important fishes and macroinvertebrates, by acting as nesting and nursery grounds. Similarly, the global mangrove primary production is estimated at about 218 ±72 Tg C whereas annual net primary production of mangroves in India is estimated at 6.05604 Tg C. Both these habitats are important primary producers of the region apart from seaweeds and phytoplanktons. This high primary production supports several hundred species that are important for livelihoods of more than half million people.

d. Cultural Services:

i. **Religious Values:** The importance of the Gulf of Mannar region dates back to the 2nd Century AD because of its highly productive pearl banks and other religious significance. Gulf of Mannar means the Gulf of Lord Krishna, a place of mythical importance, having religious significance owing to the belief that Lord Rama is said to have constructed a bridge from here over the sea waters to reach Sri Lanka. It is a hallowed place for Hindus as they conduct their religious rites in this place. Rameshwaram, Thiruchendur and Kanayakumar are important pilgrimage centre for Hindu religion. Similarly, several important and most visited Churches and Mosques are located along the coast of National Park and Biosphere Reserve. Panimaya Matha Church, Dhanuskodi Heritage church, Ovari Church, Mosque at Kilakarai, Ervadi and Thondi are most popular in the region.

ii. **Eco-tourism:** This region has a high potential for eco-tourism, as the National Park is situated between Rameshwaram and Tuticorin, with rich coral reefs and seagrass.

iii. **Support traditional fishing: Apart from mechanized fisheries that is the major economic of the coastal communities here, the t**raditional fisheries are also being sustained here because of seagrasses and coral reefs and fishing is chief livelihood of more than 100 thousands families.

Conservation implications

The interior of Tamil Nadu is made up of crystalline rocks of Precambrian age, while the coastal and off-shore area exhibits sedimentary rocks of Mesozoic to Present age, developed in a series of ridges and basins formed by horst-graben structures trending in NNE-SSW to NE-SW, E-W and N-S directions (Katz, 1978; Gopalakrishnan *et al.,* 2008). All these faults show evidence of neo-tectonic activity in the form of both vertical and lateral strike-slip movements even during the Present day. So far, 3 epicenters of earthquakes of magnitude 5-7 of the Richter scale are marked in Gulf of Mannar. The line joining the epicenters in Gulf of Mannar roughly coincides with the inferred NE-SW trending Gulf of Mannar-Palk Straight fault. Geophysical studies indicate that the Palk Bay-Gulf of Mannar region showing high gravity–high heat flow character

is potentially most vulnerable to future earthquakes (Gopalakrishnan *et al.,* 2008).

The origin of the islands in Gulf of Mannar is the product of complex biogeomorphic processes that started in the last interglacial period. During the last phase of the interglacial period, the sea level regressed up to 6 to 8 thereby exposing the sandy substratum around the present day island system. This initiated the coral growth around the present day island. When the sea level started rising the coral rose too keeping in pace with the sea level rise; thus developed the barrier island system. Due to the tectonic movement as well, a certain area of land emerged in the Gulf of Mannar (Ramasamy, 1996). Infilling of lagoon with reef sediment and the evolution of incipient cay gave shape to the present day island. (Ramanujam *et al.*, 1995).

The average height of the islands is 1 to 2 m above the Mean Sea Level (MSL) and they are very dynamic in nature (Ramanujam *et al.*, 1995; Ramasamy, 1996; Ravindran, 2012). The deepest parts of the sea are situated off Valinokkam and off Pamban island. The shallowest part is found north of Tuticorin and extends from Vaipar to Pamban. The low and narrow coastline is usually sandy, while a few islands have rocky coast. The raised reef terraces and wave terraces found in some of the islands clearly indicate sea level rise and tectonic activities in the past. Some of the geographical features within the Gulf are biologically noteworthy for their rich variety and the support they provide to sustain uniqueness of the living resources.

Mining of coral reefs around these islands for construction and other industrial purposes in the last several decades has resulted in the waves hitting directly on the shores of these islands on the windward side. The change in the biogeomorphology has destabilized these islands. As a consequence intense erosion has set in, and most of these islands have their sizes reduced and their positions shifted from their earlier location. The Islands of Tuticorin group are shifting towards mainland whereas the Mandapam group is shifting away from mainland, i.e. towards the sea. The Vilanguchalli and Poovarasanpatti islands have already been submerged on account of intense erosion activities. The Vaan Island of Tuticorin group was on the verge of sinking but construction of Artificial Reef structures has rescued it from submergence.

The mangroves, coral reefs and sea grass ecosystems are the three important and sensitive ecosystems in the coastal zone. The GOMBR possesses all these unique ecosystems and has become significant because of the presence of other associated resources such as fishes, sponges, gorgonids, holothurians, pearl beds, chank beds, sea horses, turtles and the sea cow, *Dugong dugon*.

Coral reefs are vital components of ocean ecosystems, providing shelter to nearly one quarter of all marine life forms. They are the breeding and

nursery ground for many fin and shellfishes. There are more than 793 - recorded species of corals in the world support enormous life forms. Reef ecosystems can be compared to rain forests in terms of their biodiversity and density of living organisms. They serve as atmospheric carbon dioxide sinks and act as historical climate recorders. The coral reef ecosystems play an important role in global biogeochemical processes and in the production of food resources in the tropical region. These systems are very sensitive to external impacts both natural and manmade that violate their homeostasis.

The floral components comprises of economically viable species of seaweeds such as *Gracilaria* sp., *Gelidiella* sp., *Caulerpa* sp, *Sargassum* sp. and *Turbinaria* sp. The sea grass communities of this region tops the list of marine flora of India with the highest number of sea grass species recorded, providing important feeding grounds for the endangered *Dugong dugon*.

Many commercial shoaling fishes like sardines, mackerels, anchovies, snappers and pelagic fast swimming forms like Tuna, Billfish, Sailfishes are found abundant in this region and these form a major fishery. Information regarding environmental settings of the Gulf of Mannar Biosphere Reserve has been mainly gathered from a study on Gulf of Mannar Biosphere Reseve by Anna University, Chennai.

The topography of this region is varied; including beaches, spits, beach ridges, swales and backwaters, mudflats offshore islands flanked by coral reefs, wave cut platforms, sea cliffs, sea caves, and waterlogges land.

Strandlines

In the Gulf of Mannar coast from Tiruppullani to Mandapam, eight series of strandlines in curvilinear form have been observed. The general trend of the strandline is in the east to west direction. In the south of Rameswaram area also, curvilinear strandlines have been observed.

Currents

The current in the area are swift. The sea is rough between April and August. During June to August it is very stormy. It is calm during September. October to December months have Northeast monsoon with occasional gales.

Soil

The soil is typical coastal sand, strewn with shingles in places and there are swamps in places in Van Tivu, Kasuwar Island, Poomarichan Island, Pullivasal Island, Krusadai and Shingle islands. Quick sand is seen in places in Mulli and Krusadai Island.

Chapter 2

Background information and attributes

2.1 Boundaries

As per the Notification of the Gulf of Mannar Biosphere Reserve the total area of the Reserve is 10500 sq. km, which extend from Dhanuskodi Island to Cape Comorin. But, the scope of this Management Plan is from Dashuskodi to Tuticorin. Some of the management of actions recommended in this Plan with respect to Eco-development, tourism, and biodiversity protection and restoration may be extended up to Kanyakumari depending upon availability of resources to implement the same. Further, the 20 m depth south-eastern boundary of the Biosphere Reserve may change due to dynamic nature of bathymetry of this region, therefore the actual size of the Reserve need to be calculated after the Chief Naval Hydrographer provides a detailed map up to 20m depth.

All the 19 islands and 2 submerged islands and the sea portions surrounding the islands up to 6.405m (3.5 fathoms) on the bayside and 9.5m (5 fathoms) depth toward the seaward side, which is the National Park area is the Core Zone and the rest of the area of the seascape i.e. up to 20 m depth and the coastal terrestrial areas (10 km from the high tide mark to landward side) will be the Biosphere Reserve and forms the buffer zone for the Marine National Park.

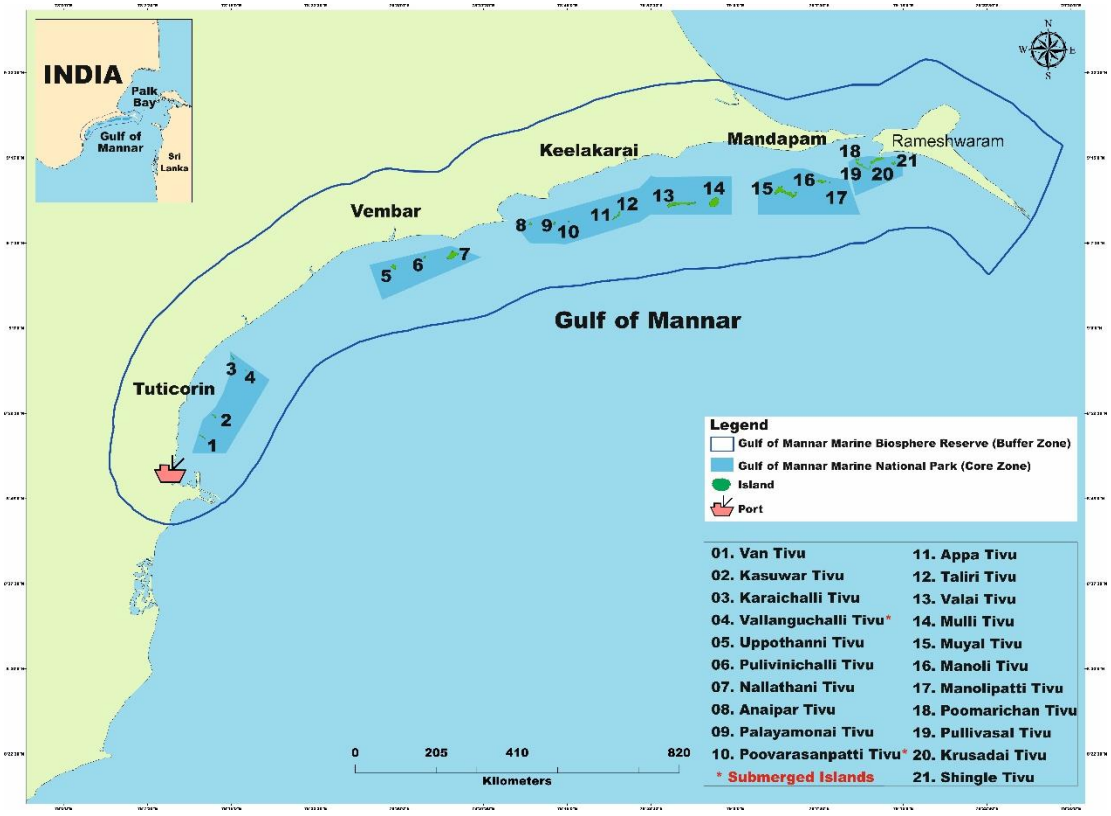

Fig 2.1: Gulf of Mannar Marine National Park: Boundaries

Table 2.1. Details of National Park boundary

Name of the island	Area in Ha.	Circum-ference (m)	Distance from main land (kms)	Latitude	Longitude
Van tivu	16	2015	6 km from Tuticorin	A 8°49'N	78° 11'30" E
Kasuvar island	19.50	2160	7 km from Tuticorin	B 8° 49' N	78°14'30" E
Karaichalli island	16.46	1610	15 km from Tuticorin	C 8°55'30" N	78° 18' 30" E
Vilanguchalli	0.95	614	15 km from Tuticorin	D 8° 58'30" N E 8° 57'N	78° 15'45" E 78°15' 45" E
Upputhani island	29.94	2292	8 km from Vember	A9° 2'30" N	78°28'30" E
Puluvinichalli island	6.12	1372	18 km from Vember	B9° 6'15" N	78° 37' 20" E
Nallathani island	110.00	4700	2 km from Mundal	C 9° 7'15" N D 9° 5' 35" N	78° 34' 40" E 78° 27' 20" E
Anaipar island	11.00	1605	9 km from Kailakarai	A 9° 7' 30" N	78° 41' 40" E
Valimunai island (Palliarmunai island)	6.72	1170	9 km from Kilakarai	B 9° 7' 23" N	78° 45' 00" E
Appa island	28.63	4840	8 km from Kilakarai	C 9° 9' 20" N	78° 51' 30" E
Poovarasanpatti island	100m*25m	---	Mid way between Valimunai & Appa	D 9° 10' 00" N E 9° 10' 00" N	78° 52' 30" E 78° 59' 45" E
Tailari island	75.15	8338	10 km from Kailakarai	F 9° 13' 20" N	78° 59' 45" E
Valai island	10.15	1889	-do-	G 9° 13' 20" N	78° 52' 45" E
Mulli island	10.20	1712	9 km from Kailakarai	HIJ 9° 13,25" N I 9° 12' 20" N J 9° 9' 15" N	78° 52' 30" E 78° 51' 30" E 78° 40' 20" E
Hare island(musal island)	129.04	11520	7 km from Mandapam camp	A 9° 10' 00" N B 9° 10' 00" N	79° 2' 5" E 79° 11' 10" E
Manoli island	25.90	2958	6 km from Mandapam camp	C 9° 13' 5" N D 9° 13' 18" N	79° 10' 5" E 79° 8'25" E
Manoputti island	2.34	940	5 km from Manapam	E 9° 14' 3" N F 9° 14' 5" N G 9° 13'.5" N	79° 6' 10" E 79° 5' 7" E 79° 2' 5" E

Poomarichan island	16.58	2500	3 km from Mandapam	AA 9^0 11' 40" N BB 9^0 13' 25" N	79^0 10' 45" E 79^0 15' 00" E
Pullivasal island	29.95	5520	3 km from Mandapam camp	C 9^0 15' 5" N D 9^0 15' 10" N	79^0 15'00" E 79^0 14'10"
Krusadai island	65.80	5193	3 km from Pamban	E 9^0 15' 00" N F 9^0 15' 00" N G 9^0 15' 10" N H 9^0 15 ' 7" N I 9^0 15' 00" N	79^0 13' 25" E 79^0 13' 10 " E 79^0 12' 10" E 79^0 11' 35" E 79^0 10' 45" E
Shingle island	12.69	1736	4 km from Pamban	J 9 ^{0} 14' 35" N	79^0 10' 5" E
TOTAL	**623.12Ha**	**64684 m**			

Sector VI : Area between islands 15 to 17 and 18 to 21

A – 9^0 13' 35" N. Lat. 79^0 8' 25" E. Long
B – 9^0 14' oo" N Lat 79^0 9' 35" E Long
C – 9^0 15' 5" N Lat 79^0 9' 15" E. Long
D – 9^0 14' 15" N Lat 79^0 8' 10" E Long

In the previous Management Plan, it was observed that by an hindsight, the boundary of the Tuticorin cluster of islands based on quadrates mentioned in the National Park Notification has omitted Karaichalli Island, which has been included into the Marine National Park, accordingly the boundary line was redrawn and the same boundary is retained in the Plan. Partitioning of the Marine National Park into five clusters of core zones provides options for planning navigation routes, better policing and protection and opportunities for sustainable migration and harvest of resources from the core to the buffer. The total area of the Marine National Park constitutes about 10% of the northern half of the Biosphere Reserve and may only be 4% of the total Biosphere Reserve as an undisturbed, closed and no take area.

Notification of Gulf of Mannar National Park and Gulf of Mannar Biosphere Reserve need to be reviewed from time to time with respect to sensitivity of the eco-zones and their response to management. It has been proposed in the Management Plan to identify and include 'Critical Wildlife Habitat'within the Biosphere Reserve and these CWH will then be protected as equivalent to core zones or CRZ 1. For example, critical dugong habitat, important sea turtle nesting beaches, oceanic bird flocking areas, etc.

The boundary demarcation of the Biosphere Reserve, especially the seascape side needs to be reviewed at five years intervals as the bathymetry of the sea tends to change. The boundaries of the National Park and of the different zones will have to be suitably demarcated with different colour buoys or markers so as to be easily visible to the users of the coastal waters as per the Notification. Coloured buoys in every 250 m

to 500 m distance for the National Park boundary and buoys with automatic illumination system to alert the vessels along the boundary of Biosphere Reserve needs to be installed in every five kilometer may be considered. Registered fishermen who use trawlers and are not supposed to fish inside the Biosphere Reserve need to be assisted by the Government to install required equipments such as GPS etc to receive the alarm signal if they approach the Biosphere Reserve boundary.

Eco-developmental Zone (Terrestrial): Ten kilometer stretch of coastal land starting from the sea shore all along the Biosphere Reserve are identified as the Eco-developmental (terrestrial) zone. This zone is also to be utilised for multiple use as like the Uilization zone.

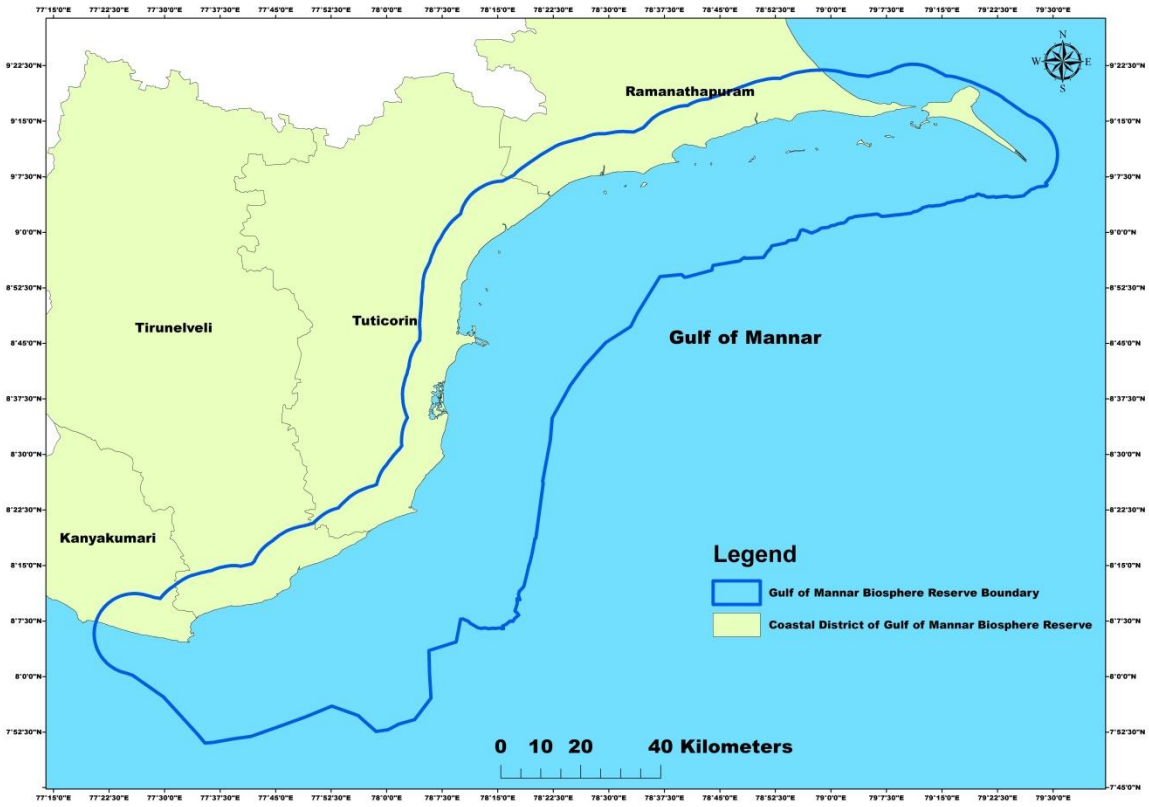

Figure 2.2: Gulf of Mannar Biosphere Reserve Boundary

Restoration zone: Restoration zone– enable damaged areas to be set aside to recover. Both core zone and buffer zone can be used for restoration of habitat/species. Northern group of islands such as Mandapam and Kilakarai groups are proposed to be used for restortation of mangrove habitat during this Management Plan period. Degraded coral reefs in the Southern group of islands need to be restored with artificial reef building measures. Detailed prescriptions are available in the concerned chapters. Further, Keelakarai and Vembar groups of islands need to be freed from exotic vegetation. Further, entire Biosphere Reserve including the National Park area should be freed from aquatic weeds including Kappaphycus spp.

Tourism zone: Tourism zone is proposed to be used for various recreational activities to increase the enjoyment and safety of the each pursuit. Eco-tourism is proposed to be allowed in the Biosphere Reserve. As a part of the value addition to the Eco-tourism in the Gulf of Mannar Biosphere Reserve, around 50 km stretches of land areas around the Biosphere Reserve has also been identified and proposed as 'Tourism Zone for Value Addition' with community participation. All the tourist centers in this area have been assessed and included as potential tourism resources in the Eco-tourism sub plan in this Management Plan. Kurusadai Island has been identified for tourism inside the National Park. More details are available in the 'Eco-tourism Chapter' of the Plan.

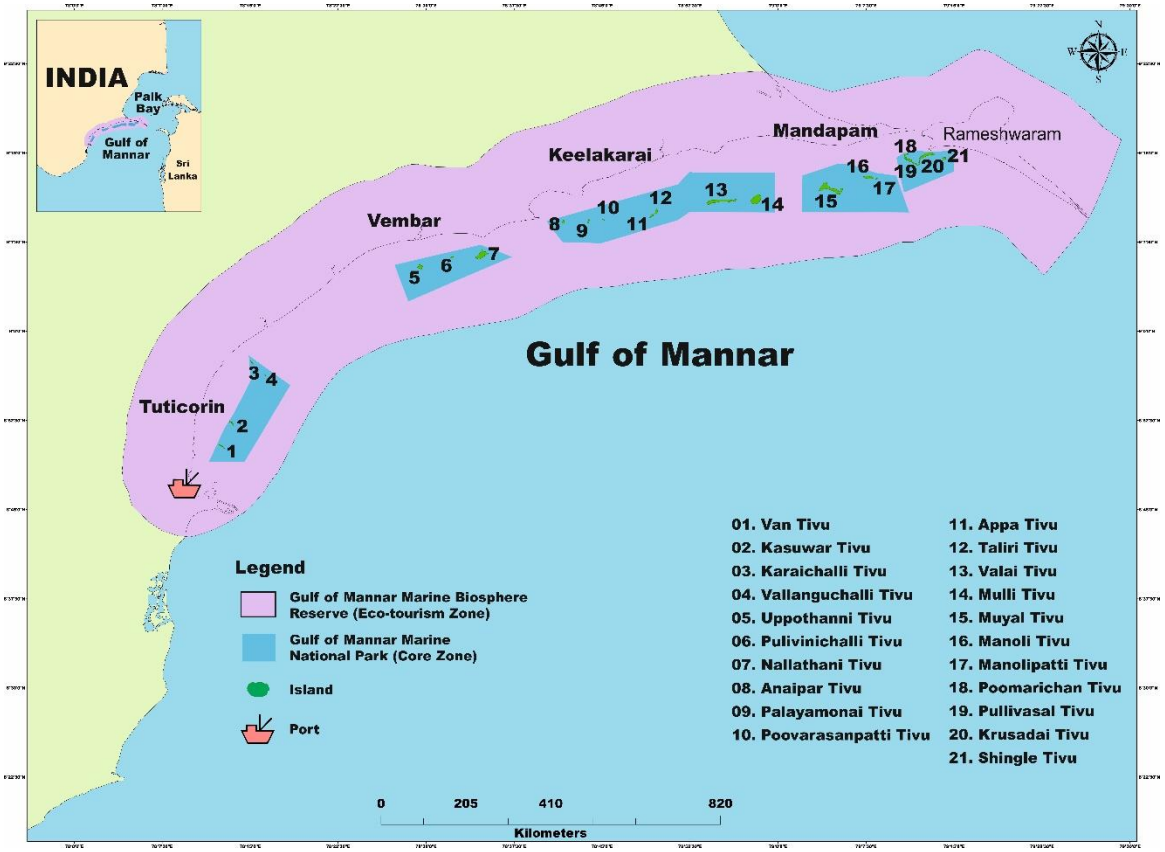

Figure 2.3: Eco-tourism Zone of Gulf of Mannar Marine National Park

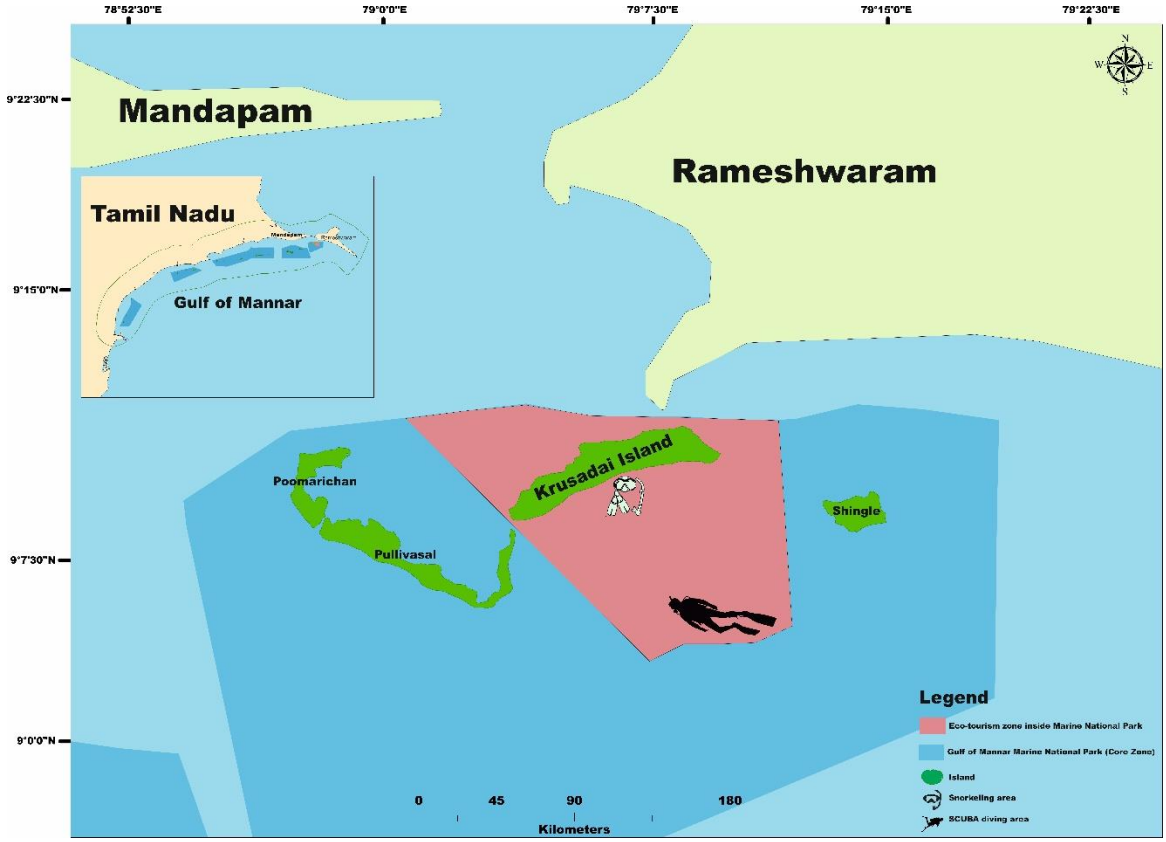

Figure 2.4: Eco-tourism zone inside Gulf of Mannar Marine National Park

2.2 Geology, rock and soil

The interior of Tamil Nadu is made up of crystalline rocks of Precambrian age, while the coastal and off-shore area exhibits sedimentary rocks of Mesozoic to Present age, developed in a series of ridges and basins formed by horst-graben structures trending in NNE-SSW to NE-SW, E-W and N-S directions (Katz, 1978; Gopalakrishnan *et al.*, 2008). All these faults show evidence of neo-tectonic activity in the form of both vertical and lateral strike-slip movements even during the Present day. So far, 3 epicenters of earthquakes of magnitude 5-7 of the Richter scale are marked in Gulf of Mannar. The line joining the epicenters in Gulf of Mannar roughly coincides with the inferred NE-SW trending Gulf of Mannar-Palk Straight fault. Geophysical studies indicate that the Palk Bay-Gulf of Mannar region showing high gravity–high heat flow character is potentially most vulnerable to future earthquakes (Gopalakrishnan *et al.,* 2008).

The origin of the islands in Gulf of Mannar is the product of complex biogeomorphic processes that started in the last interglacial period. During the last phase of the interglacial period, the sea level regressed up to 6 to 8 thereby exposing the sandy substratum around the present day island system. This initiated the coral growth around the present day island. When the sea level started rising the coral rose too keeping in pace with the sea level rise; thus developed the barrier island system. Due to the tectonic movement as well, a certain area of land emerged in

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The soil is typical coastal sand, strewn with shingles in places and there are swamps in places in Van Tivu, Kasuwar Island, Poomarichan Island, Pullivasal Island, Krusadai and Shingle islands. Quick sand is seen in places in Mulli and Krusadai Island.

2.3 Islands

These 21 islands are divided into 4 groups based on their proximity to the mainland area. These four groups are Mandapam. Keelakarai, Vembar and Tuticorin groups. The Mandapam group consist of 7 islands (Shingle, Kurusodai, Pullivasal, Poomarichan, Manoli, Manoliputi and Musal) the kellakarai group has 7 (Mulli, Valai, Talairi, Appa, Poorvasanpatti, Vallimunai and Aniapar) the Vembar group has 3 islands (Nallaithani, Pullivinichalli and Upputhani) and Tuticorin has 4 (Karachalli, Vilanguchalli, Kasuwar and Van). These islands start from the South before Tuticorin and run parallel to the shore and turns towards North till Vembar and then towards the East side ending in Rameshwaram.

Tuticorin group of islands

1. ***Van Island***. Its area is 16.0 ha and circumference is 2015m. It is 6km form Tuticorin. This island is covered with sparse vegetation of low bushes mostly grass and xerophytes plants. Fringing reefs are present on the eastern side of the island at a distance of 500m (Venketeraman et al 2002). 15species of hard corals were recorded in a survey by DOD in 2001(Usha et al 2001). This island has been observed with eroding at faster rate probably due to the Tuticorin Port and its expansion in the recent past. However, the Forest Department has initiated various management measures to minimise the erosion that included the artificial reef building at the southern off coast of Van Island. Impact of these measures on the island restoration may take more time to visibly seen. It is now important to collaborate with the Tuticorin Port Trust to restore southern group of islands.

2***. Kasuwar Island***. Its area is 19.50 ha and circumference is 2160 m. Recently this island eroded and the area becomes only 15ha only. It is 7km form Tuticorin. This Island is having small sand mounds and bushes here and there. The whole island is covered by xerophytic vegetation. Coral reefs are found at the southwest corner of the island at a distance of 500(Venketeraman et al 2002).

3. ***Vilanguchalli Island***. Its area is 0.95 ha and circumference is 614m. it is 15km form Tuticorin, this island got submerged under water a few decades ago, there are isolated patches of thin reef of corals along south-eastern side of the island(Venketeraman et al 2002). Coral mining had been the main reason for submergence. Sea level rise due toglobal climate change would further impact this island. However, good coral reefs around this island need to be protected from anthropogenic pressures.

4. ***Karaichalli Island***. Its area is 16.46 ha and circumference is 2160m. Recently some portion of the island is eroded and the area is becomes 12.70 ha. It is 15 km form Tuticorin, it is a sandy island thickly set with tall bushes in the center and the western side. The whole island is covered with grasses and small plants at a distance of 500m to 1km from the shore (Venketeraman et al 2002). A total of 25species of hard corals were recorded in a survey by DOD in 2001 (Usha et al 2001). This is the highest species diversity of corals among southern group of islands.

Vembar group of islands

5. ***Upputhani Island***. Its area is 29.94 ha and its circumference is 2292m. It is 8 km from Vembar . It is a big sandy island with plenty of coral rubbles all over. There a few trees, tall bushes, and grasses present in this island. Fringing reefs are present in the mid-eastern portion,

rounding south up to the western middle portion at a distance of 150-300m from the island (Venketeraman et al 2002). A total of 16species of hard corals were recorded in a survey by DOD in 2001· (Usha et al 2001).

6. ***Pulluvinichalli Island***. Its area is 6.12 ha and the circumference is 1372 m. It is 18km from Vembar. This island has a good sandy beach, and thick vegetation. This island is surrounded by live coral reef all around except for a small stretch on the eastern side (Venketeraman et al 2002). A total of 17species of hard corals were recorded in a survey by DOD in 2001 (Usha et al 2001).

7. ***Nallathani Island***. Its area is 110 ha and its circumference is 2700m. It is 2km away from Mundal a place near Vallinokkam. It is one of the larger islands containing about 4000 coconut trees, Palmyra and other woody trees. Coral reef and coral boulders are present all around the island at a distance of 0.5 km on the southern side and very near to the northern shore (Venketeraman et al 2002). A total of 22species of hard corals were recorded in a survey by DOD in 2001(Usha et al 2001).

Keelakarai group of islands

8. ***Anaipar Island*** .its area is 11.0 ha and circumference is 1605m. it is 9km from Keelakarai . This island is completely covered with shrubs and acacia trees. Live coral reefs are seen near western shore of the island up to a maximum distance of 200m from shore. Dead coral blocks are also found on the southern shore up to a distance of 200m (Venketeraman et al 2002). A total of 30 species of hard corals were recorded in a survey by DOD in 2001(Usha et al 2001)

9. ***Valliyarmunai Island***. Its area is 6.72 ha and the circumference is 1170 m. It is a sandy island strewn with coral rubble; completely covered with *Acacia* trees and *Zizyphus jujube* bushes. Coral reefs are present at the southwestern corner of the island at a distance of 200m from the shore. Dead coral stones are found in other regions of the shore (Venketeraman et al 2002). A total of 12species of hard corals were recorded in a survey by DOD in 2001 (Usha et al 2001)

10. ***Appa Island*** . Its area is 28.63 ha and its circumference is 4840m. it is 8 km from Keelakarai . this island is traversed on the southern side by an intervening coral stone studded sandy flat which is flooded during high tide preventing easy accessibility from the ends , the southern portion of the island is highly elevated(6m) standing on fossilized coral , the northern portion like other islands has an elevation of about 2.5m from the spring tide level. The entire southern side of the island is fringed with live coral reefs. A good number of dead coral stones and boulders are found on the northwest corner of the island that extends up to the distance of 1.5km (Venketeraman et al 2002). A total of 10 species of hard corals were recorded in a survey by DOD in 2001 (Usha et al 2001)

11. ***Poorvasanpatti Island***. This island submerged a few decades ago, coral mining being the chief reason again. It lies midway between Appa Island and Vallimunai Island. Live coral reef surrounds this submerged island up to a distance of 100m. Apart from a few massive corals occurring on the eastern side the rest are branching corals, which lie at a depth of 1-2 m(Venketeraman et al 2002). A total of 11 species of hard corals were recorded in a survey by DOD in 2001 (Usha et al 2001)

12.***Taliri Island***. Its area is 75.15 ha and the circumference is 8338m. It is 100km from Keelakarai .it is elongated island with a linear axis parallel to the shore, the broadest portion of the island is on its western tip. Coral reefs exist very close to the shore along the entire length of the island on northern shore except north western edge. Continuous fringing reefs are found at a distance of 0.75 km all along the southern side (Venketeraman et al 2002). A total of 15species of hard corals were recorded in a survey by DOD in 2001(Usha et al 2001)

13.***Valai Island***. Its area is 10.15 ha and circumference is 1889m. it is 10 km from the Keelakarai . it is a smaller linear island lying parallel to the mainland and it is connected to Talaiyari island by a channel which is submerged during high tide . The western side of the northern shore has good cover of massive corals as well as branching coral types. The southern reef is far away from the shore at 3m depth (Venketeraman et al 2002). A total of 11species of hard corals were recorded in a survey by DOD in 2001(Usha et al 2001).

14. ***Mulli Island***. Its area is about 10.20 ha and circumference is 1712m. It is 9km from Keelakarai. This is a small, sandy island covered with tall shrubs and bushes with a swamp. The northern side of the island is studded with massive corals. Eastern side with low fringing reef continues up to 3m depth. The south reef is 1.25 km from shore and extends up to the western side (Venketeraman et al 2002). A total of 18species of hard corals were recorded in a survey by DOD in 2001(Usha et al 2001)

Mandapam group of islands

15. ***Hare (Musal) Island***. Its area is 129.04 ha and circumference is 11520m. It is 7 km form Mandapam camp. This island is completely covered by thick vegetation of acacia trees, Palmyra, coconut plantations and other trees. Massive corals are found on the southern lagoon in several places as well as in northern side. Fringing reefs are also present at a distance of 1.5km on the south side; this reef continues up to the northern tip of the island (Venketeraman et al 2002). A total of 29species of hard corals were recorded in a survey by DOD in 2001(Usha et al 2001)

16. ***Manoli Island***. Its area is 25.90 ha and has a circumference of about 2958m. It is 6 km from Mandapam camp. It is a small island

surrounded by mud flats and sand flats exposed during low tide and well covered by trees and shrubs. There are extensive reefs on the southern and northern sides at 250m distance from the shore. Stony corals belonging to both *Acropora. sp* and *Porites.sp* are found in large numbers(Venketeraman et al 2002). A total of 25species of hard corals were recorded in a survey by DOD in 2001(Usha et al 2001).

17. ***Manolipatti Island***. Its area is 2.34 ha and the circumference is 940m. It is 6km away from Mandapam camp. It is a very small Island separated from the nearby Manauli Island by an extensive flat fully exposed during low tide. Through out this island a patchy distribution of massive coral is present at 500m distance form shore(Venketeraman et al 2002). A total of 13species of hard corals were recorded in a survey by DOD in 2001 (Usha et al 2001)

18. ***Poormarichan Island***. Its area is 16.58 ha and circumference is 2500m. It's about 5 km from Mandapam camp. This is almost a horseshoe shaped island, with scanty foreshore, surrounded by marshy area and broken coral stones. This island appears as a thickly wooded jungle. Extensive reefs are found on the western and eastern side of the island at a distance of 150m from island shore. On the southern side also a continuous reef exists close to the shore (Venketeraman et al 2002). A total of 12species of hard corals were recorded in a survey by DOD in 2001(Usha et al 2001)

19. ***Pullivasal Island*** . Its area is 29.95 ha and circumference is 5520m. It is 5 km from Mandapam camp. This island can be approached from Poomarichan island side by crossing the channel separating the 2 islands. This island appears thickly wooded jungle. There are fringing reefs on the southern side at a distance of 200m. Similar patchy distribution is also found in the muddy area on the northern side (Venketeraman et al 2002). A total of 16species of hard corals were recorded in a survey by DOD in 2001(Usha et al 2001)

20. ***Krusadai Island***. Its area is 65.80 ha and circumference is 5,193m. It is 3 km from Pamban and the nearest land is Kundugal point 500m away. The island is completely covered with trees and bushes having many varieties of animal life. A continuous fringing reef is present on the southern side of the islands at 500m distance. The lagoon in this area also contains live coral patches. The northern and eastern sides also have a few patches of *Acropora* sp (Venketeraman et al 2002). A total of 19species of hard corals were recorded in a survey by DOD in 2001(Usha et al 2001).

21. ***Shingle Island*** - It has an area of 12.69ha with a circumference of 1736m. It is 4 km from Pamban. This island is full of shingle and coral rubble, heaped all along the shore to a height of 0.75 m completely covered by bushes and trees. Fringing reefs are present on the eastern, northern and western side of the island. The corals are mostly of

Acropora sp. Present 300m from the island shore. Patchy distributions of boulder (massive) corals are found (Venketeraman et al 2002). 15species of hard corals were recorded in a survey by DOD in 2001(Usha et al 2001).

2.4 Climate

Rainfall pattern and distribution

This region experiences a tropical climate and is influenced by both south-west and north-east monsoon. Rainfall is moderate to heavy with occasional gales during October to December due to the Northeast monsoon. Southwest monsoon also contributes, but plays a much smaller role in overall rainfall. The annual rainfall varies from 762 to 1270 mm/year.

Temperature; a summary of year round pattern

This region experiences relatively high temperatures from January to May. The monthly average annual atmospheric temperature varies from 25^0C to 31^0C with the maximum and minimum in May and January respectively.

Wind speeds, a summary of year round pattern

During the period between June and August the weather is very stormy. It is calm from September to March. The months from October to December have Northeast monsoon with occasional gales. The current movement during Southwest monsoon is from south to north, and during Northeast monsoon it is from north to south.

Drought, and its periodicity; natural hazards and disasters frequency, intensity, loss of lives, property and economic loss and other consequences

Indian subcontinent has always been vulnerable to natural disasters on account of its unique geo-climatic conditions and floods, droughts, cyclones, tsunami, earthquakes and landslides have been a recurrent phenomena. About 60% of the Indian landmass is prone to earthquakes of various intensities; over 40 million hectares of landmass and prone to floods; about 8% of the total area is prone to cyclones, 68% of the area is susceptible to drought and the entire coast of India prone to tsunami. In India, about 30 million people are affected by disasters every year. The loss in terms of private, community, public assets and wildlife has been astronomical. In recent years studies in the Nicobar islands have proved that there was a significant adverse impact on wildlife caused by the 2004 tsunami. It was in this background that the United Nations General Assembly, in 1989, declared the decade 1990-2000 as the International Decade for Natural Disaster Reduction with the objective to reduce loss of

lives and property and restrict socio-economic damage through concerted international action, especially in developing countries. Planning the disaster management programme for wildlife habitats is much more difficult than the human habitation as it involves a lot more preparedness, especially in rescue of wildlife and its habitat from any natural disasters.

The Gulf of Mannar Marine National Park and Biosphere Reserve located at the southernmost tip of India along the Bay of Bengal in Tamil Nadu is a vulnerable Marine Protected Area from natural disasters, particularly originating from the marine environment such as cyclonic storms, tsunami and flood. Being in a low rain fall zone, the area is also subjected to recurrent droughts. The other disasters due to human errors in the coastal and marine environment expected in the region are fire, oil spillage, accidental capsize of marine vessels with chemical hazards etc. In this background, the GOMBR management plan has included this Disaster Management plan for the period 2018-2026.

Possible Disasters expected for the Biosphere Reserve & National Park

1. Cyclone
2. Drought
3. Fire
4. Flood
5. Oil Spillage
6. Accidental capsize of shipping vessel with hazardous chemicals
7. Tsunami
8. Earthquake

2.5 Water sources

Fresh water is available only in Nallathanni Tivu as the name of island itself specified. Tolerably good water is available in rainy season and winter in Talari Island, Hare Island and Pullivasal Island though not in abundance.

The biogeographic classification

The Gulf of Mannar Biosphere Reserve comes in the “Semi-Arid” under the classification of the bioclimatic zones of India. It comes under the ‘East-Coasts (8B)’ zone in the bifurcation of the different biogeographic zones of India classification by Rodgers et.al. (2002) and biogeographic province of Deccan Peninsula-Deccan South (6E). Therefore, major vegetation types in this region are scrub jungle and mangroves.

2.6 Ecological and Biodiversity profile of Gulf of Mannar Biosphere Reserve

Rameswaram Coast

The southern coast of Rameswaram island borders a part of the northern section of Gulf of Mannar. The coast is 27 Km long from the lands end, that is starting from Adam's bridge, to Kudugal Point. It is sandy and slopes down suddenly in to the sea at various points. The sea is deeper, about 5 to7 mts., even near the shore. The shore line from Kundugal point to Pamban boat jetty is a combination of marsh and sand. This area exposes itself well during low tide. The boat jetty area is sandy but the intertidal area has stony coral bottom which has been used to lay the foundation for a strong jetty. The sandy layer above the coral bed is usefull as an anchorage for the fishing trawlers.

Raman Point To CMFRI Jetty

Raman point is the tip of the land of Mandapam projecting into the Pamban bridge. It is a sandy shore pitted intermittently with leiching granite slabs both along the shore and at the intertidal region. The algal forms particularly Sargassum sps. are found in plenty which damp the wave action on the shore. The sea bottom between Kurusadai island and Mandapam shore abounds in coral reef towards the islands and is sandy clayish towards Mandapam end. Mechanized fishing trawlers in large numbers operate from Mandapam and land heavy catch of fish and prawns.

CMFRI Jetty To Pudhumadam

This area includes two major fish landing centres that is Vedhalai and Pudhumadam and a minor fish landing centre, Nochiurani . Large number of mechanized boats and sail boats operate from the shore of Vedhalai. The coast is sandy fringed with coconut plantation. A large quantity of Gracillaria sps., is landed on the coast by the sail boats. This centre is noted for sea weed harvest and export. Boats load of sea weed are landed on this coast are dried and sold to dealers for export.

Two types of fishery exist in many parts of Gulf of Mannar area which is conspicuously observed at Vedhalai. Fish, small prawns and crabs are landed for local and inland consumption while cuttle fish, large prawn, sea cucumbers, ornamental gastropods and sea weeds are landed exclusively for export purpose. Holothuria scabra is solely fished in this area as a consumable item of South East Asian countries known as bech-de-mer. Holothuria atra is left behind untouched. Hence, it is easily found every where.

Pudhumadam To Sethukarai

Muthupettai, periapattanam and Sethukarai are the three major fishlanding centres of this piece of coast. The sea is slightly deeper in this area ranging from 4 m along the coast to 8 m towards the islands. Muthupettai and Periapattanam have both mechanized and sail boats. The main profession is fishery and sea diving. During certain seasons shoreseine nets are operated or migratory fish like seer fish are targeted. Diving for corals and large gastropod shells, large seafans and sea

cucumber (Bech-de-Mer) is one of their main occupations and the products thus collected have value in the International Market. Sethukarai coast and its intertidal region are very shallow from the coast to a distance of 1 km towards the sea. This is due to the presence of stony corals. Acropora and various other corals that have grown to a distance of 2-3 km parallel to the coast to form a 'ridge'.

Sethukarai to Valinokkam

There are two major fishlanding centres i.e. Kilakkarai and Ervadi and one minor centre, i.e. Pallavasalur.In Kilarkkarai fishermen have more number of mechanized boats which cover the entire coast doing trawl fishing. The depth of the fishing area varies from 4-7 m. All along the coast from Sethukarai to Ervadi north, from the seashore to about 200 m into the sea, the sea bottom is covered with coals and lushy growth of sea weeds. The fisherwomen of both Kilakkarai and Ervadi wait for the tide to recede and harvest Gracillaria sp. and other seaweeds and process them for export. The mechanized fishing trawlers extend their fishing area upto Valinikkam. The shore from Chinna Ervadi to Valinokkam holds a large Bay. Although the shore along the coast is shallow, the core area is deep upto 6 m and the sea bed is sandy. There is a ship dismantling unit at Valinokkam. The fishermen of Valinokkam have few trawlers but they use more number of mechanized boats for gillnet operation.

Valinokkam to Sippikulam

This is a long coast with three estuaries and five fishing villages i.e., Kill Mundal, Mcl Mundal, Oppilan, Terku Mukkayur and Vembar. But majority of the population except at Kel mundal, Teuk Mukkyur and Sippikulam(sentence not complete), others are interested in jobs at the major salt factories situated is very along the coast. The landings at Sippikulam is very appreciable since the fish catch includes seer fish, tuna, carangid of very large size.

Sippikulam to Tuticorin

This covers the main fishing areas over the pearl fishing grounds (Parrs) where unbelievably large sized. There are three to four seasonal estuaries present in this stretch. A total of seven fishing villages are located in this stretch, major occupation of these villagers is fishing related activities. Villagers from this region are still involving in illegal coral mining at smaller scale. There are good beaches available in this stretch which were once used by the sea turtle for nesting.

Tuticorin to Kanyakumari

Though the coastal area between Tuticorin and Kanyakumari is densely populated a very rich marine biodiversity and potential sea turtle nesting beaches are available in this region. Good patches of sea weeds are

available throughout this coastal line. Oyster banks are also available in some estuarine areas of this coastal region. Sand mining is the major threat to the coastal ecosystem of this region apart from illegal fishing of sea turtles.

The ecology of the off shore islands in the Biosphere Reserve

Van Tivu

In the earlier management plan of the National Park, it was mentioned that of just a few Prosopis trees (10 Nos.) and Salvadora tree (10 Nos.) were seen sprouting from stumps. However, currently (in 2007) more than 40 grown trees of prosopis occur on this island. The ground vegetation has halophytic herbs, creepers and grasses. Degraded sea grass patches are seen near the island. About ¼ area of this island has already become submerged due to the removal of coral reefs. This island does not have most of the vegetation seen on the other 2 islands off Tuticorin coast. The heavy biotic interference due to its nearness to Tuticorin and frequent fires caused by fisherman is the main reason for degradation of this island's biodivesity. There are a few depressions on this island and the mangrove species are absent in this area. The open area of this island has been planted with Thespesia, Pungan, Neem, Delonix alata during 91-92 and they are getting established. There is about 35% survival of planted seedling and hence consolidation and restocking of the area is necessary.

Kasuvar Tivu

Prosopis and Salvadora trees are doiminant on the terrestrial part of the island. The ground vegetation has herbs, creepers and grasses. Due to excess removal of corals over the last decade, about ¼ of this island is sinking under water. The reclaiming work done during 92-93 has been quite successful as sand has been deposited over the coral debris dumped and the island size has increased. Due to the control exercised in removal of coral material from this island, fresh coral debris and sand accretions are taking place in other portions also and plant succession with ground vegetation and grasses is establishing over the newly built up land portions.

Almost the same vegetation as in Kariachalli island is seen except the absence of a few important species like Caralluma circarii etc. In a natural depression, good growth of Avicenia species and Suaeda are seen although on another depression mangrove species are absent. The Afforestation done during 92-93 has about 40% survival and replacement and restocking with salt tolerant species is being done. Pithacalobium dulce, Vagai, thespesia have come up well (Management Plan 1993-94 to 1997-98). The area surrounding this island is famous for chank due to good sacred chank beds, which attract nearby fishermen to collect the chank here illegally.

Velanguchalli Island

This submerged island looks like a small sand mound due to removal of coral reefs around this island in the past. Currently, good fringing corals have been observed around this island. There are good sea grasses patches in the shallow waters around the island .

Karaichalli Island

This island which had an original area of 16.46 ha ,had only an estimated 12.70 ha in 1993, considered to be due to excessive removal of corals from this island which has resulted in submergence of some portions. This island has scanty vegetation at present consisting of grasses, climbers, few Salvadora and few Prosopis trees. The detailed floristic survey of this island in October '92 revealed presence of about 54 species of plants mostly of littoral and swamp type. The native flora of this island is the better preserved due to its faraway location and less biotic interference.

Upputhanni Island

This island of around 30 ha area has good natural growth of vegetation. Thespesia and Neem are the main tree species and are growing from cut stumps. The large depression in the southern side of the island caused by coral mining about two decades back, has stagnation of rain water and sea water and has become a natural heronry for sea birds. There is good growth of Avicenia around this depression. There are good deposits of coral debris due to stoppage of coral removal in the last two decades. Patchy and fringing coral reefs are also giving protection to the island shores. There is absence of Salvadora on this island. During 91-92 afforestation was done on this island with Thespesia and Vagai.

Puluvinichalli Island

This has an area of about 6 ha. and fairly good halophytic vegetation. Thespesia, Salvadora and Neem have come up well from cut stumps. There are no mangroves or natural depressions on this island. There has been no afforestation activity on this island so far. There are good fringing and patch coral reefs around this island. There are signs indicative of large pearl oyster beds in the vicinity of this island.

Nallathanni Island

With an area of about 110 ha, it is situated about 2 kms from Mundal fishing village. In about 35 ha. of area planted by the Maraickayar family, there were 1600 coconut and 2000 palmyra palms in 1993 but now (2007) there are around 150 coconut trees and 300 palmyra palms present which are taken care by a lady who takes care the the Muniswaran temple built in this island. Many locals come to this temple for worship by private boats. Every year, in the month of March, this temple festival attaracts nearly 200-300 pilgrims from nearby fishing villages. There is heavy growth of Prosopis on this island. Big trees of Tamarind, Ficus, Thespesia, Salvadora and coconut trees were seen with top portions dried up. As per the instructions of the Chief wildlife warden the coconut trees were left without maintenance which has resulted in a

decline of coconut trees in this island. This is the only island where good potable water is available at upto 5' depth in one portion of the island.

Anaippar Island

This has an area of 11 ha. There are good coral reefs and patch coral formations around the island. There are no mangroves along the shore of the island. There are man made depressions with the island where once salt making was done and around this, Avicenia officinalis growth is present. The vegetation mainly consists of prosophis and occasionally Salvadora. There are patches of depressions where rain water and salt water accumulate during monsoons resulting in stagnation. Original stumps of mangroves plants are seen showing the degradation from previous years to the present. human interference was not much on this island though it is near to Valinokkam because of absence of good quality sea weeds and fishes around the island (Management Plan 1993-98). However, lately this island is currently used for drying seaweeds which has been collected nearby areas especially from Nallathani island by the fisher folks.

Valimunai Island or (Palliyarmunai Island)

This has an area of 6.72 ha, and the present vegetation is mostly of Salvadora and a Prosopis trees. ground vegetation and grasses is also present to some extent. There are no depressions and mangroves are absent. There are evidences of heavy biotic interference on this island. There is good reef network surrounding the island but the island shores are not being protected with any mangrove vegetation. Occasional patches of Pemphis acidula are seen.

Poovarasanpati Island

This island is submerged 25 years ago due to excessive quarrying of corals from its surroundings. The area where island was said to be present (09"09'5040N 78"45'2010E to 09"09'5080N 78"45'1890E) in the past, is now submerged at a depth of about 1.5Mt during lowtide. This is surrounded by a good growth of corals, sea grass and sea weed beds. A shifting sand mound is present near this island, which is seen during lowtides.

Appa Island

It is in 2 bits which is separated by a sand bar with shallow water permitting crossing on foot between the two bits. The southern part of the island has few proposopis and salvadora trees on it. The main vegetation is Prosophis with occasional Salvadora and Thespesia. There are no mangrove patches and Pemphis growth to protect the island shores. One part of the island is of coral base with sand deposition where it is entirely Prosophis growth. In the other part due to constant wave action, the sand has been washed away and the underlying coral rocks have been exposed to wave action. There is good coral reef growth in continuation to the island. Recently, Balanoglossus and its habitat have been found around this island (WII survey, 2007).

Thalayari Island
It is about an hour by boat from Kilakarai. The general growth is mostly littoral vegetation with a small patch of Avicenia. Most of the island shore is protected by Pemphis acidula only. Thespesia, Salvadora and Pemphis are the predominant tree species at present.

Valai Island
The Valai island has an area of 10.15 ha. There is a sand bar connecting this to Thalaiyari island. It is has good protection on either side by patchy and fringing coral reefs. The shores are protected mostly by good growth of Pemphis acidula. The vegetation is quite good with Salvadora and Thespesia as the most predominant species. Ground level halophytic grass and other flora are also good. There are small patches of vacant areas with no tree growth, which can be afforested with Salvadora, Thespesia and Neem in the coming years.

Mullai Island
The area is 1020 ha and the island is protected by both patchy and fringing coral reefs. The vegetation is sparse with mostly ground level grasses, climbers. Salvadora and Thespesia are present which are seen sprouting from heavily lopped 2 year old stumps. There are two depressions inside the island and around the large depression good growth of Avicenia avicinalis is seen. In the other depression Avicenia is absent.

Hare Island
This island is frequented by local people. Coconut plantation had been done by the private lease holder. There are natural Palmyra trees also on this island. There are 2050 coconut trees and 1800 Palmyra trees. There are good Pemphis acidula growth skirting the periphery. There is a large depression surrounded by mangrove vegetation and which support a heronry where plenty of sea birds congregate. Prosophis and other halophytic vegetation are also good. Afforestation has been done on this island during 91-92. There are good patchy and fringing coral reefs around this island.

Manoli Island
This is an island with beautiful mangrove vegetation and Pemphis acidula along the periphery. There is good natural vegetation of Salvadora, Thespesia etc. There are good patchy and fringing coral reefs around this island. There are natural depressions acting as heronries for sea birds. There is a large sand bar connecting Manoli Island to Manoliputti and it has formed in the last two years. It is getting colonized by natural vegetation. There is another sand bar recently formed on the southern side of this island. The colonization of this sand bar with natural species has not yet taken place.

Manoliputti Island

This is a very small-island separated by a shallow channel from Manoli. There is good live coral growth of both patchy and fringing type around this island. There is fairly good natural vegetation on this island including Pemphis and occasional mangrove species.

Poomarichan

The Pullivasal and Poomarichan islands are almost in the form of a horse shoe shape with the land connection during low tides and in this area a good aviary of marine birds like Seagulls, Plovers, Curlews, Terns etc can be seen. Mangrove species like Rhizophora, Ceriops are also seen in this island. Pemphis growth is very good in the intertidal region and it is a major species which is protecting the island shore line from getting eroded.

Pullivasal Islands

The Pullivasal island has a good vegetation at present and the fringes of the island in the intertidal region is has maily the mangrove associate, Pemphis and on the inside, Prosophis, Palmyrah, Thespesia and other miscellaneous species are found. It is found that Pemphis growth is very good in the intertidal region and it is a major species which is protecting the island shore line from getting eroded. There are good coral reefs about 10 meters from the Pullivasal Island. Natural regeneration of mangrove is very good and the vegetation is also fairly good.

Krusadai Island

Known traditionally as a paradise for zoological collections, the fauna around this island has been extensively depleted since many decades. Ptychodora flava, the enteropneust worm and Spirula sp. (Cephalopoda) are unique representatives on this island. There is a old Marine Biological laboratory with few other buildings and a dilapidated old museum. There is good vegetation of Palmyra, Prosopis and other natural species like Thespesia, Salvadora etc. There is good coral reef growth around this island.

There is a new sand bar developed connecting Kundugal point which is 17 ha. in area. There is colonization by ground vegetation and at present grazing by the livestock of fishermen is seen on this sand bar. Planting of Salvadora and Thespesia and sowing of Avicenia seeds will help in afforestation of this sand bar. Fencing the linking portion of this sand bar to prevent livestock entry and planting native species will stabilize this sand bar.

Shingle Island

This has an area of about 13 ha. and has a heavy deposition of coral debris built up year after year. There is no vegetation skirting the periphery. Mangrove growth is seen only in a small depression in the northern corner of the island. There were no tree growth and good vegetation except Pemphis spp due to heavy anthropogenic pressure since it is nearer to the shore. Afforestation has been taken up on this

island during 93-94. An artificial reef created by dumping of rubble to 1 m height has resulted in trapping the sand and preventing it from getting washed over the live coral growth seen around this island. Thus natural coral regeneration has been ensured. There are good coral reefs both of patchy and fringing type around this island. Currently, due to plantation several trees dominated by Thespesia spp. are present here. However, this island seems to be known for open vegetation mainly covered with grasses. Plantation on this island should not be encouraged in future.

2.6.1.2 Mangroves of Gulf of Mannar Biosphere Reserve

Mangrove ecosystem is one of the most productive ecosystems occurring in the intertidal areas of the tropical and sub-tropical coast. Mangrove ecosystems support livelihood of the fishing and farming communities. The mangrove wetlands act as breeding, feeding and nursery ground for most of the aquatic fauna especially fishes and crustaceans. In the Gulf of Mannar, mangroves help in island building process thus preventing silt carrying to the coral reefs and seagrass areas. Turbidity of water affects the photosynthetic process of the seagrass and coral reef system. Interaction between mangroves, coral reefs and seagrass communities enhances the biomass of coral reef fish in the Caribbean islands (Parrish, 1989). Current rate of mangrove deforestation have deleterious consequences for fishery productivity and resilience of reefs (Mumby et al., 2004).

Space Applications Centre (2012) has mapped the mangrove areas using IRS P6 LISS satellite 2004 data. The study could able to map mangroves only in 8 islands. The total cover in the 8 islands was about 63.5 ha. The extent of mangroves in other islands is very less. Nagarajan et al. (2015) have mapped different land use classes in the biosphere reserve and found that mangroves are in 4.22 sq km. The change detection mapping between Vembar and Manappad using the satellite data for the year 2003 and 2010 revealed that the mangrove wetland has increased from 106 to 539 ha. An area of 432 ha mangrove forest has been gained as a result of protection as well as mangrove regeneration (Muthukumar and Selvin Samuel, 2015).

Kathiresan et al., (2008b) has estimated the extent of mangrove vegetation in 11 islands as 403.74 ha (Table 2.4). However, the study carried out by the Botanical survey of India found mangrove plants in 14 islands in the Gulf of Mannar (Daniel and Uma Maheswari, 2001). Nalla Thanni island has more mangroves followed by Talaiari island and Kurusadai island. Although mangroves are reported from majority of the islands, mangroves in Manoli is healthy and rich in diversity. The mangroves in the Gulf of Mannar islands are not very tall, perhaps due to strong winds during monsoons seasons and cyclones. In addition, the soil is sandy with poor nutrient content. The area is also not receiving freshwater as well as the sediment supply. The mangroves in Mandapam

are Keezhakarai islands are diverse and healthier than the mangroves of Vembar and Tuticorin islands.

Table 2.4: Extent of mangroves in the islands of Gulf of Mannar

S.No.	Name of the Island	Area (ha)
1	Kurusadai island	65.80
2	Pullivasal island	29.95
3	Pommarichan island	16.58
4	Manoliputti island	2.34
5	Manoli island	25.90
6	Hare island	29.04
7	Mullai island	10.20
8	Valai island	10.15
9	Talaiari island	75.15
10	Appa island	28.63
11	Nalla Thanni island	110.00
Total		403.74

Mangroves are also found in the mainland. The mangroves in Punnakayal are predominantly occupied by stunted *Avicennia marina*. *Suaeda* sp., *Arthrocnemum glacum* and *Salicorina brachiata* are other associated mangroves found in the area. Shrubs of *Pemphis acidula* and invasion of *Prosopis* in large areas are observed. The forest department, Government of Tamil Nadu restored large degraded areas. Similarly, the Pazhayar estuary in the Arabian Sea near Manakkudi village (Manakkudi estuary) has mangroves in small area. Neelakantan (1994) has estimated the extent of the mangroves in the mainland as 187 ha with 40 ha at Kundhukal, 10 ha around Tuticorin and 137 ha at Punnakayal. *Avicennia marina* is seen in the Veppalodai estuary and in the vicinity of the Tuticorin.

Iyengar (1927) recorded *Avicennia officinalis, Excoecaria agallocha, Bruguiera cylindrica, Ceriops tagal, Lumnitzera racemosa, Suaeda maritima, S. monoica* and *Sesuvium portulacastrum*in the Krusadai Island. Krishnamurthy et al. (1987) recorded 9 species of mangroves and 7 associated species of mangroves while Perichiappan et al.(1995) reported 13 species of mangrove and mangrove associates. The Mandapam group of islands has maximum number of species (Daniel, 1998).

Jeganathan et al. (2006) reported 10 true mangroves and 24 mangrove-associated species from the islands in the Gulf of Mannar. Gopal and Krishnamurthy (1993) have recorded only 4 mangroves species while Kathiresan and Rajendran (1998) have recorded 7 mangrove species. The diversity of mangroves and associates in Krusadai and Pullivasal was 11, followed by Manoli (10 species), Poomarichan and Hare island (9), Manoliputti (8) and Shingle (7). *Pemphis acidula* and *Avicennia marina* were recorded in 13 islands and *Sesuvium* in 15 islands. Mandapam group of island has rich diversity of mangroves. Krusadai, Poomarichan, Pullivasal, Manoli and Manoliputti Islands have large areas of mangroves of *Aegiceras corniculatum*, *Avicennia marina, Bruguiera cylindrica, Ceriops tagal, Lumnitzera racemosa, Rhizophora apiculata* and *R. mucronata*.

Muyal and Shingle Islands, have only *Avicennia marina*, *Lumnitzera racemosa* and *Excoecaria agallocha*. In the Keelakarai group has *A. marina* and *Lumnitzera racemosa* in Talaiari Islands and *A. marina* and *Pemphis acidula* in Valai Islands. The Tuticorin group of Islands is very poor in mangroves. Upputhanni island has only *A. marina*. Kaswari Island had a small patch with *A. marina* and *P. acidula*. The associated species namely *Aeluropus lagopoides, Arthrocnemum glaucum, Atriplex repens, Clerodendrum inerme, Fimbristylis ferruginea, F. polytrichoides, Halosarcia indica, Ipomoea violacea, Pandanus fascicularis, Salicornia brachiata, Salvadora persica, Sesuvium portulacastrum, Sporobolus tremulus, Suaeda maritima, S. monoica, S. nudiflora* and *Thespesia populnea* are found in the islands of Gulf of Mannar (Daniel and Umamaheswari, 2001). In general, mangrove diversity and also health is good in the Mandapam groups of islands when compared to Keezhakarai, Vembar and Tuticorin groups.

In Gulf of Mannar, a total of 11 mangrove species and 17 mangrove associates were identified (Database on Gulf of Mannar Biosphere Reserve, 2015). *Ceriops tagal* in Pamban, *Pemphis acidula* and *Avicennia alba* in Palayakayal estuary are rare species found only in the Gulf of Mannar in Tamil Nadu. *Pemphis acidula* is endemic to Gulf of Mannar.

Change in soil properties and other edaphic factors and overexploitation might lead to vanishing of these mangrove species. Expansion of salt pans in and around Tuticorin is another factor leading to the shrinkage of mangroves (Kathiresan, 2008; Kathiresan et al., 2008b; Daniel and Uma Maheswari, 2001). Mangroves in Muyal and Pullivasal islands were harvested by the local community for their firewood needs. Rapid industrialization in the mainland is also occupying the areas of mangroves. These industries also pollute the environment. Sea level rise is expected to aggravate inundation; storm surges and erosion affect the mangroves along the fringes of the island.

Table: True mangrove flora recorded in Gulf of Mannar Islands

Species \ Islands	Shingle	Krusadai	Pullivasal	Poomaricha-	Manoliputti	Manoli	Muyal	Mullai	Vaaail	Thalaiyari	Appa	Puliarmunai	Anaipar	Nallathanni	Pulivinichal-	Upputhanni	Kariachali	Kaswar	Van
Aegiceras corniculatum	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Avicennia marina	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	-	✓	✓	-	✓	-	-	✓
Bruguiera cylindrica	-	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
Bruguiera gymnorrhiza	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceriops tagal	-	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
Excoecaria agallocha	✓	✓	✓	✓	✓	✓	✓	-	-	-	✓	-	-	-	-	-	-	-	-
Lumnitzera racemosa	✓	✓	✓	-	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
Pemphis acidula	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-
Rhizophora apiculata	-	-	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhizophora mucronata	-	✓	✓	✓	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-

Sea grass meadows and other floral elements

The Gulf of Mannar coast and Islands have dense meadows of seagrasses, mainly between the mainland and the islands (shoreward from island), as well as towards the seaward sides of the islands. A total of 13 species of seagrasses have been documented in Gulf of Mannar. In the seaward sides of the islands, seagrasses are seen in patches. They extend to about 2 to 3 km from the Island shores towards the open sea. Little seagrass patches have been observed up to a depth of 18 m. Occurrence of persistent, strong waves in the seaward side is the primary reason for the relatively low percentage cover. Shoot density, biomass and diversity are higher in the shoreward side than the seaward side. Seagrass meadows around the islands of Gulf of Mannar form a significant grazing ground for the sea cow, *Dugong dugon*. *Thalassia hemprichii, Syringodium isoetifolium* and *Cymodocea serrulata* are the dominant seagrass species in Gulf of Mannar. *Enhalus acoroides* is said to be an endemic species growing abundantly in the rich clay-toasted silt soil in Gulf of Mannar.

Total seagrass cover in Gulf of Mannar Marine National Park is approximately 76 km^2. The following are the seagrass species recorded in Gulf of Mannar, *Cymodocea rotundata, Cymodocea serrulata, Enhalus acoroides, Halodule pinifolia, Halodule uninervis, Halodule wrightii, Halophila decipiens, Halophila ovalis, Halophila minor, Halophila stipulacea, Halophila becarii, Syringodium isoetifolium* and *Thalassia hemprichii.*

Seagrass area cover in Shingle Island is 2.03 km2; Krusadai Island 2.36 km2; Pullivasal Island 2.86 km2; Poomarichan Island 2.8 km2; Manoliputti Island 2.45 km2; Manoli Island 2.7 km2; Hare Island 4.53 km2; Mulli Island 3.2 km2; Valai Island 3.14 km2; Thalayari Island 4.64 km2; Appa Island 6.96 km2; Poovarasanpatti Island 3.33 km2; Valimunai Island 4.29 km2; Anaipar Island 4.09 km2; Nallathanni Island 4.18 km2; Puluvinichalli Island 3.09 km2; Upputhanni Island 3.38 km2; Kariyachalli Island 3.87 km2; Vilanguchalli Island 4.62 km2; Koswari Island 3.55 km2; Vaan Island 4. km2. Seagrass percentage cover in Shingle Island is 42.19%; Krusadai Island 36.68%; Pullivasal Island 40.63%; Poomarichan Island 38.75%; Manoliputti Island 28.38%; Manoli Island 29.88%; Hare Island 32.03%; Mulli Island 28.5%; Valai Island 42.2%; Thalayari Island 27.9%; Appa Island 32.75%; Poovarasanpatti Island 29.85%; Valimunai Island 32.75%; Anaipar Island 29.15%; Nallathanni Island 38.4%; Puluvinichalli Island 38.4%; Upputhanni Island 38.25%; Kariyachalli Island 38.25%; Vilanguchalli Island 29.13%; Koswari Island 34.79%; Vaan Island 31%.

Seagrass meadows in Gulf of Mannar are also found outside the Gulf of Mannar Marine National Park. Survey carried out in four distinct areas outside the Park area revealed the following results: overall

seagrass area cover (51.69%) was recorded in the area between Periyasamipuram and Vembar with 9.42 km2; seagrass cover (51.78%) was 6.22 km2 in the area between Vipar and Periyasamipuram; seagrass cover (44.78%) was 5.25 km2 in the area between Valinokam and Erwadi; seagrass cover (45.11%) was 3.56 sq.km in the area between Koswari and Kariyachalli islands.

About 147 species of seaweeds recorded inside the Biosphere Reserve. The production of seaweeds in the Gulf of Mannar has been estimated to occur in 171.25 sq km. Luxuriant growth of seaweeds is found in the areas between Mandapam and Keelakkarai while it is comparatively less in the southern side of the reserve i.e. the area between Tuticorin and Kanyakumari. The seaweeds namely *Sargassum* sp., *Turbinaria* sp., *Gelidiellaacerosa*, and *Gracilaria* sp., are collected for making agar, cellulose and algin.

Increase in the global average temperature has been unprecedented during the past few decades because of the Global Climate Change. The year 2015 became the hottest year on record by breaking the previous record held by 2014. Elevated sea surface temperature directly affects seagrass metabolism, photosynthesis and respiration, thereby acting as a limiting factor which decides the abundance and distribution of seagrass meadows. It is likely that temperature elevation has its impact on flowering and seed germination in seagrasses. Detailed studies on the impacts of elevated sea surface temperature have not been carried out in Gulf of Mannar. Pollution, boat traffics, ports and mechanized fisheries related activities in the seagrass meadows are threatening the seagrass habitats in the Biosphere Reserve.

Marine mammals

Gulf of Mannar Biosphere Reserve is an area of high productivity with rich marine biodiversity including marine mammals such as dugongs etc (Choudhary and Sivakumar, 2009). This region is holding an isolated but an important dugong population of south Asia (Marsh, 1989; Marsh et al., 2002; Ilangakoon, et al., 2007; Pande et al., 2010; Sivakumar and Nair, 2013), along with few other mammalian species of dolphins, porpoises and whales. Interview surveys have suggested that at least three species of baleen whales, killer whales, pilot whales, small delphinids and dugongs use this area (Sutaria and Jefferson, 2004 ; Sutaria et al., 2017). In 2017, hundreds of piolet whales stranded along this coast (Sakthivel et al., 2017) and further, there were significant number of other marine mammal species stranding were also observed in last few decades along the coast of Biosphere Reserve (though the Striped Dolphins *Stenella coeruleoalba* observed rarely) (Alling, 1986; Pillai and Kasinathan, 1987; James and Mohan, 1987; Ilangakoon, 1997; Sathasivam, 2000) reveals that this

regionhas been used either as feeding or migratory path of several species but this needs to be verified with a systematic study.

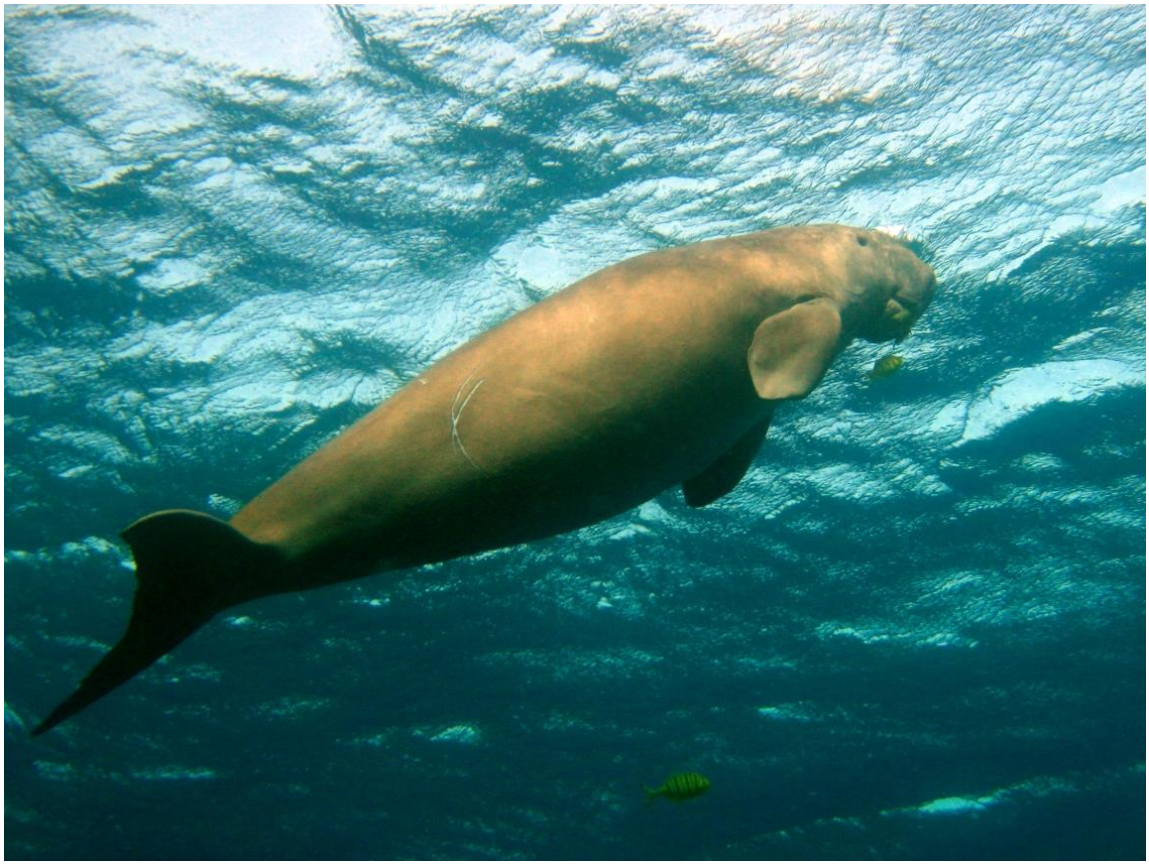


Figure 1 Dugong

Although, dugongs, dolphins, porpoises and whales were stranded along the coastal region of this region but there was no systematic survey carried out with respect to marine mammals (Sutaria and Jefferson, 2004 ; Sutaria et al., 2017). A boat survey with participation of local fishermen was carried out by WII, in February and March, 2018 to assess the dugong population but there was no sighting of dugong. Saravanan et al., (2013) have identified this region is an Important Coastal and Marine Biodiversity Areas of India, which similar to EBSA due to presence of rich biodiversity especially dugongs and their seagrass habitats.

Marsh (1989) based on the data of Dr. Eric Silas and Mr. Bastion Fernando indicated that 250 dugongs were illegally caught and butchered at the villages of Kilakarei and Peripattinum alone between April 1983 and August 1984. This information clearly shows that once the Gulf of Mannar BR had a good population of dugong but due to illegal off take of this species caused the species to be threatened with local extinction. Though, the illegal off take of this species drastically reduced their population, information on current status and distribution is not known in detail (Sivakumar and Nair, 2013 Ministry of Environment, Forest and Climate Change (CAMPA),

Government of India in collaboration with Wildlife Institute of India and Tamil Nadu Forest Depart has initiated a species recovery programme of dugong in this region.

Figure 2Stranded Pilot whale along Biosphere Reserve

Other Marine Mammals of Biosphere Reserve

Scientific Name	**Common Name of Species**	**IUCN / other status assessment**
Balaenoptera musculus	Blue whale	EN
Balaenoptera edeni	Bryde's whale	DD
Orcinus orca	Killer whale	DD
Globicephala macrorhynchus	Pilot whale	DD
Steno bredanensis	Rough toothed dolphin	LC
Stenella attenuata	Pantropical Spotted Dolphin	LC
Stenella longirostris	Spinner Dolphin	DD
Delphinus delphis	Common Dolphin	LC
Neophocaena phocaenoides	Finless Porpoise	VU
Physeter macrocephalus	Sperm whale	VU

Sharks

Having a healthy population of sharks is very important in preserving seagrass and coral reef ecosystems as they keep the populations of their prey controlled.Shark catches along Tuticorin coast are mainly supported by the families Carcharhinidae, Echinorhinidae, Hemiscyllidae, Alopidae, Sphyrnidae and Squalidae. The family

Carcharhinidae alone represented 45.1% of shark catch and family Hemiscyllidae represented 30.6% of shark catch (Abdussamad et al., 2006). In the Pamban region of Gulf of Mannar about half a dozen species of sharks are commonly reported from the catches by drift nets at 20-60 metres of which the most important are Sphyrna zygaena, Carcharhinus limbatus and Scoliodon laticaudus. Occasional and accidental catches of the tiger shark and whale shark are also recorded in this area. The carpet shark Chiloscyllium spp. is often caught with bottom-set gillnets operated in the Gulf of Mannar region.

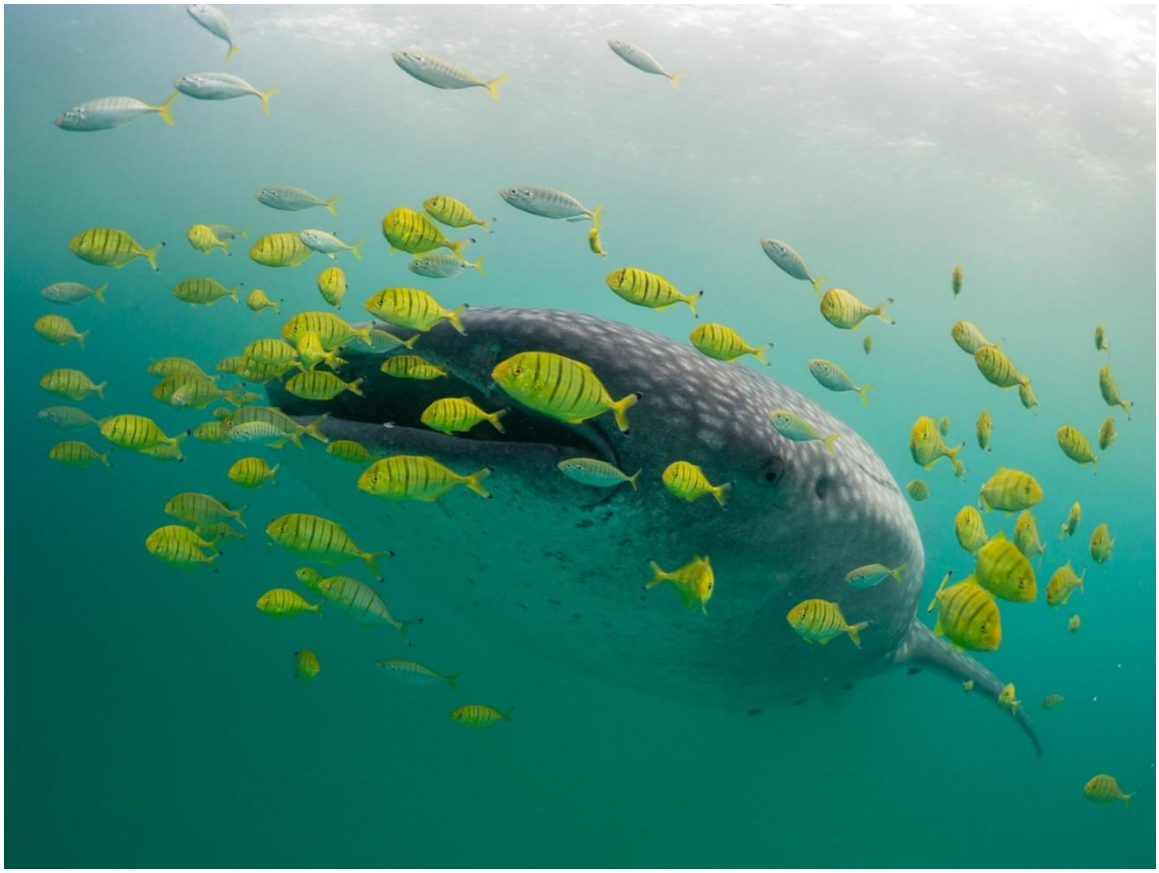


Figure 3Whale shark

The deeper areas of Gulf of Mannar off Pamban have been observed to be good potential fishing grounds for a number of sharks, especially for the hammer-head (S. zygaena), which is observed to breed in this area. Sudarsan et al. (1988) identified the existence of potentially rich grounds for pelagic sharks off the Gulf of Mannar. The incidence of non-conventional species of deep-sea shark species has also been reported from the Tuticorin region of Gulf of Mannar by the deep-sea trawlers (Devadoss, 1996). Nair and Mohan (1973) reported deep sea sharks such as, *Halaelurus hispidus, Eridacnis radcliffei and Eugaleus omanensis* in the Gulf of Mannar region at the depth of 200 fathoms. The landing of whale shark (Kasinathan et al. 2006; Ranjith et al. 2014) and thresher sharks (Ranjith et al., 2014; Gowthaman et al.,

2013) have also been reported from Tuticorin waters of Gulf of Mannar.

Birds

As per the Birdlife International database, about 187 species of aquatic and terrestrial birds have been identified from the Biosphere Reserve (Balachandran 1990, 1995), which is famous for waders and seabirds. Sometimes >50,000 water birds are found here. Pelagic birds are also recorded (Balachandran 1990). Among the waders, the Lesser Sand Plover *Charadrius mongolus*, Curlew Sandpiper *Calidris ferruginea* and Little Stint *Calidris minuta* are the most abundant. Red Knot *Calidris canutus* is a regular winter visitor in small numbers, and the species is not a vagrant as reported previously. The rare Eastern Knot *C. tenuirostris* has also been recorded from this area. The occurrence of Crab Plovers *Dromas ardeola* in hundreds indicates that the two islands (Manali and Hare) in the Gulf of Mannar are important habitats for the species, next only to Pirotan Islands in Kutch (coastal northwest India, another IBA) (where two to three thousand individuals were reported to winter regularly). The Bar-tailed Godwit *Limosa lapponica*, reportedly a straggler in south India, has been recorded in hundreds. The status of Sanderling *Calidris alba* was confirmed as a regular common winter migrant, after being first recorded by Biddulph (1938) earlier. The marine terns, such as the Lesser Crested *Sterna bengalensis* and the Sandwich *S. sandvicensis* commonly occur, and the former was found breeding. The other breeding species at Mandapam are: Little Tern *Sterna albifrons*, Kentish Plover *Charadrius alexandrinus*, Stone Plover *Esacus magnirostris* and Stone Curlew *Burhinus oedicnemus*. Since Greater flamingos *Phoenicopterus ruber* frequent this area in several thousands, this IBA ranks third as an important wintering ground for flamingos along the east coast, after Pulicat Lake (IBA) and Great Vedaranyam Swamp. Rare waders in this area are the Broad-billed Sandpiper *Limicola falcinellus*, Dunlin *Calidrisalpina*, Long-toed Stint *Calidris subminuta* and Red-necked Phalarope *Phalaropus lobatus*. The Gulf of Mannar lies within the passage of many migrants such as Black-tailed Godwit *Limosa limosa* and Broad-billed Sandpiper. Also, 15 species of migratory waders and 8 species of migratory terns were found to summer here especially on the two islands. Along with Chilika Lake in Orissa (an IBA) and Point Calimere in Tamil Nadu (an IBA), the Gulf of Mannar forms an extremely important link for migrant and resident waders. Gulf of Mannar National Park has been identified as an Important Bird Areas.

The **Melaselvanur Bird Sanctuary** is an important breeding area for many of the migratory birds coming from Europe and Australia during the winter months (November-March/April) every year, which is inside the Biosphere Reserve but on terrestrial part. Grey pelican and painted stork are among the birds visiting this place. A tiny village in

the far south, Koonthankulam in Nanguneri Taluk of Tirunelveli District is emerging as a new favorite for migratory birds. It may soon be catapulted into the list of popular water bird sanctuaries in the country. This village is sparsely populated. Migratory birds start coming by December end and fly away to their northern homes by June or July after they lay eggs, hatch them and the young ones grow old enough to fly with the older ones. About 35 species of birds visit this calm but congenial village for breeding. Birds such as Painted Storks migrate here from North India and East European Countries . Similarly the Flamingoes also fly-in mainly from the Rann of Kutch also lay, hatch and rear their young ones in the village.

The swamp near the Kodandaraman Temple near Rameswaram gives shelter to a flock of thousands of Flamingos every year, during the months of December to March along with various other species of waders and wetland birds. The large depression in the southern side of Upputhanni island caused by coral mining about two decades back, has stagnation of rain water and sea water and has become a natural heronry for sea birds. There is a large depression surrounded by mangrove vegetation and which support a heronry where plenty of sea birds congregate on Hare island. Similar sites are found on Manoli island. The Pullivasal and Poomarichan islands are almost in the form of a horse shoe shape with the land connection during low tides and in this area a good aviary of marine birds like Seagulls, Plovers, Curlews, Terns etc can be seen.

Turtles

Four of the seven species of sea turtles found world wide are reported to occur in the Gulf of Mannar Biosphere Reseves (Kar & Bhaskar, 1982; Bhupathy & Saravanan, 2003). These are the olive ridley (*Lepidochelys olivacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys mbricate*) and leatherback (*Dermochelys coriacea.* All the four species of sea turtles that occur in these coastal waters are protected under Schedule I of the Wildlife (Protection) Act, 1972, as well as listed in Appendix I of Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) which prohibits trade in turtle products by signatory countries. At present there exists no commercial or international trade of marine turtles or turtle products in India. However, incidental capture in trawls is a well-known cause of mortality for sea turtles and have been reported all over the world (Eckert, 1995; Seidel & McVea, 1995; Hillestard, *et* al., 1995; Lutcavage, *et al.,* 1997; Oravetz, 1999) and India is not exceptional to this (Bhupathy & Saravanan, 2003; Pandav *et al.,* 1997).

Figure 4Olive Ridley turtle

During 1971-76 the percentage of green turtle and olive ridley caught in the Gulf of Mannar and adjoining areas was 89% and <10% respectively (Agastheesapillai & Thiagarajan, 1979) and during November 2001 it was 46% and 48%[2] but in this study the percentage was 13% and 83% which shows that the proportion of green sea turtles catch declined in this region drastically. The reduction in the green turtle catch could be due to overexploitation as local people prefer this species to other species for food. Since the population of green turtle was smaller in size the people were forced to exploit the olive ridley nowadays (Sivakumar, 2005).

Important invertebrates, invertebrates, their status, distribution and habitat.

Balanoglossus, the unique link between the invertebrates and vertebrates which is said to be so rare is seen to occur only near Kurusadai Island. *Chlamydotorax ceylonensis, Ptychodera flava* and *Chlamydothorax (Ptychodera) krusadiensis* are reported around the Krusadai Island (Horst, 1932). However, in the recent past the taxonomy of this species is under debate. Many believe that this species may be *Ptychodera flavor.* A genetic study is required to

confirm whether the balanoglossus occur in Gulf of Mannar is an endemic or not.

Balanoglossus, is the general name given to certain peculiar, opaque, worm-like animals which live an obscure life under stones, and burrow in the sand from between tide-marks down to the abyssal regions of the sea. Balanoglossus *Ptychodera flavo* the unique link between the invertebrates and vertebrates which is said to be so rare is seen to occur only in the Mandapam and Keelakarai groups of islands in the Gulf of Mannar. There is no detail information available on this species regarding their status, distribution and ecology.

Recovery of balanoglossus

First, it is important to know the status and distribution pattern of this species. During this Management Plan preparation exercise, the WII team had discovered new balanoglossus habitats from the Keelakarai group of islands. It shows that the extent of balanoglossus distribution in the Gulf of Mannar Biosphere is not known correctly which needs to be assessed immediately. Protecting their habitats from any anthropogenic activities will help this species to recover. Public awareness programme about this species needs to be initiated.

Coral Reefs- species, extent, distribution and status

Coral reef system as also the ecosystem of the tropical rain forest, are the most matured marine ecosystems of our planet. They play an important role in global biochemical processes and in the reproduction of food resources in the tropical regions. Coral reefs act as a barrier against wave action along coastal areas thus preventing coastal erosion. In addition, coral reefs protect mangroves and seagrass beds in certain areas, which are the breeding and nursing grounds of various economically important fauna. Coral reefs are also important breeding, spawing, nesting, and feeding areas for many economically important varieties of fishes and other marine organisms. The people living along the coast obtain a considerable proportion of their food and earnings from the productivity of coral reefs. Coral reef ecosystems are very sensitive to external impacts both natural and manmade, which violate their homeostasis (Sorokin 1992). The majority of damage to coral reefs around the world has been through direct anthropogenic stress (Grigg and Dollar 1990). According to Bryant et.al (1998), 57% of the world's coral reefs are potentially threatened by human activity such as coastal development, destructive fishing, over exploitation, marine pollution, runoff from deforestation and toxic discharge from industrial and agricultural chemicals. Some of the factors affecting coral reefs growth are regression of coral growth due to silt laden water with greater load of suspended matter during monsoon flow, wind blown sandy deposition, cyclone, quarrying for limestone, effect of current, etc.

Of the Gulf of Mannar islands, the eastern side of the islands hasve a greater expanse of living coral reefs since the human exploitation of the coralline stones is concentrated on the northern and the western sides. (Issac Rajendran and Kanagaraj David, 1972). The Government of Tamil Nadu have prohibited the quarrying of corals.

There are about 120 species corals in the Gulf of Mannar alone (Gopinatha Pillai, 1971). They belong to 33 genera. Of this, 110 species grouped in 26 genera are hermatypic. The conspicuous species of corals belong to the families Acroporidae, Poritidae and Faviidae. The corals here are fast deteriorating in the 4 islands off the Chidambaranar coast due to human interference.

Reef flat of Gulf of Mannar has been reported to be extensive (Pillai, 1971, 1977). Pillai (1986) reported that coral diversity in Gulf of Mannar comprises 94 species belonging to 37 genera. Edward et al. (2004) updated the list to 104 species and Edward et al. (2007) updated the list further to 117 species of corals belonging to 40 genera. The fast growing corals such as Acropora spp., Montipora spp. and Pocillopora spp dominate shallow waters of depth ranging between 0.5 and 2 m.. Boulders such as Porites spp., Goniastrea spp., Favia spp., Favites spp., etc. are dominant in depths between 3 to 9 m around the islands.

A detailed account on the exploitation of corals for using them (in trade of the exploited products) as raw materials in industrial ventures such as cement industries, brick manufacture, masonry work, limekilns, etc., is given by Mahadevan and Nagappan Nair (1972). For the industries in the adjoining Tirunelveli district, the exploited materials are ferried from islands north of Nalla Thanni Tivu. The reefs on some islands have been totally exploited beyond recognition.

The coral reefs are fast deteriorating in the Gulf of Mannar due to human interference such as coral mining, greater silt inflow draining from the mainland, destructive fishing practices etc., Silt affects racemose types of corals greater than the encrusting and massive coral types. Loss of vegetation on the coast-line causes extensive siltation. The coral reefs act as breakers and their removal will alter the current pattern along the coastline. They act as coastguard against powerful tidal waves. The reefs on the four islands of the Chidambaranar coast have been exploited beyond recognition; and portions of these islands and one island entirely have become submerged under water and visible only at low tides. Hence caution should be exercised against indiscriminate exploitation and loss of forest cover on the coastline causing extensive siltation.

The total coral reef area in Gulf of Mannar is about 61.01km^2, of which reef area covers 48.18 km^2, reef vegetation covers 10.15 km^2

and degraded coral occupies 2.68 km² (Thanilachalam and Ramachandran, 1998).

Coral reefs in Gulf of Mannar occur mainly around the 21 uninhabited islands encompassing an area of about 683 ha.

Sedimentation is a major factor controlling the distribution of reef organisms and overall reef development (Macintyre 1988). The reduced level of light due to suspended sediment in the water column can reduce coral growth (Hubbard et al 1986) and has an impact on natural zonation patterns (Morelock et al 1983). Excessive sedimentation can also discourage the settlement of coral larvae. Most of the studies on the effects of turbidity on corals have concentrated on anthropogenic-increased sedimentation and turbidity. According to Thanilachalam and Ramachandran (1998), nearly 67.2% of the coral reefs in Gulf of Mannar is not in living condition due to sedimentation and turbidity caused by anthropogenic and natural activities. The anthropogenic activities like destructive fishing methods, seaweed collection, commercial shell collection, coral mining, intensive agriculture, changing land use practices, deforestation and industrial waste input etc. and natural activities like monsoon, wave action, ocean current and tides were identified as the agents that increase the sedimentation and turbidity in coastal waters of Gulf of Mannar.

Table. Offshore islands and reef status in GOMMNP (Source: Patterson *et al.,* 2007)

	Status of coral reefs			Live coral cover (%)		Reef
Islands	[Area cover (Km²)]					condition
	CC &DCA	DC	DCA	Acropora	*Non* - Acropora	
Shingle	2.16	0.86	0.91	20.11	27.81	Fair
Krusadai	4.26	1.12	3.15	25.27	13.04	Fair
Pullivasal	2.32	2.13	--	24.85	21.52	Fair
Poomarichan	3.16	0.96	--	4.20	21.34	Fair
Manoliputti	1.83	1.57	--	6.92	20.25	Fair
Manoli	2.35	~	1.97	26.02	14.66	Fair
Hare	6.56	1.86	5.35	23.18	9.40	Fair
Mulli	2.21	1.12	--	22.03	20.00	Fair
Valai	1.20	1.41	--	21.67	26.74	Fair
Thalaiyari	5.90	~		19.57	28.95	Fair
Appa	4.82	0.95	--	31.75	27.95	Good
Poovarasanpatti(Submerged)	1.48	~		25.50	3.57	Fair
Valimunai	2.83	1.11		13.29	16.11	Fair
Anaipar	1.91	2.15	--	20.11	27.81	Fair
Nallathanni	7.77	4.55	--	0.66	11.40	Poor

Pulivinichalli	2.15	2.21	--	32.77	26.01	good
Upputhanni	2.12	3.92	--	5.29	19.83	Fair
Kariyachalli	3.37	1.63	--	11.23	35.37	Fair
Vilanguchalli (Submerged)	0.98	1.35	--	6.04	18.30	Poor
Koswari	3.54	2.73	--	1.17	14.09	Poor
Vaan	3.05	1.77		6.97	24.16	Fair

A separate chapter on 'Ecology, review on current status, monitoring and restoration of coral reefs in the Gulf of Mannar Biosphere Reserve' is included in this Management Plan and provides management prescriptions.

Salt marshes-extent, distribution and status

In the Biosphere Reserve, areas under salt pans is about 103.7 sq km, marsh land 18.17 sq km and saline land is about 16.32 sq.km area. Most of salt marshes have been converted into salt pans then to industry development or aquaculture. These salt marshes are important feeding ground of many migratory birds and other invertebrates.

In recent years in the west coast of India vegetation based natural salt are being produced from coast-based halophytes like *Salicornia brachiata* and *Salicornia brachiata*. Such natural vegetation origin salt are in high demand in the ayurvedic pharmaceutic industries. Such halophyte plantations also helps in desalining the hypersaline soils. Such activities can be encouraged by allocating degraded saline patches to village EDCs. Such plantations can also be cultivated along the banks of salt pans or in the salt marshes. In addition natural vegetation salt, pickles can also be prepared from these plants. These products can be sold in the community owned stalls at the main tourist centers or link to other user and marketing agencies. The GOMBRT may organize exposure visit for identified EDC memners to the west coast to enable them understand the prospect of such alternate income generation option.

Sand dunes, beaches, rocky shores, cliffs-extent, distribution and status

Sand Dunes and beaches

Sand dunes represent flexible barriers that absorb wave energy during high waves and storms by moving and adjusting their shape and position. Dunes are essentially sand reserves where sand accumulates during normal conditions and then released to the beach and offshore zone during high waves and storms. It also acts as ground water reservoir supporting freshwater to the vegetation in the island

ecosystem, besides preventing the intrusion of salt water, which affects the vegetation cover. Sand dunes seen in the islands of Gulf of Mannar are mostly small to medium scale with creepers. In the current scenario of sea-level rise, stabilized sand dune along the beaches can act as natural barrier to the sea-level rise in low-lying islands. Sand dunes however cannot be viewed in isolation from the other components of the coastal system. It is recognized that sand dunes and beaches are so interdependent that they have to be managed together, and sand dune management should be viewed within the overall context of integrated coastal zone management (ICZM)

Beaches are extensively developed along the entire coast of Gulf of Mannar except at some places. The shore between Tuticorin to south Sippikulam (2.04 km^2) , Vaippar River and Gundar River (2.56 km^2), Gundar River and Palar River,(2.64 km^2), Palar River and Kottakkarai River (2.189 km^2), Kottakkarai River and Marakkayarpattanam (2.18 km^2)southern coastal parts of the Rameswaram Island (2.91 km^2)and the western part of the Rameswaram Island from Pamban to Peikkarumbu are observed as the important beach areas in Gulf of Mannar coast. All along the shore the beach as are observed to be gently sloping and marked with altered crusts and troughs that are formed due to wave action. There are also good beaches available along the coasts of Tirunelveli and Kanyakumari districts which also forms a part of the Biosphere Reserve.

Spit

Among the various depositional landform features encountered, the formation of spit is a significant feature of recent age. South of Tuticorin coastal area two spit formations have been observed. It appears to have been built by the sediments brought by long shore current during southwest monsoon. As the Gulf of Mannar is on the lee of the northeast monsoon, there is no long shore drift from the northeast that might be the cause for the inward curving of this spit (Ahmad 1972). The southwestern shore of Rameswaram has a tongue shaped spit. SOI toposheet of the year 1969 does not show any spit but recent IRS LISS-III imagery (1998) clearly shows the spit. Hence it may be assumed that these spits are recently formed. It can be explained that the Rameswaram spit may have been the result of littoral current from Palk Bay to Gulf of Mannar during northeast monsoon period.

Mud flat

Mud flats are wide expense of deposit of clay, silt, ooze, etc (Davies 1972). The mudflats are observed near Vaippar River mouth, around Valinokkam backwater lagoon, Kallar River mouth and Gundar River mouth. The area covered by mudflat has been estimated to be 14.50 km^2.

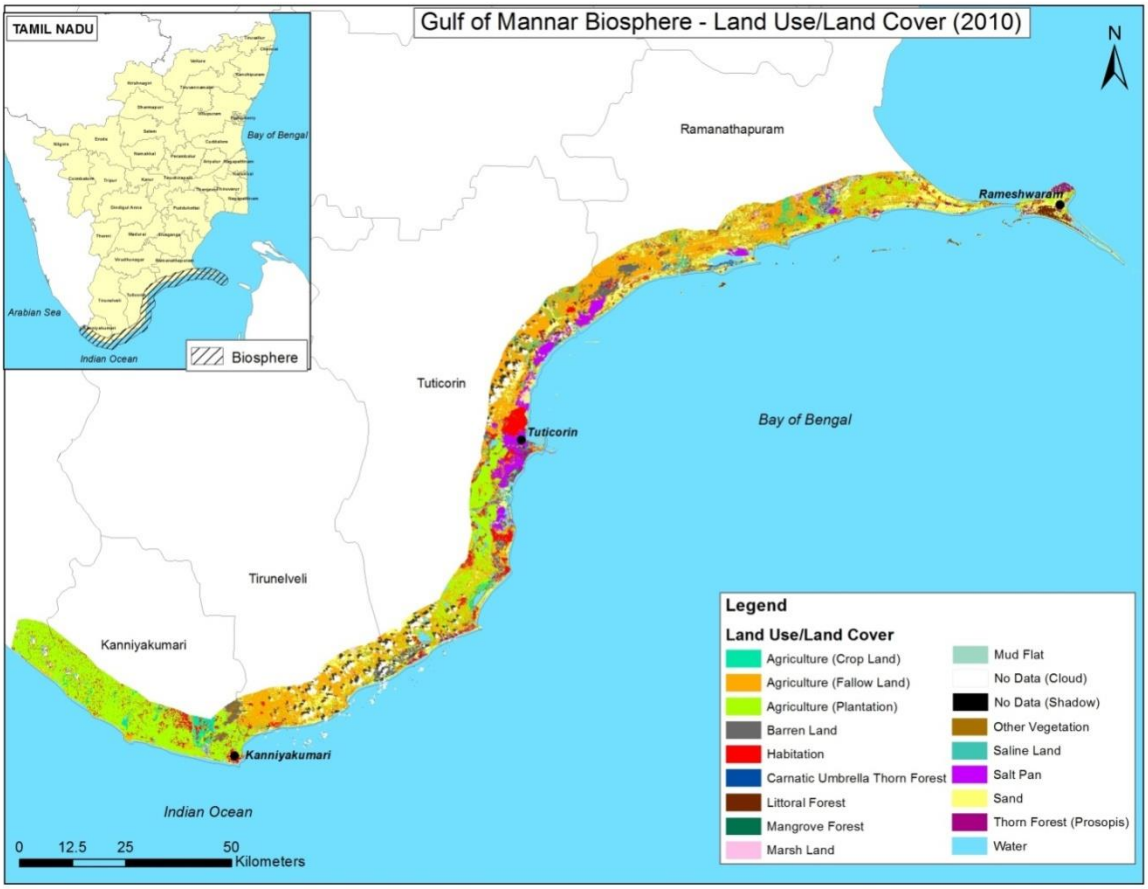
Sea cliff and sea cave

Along the coast of Gulf of Mannar cliffs have been observed in Mandapam, Rameswaram, Pudumatam and Appa Island coastal areas. Generally the sea cliff and caves are made up of calcareous sandstone and located at the high water level. Due to intensive action of waves on cliffs, at some places, sea caves are formed. Such caves have been observed near Mandapam coastal area and Southwestern and Southern coastal areas of Appa Island. At some places, these features have been destroyed due to slumping of upper cliff materials.

Land use and Land cover of Biosphere Reserve

The landscape of the biosphere reserve is with beaches, algal beds, minor deltas, backwater areas, creeks, mudflats, seagrass beds, coral reef, salt marshes and mangroves. Beaches are extensively developed along the entire coast of Gulf of Mannar. The beach is gently sloping and marked with altered crusts and troughs formed due to wave action. The coastal areas between Mandapam and East of Vaippar River are covered by twelve well-developed beach ridges. Sand spits are observed in the southern side of Tuticorin and in the southwestern shore of Rameswaram. Swales and backwater zones are seen between coastal plains of Mandapam and Kottakkarai River. Mudflats are observed near Vaippar River mouth, around Valinokkam backwater lagoon, Kallar River mouth and Gundar River mouth. The 21 off shore islands are made up of a calcareous dead reef and sand. Coral reefs extends from south of Rameswaram to Tuticorin. It is believed that the Gulf of Mannar region was once covered with thick mangrove forests.

The LISS III satellite image of the year 2010 was used to classify the Landuse/ Landcover of the biosphere reserve (Nagarajan et al., 2015). Thirty kilometres of the coastal area (10 km land and 20 km towards sea) was used for classification (Fig. 3). In the total area of 10,500 sq km the area under agriculture is about 1763.78 sq km while the wooded area is about 230.62 sq km. The mangrove wetland constitutes merely 4.22 sq km. The areas under salt pans is about 103.7 sq km, marsh land 18.17 sq km, mudflat 24.52 sq km, the sandy beach is about 402.43 sq km while the remaining area is under water body (Table 1). The extent of seaweeds in the Gulf of Mannar is about 171.25 sq km. The islands vary in size and shape and the total area of all 21 islands is about 6.23 km^2. About 25.56 km^2 of coral reef area and 2.16 km^2 of seaweed area were lost between 1988 and 1998 in Gulf of Mannar (Thanikachalam and Ramachandran, 2003).



Land Use / Land Cover of Gulf of Mannar Biosphere (2010)

Table. Land Use / Land Cover of Gulf of Mannar Biosphere (2010)

S.No	Land Use/Land Cover	Area (sq.km)
1	Agriculture (Crop Land)	76.87
2	Agriculture (Fallow Land)	856.78
3	Agriculture (Plantation)	778.8
4	Barren Land	51.32
5	Carnatic Umbrella Thorn Forest	20.69
6	Littoral Forest	35.11
7	Mangrove Forest	4.22
8	*Prosopis*	63.35
9	Other Vegetation	107.25
10	Marsh Land	18.17
11	Mud Flat	24.52

12	Saline Land	16.32
13	Salt Pan	103.7
14	Sandy beach	402.43
15	Water Body	7,652.64

Chapter3

History of management and present practices

3.1 General

Gulf of Mannar National Park

Historically, the entire region of the National Park was under the control of the Tamil Nadu State Revenue and Fisheries Departments. Government of Tamil Nadu vide G.O. Ms. No. 226 Forest and Fisheries, Department dated 3 March 1980 notified the intention of setting up of the Marine National Park in Gulf of Mannar for the protection of Wildlife and its environment. Subsequently vide G.O. Ms. No. 962, Forests and Fisheries Department dated: 10.09.1986 renotification on the intention to declare the Marine National Park in Gulf of Mannar area in Tamil Nadu for the purpose of protecting Wildlife there in and its environments, including 3.5 fathom depth of sea on the Bay side and 5 fathom depth on the seaward side was issued.

Since all the islands except Nallathanni island and Hare island were poramboke lands, the Hare island which belonged to Mandapam Marakayar was purchased by the State Government of a cost of Rs.29,88,216/-, and Nallathani island from Lottampsa for Rs.9,03,138/-. All these 21 islands were than notified as reserve lands under Sec.26 of the Tamil Nadu Forest Act and were proposed to be notified as reserve forests. The intention to notify these islands and the sea around the islands upto 3.5 to 5 fathom depth, as a National park under the provisions of the Wildllife Protection Act 1972 have also been published in the Gazette Notification of Tamil Nadu Government. Draft notification of the islands under Section of the Tamil Nadu Forest Act 1882 has been sent and is under scrutiny. The Forest settlement officer Sivaganga is taking further action under sections 19 to 25 of the Wildlife Protection Act 1972 to constitute these islands and the area around them as a National Park. Actions area being pursued by him/her on this mater.

It was only after declaration of the Marine National Park in September 1986, the Forest Department took over the management of the islands of Gulf of Mannar in November 1989. From 1990 – 1991 onwards, Annual Management Action Plans were formulated by the Forest Department and activities in the Gulf of Mannar Marine National Park had been regulated. \

The first Management plan for the Gulf of Mannar Marine National Park for the period of 1993-94 to 1997-98, was prepared by Thiru K. S. Neelakantan (TN Forest Department, 1994). The Plan proposed a detailed study on all possible aspects of the entire coastal and marine ecosystems, including socio-economic status of the dependent fisher-

folk. After 1998, there has been no management plans, for the Marine National Park and management activities have been carried out as per the Annual Plan of Operation prepared by the Wildlife Warden of the National Park from 1999 to 2007.

The previous Management Plan that was prepared by GoMBRT with help of Wildlife Institute of India was an integrated Management Plan that encouraged the high level participation of stakeholders in the management and governance of National Park, that was ended in 2016. The Management Effectiveness Evaluation score of the Gulf of Mannar National Park after implementation of the Management Plan 2007-2016 was significantly improved from 57% (in 2010) to 68.7% (in 2018) but still assessed as 'Good'. This might be due to 40% of planned management actions were either not implemented fully or partially tried on adhoc basis. MEE of Gulf of Mannar National Park with conducted through a three-days consultation workshop at Tuticorin in 2018. This workshop was attended by various managers from different state forest departments from India and abroad including the CWLW of Tamil Nadu, current and previous Directors and WLWs of Gulf of Mannar National Park. The main reasons cited for the poor implementation of these 40 % actions were a) lack of required fund, b) lack of inter-sectoral coordination, c) prevailing poor socio-economic status of coastal communities, and d) lack of adequate capacity of National Park Authority. MEE evaluators strongly felt that most of management prescriptions sugguested in the previous Management Plan are still valid and need to be continued in the next Management Plan with adequate resources and capacity.

Table 3.1. Management Effectiveness Evaluation of Gulf of Mannar National Park in 2018.

Framework Element Number	Framework Element Name	Number of Questions (a)	Maximum Mark per question (b)	Total (a x b)	Marks obtained for the Element	Overall Score
1.	Context	03	10	30	30.0	68.7% GOOD
2.	Planning	09	10	90	65.0	
3.	Inputs	05	10	50	30.0	
4.	Process	05	10	50	32.5	
5.	Outputs	04	10	40	22.5	
6.	Outcomes	06	10	60	40.0	
Total				320*	220.0	

Gulf of Mannar Biosphere Reserve

After the concurrence of the Tamil Nadu Governemnt (Telex message NO.75612 / FRV / 88 –3, dated the 24th January 1989) to the proposal of the Government of India for setting of a Marine Biosphere Reserve in Tamil Nadu, the Government of India vide their Notification No. No. 1/6/80-Mannar, dated 4th April 1989, declared the Indian part of the Gulf of Mannar region covering an area of 10500 sq. km as the Gulf of Mannar Biosphere Reserve (GOMBR). Suggesting the Tamil Nadu Government for preparation of detailied maps of the Biosphere Reserve and to initiate management of the BR as per the Government of India Guidelines. However, there have been no management plan for the GOMBR though the management of the BR was under the direction of the CWLW, TN and implemented by the Wildlife Warden under the supervision of the Southern Regional Wildlife circle at Madurai and later under the supervison of Conservator of Forests, Virudhanagar circle designated as the Director, GOMBR.

The Tamil Nadu Government also established the Gulf of Mannar Biosphere Reserve Trust in the year 2000 to coordinate and synergize involvement of other sectoral agencies with the Tamil Nadu Forest Department in activities related to sustainable coastal and marine biodiversity conservation through rational utilization and management in the Biosphere Reserve through community participation. Since the establishment of the GOMBRT, activities in the BR have been managed through Annual Plan of Operation prepared by the Trust. After the approval of a GEF-UNDP sponsored project in year 2002 (which ended in 2012), the GOMBRT, all activities in the BR have been carried out by the Trust under the supervision and approval of its 'Board of Trustee' chaired by the Chief Secretary, Government of Tamil Nadu.

The ten year composite integrated management plan for the period 2007-2016 for the Gulf of Mannar Marine National Park and Gulf of Mannar Biosphere Reserve has been developed in the year 2007 by the Wildlife Institute of India facilitated by the GOMBRT and the first Management Plan for a Marine Biosphere Reserve in India.

3.2 Fisheries

The livelihoods of people in the coastal buffer zone of the Gulf of Mannar Biosphere Reserve region largely depend on coastal and marine resources. However, agriculture and allied activities also plays a significant role in providing livelihoods for the poor. The activities of coastal-based people largely include fishing, salt making and seaweed collection while other marine-based activities are also gaining importance. Ninety percent of the fisherfolk in the GOMBR region are artisanal (using wind or small engine powered craft) and only 10% use

mechanized trawlers.

There are about 47 fishing villages along the Gulf of Mannar Marine National Park coast, of which 38 are in Ramnad District and 9 villages are in Tuticorin District. The fishermen from these villages depend solely on fishing for their livelihood. There are altogether about 50,000 fisher-folk living in these villages of which more than 12,000 are active fishermen.. The fisher-women are engaged in allied activities such as marketing, dry fish and net mending. The Department of Fisheries had in the recent years taken steps to formulate and implement special schemes to benefits fisherwomen in the hope that the fishing community will to gain economically and socially.

Table 3.2. Details of fishermen communities who depend on marine resources of Biosphere Reserve

District	Landing centres	Fishing villages	Fishermen Families	Traditional fishermen families	BPL families	Fisherfolk Population
Ramanathapuram	90	178	41,048	37,680	33,429	193,413
Tuticorin	27	32	19,998	18,828	13,212	82,560
Tirunelveli	9	9	6,132	6,125	2,399	24,639
Kanyakumari	46	47	40,266	39,941	7,601	156,595
Total	**172**	**266**	**107,444**	**102,574**	**56,641**	**457,207**

Table 3.3. Details of fishermen communities who engaged in aquaculture activities along Biosphere Reserve

District	Type of aquaculture						Acquired training
	Fish	Prawn	Crab	Lobster	Seaweed	Total	
Ramanathapuram	61	0	0	1	149	211	130
Tuticorin	3	2	1	2	0	8	508
Tirunelveli	8	1	0	0	0	9	16
Kanyakumari	2	2	0	0	0	4	61
Total	**74**	**5**	**1**	**3**	**149**	**232**	**715**

The GOMBR coastal belt has a very large proportion of country crafts, about 87%, against the mechanised boats, about 13%, in the total crafts. Thus a very large segment of traditional fishermen population has to work closer to the shoreline in shallow waters where the resources are poor and thereby their income is also poor. There are increasing number of instances where, due to poor catches and diminishing economic returns, the owners are selling the mechanized boats.

The fishermen employ traditional crafts such as catamarans, vallams, masula boats and dug-out canoes for their fishing operations. The mechanized fishing boats of 30' – 32' size, introduced by the Fisheries Department in the late fifties have proved extremely popular especially with the subsidy and soft loan facilities. Presently, 500 of these boats operate in this area mainly from Pamban, Mandapam and Valinokkam. About 165 traditional crafts in this area are mechanized

under the Modernization Programmes introduced by the Department during the last few years. Despite the mechanization programmes initiated four decades ago, about 70% of the fish landings are still brought in by the traditional crafts. Since these islands are in close proximity to the main land, most of the fishing operations are conducted with their bases in the main land.

The mechanisation of fishery has displaced women from their traditional roles in processing, marketing and making of nets; forcing them to take up alternative livelihoods. As women play a major role in supporting the sector, they would be the primary beneficiaries. Existing livelihoods related programmes in the buffer zone area do not provide adequate economic alternatives and in particular do adequately address the needs of women fisher-folk. As a result, people's only alternative livelihood option has been harvesting of wild seaweed or coral, which they have been over harvesting.

As a result of the complexity of the types and efficiency of fishing craft and gear and the fluctuations in the available fishery resources, there are wide variations in the catch and income of fishermen. More than 70% of the active fishermen work as labourers in the boats owned by others on share-basis or for wages. The fishermen working in the country crafts such as catamarans, vathai, thoni and vallam (not motorized) earn a daily income in the range of Rs.20-30, except on a few days during the peak fishing season.

Average annual fish landings from the Marine park area during the last five years are about 46,000 tons of demersal fishes and 33,000 tons of pelagic fish. These are landed in 33 fish landing centres along the coast bordering the park area. Of the total landings of 1,05,273 tonnes during 1988-1989, prawns constitute 2300 tonnes which has become an important fishery in the last 3 decades in view of the high unit price it commands both in National and International markets.

Almost all ecological assessment on the current status of the coral reef system in the Gulf of Mannar region by professional agencies have opined that, unless restored, this region will not provide the ecological services and required habitat condition as a marine reef fish breeding ground. Almost 50,000 fisherfolk of the region are dependent on artisanal fisheries based livelihoods in the region and their well being is closely linked to the ecological security of the coral reef ecosystems in the Gulf of Mannar region in Tamil Nadu.

Unscientific and uncontrolled fishing and fisheries related activities are the major threats to the Biodiversity of the Gulf of Mannar Marine National Park.

The buffer zone is proposed to be permitted for local people's use such as fishing and fisheries related activities. The seascape surroundings the islands beyond the limits of the National Park will form the buffer zone i.e. up to 20 m depth in seascape around the National Park and the coastal areas (10 km from the high tide mark to landward side) will form the buffer zone of the Biosphere Reserve.

It is proposed that such protection staff in islands be chosen from amongst the fishermen community who may have lost their fisheries related livelihood because of the establishment of the Marine National Park

Reef fisheries are generally at the subsistence level and catches are unrecorded. Wafar (1986) estimates the potential yield to be about 0.2 million tonnes a year, or about 10% of the total marine fish production in India. The Gulf of Mannar in particular is used by many fishermen from the mainland and from Rameswaram Island, especially in winter: caches include parrotfish, carangids and triggerfish; some 2,150 tonnes were taken in 1983 (Salm 1975). However, fast declining of reef fish resources in the Gulf of Mannar has been expressed by the Scientific community who attended the 'National Research and Monitoring Moderation Workshop' at Madurai organized by GOMBRT in December 2006. Recovery of reef fish resources in the National Park will improve the catches of the fishermen who fish in the buffer zone of the Biosphere Reserve.

Researches carried out in the second half of 20th century have emphasized more on the fish and fisheries of this region. Some research on the environment of this region was carried out in the later part of the 20th century and at present. Regardless of the numerous papers published on the Gulf of Mannar, emphasis was given to fish and fisheries related research activities and there is no detail information on the status, distribution pattern and ecology of several species and their habitats occur in this region, and also there is no detailed study carried out to understand the resource availability and its utilization by the local communities, impact of present fishing activities on biodiversity as well as the future generations of local communities, which are essential for the biodiversity conservation as well as sustainable utilization of resources by the local dependent communities. Prevailing poverty in the region especially among fishermen community force them to use some indiscriminate fishing methods that are harmful to certain vulnerable habitats such as corals, seagrass etc. Further, encroachment of mechanized fishermen especially trawlers in the traditional fishing grounds create a lot of conflict among fishermen and it also adversely affects the important fish breeding habitats of Biosphere Reserve. Industrial and domestic wasteges from adjoining landscape is also affecting the fisheries resources of Biosphere Reserve.

Holothurian Fishing

Fishing for holothurians has gained importance during 1980s although the industry is ancient and reported to have been established about hundred years ago. The two commercial important species that are collected by fishermen are *Holothuria scabra* and *Holothurai spinifer* which are processed and exported to Singapore and Hong Kong. The fishermen collect the holothurians by diving in shallow waters of 2 to 10 metre depth. Fishermen from Chinnapalam, Vadalai, Mandapam, Periapattinam, Kilakarai and Tuticorin are engaged in this kind of fishing. Annually 60 tons of Holothurians valued at Rs. 90 lakhs were collected from Ramanathapuram district of which 50% are estimated from the Gulf of Mannar area. Due to the over exploitation of the holothurians their population have drastsically declined, therefore, the Government of India banned Holothurians fishing, henceforth also in the Gulf of Mannar Biosphere Reserve.

Holothurians are naturally large and sedentary organisms and fishing techniques do not require sophisticated equipment, these attributes attract the fishermen to harvest some high value species that is seen as a valuable source of income particularly to local fisheries communities in many developing countries. Present fishery systems seem to be open for sea cucumbers resource access and overfishing to supply the demand of commercial merchandiser. Holothurians fisheries are commonly targeting the high value species, which taxonomical are mostly identified in families Stichopodidae and Holothuriidae. Meanwhile, since certain populations of these high value sea cucumbers are in decline, new species are now being collected, adding to the number of commercial species. The Government of India banned the holothurians fishing due to drastic population decline that has been noticed in this group. The Gulf of Mannar once known for major holothurians fishing has lost a majority of its holothurians stock due to overexploitation. It is important to enhance the stock of the holothurians in the National Park because the excretions of holothurians are known to improve the populations of benthic fauna and flora which are important food for several commercially important fishes.

National Park Authority could successfully have confiscated several illegal trades of sea cucumbers from the Biosphere Reserve during the previous Management Plan. It reveals that illegal collections of sea cucumber is still continuing and there is a request from certain stakeholders to lift ban on sea cucumber trade. However, it was observed that the populations of sea cucumbers in the Biosphere Reserve was not good while preparing this Management Plan by the Wildlife Institute of India.

Sea-weed collection

The species that are commercially valuable are *Sargassum* spp. *Turbinaria* spp., *Gelidiella* spp., *Gracillaria* spp., which are in demand for the production of agar, cellulose and algin used for food processing and pharmaceutical industries. 5000-7000 tons (dry weight) are harvested annually of which *Sargassum* spp. form the bulk. More than 1000 fishermen and 450 fisherwomen are engaged in seaweed collection which brings in a daily income on Rs. 20/- to 30/- per fisherman. The fishermen and women collect seaweeds near the islands and at times stay in the islands and collect them. The islands where significant quantities of seaweeds are harvested are Anaiparai, Pallimunai, Nallathanni, Challi island, Puthur theevu, Pamban island, Appa tivu, Anaipar, Manoli island, Putti island and hare island.

Coral collections

Coral reefs play a complex but a significant role in the marine eco-system. Coral reefs are said to be one of the most productive areas in the sea. Corals which were indiscriminately mined and harvested a few years ago from the Gulf of Mannar have been banned since 1982. Although this may help halt further degradation and facilities the recovery of the depleted areas, improved protection would be necessary to halt any illegal coral collection practiced now and suitable restoration and management to maintain a possible sustainable utilization of reef resources. Efficient protection of the Park Authority, illegal collection of corals from the region is almost stopped now.

Chank, Pearl and Oyster fishing

Diving for pearl oysters and chanks had been another important occupation of fishermen for more than 2000 years. Collection of chanks and oyseters by diving is still a major vocation for several hundred fishermen in Gulf of Mannar region. Pearl fishery which was a government monopoly had been conducted sporadically depending on the abundance of spat falls with great fan fare and had attracted pearl merchants from all over the world into this region. The last pearl fishery in Gulf of Mannar was conducted in 1961 and since then due to various reasons, the population of pearl oysters had not been adequate enough to organize such fishery.

Chank fisheries is also a Government controlled activity and continues to be fished on an annual basis, which is of considerable commercial importance to government. The Department of Fisheries registers divers for fishing from November to May; takes over the chanks collected and pay the Divers at a predetermined rate depending on the size and quality of chanks fished. The Tuticorin *jadi* varieties of chanks are in demand in West Bengal for making ornaments and for manufacturing artifacts. Chanks below the size of 60 mm. diameter considered juvenile when caught are released to sea and no payment is paid for such collections. Chank diving supports

nearly 770 divers who take to this profession by hereditary. The average collection of chanks during the last five years is 4,80,000, which fetch a revenue of Rs. 48 lakhs.

The Gulf of Mannar is also famous for its chank and pearl fisheries. They were the state's monopoly. There are about ten pearl banks. The most preferred species of pearl oyster is *Pinctada fucata*. there are four sps., of pearl oysters. *P. fucata* is abundant off-Tuticorin and the banks of pearls are called in Tamil "*parai*".It was observed that the spat falls of pearl oysters get periodically replenished by larvae carried by currents from Sri Lankan coasts and the Sri Lankan beds gets transported the larvae from the Indian sides.

Chank fisheries is also a Government controlled activity and continues to be fished on an annual basis, which is of considerable commercial importance to government. The Department of Fisheries registers divers for fishing from November to May; takes over the chanks collected and pay the Divers at a predetermined rate depending on the size and quality of chanks fished. The Tuticorin *jadi* varieties of chanks are in demand in West Bengal for making ornaments and for manufacturing artifacts. Chanks below the size of 60 mm. diameter considered juvenile when caught are released to sea and no payment is paid for such collections. Chank diving supports nearly 770 divers who take to this profession by hereditary.

3.3 Other activities

The Gulf of Mannar Biosphere Reserve Trust (GOMBRT) which was set up by Tamil Nadu Government in December 2000 have been responsible for initiating several eco-developmental activities in the Gulf of Mannar Biosphere Reserve area after the GEF-Supported UNDP Project for Strengthening the Management of the Gulf of Mannar Biosphere Reserve was initiated in the year 2002.

The project addresses a major challenge, namely the conservation of coastal biodiversity of the highest ecological value in a large area subject to considerable pressure from poor populations upon the sole resources that appear to be at their disposal. To meet this challenge, the project follows the only framework which can succeed, namely to combine the necessary protection of the threatened ecosystem and ecological processes while facilitating other economic and social benefits which will meet the essential need of local people, through providing appropriate institutional, financial and managerial arrangements.

In order to integrate the concerns of livelihood security of the people in the vicinity of the BR with Conservation, GOMBRT in collaboration with several Non-Governmental Organization has divided the entire Marine National Park coastal area into core zones and in a 10 kilometer terrestrial area from the coast has identified a total of 306 villages (Table 5.5.3) which are considered to have been located within the area of influence and impact the coastal and marine resource. Of these, 222 coastal villages have been prioritized to be covered under the UNDP-GEF project based on their marine resource dependency (Table 5.5.4). Of these, 139 villages have organized democratic institutional structures in the form of municipalities and panchayats (Table 5.5.5). Eco-development committiees have been established in 73 villages till the first week of October 2006 out of the 222 prioritised in Ramnad and Thoothukudi Districts. An institutional mechanism for each of these EDCs have been set in place through a governing body consisting of 8 members representing different castes among villagers with one member being from the Forest Department (Forest Guard) representing the GOMBRT for implementing the eco-development programs in each of these villages. Various eco-developmental programmes (alternate liverlihood options) have been initiated by the Trust in these 73 villages based on detailed micro-plans developed by collaborating NGOs (Table 5.5.6) through Participatory Rural Appraisal (PRA). After a review of the existing eco-development programs implemented by the GOMBRT under the supervision of the Eco-Development Officer (EDO), the present eco-development plan proposes the need to continue and enhance the eco-developmental activities with certain modifications as suggested in this management plan in all the identified villages during the 10 year plan period.

This Plan has also identified the villages along the Gulf of Mannar Biosphere Reserve in the two other distrcts such as Tirunelveli and Kanyakumari, where the process of micorplan and VMC development needs to be taken up gradually during this 10 year Plan period.

Reclamation of the coastal habitats for developmental activities, dumping ground for garbage, conversion of salt pans into aquaculture farms, in addition to the anthropogenic disturbances, the setting up of shrimp farms along the coast of estuaries in GOM has also become a matter of great concern. Due to delicious taste, universal acceptance, high unit value, quick growth rate, short culture period, high returns on investment and insatiable demand, shrimp farming had spread its root in India. With the recognition by Government of India as an extreme focus sector and with the patronage of government agencies and financial institutions, shrimp farming picked up fast. But due to lack of planning, there was unregulated growth leading to social resistance and outcry by environment groups regarding degradation of habitats and erosion of livelihood opportunities. It was reported that due to shrimp farming, the biota has changed and many species have

disappeared (Johnston, 1976; Varshney; Amaral & Costa, 1998 and Govindan, 1995). The aftermath of industrialization, urbanization and increase in population resulted in the release of discharges to the immediate ecosystem, which causes the deleterious effects as one of the exigent and perplexing problems of the coastal environment (Folke and Kautsky 1992; Pillay, 1992 and Gajbhiye, 1995). Coastal waters of Gulf of Mannar has also reportedly become polluted due to activities in ports and harbors, sewage discharge from human settlements along the coast and industrial effluents. Disposal of wastewater and industrial effluents into the estuaries and oceans has also increase the organic pollutant load in the coastal environment (Jayamani,2002).

Community based Aqua culture: With the traditional involvement of coastal communities in fisheries sector the EDCs may be at ease to adopt aquaculture involving select marine species. Since export of prawn, lobster, brackish water fishes, and marine ornamental fishes gaining importance day-by-day, prawn/shrimp and other marketable aquaculture may be promoted as alternate livelihood with the EDC members. Suitable villages with brackish water provision located near the coast needs to be identified for this purpose. Training and extension through involvementof professional institutions fromt he Tamil Nadu fisheries Department, CMFRI Mandapam and Tuticorin Fisheries College may be involved in proving training and promoting such activities. Aqua culture practices shall also include culture of edible oyster, pearl oyster etc. Facilities like cold storage and processing plants may also be required at a later stage if a larger number of EDCs become involved in such alternate income generation options.

Mariculture

Other: In addition to fisheries-related occupations along the coast, there are opportunities for employment in salt extraction, particularly in the western side of the Gulf near Tuticorin, and also in Palmyrah (toddy) tapping and agricultural labour. Skilled work is also undertaken, with mat weaving common in Ramanathapuram district. Moving inland from the coast toddy tapping and agriculture are the predominant occupations with small business-related opportunities prevalent near Rameswaram in connection with the tourism in this area (SSFRD, 1998).

In addition to fishing many are involved in various supplementary activities for their livelihoods viz., charcoal making, salt making, mat weaving, coir making and agriculture and allied activities. Availability of timely and adequate credit from the formal system and lack of support systems for marketing are the two main problems faced by the people.

The fisherwomen are more burdened and try to supplement the family income through fishery related trades such as dry fish preparation and marketing, seaweed collection and net-making and mending, and non-fishery activities such as working as labour in salt pans, and beedi making. These activities are seasonal and possible only in certain areas and do not add much to the family income.

Drift wood and dry twigs are collected from the islands mostly by fisherwoman as firewood and sold. Tough this is not a major occupations, this is taken up by fisherwomen for supplementing the family income.

3.4 Entry of effluents, kind and issues

Reclamation of the coastal habitats for developmental activities, dumping ground for garbage, conversion of salt pans into aquaculture farms, in addition to the anthropogenic disturbances, the setting up of shrimp farms along the coast of estuaries in GOM has also become a matter of great concern. Due to delicious taste, universal acceptance, high unit value, quick growth rate, short culture period, high returns on investment and insatiable demand, shrimp farming had spread its root in India. With the recognition by Government of India as an extreme focus sector and with the patronage of government agencies and financial institutions, shrimp farming picked up fast. But due to lack of planning, there was unregulated growth leading to social resistance and outcry by environment groups regarding degradation of habitats and erosion of livelihood opportunities. It was reported that due to shrimp farming, the biota has changed and many species have disappeared (Johnston, 1976; Varshney; Amaral & Costa, 1998 and Govindan, 1995). The aftermath of industrialization, urbanization and increase in population resulted in the release of discharges to the immediate ecosystem, which causes the deleterious effects as one of the exigent and perplexing problems of the coastal environment (Folke and Kautsky 1992; Pillay, 1992 and Gajbhiye, 1995). Coastal waters of Gulf of Mannar has also reportedly become polluted due to activities in ports and harbors, sewage discharge from human settlements along the coast and industrial effluents. Disposal of wastewater and industrial effluents into the estuaries and oceans has also increase the organic pollutant load in the coastal environment (Jayamani,2002).

A major outcome of increasing industrial water use has been the increase in conflict between local communities and the industry on issues ranging from water pollution to water scarcity. In areas where there is water scarcity, industries are under tremendous pressure from community and government alike to reduce water use (Murugan, 1989). Depletion of groundwater by industries, supply of water meant

for irrigation to industries, preferential treatment given to industries by the government are some of the major reasons for the conflict between industry and community over water use (Zingde and Desai, 1980; Zingde and Sabnis, 1994).

Land-based pollution Increasing industrialization has also added stress to the coastal marine ecosystem, comparatively more so on 49 the Tuticorin coast, e.g. with the discharge of untreated or partially treated effluents. At present, the major sources of pollution include a fertilizer plant, a thermal power generation plant, and the Dharangadhare Chemical Works Ltd (DCW). Acid wash from shell craft industries and, more importantly, solid wastes and wastewater from ice plants and seafood processing centers have also caused localized pollution (Easterson, 1998). The 210 MW Tuticorin Thermal Power Station burns up to 2800 tons of coal/day, producing an estimated 560 – 700 tons of ash per day. 750 m3 of seawater, used to cool the turbines, is discharged into the Tuticorin Bay every hour. The discharged "slurry" is noted from a distance of over half a kilometer away, with a thickness varying from 6 – 70 cm (Easterson, 1998). Though there is little variation in the salinity, pH and the dissolved oxygen content, increased levels in nitrite (0.4 – 0.84 µg N/ l) and silicate (17.6 – 19.8 µg Si/ l) were recorded by Easterson et al., (2000). The discharged seawater is usually 2 – 4° C above the ambient level and can be experienced up to 2 kilometers away (Easterson et al, 2000). The National Institute of Oceanography (1991) reported that, compared to other coastal regions in Tamil Nadu, Tuticorin is highly contaminated with metals (levels of Cadmium were between 0.4 – 2 µg/l, copper 4 – 5 µg/ l, lead 2 – 7.8 µg/l and mercury 0.1 – 0.12 µg/l). Copper and zinc are also found in high concentrations in seaweeds in the Tuticorin region (Ganesan, 1992). Elevated levels of metals like zinc, iron, copper and lead (> 100 ppb) were recorded among edible gastropod species in the Gulf of Mannar, including *Melo melo, Babylonia spirata, Hemifusus pugilinus*.

Benthic organisms have long been recognized as an integral part of coastal ecosystems and have been used as biological indicators of water quality for assessing the effects of industrialization and urbanization in various parts of the world (Pearson and Rosenberg 1978). A total of 122 species have been identified from 8 sampling sites of Gulf of Mannar Marine Biosphere Reserve area, Tamil Nadu. Among these, polychaetes are the dominant species and are followed by Crustaceans, Molluscs. Off 122 species identified, 47 polychaetes, 34 crustaceans, 33 molluscan belong to 21, 18 and 15 families respectively.

3.5Ports

The Gulf of Mannar Biosphere Reserve in Tamil Nadu covering an area in excess of the 10000 sq. km spread over four districts, continental

shelf, territorial waters and EEZ has the involvement of national agencies such as Indian Navy and Coast Guard, four district Collectors, a rapidly growing commercial and industrial centre and Port Trust etc. requires an equally higher level Authority with complementary specialized unit/wings to implement the strategy and action plans. Needless to say all these wings are required to be empowered with complementary staff and infrastructure befitting their status and planned activities. With the existence of Tuticorin Port and establishment of Sethusamuthram Canal, the chances of chronic oilspill and possible acute oilspills in the region is very high. Also the recent oil exploration activities and possible strike of hydrocarbon in the offshore areas of Gulf of Mannar will increase chances of hydrocarbon related disasters. The Biosphere Reserve Management therefore, is to set in place a mechanism and protocol for facing such eventualities in consultation with the Indian Coast Guard (Nodal agency in India for Oil spill Management), Tuticorin Port Trust and the Sethusamuthram Canal Management Authority.

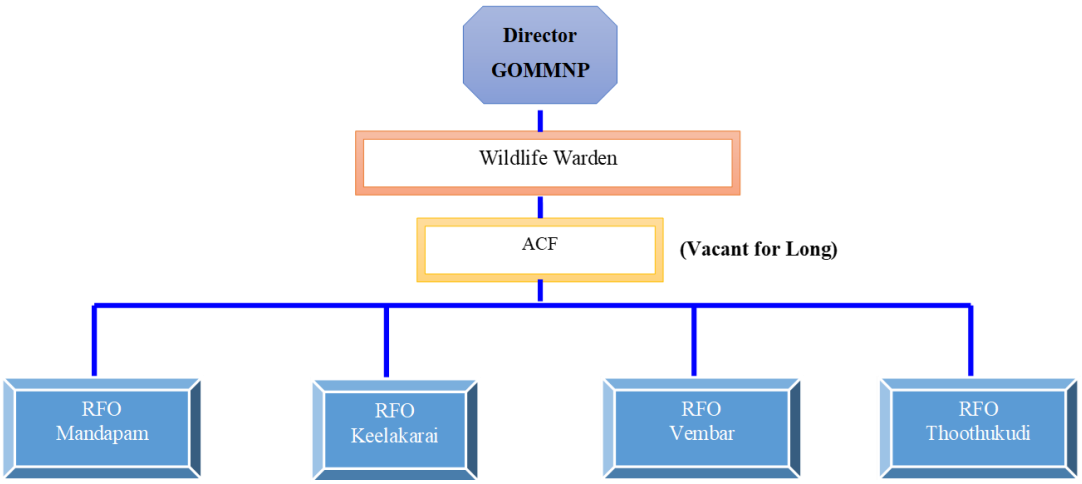
Southern group of islands have been observed with eroding at faster rate probably due to the Tuticorin Port and its expansion in the recent past. However, the Forest Department has initiated various management measures to minimise the erosion that included the artificial reef building at the southern off coast of Van Island. Impact of these measures on the island restoration may take more time to visibly seen. But, it is now important to collaborate with the Tuticorin Port Trust to restore southern group of islands. The Gulf of Mannar Biosphere Reserve Trust or establish a foundation 'Gulf of Mannar Biosphere Reserve Foundation' should collaborate with all corporate sectors of the region and collect minimum of 5% of CSR Fund for the management of Biosphere Reserve.

3.6Protection

Legal status

The Tamil Nadu Forest Department, Wildlife Wing (FD-WW) of the Department of Environment and Forests has primary responsibility for the protection of the National Park. However, the Indian Coast Guard, the Indian Navy and Marine Police too have responsibility of protecting the National Park and its resources. The Tamil Nadu Forest Act (1887) gives it the responsibility for the sustainable management of forest (mangrove) resources and it is the legal instrument under which the GoTN develops and enforces forest management regulation. This is applicable not only to the mangrove forests in the Park, but also to fuel wood plots along the coastal area of the Park's buffer zone. The Wildlife (Protection) Act, 1972, vests the FD-WW with the authority to enforce wildlife protection measures and establishes a Wildlife

Advisory Board to formulate policies for the conservation of terrestrial and marine wildlife and to identify and select priority areas to be protected. There are four ranges established for the better management, protection and monitoring of the National Park. Based on recommandatons of previous Management Plan, patrolling huts were established in few islands. However, due to poor infrastructure such as good boats and funds to maintain the same was the major setback for the frontline staff to efficiently protect the islands and its surroundings. Further, lack of incentives such as free rations and welfare scheme for frontline staff at patrolling huts and patrolling trip were also adversely affected the frontline staff. But, due to their sincerity and dedications in duty helping the Park to be protected.



Fishing, Effluents and their control

The Wildlife (Protection) Act, 1972 provides legal protection to many endangered and threatened organisms viz., Marine mammals, turtles, some of the sharks, fishes like the giant grouper and sea horse, corals, sea cucumbers, gorgonids, some of the molluscs etc.

There exists strict enforcement of rules against capture and possession of the protected animals. Joint patrolling is being carried out by the Forest Department, Fisheries Department, Police and Coast Guard to ensure better protection of endangered resources of Gulf of Mannar.

The Marine Fisheries Regulations Act (MFRA) was adopted in 1983, amended in 2000 and Rules notified in 1983. The regulatory measures formulated under the above Acts and Regulations by and large cover prohibition of exploitation of resources by destructive gears, explosives and poison,restriction of number of fishing boats, restriction of number of fishing gears which exploit juveniles in the backwaters, estuaries and shallow inshore waters, mesh size regulation, minimum legal length for capture, seasonal ban on fishing. The MFRA insists registration of all fishing vessels, and license required for fishing.

Daily tokens are issued to mechanized vessels, to venture into the sea. The use of fishing gears with a mesh size of 10mm (knot to knot) is strictly prohibited. Pair trawling and purse seining are strictly prohibited. Bottom trawling operations within three nautical miles from the shore is restricted. Non-mechanised fishing vessel should operate within three nautical miles shall go for hook and line fishing and boat seine. Fishing within 100 metres below a river mouth is restricted. The owner of a non-mechanised fishing vessel shall not use his gill net in the channel earmarked as the passage for mechanised fishing vessel. There is a trawl ban for a period of 45 days every year (closed season).Although seasonal fishing ban is just one of the many tools available for fisheries management, it is the only instrument which is being diligently followed in the country. Earlier there was no uniformity of ban period, but after the intervention of the Ministry of Agriculture, Government of India, the ban has been made uniform all along the west coast (June15 – July 31) and east coast (April 15 – May 31) states and Union Territories. The closed season is followed during different seasons and for varying duration along the east and west coasts. Whereas closed fishing season appears to improve the catch for a few months after the ban is lifted, there is no indication on the sustainability of fish stocks and long-term benefits (Vivekanandanet al., 2010).

It was observed that the spat falls of pearl oysters get periodically replenished by larvae carried by currents from Sri Lankan coasts and the Sri Lankan beds gets transported the larvae from the Indian sides.

Unscientific and uncontrolled fishing and fisheries related activities are the major threats to the Biodiversity of the Gulf of Mannar Marine National Park.

This zone is proposed to be permitted for local people's use such as fishing and fisheries related activities. The seascape surroundings the islands beyond the limits of the National Park will form the buffer zone i.e. up to 20 m depth in seascape around the National Park and the coastal areas (10 km from the high tide mark to landward side) will form the buffer zone of the Biosphere Reserve.

It is proposed that such protection staff in islands be chosen from amongst the fishermen community who may have lost their fisheries related livelihood because of the establishment of the Marine National Park

Marine fisheries in the GOM region is currently being governed by the Tamilnadu
Fisheries Act. Ever since the area was declared as a Marine National Park in 1986 and Biosphere Reserve in the year 1989, like any other Protected Area in the world, it has been almost impossible to implement any regulatory management strategies or enforcing any

laws without the support and active participation of the local communities/resource users. Development of Model Village Marine Conservation (VMC) Plan, is therefore, an exercise to examine how such plans of Eco-development approach of conservation and sustainable use of marine and coastal resources with the active participation of the local communities can be implemented, and whether this may have the prospect of replication in other coastal villages in the GOMBR region.
The VMC plan development is based on the premise of setting in place a mechanism for

- Active Participation of local communities in protection and sustainable use of biological resources in the GOMBR
- Elimination of further deterioration or alteration of natural habitats for the benefit of resource generation.
- Protection of endangered and threatened animal and plants species inclusive of their habitats and
- Sustainable use and careful Management of commercially important species and their habitats for the economic benefit of user communities.

Effluents:
Two laws are in force to prevent and control land-based pollution along the Gulf's coast: the Water Prevention and Control of Pollution Act (1974) and the Air Prevention and Control of Pollution Act (1974). These laws p rescribe the standards for effluent discharge and air emissions and established the Tamil Nadu Pollution Control Board (TNPCB) to enforce these prescriptions.The TNPCB also administers the GoI's Coastal Regulation Zone Notification (CRZN, 1986) issued by the Ministry of Environment and Forests. The Notification regulates land-use on the coastline, sets specific pollution control measures, and requires new development to be set back at least 200 meters from the high -tide mark. {UNDP:Project of the Government of India: Project Document; March, 2002}

Illegal activities

Poaching

Killing of dugongs and dolphins (both these are locally called as "Avolia" and "Kadalpandir") and turtles for sale for meat has reduced currently, owing to the implementation of the wildlife (protection) Act 1972 and the publicity given about the protection accorded to these mammals in the Act. However stray incidents of poaching and of incidental catches of these by the fishermen are known to still occur.

In 1988, Helene Marsh (Marsh, 1988) quoted the data of Dr. Eric Silas and Mr. Bastion Fernando indicates that 250 dugongs were illegally caught and butchered at the villages of Keelakarai and Peripattinum alone between April 1983 and August 1984. This information clearly

shows that once the Gulf of Mannar had a good population of dugong but due to poaching of this species , the population is now under threat. Catches were higher in Palk Bay between Devipattanam and Pamban on Rameswaram Island than in the Gulf of Mannar between Musal and Appa Islands and the mainland (Marsh 1988). Though, the illegal take of this species has drastically been reduced , the information on current status and distribution of this species is not clearly known. It is understood that a small scale of poaching on this species is still continuing along the Keelakarai and Sethukarai coasts . Though laws and awarness has reduced poaching in this region,many of these dugongs are still caught accidentally when they are traped and drowned in fishing nets,

Illegal fishing

Illegal, Unreported and Unregulated(IUU) Fishing: Fishermen the world over are involved in poaching wherever surveillance and antipoaching measures are weak. Fishers from neighbouring countries such as Pakistan, Bangladesh, Sri Lanka, and others from South East Asian countries are also regular poachers in unmonitored fishing areas, irrespective of who owns that Exclusive Economic Zone(EEZ). The overlapping claims of the EEZ in the South China Sea between China and its maritime neighbours (Taiwan, Philippines, Brunei, Malaysia and Vietnam) has resulted in aggressive fishing by Chinese fishers who are even escorted by the Chinese Coast Guard. With dwindling stocks and increasing demand, the resulting conflicts have become a regular occurrence. The situation in Europe and west appears to be better managed, withclear demarcations and the monitoring of activities in the fishing zones. However, what needs to be noted is that, irrespective of which country's EEZ is violated, the activities such as the ones witnessed in the Palk Bay would come under the category of IUU, i and needs to be dealt with as such by the concerned Governments. From this point of view, the navies and the coast guards of the countries charged with the protection of the EEZ and the prevention of poaching by foreign vessels are well within their rights to apprehend the offenders, and try them according to the law of the land. In the Indian context, due to the seriousness of the problem between Gujarati fishers and Pakistan fishers, a hot line was set up between the MSA and the Indian Coast Guard. This has certainly helped in resolving such issues as crossing into each other's territory and consequent apprehension. Signed in 2005, this MOU has been extended for another five years—from March 2016ii onwards. This CBM has, to a large extent, addressed the issue of the unwarranted detention and harassment of fishermen who are pursuing their livelihood. However, the problems are most acute in the respect of TN fishers who have a Hobson's choice in Palk Bay. It has also been reported that a similar MOU on the lines of the existing one with MSA of Pakistan is being considered for implementation with the Coast Guards of India and Sri Lanka. {Illegal Unreported and Unregulated(IUU) Fishing in Palk Bay: Issues and Challenges; R. S.

Vasan*; 20 February 2017}

Other illegal activities

Coral mining Coral has traditionally been collected from the seabed for use in construction or as raw material for the lime industry, as well as for ornamental purposes. The Indian Ocean tsunami, however, made a change in the minds of fishermen, who attributed protection of their villages from the tsunami to the presence of corals reefs and islands. Therefore, the majority of them voluntarily stopped the coral mining activity, particularly on the Tuticorin coast, and today only sporadic mining incidents are reported.

Aquaculture

Seaweeds are cultured in Rameswaram, Pamban, Vedalai, Pudumadam, Periapattanam, Kalimankundu, Kilakarai, Ervadi, Valinokkam and Kanyakumari area of the Gulf of Mannar by means of vegetative propagation and using spores such as swarmers.

Tuticorin Coast in Tamilnadu is well suited for Pearl Oyster farming. This farming technology can be done by Raft culture, Rack culture and Long line culture. {http://www.fisheries.tn.gov.in/aquaculture.html}

Epinephelus tauvina (Grouper) has been cultured experimentally using net-cages in Mandapam. The suitability of net-cage culture in the Gulf of Mannar has been demonstrated. A private entrepreneur at Tuticorin near the Van tivu Island in the Gulf of Mannar has developed recently a commercial net-cage culture system (only holding). This firm gathers groupers from different fishing grounds with the help of trained fishermen in the Gulf of Mannar region. Floating net cages in a raft anchored at 4-m depth close to this island are used for holding the live groupers weighing from 0.5 to 15 kg. Sardines and fresh trash fish are given as food.

Aquaculture vis-à-vis Coastal Regulations Zone rules and regulations - The aquaculture policy recently declared by the Government of India ensures protection of the coastal environment. The policy gives extensive guidelines on how the coastal environment should be protected from possible pollution or other damages consequent to the setting up of aquaculture farms. Under the Coastal Regulation Zone (CRZ), any type of construction within the 500 m landward from the High Tide Line (HTL) is prohibited. The aquaculture policy demands the protection of the integrity of the shore as a condition in constructing a farm. Hatcheries are also permitted in the CRZ possibly with inferred provision for pollution control measures. The relevant extracts from the concerned Acts, Rules, and Notifications are stated below:

Environment (Protection) Act 1986, under Section 3(1) and 3(2)(v) and Rule 5(3)d of Environment (Protection) Rules, 1986 – The Notification

on 19 February 1991 declares the coastal stretches as Coastal Regulation Zone (CRZ) and regulates activities in the CRZ. The 1986 rules apply to the coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters that are influenced by tidal action up to 500 metres from the HTL landward. The 1991 Notification imposes restrictions on industries, operations and processes in the CRZ.

· 2(iii) of the 1991 Notification - Setting up and expansion of fish processing units including warehouse are prohibited. This restriction seems too harsh and unreasonable. However, hatcheries, that require inevitably a waterfront, are permissible.

· Para. 3(1) of Notification - Clearance for certain activities within the Coastal Regulation Zone Clearance shall be given for any activity only if it requires waterfront and foreshore activities. This implies that if the clearance is obtained from the Ministry of Environment, aquaculture/hatcheries can be set up. However, there is no mention of aquaculture in the list of allowable activities, such as agriculture, horticulture, and salt manufacture, within category III (200 to 300 m) of the CRZ. Construction of hotels/beach resorts are allowed with prior approval.

Thus, the essence of the Notification is that the coastal ecosystem should not be damaged. This is echoed in the Aquaculture (Regulation) Act 1995 of the State of Tamil Nadu that permits aquaculture activity within the 500 m CRZ, albeit with some environmental safeguards. {The Fisheries for and the Mariculture Potential of Groupers, Red Red Snappers, Breams, and other Coral Reef Fishes in India; M. Devaraj and V. Sriramachandra Murty[1], CMFRI}

Exotics

Alien invasive species (AIS) are one of the major threats to the ecological and economic well being of the planet (McNeely et al. 2001). AIS may occur in terrestrial, freshwater or marine environments and may be vertebrates (animals with backbones), invertebrates (animals without a backbone) or plants (weeds). AIS are highly adaptable and usually widespread and can live in a wide range of environments.It has been recorded that when they arrive in a new area, the predators which keep their numbers in check are absent and this leads to prolific growth of the species. Besides, they also introduce new diseases which might be harmful to the already existing species..

The primary focus of concern over the role of introduced species within the Gulf of Mannar Marine National Park ecosystem, especially from the flora point of view are the processes of disturbance and competition. Evaluation of the consequences of introductions requires the formulation of evidence of the affects these processes have. This assessment is difficult due to the lack of historical data. However, it is presumed that species introduced during the 19th and 20th centuries

are interacting with native biota. Thus, potential impacts are difficult to discern due to this interaction. Additionally, the island ecology of the Gulf of Mannar has continually changed as a result of intensified land use and modifications due to human pressure in past. These changes alter the conditions of the dynamic relationships between the introduced and native species interactions especially on terrestrial ecosystems. The status of invasive species in both aquatic and terrestrial ecosystems is not known except *Prosopis juliflora, Acacia spp.*, Parthenieum(which occurs on almost all islands) and *Kappaphycus alvarezii*

Prosopis juliflora, was abundant, and had became a serious range problem on the Gulf of Mannar islands. The carrying capacity of other species on many islands seems to be seriously reduced due to its tremendous increase of Prosopis. In olden days, fishermen use to graze their cattle in these islands. Dissemination of the seeds in cattle dung has been an important factor in this invasion. *P. juliflora* pods are relished by all livestock, which, unlike most other pea pods, do not shed their seeds. The invasive species, *Prosopis juliflora* was found in 13 islands. It was found that there seem to be a competition between the existence of *Acacia* and *Prosopis*. It was also observed that both these species were found growing with an interaction. During private ownership of islands Krusadai, Muyal and Nallathanni, cattle were allowed to graze on the grass and other palatable vegetation payment. But, the Park authority could successfully intiate the eradication of Prosopis from the island and replaced with native plants but it needs to be continued.

Similarly**,** exotic seaweed Kappaphycus alvarezii in the reefs and seagrass areas of Gulf of Mannar, which was noted in 2008 is 61 posing severe threat to the reefs, associated marine life and livelihood of fisher . Kappaphycus alvarezii is red seaweed native to the Philippines and is an invasive species in the non-native environs of Gulf of Mannar. The introduction of this exotic seaweed in Gulf of Mannar in 2005 as a maricultural measure to enhance the livelihood of the coastal people was carried out without conducting proper Environmental Impact Assessment. The overall area occupied by *K. alvarezii* in Krusadai Island was 1,524 m^2 during 2014, and it was 368 m^2 in Mulli Island while in Shingle Island it was 152 m^2. During coral bleaching in 2016, live coral cover in Gulf of Mannar was reduced considerably and significant mortality was recorded in the islands affected with *K. alverezii*. As the substrate (live corals) cover was reduced the *K. alverezii* cover was also correspondingly decreased. Now, except for a few fragments in Krusadai Island, *K. alverezii* has been completely wiped out from Gulf of Mannar for want of a continuous stretch of live corals. However, the left-over fragments of *K. alverezii* are capable of increasing their biomass in the event of their finding proper substrate through currents.

Wildlife Health

About 3600 species of fauna and flora have been identified in the GOMBR by the Central Marine Fisheries Research Institutes and other organizations. The fauna is said to be one of the richest in the whole of Indo-west pacific region. So far, there was no information collected with respect to wildlife health. However, some of stranding marine mammals believed to be died due to certain diseases but due to lack of capacity the port-mortem of these stranded marine mammals including dugong was not carried out properly. Further, several industries effluents and domestic sewages were drained into the Biosphere that might be affecting the health of corals, fishes, crabs, molluscans, seagrasses etc. But this needs to be studied in detail.

Inter-agency programmes and problems

3.7 Tourism

So far, there was no tourism inside the National Park due to its vulnerability. Further, marine tourism inside the Biosphere Reserve (in sea) was also not carried out at big way. Therefore, impact of tourism on Biosphere Reserve was not significant. Pilgrimage tourism is the major tourism activity in the region that was largely restricted on land. However, based on recovery status of different habitats in

3.8 Research,monitoring and training

The purpose of the Gulf of Mannar National Park is to enhance resource protection and preserve the natural integrity of the marine ecosystems within its boundaries. The opportunities for marine research within the National Park and Biosphere Reserve are abundant, as seen by past research studies that have provided important baseline information about the area. The diversity of habitat types and communities provides a wealth of opportunities for conducting a variety of research programs. For example, the Biosphere Reserve provides a unique opportunity to engage in both shallow and deep- water marine research without extensive voyages offshore. Studies on the natural processes at the land-sea interface are also feasible due to the accessibility of extensive coastline. Finally, the marine research institutions within the area provide an exceptional resource to draw upon in furthering our understanding, and thus the management of, the Biosphere Reserve's marine resources.

A research and monitoring cell was recommended for the Biosphere Authority to conduct inhouse research and monitoring programs, coordinate the existing research programs and addresses management issues. A Research Advisory Committee of the GONBR also recommended to provide a forum for discussion of research programs,

addresses management issues, and disseminates research information as widely as possible. But, these recommandations were not implemented satisfactorly in the last 10 years. A research officer was appointed at very lower level and the authority was unable sustain him for long time due to lack of fund. However, the National Park authority could successfully utilize their research and monitoring requirements using regional institutions.

State Forest Department has organized various professional training for staff of the Biosphere Reserve towards marine biodiversity management, protection, research and monitoring. Training for various level of staff starting from WLW to Front Line were provided. Wildlife Institute of India organized under water biodiversity monitoring training programme for the front line staff of the Biosphere Reserve as part of the CAMPA-Dugong Recovery Programme.

3.9 Administrative setup

To implement, administer and review the management activities of the Biosphere Reserves, the Government of India and the Tamil Nadu State Government have constituted a National level and a State level committee respectively. However, with the experience gained from the administrative mechanism in place it is proposed that a new model organizational structure for the administration of the Gulf of Mannar Biosphere Reserve be estabilised. The suggestion is based on the rational that unlike terrestrial protected areas which are under the administrative control of one agency i.e. forest department, the coastal and marine protected areas resources are common property resources and activities therein are control by a multitude of stakeholders agency.

For the management of the Gulf of Mannar Biosphere Reserve, the Tamil Nadu Government has established the Gulf of Mannar Biosphere Reserve Trust, a special purpose vehicle to co-ordinate project implementation in order to effective inter-sectoral co-ordination and facilitate mainstreaming of biodiversity conservation issues into the productive sector and policy development. The Trust is registered under the Tamil Nadu Society Registration Act, 1975. However, the management and activities of the Gulf of Mannar Marine National Park is governed by the Conservator Forests, Virudhunagar Circle and implemented by the Wildlife Warden of the National Park. The Principal Chief Conservator of Forests and the Chief Wildlife Warden guides both the GOMBRT's Director as well as the GOMMNP's Director. And hence, in a way the Chief Wildlife Warden is the statutory head for the GOM Conservation Area, the GOMBRT has statutory authority to play a focal role in the implementation of the project providing the institutional framework and to work with Government to strengthen the over all policy framework and to enable

other governmental agencies for better co-ordinate and collaborate in the enforcement of Coastal Zone Regulation and biodiversity conservation.

It was earlier felt that the GOMBRT be made into **Gulf of Mannar Biosphere Reserve Management Authority**' (GOMBRA) not only for unified control and management of all activities of the core area of the Biosphere Reserve i.e. the Marine National Park and the buffer and multiple use area i.e. Biosphere Reserve but also for better coordination and synergy with all other stakeholders agencies who will play an important role in the management of Reserve. The new Authority in such a situation will have better co-ordination between the management of the Marine National Park as well as the Biosphere Reserve through its own staff i.e. the Wildlife Warden, the Eco-development Officers and the suggested sociologist, biologist, fisheries and tourism officials to deal with human dimensions, research and monitoring unit, fisheries and eco-tourism aspects as well as eco-compatible and sustainable marine resource utilization activities. This kind of an authority structure is suggested since such models of common property resource harbouring protected areas are successfully being managed in India as well as outside e.g. Chilka Development Authority in Orissa and Loktak Development Authority in Manipur, both of which are RAMSAR wetland sites and the authorities are chaired by the respective Chief Ministers of the State. Similar international models for marine protected areas have been in existence and successfully working in the Great Barrier Reef Management Authroity in Australia, St. Lucia Management Authority in South Africa. While it is suggested that the Chief Executive of the suggested GOMBRA will be a Chief Conservator of Forests, the Chairperson of its Governing Council be the Chief Minister/Chief Secretary of Tamil Nadu State. However, due to some reason the Authority was accepted by the Government of Tamil Nadu and it was not implemented. But, an Authority or a Foundation is essential to mainstream the biodiversity conservation into production sectors and strengthen the participatory management of Biosphere Reserve. Therefore, this Management Plan is also suggest to establish either an Authority or Foundation that could integrate all line agencies to sustainably manage the Biosphere Reserve.

3.10Summary of threats

The Gulf of Mannar Biosphere Reserve has a rich resource base. However, over the years the marine wealth has been over exploited leading to drastic loss of marine wealth and marine diversity. Presently over 50,000 local fisherman in a population of 1.60 lakhs in 125 villages directly depend on marine resource. Of late, the agriculturists from the main land area are switching over to fishing activities in a big way due to consistent failure of monsoon. The adds

a new dimension to the already existing pressure on the marine resources of the project area.

As a result, the marine resources of the Gulf of Mannar are over exploited for beyond the carrying capacity. Due to lack of awareness and poverty, the fisher man are forced to indulge in destructive fishing practices such as dynamite fishing, using "Taallumadi' and 'Rollermadi' kind of nets. It is estimated that for every 1000 kg of fish collected, 325 kg of variety of marine organisms are discarded and allowed to die outside the sea. Thus huge quantities of a wide variety of untargeted marine organisms are thrown on the shore as debris. Further illegal coral mining for cement industries and indiscriminate collection of sea grass for industrial use collectively cause the collapse and breakdown of variety of sensitive marine eco-system. Presently it is estimated that 65% of the existing coral reefs in the project area are dead, mostly due to human interference.

Over exploitation of fisheries resources
Unscientific and uncontrolled fishing and fisheries related activities are the major threats to the Biodiversity of the Gulf of Mannar Marine National Park.

Poaching of Dugongs, dolphins and Turtles
Killing of dugongs and dolphins (both these are locally called as “Avolia” and “Kadalpandir”) and turtles for sale for meat has reduced currently, owing to the implementation of the wildlife (protection) Act 1972 and the publicity given about the protection accorded to these mammals in the Act. However stray incidents of poaching and of incidental catches of these by the fishermen are known to still occur.

Coral mining
Due to strict vigilance coral mining in the National Park and Biosphere Reserve has almost stopped, however, southern group of National Park is still used for small scale illegal coral mining by the coastal villagers from Vellapatti, Tharavaikulam and D Savariyarpuram.

Pollution and other hazards
The multitude of mechanized vessels operating in the area leads to pollution of the sea waters by the diesel and oil used by these vessels. Some times explosives are also used by the fishermen, which also causes lot of damage.

The thermal pollution caused by the thermal power station at Tuticorin and the possible effluents from the atomic power at Koodankulam also need to be studied and monitored. Adverse impact of industrial effluents from the various industries located at Tuticorin

and along the coastal area also threatening the biodiversity of this region.

The high levels of organic load further enhance the coastal productivity and induce algal bloom. Severe fish kill was observed near Keezhakarai due to *Noctiluca* bloom which affected the total reef ecology. Harmful algal blooms are occurring frequently in Gulf of Mannar.

About 35,789 metric tonnes of chemical fertilizers were used in 1995-96, out of which more than 60% constitutes the nitrogenous fertilizers. The usage of chemical fertilizers, bio-fertilizers and dust and liquid pesticides were 65702 tonnes, 2,08,670 pockets and 2,79,500 kg and 29548.10 liters respectively in the years. Their usage much be reduced. Industrial sewage discharge of 1025 m^3/d is estimated to be dumped into the coastal water of Thoothukudi district.

The combined effect of so many habitat disruptive and destructive factors operating on the marine ecosystem has progressively diminished the value of the entire ecosystem from various angles.

Ports and Oil spil

With the existence of Tuticorin Port and establishment of Sethusamuthram Canal, the chances of chronic oilspill and possible acute oilspills in the region is very high. Also the recent oil exploration activities and possible strike of hydrocarbon in the offshore areas of Gulf of Mannar will increase chances of hydrocarbon related disasters. Southern group of islands have been observed with eroding at faster rate probably due to the Tuticorin Port and its expansion in the recent past.

Extraction of salt and soda ash

Saline lakes and pans traditionally have been important sources of salt for human use. Extraction methods range from small local evaporation process that is observed in the Biosphere Reserve area to large commercial operations. While the small scale local evaporation doesn't pose much of a threat to the fauna and flora but the large commercial operations can have devastating effects, depending on their size, location, methods and hours of operation.

Solid waste pollution

Pollution is a growing concern in the area. Due to easy accessibility and proximity to dumping grounds as well as road and rail, a lot of solid waste including plastics, worship items, idols etc. are being

dumped which in the long haul will disrupt the fragile ecosystem and the ecosystem services provided by it.

Exotics

Invasive species such as Prosopis juliflora in terrestrial areas and Kappaphycus in marine areas have been harming the native biodiversity in the region that needs to be address soon.

Sethusamudram Canal Project

The islands are built of a calcareous frame work of dead corals and coral reefs. The coral formations have taken place in the Gulf of Mannar due to the shelter provided on three sides by the Pamban, Srilankan and the Indian coast line. The Sethusamudram canal project across the Pamban may result in change of current patterns and a reversal of all marine factors which may drastically alter the dynamics of the ecosystem. Some of the islands may also be extensively obliterated by the dredging operations and alignment of the Sethusamudram canal. Though, the EIA study on this project by NEERI predicted that there will not be any damage to the National Park and its biodiversity, it would be better that the Biosphere Authority should be prepared to tackle any kind of disaster caused due to this project, especially unfortunate accidents involving spill of hazardous chemical or oil from vessels using this canal, which may totally damage the ecosystem of the National Park.

Tourism Development on the islands

The department of tourism time and again propose to develop tourism on the islands of the Gulf of Mannar. Any tourism developmental activity on the islands by way of construction of lodges, restaurants, development of water sports etc will effect prevailing ecological balance. Hence, this management plan is not recommending any tourism activities in National Park except Kurusadai Isladn but tourism zone has been identified outside the National Park (see chapter on tourism).The major ecosystems around these islands are now mostly recovering and any development process here would impede the natural recovery of these ecosystems, hence it is suggested that a few more years be given before considering opening up the islands to tourism, preferably in the next management plan.

Global warming

It is widely accepted that due to global warming the sea level is increasing world wide, therefore, the coral reef ecosystem are suspected to be under severe threat due to global warming and climate changes. In the Gulf of Mannar region, two islands are already been submerged and one of the reason for their submergence might be due to climate change and global warming.

Other possible threats to the Biosphere Reserve in future

1. Sand mining along the coasts

2. Mineral extraction from sea bed
3. Human migration and demographic changes in the local community.
4. SEZ if any

Chapter 4

Interface between the Gulf of Mannar Biosphere Reserve and People

4.1 Introduction

The geographic scope of this Management Plan encompasses the Gulf of Mannar Biosphere Reserve (GOMBR) and the core zone, which is the Gulf of Mannar Marine National Park. The Gulf of Mannar Marine Biosphere Reserve that runs southward from Rameswaram (Dhanuskodi Island) to Kanyakumari (Cape Comorin) in Tamil Nadu, India, is situated between Longitudes $78^0 08'E$ to $79^0 30'E$ and along Latitudes from $8^0 35'N$ to $9^0 25'N$ with a total area of 10,500 Km^2. However, based on the 20 m depth south-eastern boundary of the Biosphere Reserve the actual size of the Reserve is to be calculated regularly, as it varies in nature due to changes in the benthic surface. The GOMBR also encompasses a terrestrial area of up to 10 km landward from the coast line from Dhanuskodi Island on the north-east (Ramanathapuram District) to Cape Comorin in South (Kanyakumari District) covering the four coastal districts of Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari.

This marine Biosphere Reserve encompasses a chain of 21 islands and adjoining coral reefs off the coasts of the Ramanathapuram and the Tuticorin districts forming the core zone; the Marine National Park. The surrounding seascape of the Marine National Park and a 10 km strip of the coastal landscape covering a total area 10,500 sq. km., in the Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari Districts forms the Gulf of Mannar Biosphere Reserve.

The Buffer zone is proposed to be permitted for local people's use such as fishing and fisheries related activities in a sustainable manner. The seascape surrounding the islands beyond the limits of the National Park will form the buffer zone i.e. up to 20 m depth in seascape around the National Park and the coastal areas (10 km from the high tide mark to landward side) will form the buffer zone of the Biosphere Reserve.

Natural Attributes of the Reserve

The mangroves, coral reefs and sea grass ecosystems are the three important and sensitive ecosystems in the coastal zone. The GOMBR possesses all these unique ecosystems and has become significant because of the presence of other associated resources such as fishes, sponges, gorgonids, holothurians, pearl beds, chank beds, sea horses, turtles and the sea cow, *Dugong dugon*.

Coral reefs are vital components of ocean ecosystems, providing shelter to nearly one quarter of all marine life forms. They are the

breeding and nursery ground for many fin and shellfishes. There are more than 793 - recorded species of corals in the world support enormous life forms. Reef ecosystems can be compared to rain forests in terms of their biodiversity and density of living organisms. They serve as atmospheric carbon dioxide sinks and act as historical climate recorders. The coral reef ecosystems play an important role in global biogeochemical processes and in the production of food resources in the tropical region. These systems are very sensitive to external impacts both natural and manmade that violate their homeostasis.

The floral components comprises of economically viable species of seaweeds such as *Gracilaria* sp., *Gelidiella* sp., *Caulerpa* sp, *Sargassum* sp. and *Turbinaria* sp. The sea grass communities of this region tops the list of marine flora of India with the highest number of sea grass species recorded, providing important feeding grounds for the endangered *Dugong dugon*.

Many commercial shoaling fishes like sardines, mackerels, anchovies, snappers and pelagic fast swimming forms like Tuna, Billfish, Sail fishes are found abundant in this region and these form a major fishery. Information regarding environmental settings of the Gulf of Mannar Biosphere Reserve has been mainly gathered from a study on Gulf of Mannar Biosphere Reserve by Anna University, Chennai.

4.2 People and their dependancy

The inhabitants of Gulf of Mannar Biosphere Reserve are mainly Marakeyars, local people principally engaged in fisheries. There are about 47 villages along the coastal part of the biosphere reserve which support some 100,000 people. The Global Environmental Facility (GEF) has provided support to the establishment of the biosphere reserve, including the setting up and functioning of the Gulf of Mannar Biosphere Reserve Trust, which is responsible for the coordination of the management plan for the biosphere reserve in concertation with government agencies, private entrepreneurs, and local people's representatives. Priority is being given to encouraging community-based management. Major ecosystem type Islands including coastal/marine component; coral reefs and mangrove major habitats & land cover types

The livelihoods of people in the coastal buffer zone of the Gulf of Mannar Biosphere Reserve region largely depend on coastal and marine resources. However, agriculture and allied activities also plays a significant role in providing livelihoods for the poor. The activities of coastal-based people largely include fishing, salt making and seaweed collection while other marine-based activities are also gaining importance. Ninety percent of the fisherfolk in the GOMBR region are artisanal (using wind or small engine powered craft) and only 10% use

mechanized trawlers.

There are about 47 fishing villages along the Gulf of Mannar Marine National Park coast, of which 38 are in Ramnad District and 9 villages are in Tuticorin District. The fishermen from these villages depend solely on fishing for their livelihood. There are altogether about 100,000 fisher-folk living in these villages of which more than 50,000 are active fishermen.. The fisher-women are engaged in allied activities such as marketing, dry fish and net mending. The Department of Fisheries had in the recent years taken steps to formulate and implement special schemes to benefits fisherwomen in the hope that the fishing community will to gain economically and socially.

Success of a participatory protected area management depends to a large extent on the active involvement of the stakeholders in all aspects, from planning through to implementation, monitoring and evaluation (Naganathan, 2009). Shared responsibility and ownership are key to effective participation. It has become evident that the initiatives of the GOMBRT to address the multidimensional threat issues of the GoM has resulted in better understanding of the importance of various critical ecosystems in GoM and reduced use of Islands and surrounding breeding habitats. The fishing operation in the area has changed its place from around the islands to deep sea as well as the coastal waters to reduce the pressure on critical habitats.

The issue of livelihood enhancement and diversification amongst coastal fishing communities gained prominence since early 1990's. However, livelihood diversification will continue to remain as an important strategy for a number of people and may become an urgent necessity further in the coming years. Diversification should start by developing the basic skills, knowledge and capacity of the fishers rather than by presenting specific ideas for diversification followed up with efforts to make people to relate to them which frequently boil down to fitting square pegs in round holes. As Thompson (1989) suggests, fishers can not enforce a permanent individual claim on communal fishing grounds/ territories because the price of enforcing such rights are more costly than the benefits from fishing. The shift from indigenous technologies to more sophisticated ones marginalized some local artisanal groups who depend entirely on fisheries for their livelihood. The present study reveals that alternative livelihood and diversification opportunities are in operation in GoM as the fishermen are being engaged in various site specific local skilled alternative livelihood activities. It has also revealed that the use of mechanized boats in the nearshore area has significantly reduced and their area of operation has been moved towards deep sea which will provide enough vocational space for artisanal fishermen to earn their livelihood with comfort.

Coral mining, which reduces the function of reefs as natural barriers and lead to increased beach erosion, has transformed the coast (Qazim, 1999; Ramanujam and Sudarsan, 2003), and is probably responsible for the submersion of two islands in the GoM (Patterson et al., 2007). Because of the strong regulations and implementations, the coral mining has been completely stopped in the GoM which helped in significant increase of recruit density around the islands after 2004 tsunami (Patterson et al., 2008). This study also confirms that the use of islands for fishing activities by local fishermen has significantly reduced quantitatively and temporally which has provided undisturbed environment for coral recruits to establish faster.

The rapidly expanding scientific knowledge on seagrasses has led to a growing awareness that seagrasses are valuable coastal resources. Where seagrasses abound, humans benefit directly and indirectly from the presence of this marine vegetation (Marten and Carlos, 2000). Seagrasses are a vulnerable resource and subjected to various kinds of destructive disturbances all over the world, due to both natural and man induced influences. It is due to both natural pressure and anthropogenic influences such as inputs of nutrients, discharge of industrial and other wastes etc. Apart from this, fishing activities and anchoring of boats on the seagrass meadows also cause serious threats to the seagrass ecosystem (Kannan and Thangaradjou, 1998). The present study revealed that the awareness of seagrass ecosystem as a breeding habitat for cephalopods, holding area for sediments and surviving habitat for seahorses, turtles and anemones has reached the fishermen and has helped in reducing misuse of seagrass ecosystem any further to maximize the harvestable commercial resource from the area.

Coastal areas have traditionally suffered from a range of conflicting resource use pressures which have been exacerbated by inappropriate forms of managerial intervention (Olsen et al., 1997; Cicin-Sain and Knecht, 1993). Capacity building for sustainable development in coastal areas is not only a matter of providing opportunities for involvement in decision-making; it is also a matter of enabling local communities to take a degree of 'ownership' over local development trajectories. Awareness of the significance of self-reliance has led to the development of 'community based management' (Barker, 2005). Increased community interest in local development, increased awareness and involvement and relatively high levels of project activity will add to community value and accelerated community development (Barker, 2005).

In the last 15 years of implementation of GEF-UNDP project by GOMBRT, various meaningful stakeholders who have critical role in the management of the marine resources in GoM were identified, categorized and addressed to various awareness initiatives and has resulted in better understanding of existing critical ecosystems such

as corals, mangroves, seagrasses and various legal, social issues of the area to bring in a more participatory marine resource conservation mechanism in the area. The communities have understood the ownership responsibility of various marine resources available in the area and the need to maintain some critical habitats as no take zones for different resources.

Resource use and dependency of people

India is one of the lower ranking Medium Human Development countries. Coastal areas of India are heavily populated. Reef fisheries in India have been estimated to contribute to 5–10% of the total marine landings (Pet-Soede *et al.*, 2000), and contribute significantly to the subsistence and income of coastal fishing communities of Gulf of Mannar regions. Estimates of the numbers of small-scale fishers, amount to 21, 000 in the Gulf of Mannar (Rengasamy *et al.*, 2003).

In the Gulf of Mannar, coral reefs fringe a chain of 21 coralline islands, sheltering mangroves, lagoons and a shallow 'trapped sea' with extensive seagrass beds. This mosaic of coastal ecosystems forms the basis for sea-based livelihoods among the coastal communities, including the extraction of seaweed, shells, lobsters, sea cucumbers and reef fish from the reef flats and lagoons; and the harvest of crabs, squid, fish and shells from the seagrass beds and 'trapped sea' between the islands and the mainland coast. For the coastal people of the Gulf of Mannar coral reefs are perceived as part and parcel of the ocean, as expressed below:

a. 'It is the reef from where everything sprouts and spreads throughout the entire sea'
b. 'The reef is a natural nursery'
c. 'It is because reefs are there and its fertility, we get different varieties of fish to catch and we have to keep different nets' (Rengasamy *et al.*, 2003)

Exploitation of fishery resources in the inshore waters had been the sole occupation of several thousand fishermen families living along the Gulf of Mannar coast for centuries. They have been in such close intimacy with the sea that their life-style, culture, community and social life all centres around the sea.

Fisheries is the predominant industry in the coastal belt of the Gulf of Mannar. In Tamil Nadu marine fisheries account for 82% of all active fishermen, who are responsible for 76% of the total fish production in the state and 8% of the total marine catch for India. Tamil Nadu's fishing fleet numbers 64 126 vessels of which 84% are traditional crafts (known locally as *Vallams* and *Vathai*) contributing 47% of the total fish landings. There are an estimated 3,16,422 people earning

their livelihoods from marine fishing in the state, distributed among 591 fishing villages.

Traditional or small-scale fishing is carried out predominantly in the 'trapped sea' between the islands and the mainland coast and in the shallow waters and reef areas surrounding the islands. Fishing takes place throughout the year, but changes in nature according to local availabilities of different species. Wind patterns generally restrict the use of small-scale crafts between the months of August and October, and during this period many fishermen simply switch to labouring on larger mechanized boats.

In addition to fisheries-related occupations along the coast, there are opportunities for employment in salt extraction, particularly in the western side of the Gulf near Tuticorin, and also in Palmyrah (toddy) tapping and agricultural labour. Skilled work is also undertaken, with mat weaving common in Ramanathapuram district. Moving inland from the coast toddy tapping and agriculture are the predominant occupations with small business-related opportunities prevalent near Rameswaram in connection with the tourism in this area (SSFRD, 1998).

Other non marine based livelihood activities in Biosphere Reserve

In addition to fishing many are involved in various supplementary activities for their livelihoods viz., charcoal making, salt making, mat weaving, coir making and agriculture and allied activities. Availability of timely and adequate credit from the formal system and lack of support systems for marketing are the two main problems faced by the people.

The fisherwomen are more burdened and try to supplement the family income through fishery related trades such as dry fish preparation and marketing, seaweed collection and net-making and mending, and non-fishery activities such as working as labour in salt pans, and beedi making. These activities are seasonal and possible only in certain areas and do not add much to the family income.

Drift wood and dry twigs are collected from the islands mostly by fisherwoman as firewood and sold. Tough this is not a major occupations, this is taken up by fisherwomen for supplementing the family income.

4.3 A summary of problems faced by people that affect the management of Biosphere Reserve

- In the Gulf of Mannar, coral reefs fringe a chain of 21 coralline islands, sheltering mangroves, lagoons and a shallow 'trapped

sea' with extensive seagrass beds. This mosaic of coastal ecosystems forms the basis for sea-based livelihoods among the coastal communities, including the extraction of seaweed, shells, lobsters, sea cucumbers and reef fish from the reef flats and lagoons; and the harvest of crabs, squid, fish and shells from the seagrass beds and 'trapped sea' between the islands and the mainland coast. For the coastal people of the Gulf of Mannar coral reefs are perceived as part and parcel of the ocean. After declaration of the National Park, fishermen feels that their livelhoods have been taken away. Further, banning of collection of certain threatened taxa such as sea cucumber, mollusk etc are also not welcomed by people here especially fisher-women.

- Encroachment of mechanized fishing vessels in the traditional fishing ground is also affecting the livelihoods of traditional fishermen who use indigenous gears and crafts.
- Lack of inter-sectoral co-ordinations in planning and management of Biosphere Reserve especially between the fisheries and forest departments. People are more willing to listen to fisheries officers than the forest officers. GoMBRT could successfully change this scenario at certain extent.
- Poor socio-economic condition of people who live around the Biosphere Reserve.
- Lack of alternative and additional livelihoods available in the region.
- Increasing population and increasing anthropogenic pressure around the National Park.
- Over exploitation of resources inside the Biosphere Reserve.
- Industrial and sewage pollutions destroying the breeding habitats of fishes that in turn affects the livelihoods of people.
- Bioaccumulation of inorganics and heavy metals in fauna and flora may lead to health hazards to fishermen community.
- Continous decline of fish diversity and fish catch due to over exploitation putting more pressure on both Biosphere Reserve as well as people.

Part II

MANAGEMENT STRATEGIES

Management Philsophy

The strategies of Integrated Management Plan of the Gulf of Mannar National Park and Biosphere Reserve (2018-2026) is built on the pillars of International Conventions, National and Regional programmes of action, Partnerships, Self-reliance and Sustainability. Further, the Management Plan is largely based on following recommendations of 3rd National Wildlife Action Plan of India (2017-2031);

1. Establish a 'Coastal and Marine Ecosystem Cell' to strengthen the conservation and management of coastal and marine biodiversity in all coastal States and UTs.

2. Strengthen the Coastal and Marine Protected Area (CMPA) network and its management in the country with active participations of stakeholders, both in governance and decision making.

3. Develop a common action plan for all coastal States and UTs integrating 'Climate Change Adaptation' (CCA) and 'Disaster Risk Reduction' (DRR) with shared responsibility into all sectors of governance and keeping the needs and aspirations of the local communities in focus.

4. Undertake 'Coastal and Marine Habitats Restoration Programme', especially for mangroves, coral reefs, seagrass beds, intertidal zone, sand dunes, lagoons, etc., so that livelihood opportunities of coastal communities are enhanced and they are also protected from impacts of various natural disasters and climate change.

5. Initiate programmes for long term studies and monitoring of threatened coastal and marine species, mitigation of human-marine species conflicts as well as rescue and rehabilitation of marine species.

6. Undertake cumulative and strategic impact assessments to harmonize development with conservation in the context of coastal and marine biodiversity.

7. Prepare guidelines for management of marine invasive species in India.

8. Establish a special centre for strengthening the knowledge management system of coastal and marine biodiversity and their

conservation in India in coordination with a network of related organizations.

9. Ensure a 'clean coastal and marine environment in India' by preventing sea pollution including underwater noise.

10. Strengthen the field-based capacity to promote integrated and sustainable management of coastal and marine biodiversity. Training institutes should tailor their training curricula to meet needs of professionals of SFDs and all other Departments /Agencies at all levels of responsibilities to manage coastal and marine ecosystems.

Chapter 5

Vision, Objectives and Problems

Rich biological diversity of Gulf of Mannar Biosphere Reserve is not only strengthens its ecosystem functioning but also endow with ecosystem services essential for human well-being. It provides for food security, human health and provision of clean air and protection from natural calamities. It contributes to local livelihoods, and economic development through poverty reduction in four southern coastal districts of Tamil Nadu.

The following are some major Multilateral Environmental Agreements (MEAs) ratified by India. i) Convention on Wetlands of International Importance (1971) came into force on 21.12.1975 and is ratified on 11.02.1982 for conservation and wise use of wetlands, primarily as the habitats for the water birds; ii) The Stockholm Convention on Persistent Organic Pollutants (2001) entry into force on 17.05.2004 and ratified by India on 13.01.2006 covering the issue related to protect human health and the environment from persistent organic pollutants; iii) this is the first Indian Marine Biosphere Reserve, which is internationally recognised under the UNESCO-MAB programme. Further, several marine species occur here are comes under the Convention for Migratory Species and the International Whaling Commission.

The principal aim of our National Forest Policy, 1988, Environment (Protection) Act, 1986 and the Wildlife (Protectin) Act, 1972 are to ensure environmental stability and maintenance of ecological balance including atmospheric equilibrium which is vital for sustenance for all living forms viz., humans, animals and plants. The derivation of direct economic benefit must be subordinated to this principal aim.

Therefore, the aim of the Management Plan is to conserve *in situ* all taxas of flora and fauna along with the full range of ecosystems they inhabit. It calls for healthy ecosystems with following 'Vision'.

5.1 VISION

"Ecologically functional 'Gulf of Mannar National Park and Biosphere Reserve' is an important marine biodiversity heritage site of India that should be conserved and managed as a 'Centre of Excellence for marine biodiversity, livelihoods, recreation and nature education"

5.2 OBJECTIVES OF MANAGEMENT PLAN

The overall objective of the Management Plan is to conserve Biosphere Reserve and its rich biological diversity for the people and by the poeple. This will be achieved through innovative scientific approaches to protected area management, integrated development planning, staff capacity development, information exchange and local participation in management of the protected area. The emphasis of the Plan is targeted on increased development of human skills and resources, improvement of field protection, strengthening the management and monitoring systems and in turn improve the livelihoods of people who live around BR. The Management Plan provides both guidelines for management of the National Park and a blue print for directing management, sustainable use and development of resources within the reserve. The following are the management objectives for achieving the vision statement:

- Appreciate and promote the importance of integrated and sustainable management of Gulf of Mannar Marine National Park and Biosphere Reserve.
- Promote participation of stakeholders in the management of Gulf of Mannar Marine National Park and Biosphere Reserve, and improve their livelihoods with eco-development programs.
- Mainstream biodiversity conservation into production sectors of the region especially fisheries, tourism, ports, industries and urban development.
- Effectively as well as scientifically protect, manage and monitor the biodiversity of Gulf of Mannar Marine National Park and Biosphere Reserve.
- Promote eco-friendly tourism that provides a rich experience for tourists, economic benefits to the local people and support to the Gulf of Mannar Marine National Park and Biosphere Reserve.
- Develop Gulf of Mannar Marine National Park and Biosphere Reserve as a world class coastal biodiversity site to promote eco-tourism and nature education.

5.3 EXISTING PROBLEMS

The Management Plan could identify the following problems and attempted to find solutions to all these problems in the Plan.

- Multi-stakeholders but lack of ownership and participation in conservation.

- Lack of inter-sectoral co-ordinations in planning and development that prevent the mainstreaming of biodiversity conservation into production sectors in the region.
- Poor socio-economic condition of people who live around the Biosphere Reserve.
- Limited alternative and additional livelihoods options are available in the region due to poor rainfall.
- Increasing anthropogenic pressure exerted by both local communities and industries inside and outside the National Park.
- Over exploitation of resources especially the fisheries resources inside the Biosphere Reserve.
- Industrial and sewage pollutions posing threat to wildlife as well as human health.
- Poor infrastructure and financial resources available with the Management Authority of Biosphere Reserve.
- Decline of fish diversity and fish catch and thereby poor socio-economy condition of fishing community.
- Lack of clarity on 'Scope of the Management Area of Gulf of Mannar Marine National Park and Biosphere Reserve'.
- Poor infrastructure to promote eco-tourism, eco-development and nature education, to strengthening protection and monitoring.
- Lack of knowledge to develop better climate change adaptation plan.

Chapter 6

The strategies

6.1 Introduction

Main strategy for the better management of Gulf of Mannar Biosphere Reserve should be the mainstreaming of its biodiversity conservation into production sectors especially the fisheries and tourism, so that both biodiversity conservation and livelihoods of people are taken care. Further, this could be achieved with an integrated and sustainable planning. Marine protected areas (MPA) are very different from terrestrial protected areas (Naganathan, 2013). Important factors that contribute to the difference are the nebulous nature of boundaries in the fluid sea and the continuous nature of the ecosystem. It is very difficult to control over the boundary of MPAs as we do in the Terrestrial system. There is difficulty in fixing the sanctum sanctorum of the marine ecosystem. It is not possible to fence-in the living resources or the critical ecological processes that support them. It is also difficult to have control over the degradation of the ocean system from land based pollution, changes in hydrology or many other ecological disruptions. Long distance dispersal and the vastness of linkages between critical habitats in marine ecosystem require comprehensive management of all their parts. But, there is an opportunity to have visual boundary with help of users (Naganathan, 2013).

6.2 Spatial Planning

Marine spatial planning is a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process. Gulf of Mannar Biosphere Reserve has already been spatially divided into to two zones such as the core and buffer. Core zone of the BR is the National Park that was largely kept untouched till the last management plan. And the buffer zone is the remaining part of the Biosphere Reserve that supposed to be sustainably used for its resources but unfortunately over exploitation of resources was observed inside the buffer zone due to ever growing demand. Two more zones i.e. Eco-Development Zone and Tourism Zone have been proposed in this Management Plan using the Marine Spatial Planning (MSP) to avoid user conflicts, and to manage marine conservation activities more sustainably and to implement area based protection and conservation of marine resources.

6.3 Zonation

As per the Notification of the Gulf of Mannar Biosphere Reserve the total area of the Reserve is 10500 sq. km, which extend from Dhanuskodi Island to Cape Comorin. But, the scope of this Management Plan is from Dashuskodi to Tuticorin. Some of the management of actions recommended in this Plan with respect to Eco-development, tourism, and biodiversity protection and restoration may be extended up to Kanyakumari depending upon availability of resources to implement the same. Further, the 20 m depth south-eastern boundary of the Biosphere Reserve may change due to dynamic nature of bathymetry of this region, therefore the actual size of the Reserve need to be calculated after the Chief Naval Hydrographer provides a detailed map up to 20m depth.

The Gulf of Mannar Marine Biosphere Reserve has been divided into two main zones. This marine Biosphere Reserve encompasses a chain of 21 islands and adjoining coral reefs off the coasts of the Ramanathapuram and the Tuticorin districts forming the core zone; the Marine National Park. The surrounding seascape of the Marine National Park and a 10 km strip of the coastal landscape covering a total area 10,500 sq. km., in the Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari Districts forms the Gulf of Mannar Biosphere Reserve.

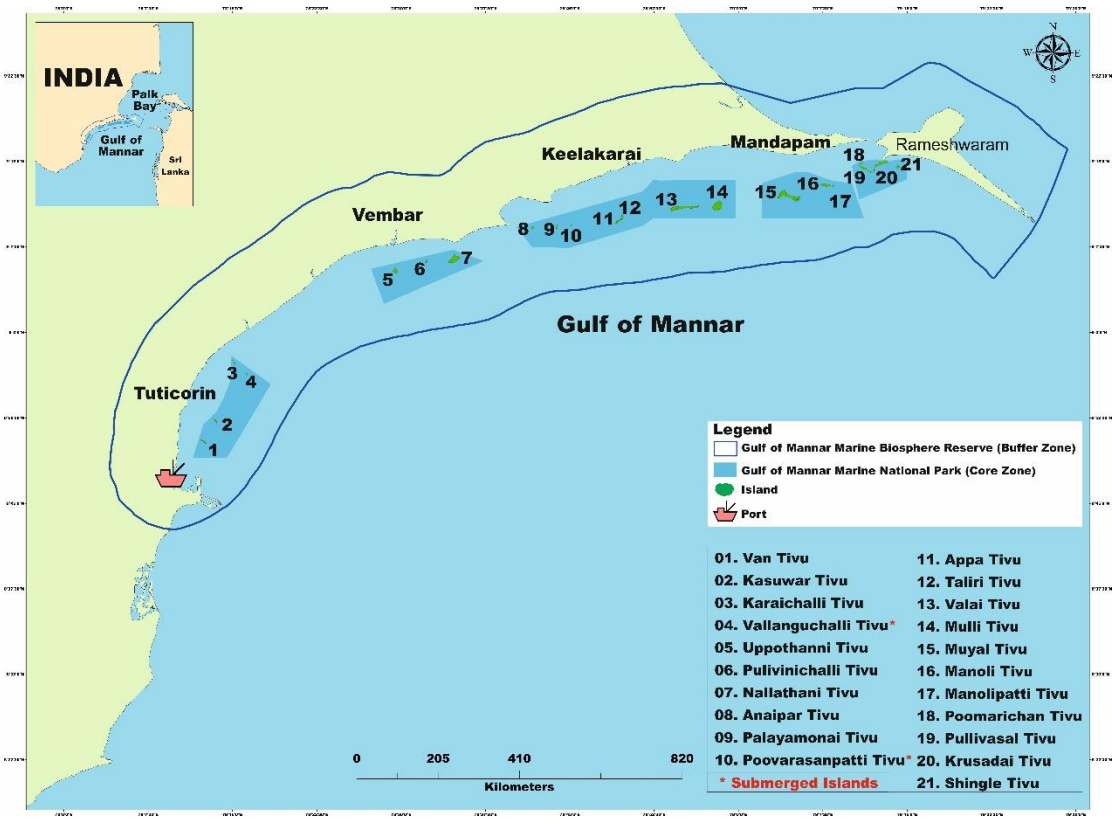


Figure 5.1: Boundaries of Gulf of Mannar Marine National Park

The Core zone (Gulf of Mannar Marine National Park)

Core conservation areas (sites of high diversity, critical habitats of threatened species, and special research areas) in which disturbing/destructive uses are strictly prohibited. This zone can also protect breeding populations of fishes and other organisms for the natural replenishment of neighboring fishing areas such as buffer zone where resource utilization is allowed. Kurusadai Island with buffer of 1 km of its surroundings has been identified for tourism inside the National Park has been recommanded. Based on a study on impact of tourism on this zone would determine the further course of action related to opening up newer islands for tourism or completely closing tourism inside the National Park. This impact assessment study may be carried out after 5 years from now.

All the 19 islands and 2 submerged island and the sea portions surrounding the islands up to 6.405m (3.5 fathoms) on the bayside and 9.5m (5 fathoms) depth toward the seaward side, which is the National Park area is the Core Zone and the rest of the area of the seascape i.e. up to 20 m depth and the coastal terrestrial areas (10 km from the high tide mark to landward side) will be the Biosphere Reserve and forms the buffer zone for the Marine National Park.

It is observed that by a hindsight, the boundary of the Tuticorin cluster of islands based on quadrates mentioned in the National Park Notification has omitted Karaichalli Island, which has been included into the Marine National Park, accordingly the boundary line was redrawn during the earlier Plan and the same boundary line retained in this Management Plan too. Partitioning of the Marine National Park into five clusters of core zones provides options for providing and planning navigation routes, better policing and protection and opportunities for sustainable migration and harvest of resources from the core to the buffer. The total area of the Marine National Park constitutes about 10% of the northern half of the Biosphere Reserve and may only be 4% of the total Biosphere Reserve as a undisturbed, closed and no take area.

Except research, monitoring and restoration of biodiversity, no other activities is proposed to be permitted in the core zone, except Kurusadai Island and its surroundings for tourism. The strict protection given to the core zone will result in spillover and migration of the faunal wealth to the buffer zone and will be available and can be harvested in sustainable manner by people who directly depend on these resources for their livelihood especially those who live in the buffer zone. It will also help in the economic development and a source of revenue to these coastal districts.

Core zone at present have a good representation of the various marine ecosystems component and are fairly in good condition, which need to be strictly protected without major management activities. Research and monitoring, habitat restoration (mangrove restoration, coral reef restoration, seagrass beds restoration, stock enhancement of critically endangered species such as sea horse, holothurians etc., removal of invasive species) and protection are the only three activities proposed to be taken up inside the National Park. Plantation of exotic species is to be strictly prohibited on the islands and removal of existing exotic species is also prescribed with proper planning.

The Buffer zone - Gulf of Mannar Biosphere Reserve (The Utilization/ Manipulation/Experimental zone)

This zone is proposed to be permitted for local people's use such as fishing and fisheries related activities, tourism and tourism related activities. The seascape surroundings the islands beyond the limits of the National Park will form the buffer zone i.e. up to 20 m depth in seascape around the National Park and the coastal areas (10 km from the high tide mark to landward side) will form the buffer zone of the Biosphere Reserve. As per the Notification of the Gulf of Mannar Biosphere Reserve the total area of the Reserve is reported to be 10500 sq. km which extend from Dhanuskodi Island to Cape Comorin.

Activities in this zone suggested are:

11. Eco-developmental activities
12. Tourism
13. Permitted eco-compatible fishing
14. Maritime navigation
15. Artisanal fisheries
16. Sea weed collection
17. Shell collection using traditional methods
18. Restoration of habitats/species
19. Mariculture using native species
20. Research and monitoring

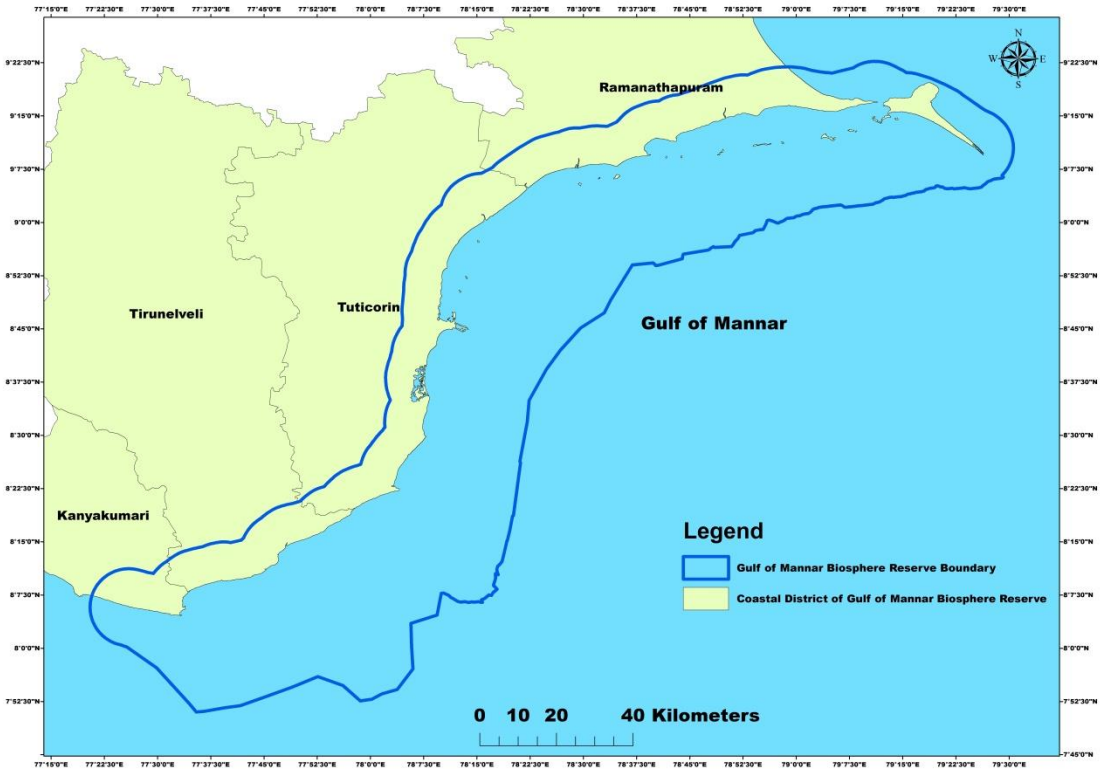


Figure 5.2: Boundary of Gulf of Mannar Biosphere Reserve

Eco-developmental Zone (Terrestrial)

Ten kilometer stretch of coastal land starting from the sea shore all along the Biosphere Reserve are identified as the Eco-developmental (terrestrial) zone. This zone is also to be utilised for multiple use as like the Uilization zone. Drought resistant crops should be promoted in this zone so that extra pressure on marine resources would be minimised becuase of horti and agriculture activities.

Restoration zone

Restoration zone– enable damaged areas to be set aside to recover. Both core zone and buffer zone can be used for restoration of habitat/species. All the islands are infested with invasive species. These islands need to be restored to their original state by eradicating invasive species from these islands. Northern group of islands such as Mandapam and Kilakarai groups are proposed to be used for restortation of mangrove habitat during this Management Plan period. Degraded coral reefs in the Southern group of islands need to be restored. Detailed prescriptions are available in the concerned chapters. Efforts were put in this regard during the previous Management Plan period but it should be continued till the last plants of exotics removed.

Eco-Tourism zone

Eco-tourism zone is proposed to be used for various recreational activities (bird watching snorkeling, coral watching, aquatic sports, diving, sea walk, etc) to increase the enjoyment and safety of the each pursuit. Eco-tourism is proposed to be allowed in the Biosphere Reserve. As a part of the value addition to the Eco-tourism in the Gulf of Mannar Biosphere Reserve, around 50 km stretches of land areas around the Biosphere Reserve has also been identified and proposed as 'Tourism Zone for Value Addition' with community participation. All the tourist centers in this area have been assessed and included as potential tourism resources in the Eco-tourism sub plan in this Management Plan. Kurusadai Island and its surrounding areas has been identified for eco-tourism inside the National Park.

6.4 Demarcation of Boundaries

Marine protected areas (MPA) are very different from terrestrial protected areas due to the nebulous nature of boundaries in the fluid sea and the continuous nature of the ecosystem. It is not possible to fence-in the living resources or the critical ecological processes that support them. However, it is important to inform the boundary of the 'Core Zone' to the users of buffer zone. The boundaries of the National Park and of the different zones will have to be suitably demarcated with different colour buoys or markers so as to be easily visible to the users of the coastal waters as per the Notification. Coloured buoys in every 250 m to 500 m distance for the National Park boundary and buoys with automatic illumination system to alert the vessels along the boundary of Biosphere Reserve needs to be installed in every five kilometer may be considered. Registered fishermen who use trawlers and are not supposed to fish inside the Biosphere Reserve need to be assisted by the Government to install required equipments such as GPS etc to receive the alarm signal if they approach the Biosphere Reserve boundary. The boundary demarcation of the Biosphere Reserve, especially the seascape side needs to be reviewed at five years intervals as the bathymetry of the sea tends to change.

Further, demarcation of 'Tourism Zone inside the National Park i.e. Kurusadai Island' by colour buoys is required.

In the previous Management Plan, it was observed that by an hindsight, the boundary of the Tuticorin cluster of islands based on quadrates mentioned in the National Park Notification has omitted Karaichalli Island, which has been included into the Marine National Park, accordingly the boundary line was redrawn and the same boundary is retained in the Plan. Partitioning of the Marine National Park into five clusters of core zones provides options for planning navigation routes, better policing and protection and opportunities for sustainable migration and harvest of resources from the core to the buffer. The total area of the Marine National Park constitutes about 10% of the northern half of the Biosphere Reserve and may only be

4% of the total Biosphere Reserve as an undisturbed, closed and no take area.

Notification of Gulf of Mannar National Park and Gulf of Mannar Biosphere Reserve need to be reviewed from time to time with respect to sensitivity of the eco-zones and their response to management. It has been proposed in the Management Plan to identify and include 'Critical Wildlife Habitat' within the Biosphere Reserve and these CWH will then be protected as equivalent to core zones or CRZ 1. For example, critical dugong habitat, important sea turtle nesting beaches, oceanic bird flocking areas, etc.

Chapter 7

Administration and Protection Strategies

7.1 Administration

The Government of India and the Tamil Nadu State Government have constituted a National level and a State level committee respectively to implement, administer and review the management activities of the Biosphere Reserves. However, with the experience gained from the administrative mechanism in place it is proposed that a new model organizational structure for the administration of the Gulf of Mannar Biosphere Reserve be established. The suggestion is based on the rational that unlike terrestrial protected areas which are under the administrative control of one agency i.e. forest department, the coastal and marine protected areas resources are common property resources and activities therein are control by a multitude of stakeholders agency. Based on Management Effectiveness Evaluation report of the previous Management Plan that highlighted the lack of inter-sectoral coordination, lack of fund and lack of capacity were the main reasons for shoddy implementation of previous Plan. Therefore, it is suggested to establish the '**Gulf of Mannar Biosphere Reserve Foundation (GOMBRF)'** merging both the Gulf of Mannar Biosphere Reserve Authority and the Gulf of Mannar Biosphere Reserve Trust.

Finance: In addition to the funding support from the Government of Tamil Nadu and Government of India, all the developmental projects along coastal regions of entire Tamil Nadu should contribute certain percentage of fund (not less than 5% of the project cost if the project area falls inside CRZ 1 & 3, or Eco-sensitive zones or 1% of the project cost if the project areas in CRZ 2 or within 10 km from the high tide line) as compensation to the GOMBRF. GOMBRF should also be given responsibility of coordinating the management of all coastal Protected Areas of the State including Dugong and Sea turtles recovery programs. Further, all industries in the Gulf of Mannar Biosphere Reserve region should contribute 10% of their CSR fund to the management of Biosphere Reserve. This CSR grant should be used largely for Eco-development related activities that are beneficial for the livelihoods generation of the local communities.

The Tamil Nadu Government with help of GEF-UNDP has earlier established the Gulf of Mannar Biosphere Reserve Trust, a special purpose vehicle to co-ordinate project implementation in order to effective inter-sectoral co-ordination and facilitate mainstreaming of biodiversity conservation issues into the productive sector and policy development. The Trust is registered under the Tamil Nadu Society Registration Act, 1975. However, the management and activities of the Gulf of Mannar Marine National Park is governed by the

Conservator Forests, Virudhunagar Circle and implemented by the Wildlife Warden of the National Park. The Principal Chief Conservator of Forests and the Chief Wildlife Warden guides both the GOMBRT's Director as well as the GOMMNP's Director. And hence, in a way the Chief Wildlife Warden is the statutory head for the GOM Conservation Area, the GOMBRT has statutory authority to play a focal role in the implementation of the project providing the institutional framework and to work with Government to strengthen the over all policy framework and to enable other governmental agencies for better co-ordinate and collaborate in the enforcement of Coastal Zone Regulation and biodiversity conservation.

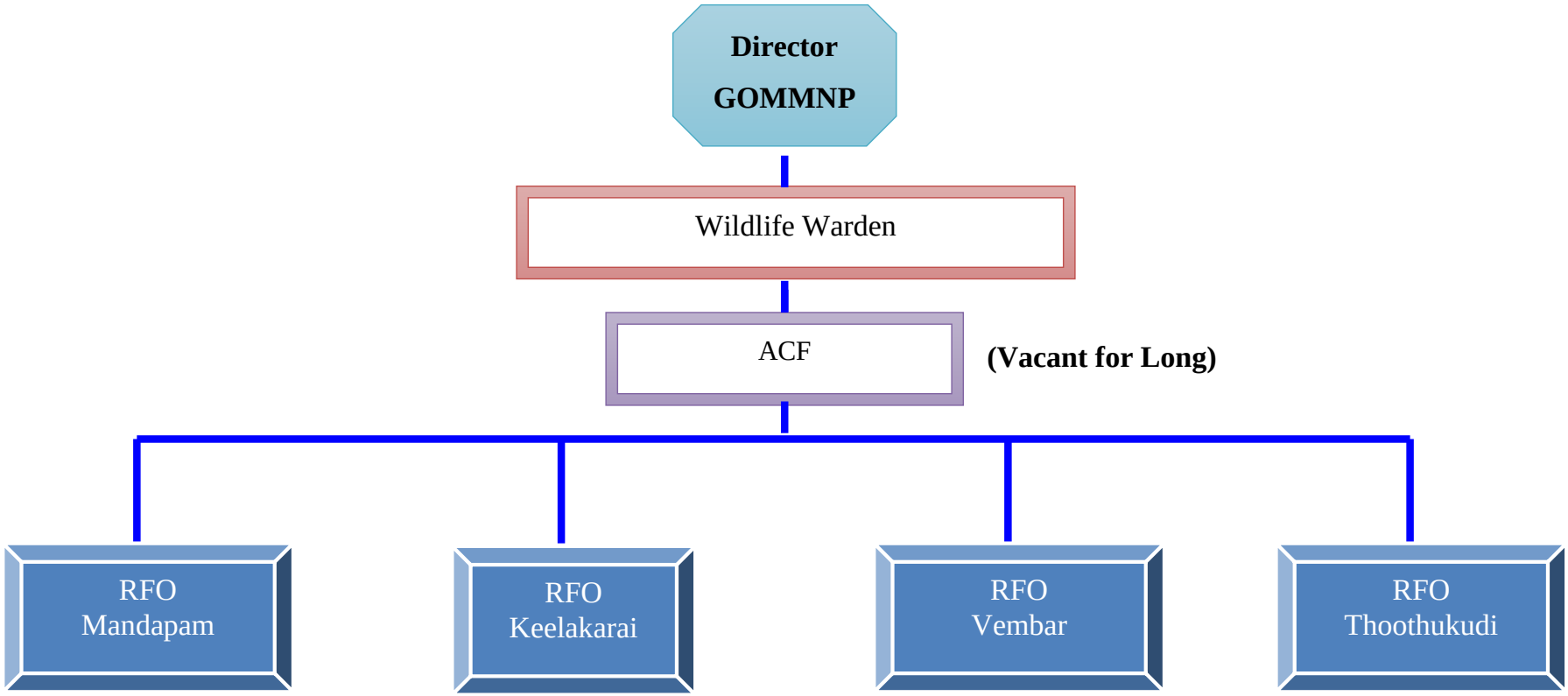
It is now felt that the GOMBRT to be merged with **GoMBRF** not only for unified control and management of all activities of the core area of the Biosphere Reserve i.e. the Marine National Park and the buffer and the multiple use area i.e. Biosphere Reserve but also for better coordination and synergy with all other stakeholders agencies who will play an important role in the management of Reserve. The new Authority in such a situation will have better co-ordination between the management of the Marine National Park as well as the Biosphere Reserve through its own staff i.e. the Wildlife Warden, the Eco-development Officers and the suggested to coordinated with other line departments to seek the help of sociologist, biologist, fisheries and tourism officials to deal with human dimensions, research and monitoring unit, fisheries and eco-tourism aspects as well as eco-compatible and sustainable marine resource utilization activities.

This kind of an authority structure is suggested since such models of common property resource harbouring protected areas are successfully being managed in India as well as outside e.g. Chilka Development Authority in Orissa and Loktak Development Authority in Manipur, both of which are RAMSAR wetland sites and the authorities are chaired by the respective Chief Ministers of the State. Similar international models for marine protected areas have been in existence and successfully working in the Great Barrier Reef Management Authroity in Australia, St. Lucia Management Authority in South Africa. While it is suggested that the Executive Director of the suggested GOMBRF will be a Chief Conservator of Forests, the Chairperson of its Governing Council be the Chief Minister/Chief Secretary of Tamil Nadu State. Appropriate level of people representative and other stakeholders agencies officials being members of the Governing Council. The Tamil Nadu Government may consider this and constitute an appropriate Governing Council for the proposed GOMBRF with statutory powers for over all governance of the country's first Marine Biosphere Reserve.

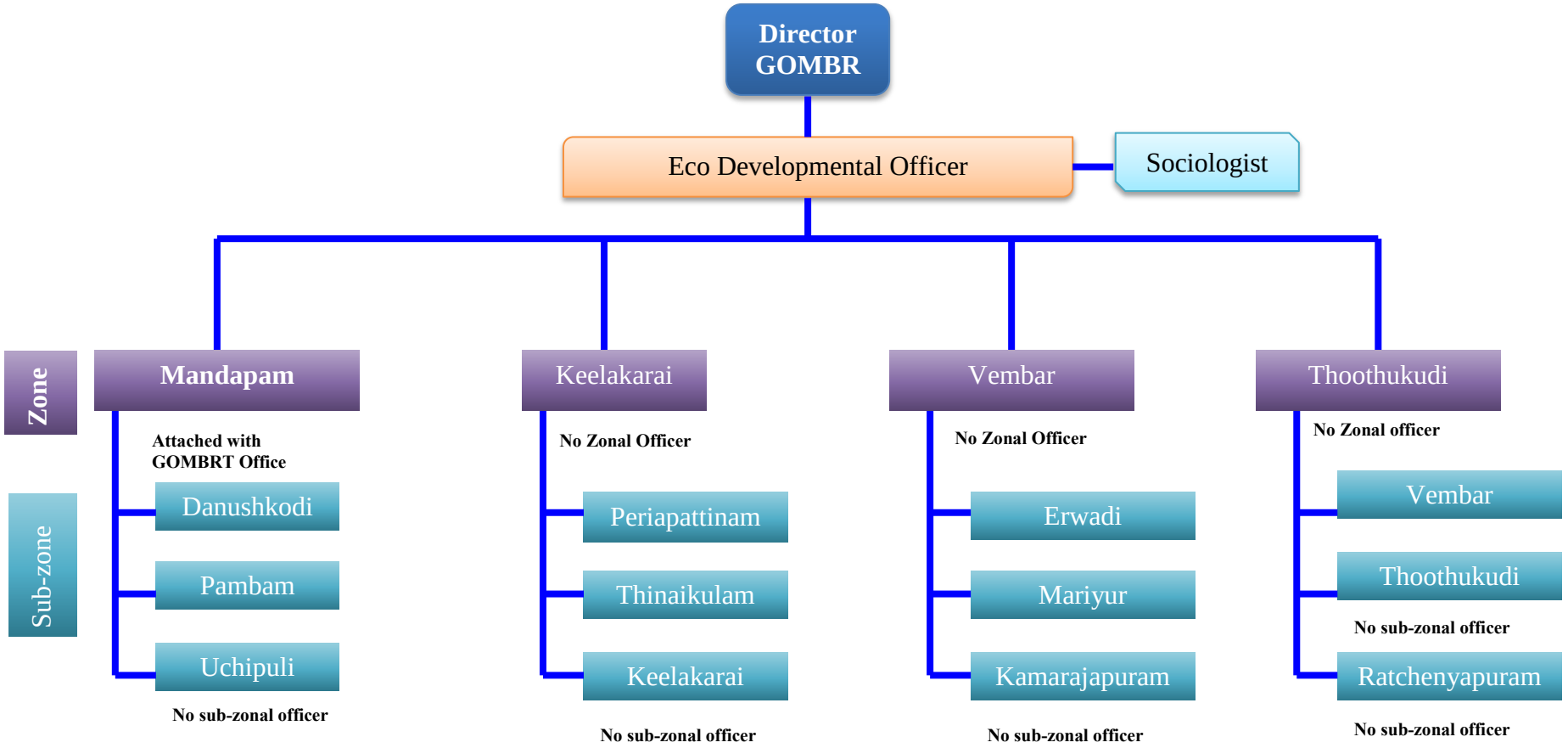
The Gulf of Mannar Biosphere Reserve in Tamil Nadu covering an area in excess of the 10000 sq. km spread over four districts, continental shelf, territorial waters and EEZ has the involvement of national

agencies such as Indian Navy and Coast Guard, four district Collectors, a Port Trust etc. requires an equally higher level Authority with complementary specialized unit/wings to implement the strategy and action plans. Needless to say all these wings are required to be empowered with complementary staff and infrastructure befitting their status and planned activities.

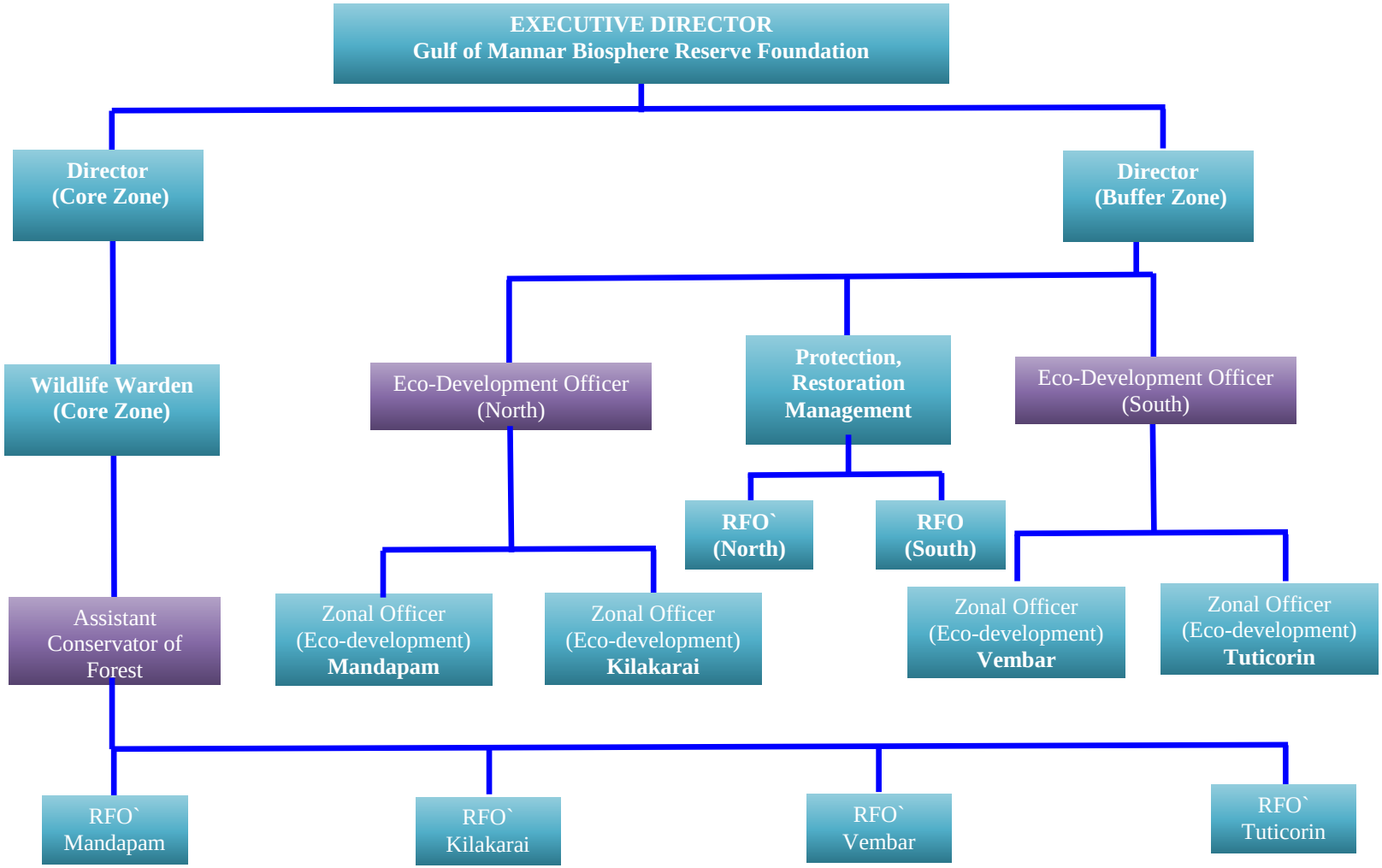
Current Administrative setup of Gulf of Mannar Marine Biosphere Reserve (up to RFO level)



Current Status of EDC Zone (Administrative setup) of Gulf of Mannar Biosphere Reserve



Proposed unified Administrative Setup of the Gulf of Mannar Biosphere Reserve Management i.e. Gulf of Mannar Biosphere Reserve Foundaton



7.2 Required Policy Level Reforms

1. Gulf of Mannar Biosphere Reserve Trust and Gulf of Mannar Marine National Park to be under an unified control of a statutory authority '**Gulf of Mannar Biosphere Reserve Management Foundation**' coordination with multidisciplinary agencies/line departments participation, since Fisheries, Animal Husbandry, Rural Development and Agriculture have far greater gross-root level interface with community.
2. Empower the GOMBRF to receive funds directly from identified sources and utilize for the implementation of this Management Plan. All the developmental projects along coastal regions of entire Tamil Nadu should contribute certain percentage of fund (not less than 5% of the project cost if the project area falls inside CRZ 1 & 3, or Eco-sensitive zones or 1% of the project cost if the project areas in CRZ 2 or within 10 km from the high tide line) as compensation to the GOMBRF. GOMBRF should also be given responsibility of coordinating the management of all coastal Protected Areas of the State including Dugong and Sea turtles recovery programs. Further, all industries in the Gulf of Mannar Biosphere Reserve region should contribute 10% of their CSR fund to the management of Biosphere Reserve. This CSR grant should be used largely for Eco-development related activities that are beneficial for the livelihoods generation of the local communities.
3. Fisheries: A review of Tamil Nadu Marine Fisheries Policy with special focus on
    a. Bottom trawling should be banned inside the Biosphere Reserve
    b. Review of using the destructive fishing gear and crafts in the Gulf of Mannar region and their control.
4. A decision to ban untreated industrial pollutants and sewage release into the Gulf of Mannar Biosphere Reserve which should taken up the State Pollution Control Board.
5. All industries including Ports in the Gulf of Mannar region should be addressed and facilitated to prepare, submit and implement an Environmental Management Plan (EMP).
6. Review of changes in the demographic profile of the coastal talukas and eliminating the causes of human migration into the coastal zone (e.g. Gradual disappearance of freshwater storing natural depression (*taruva*i) beyond the coastal sand dunes areas).
7. Examine the possibility of marine shell trade industry to be under the State Control as there are signs of over and indiscriminating harvesting of shells from sea.
8. Since the implementation and activities of sustainable utilization of coastal and marine resources in the multiple use area of the Biosphere Reserve is to take place through community

participation and community based institutions, it is suggested to develop an appropriate mechanism to bring in the larger number of line departments officials at the middle and grass root level positions as per the recommendation made in the Management Plan.

9. The Gulf of Mannar Biosphere Authority and the Forest Department through the Government of Tamil Nadu may request the Government of India to initiate the process of co-ordination mechanisms with the Sri Lanka Government since the Gulf of Mannar Region and Biodiversity are Trans Boundary Issues.
10. Creation of a 'Anti-poaching Unit (initially proposed as 'Pilot Marine Patrolling and Policing Unit')' consisting of Ex-Indian Navy and Coast Guard Personals at the top and middle level and local fishermen at lower level be considered with the special focus for marine habitat and biodiversity protection. This will ensure presence of people with enough marine habitat experience in field.
11. Government of Tamil Nadu may be requested to involve the proposed Gulf of Mannar Biosphere Authority to review the regional developmental plans of the Gulf of Mannar Region and also to make the Authority a member in all future developmental projects so as to ensure a eco-compatible developmental plan for the region.

7.3Management Plan Implementation and Review Committee

It is suggested the implementation and activities of the 10 Year Management Plan be reviewed at an interval of three years and corrective measures included for implementation for the next three years phase. With the third review setting tone for the next 10 year Management Plan to be developed during the 10th Year of the current Management Plan. A management plan implementation review committee has been suggested with following members:

Chief Wildlife Warden	**- Chairman**
Executive Director, GOMBRF	**- Member Secretary**
Representative from MoEFCC, GOI	**- Member**
Director, AIWC, TNFD	**- Member**
Director, Tamil Nadu Fisheries Department	**- Member**
Director, CMFRI	**- Member**
Director, WII	**- Member**
Director, ICMAM, As representative of DES (DOD)	**- Member**
Director, Environment, GoTN	**- Member**
Director, CMCS, MKU	**- Member**
Director, CASMB	**- Member**
NGOs Representative (Two members)	**- Invited Member**

7.4 Protection Strategies

Except research, monitoring of biodiversity and restoration, no other activities is proposed to be permitted in the core zone (except Kurusadai Island where tourism allowed). The strict protection given to the core zone will result in spillover and migration of the faunal wealth to the buffer zone and will be available and can be harvested in a sustainable manner by the people who are directly depend on these resources for their livelihood, especially those who live in the terrestrial buffer zone. It will also help in the economic development and a source of revenue to these coastal districts.

Core zone area at present has a good representation of the various marine ecosystems components and are fairly in good condition which need to be strictly protected without major management interventions. Research and monitoring, habitat restoration (mangrove, coral reef, seagrass beds and stock enhancement of critically endangered species such as sea horse, holothurians etc., removal of invasive species) and protection are the only three activities proposed to be taken up within the National Park. Plantation of exotic species is to be strictly prohibited on the islands and removal of these exotic species with proper planning is also prescribed.

The core zone of the Biosphere Reserve i.e. the Marine National Park and its biodiversity need to be protected strictly from any kind of anthropogenic activities except the activities related to habitat and species restoration and research and monitoring. Therefore, it is important to strengthen the protection force of the Biosphere Authority by having Forest Watchers Headquarters in each island, which is in addition to the existing protection force. Minimum of two forest watchers should be posted in each of the island with a motorboat and communication systems. People who are posted on the island needs to be given special incentives and their stay on the islands should not harm the biodiversity at any level. Minimum accommodation facilities (eco friendly protection huts) may be created in each larger island. Responsibilities of the proposed protection force under the control of the Wildlife Warden need to be extended to other zones of the Biosphere Reserve too. Any violation of the Indian Wildlife Protection Act, 1972 and the Management Plan of GOMBR, any where in the Biosphere Reserve should not be allowed. This should be the responsibilities of the protection force under the Wildlife Warden of the National Park and also by the other staff of the Biosphere Authority.

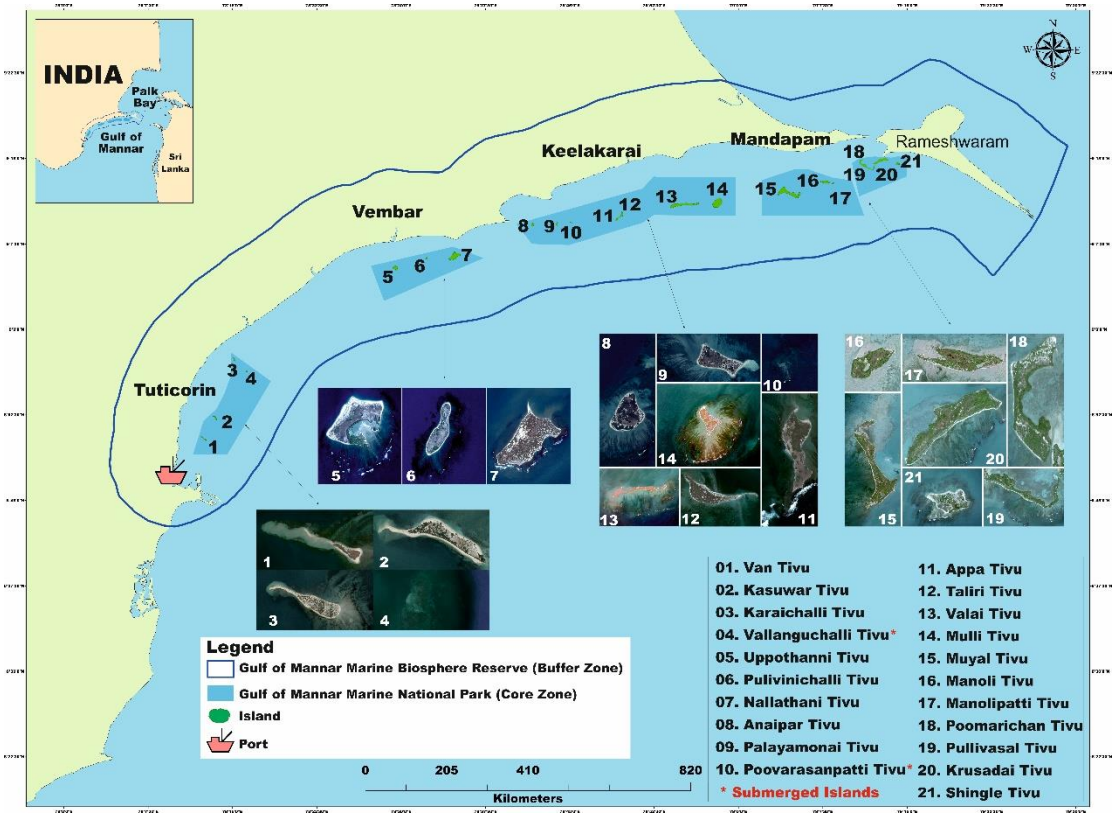


Table Existing head quarters and stations of the protection personnel of Gulf of Mannar Marine National Park division

Sl. No.	Name of Division / Range	Head quarters of Division / Range	Forester's head quarters	Forest Guard's head quarters	Forest Watchers head quarters	Mali head quarters
	I. Sanctioned					
1.	Wild Life Warden	Ramanathapuram	-	-	-	-
2.	Forest Ranger, Ramanathapuram	Ramanathapuram	1. Ramanathapuram 2. Thondi	1. Ramanathapuram 2. Thondi 3. Uppar *	-	1. Ramanathapuram *
3.	Forest Ranger, Kilakarai	Kilakarai	1. Kilakarai	1. Kilakarai 2. Earwadi 3. Periyapattinam	1. Earwadi	-
4.	Forest Ranger, Mandapam	Mandapam	1. Mandapam 2. Rameswaram *	1. Mandapam 2. Rameswaram 3. Utchipuli	1. Mandapam	-
5.	Forest Ranger, Tuticorin	Tuticorin	1. Tuticorin * 2. Vembar	1. Tuticorin 2. Tuticorin 3. Vembar *	-	-
	Total	**4**	**7**	**12**	**2**	**1**

Table Existing network of wireless communication in Gulf of Mannar Marine National Park division, Ramanathapuram

Stock particulars			Particulars of distribution		
Base set	Mobile	Walkie talkie	Base set	Mobile	Walkie talkie
11 Nos	9 Nos	25 Nos	Wild Life Warden Office – 1 No	Warden Jeep - 1 No	Warden Office - 1 No
			Mandapam Range Office - 1 No	4 Range Jeeps - 4 Nos	Ramnad Range - 3 Nos
			Tuticorin Range Office - 2 Nos	CF Office - 1 No	Mandapam Range - 5 Nos
			Kilakarai Range Office - 2 Nos	Stock at Office - 3 Nos *	Tuticorin Range - 6 Nos
			Stock at Office - 5 Nos *		Kilakarai Range - 5 Nos
					Stock at Office - 5 Nos *

* To be distributed to field staff and division office.

Table 7.3. Details of existing patrolling vehicles, boats and other infrastructure inGulf of Mannar Marine National Park division, Ramanathapuram

Description		Nos
I Boats		
Wooden boat	i) At Tuticorin - 32" length	1
	ii) At Rameswaran - 32" length	1
II. Out board motor fiber boats		
OBM Fiber boat	i) At Tuticorin	1
	ii) At Kilakarai	1
	iii) At Mandapam	1
III. Jeeps		
	i) Wild Life Warden, Ramanathapuram	1
	ii) Assistant Conservator of Forests, Ramanathapuram	1
	iii) For Kilakarai Range Officer	1
	iv) For Mandapam Range Officer	1
	v) For Ramanathapuram Range Officer	1
	vi) For Tuticorin Range Officer	1

Prescriptions

i. The Gulf of Mannar Marine National Park is governed by the Wildlife (Protection) Act, 1972, therefore, no resource exploitation and trade related activities other than protection, eco-restoration, research and monitoring have been prescribed (except Kurusadai Island where tourism allowed). Creation of a new Range at Vembar for Vembar group of islands is proposed. Appropriate infrastructure facilities for each protection staff need to be established at the proposed head quarters and other stations mentioned in the Plan.

ii. In addition to the existing patrolling vehicle and vessels (Table 4.3), it is proposed to procure two faster and bigger sea going vessels with communication systems, arms and first aid kits for patrolling as well as for rescue operation. Budget allotment for these boats should also include the operational and maintenance cost. One boat for Mandapam and Keelakarai groups and another one for Vembar and Tuticorin groups of islands and adjoining Biosphere Reserve areas as proposed.

iii. In addition to the above, each of the Range must have a patrolling vehicle as well as smaller vessel (speed boat).

iv. Existing wireless communication facilities are adequate to meet the suggested enhancement of protection network, however, it is proposed to expand the communication/patrolling efficiency by providing minimal infrastructure in each island (such as patrolling hut) for the island watchers. Each of the Island Protection unit should be provided with a small motor boat, walkie talky equipment, spot light, life jacket, camping gear etc.

v. It is proposed that such protection staff in islands be chosen from amongst the fishermen community who may have lost their fisheries related livelihood because of the establishment of the Marine National Park

vi. Two more Range Forest Officers are proposed for patrolling and protection in the Biosphere Reserve areas and therefore, one RFO each is prescribed with two Eco-development Officers. These Range Officers will collect intelligence information from the terrestrial part of the buffer zone and fish landing centers etc. in addition to their other works.

vii. Creation of a 'Anti-poaching squad proposed as 'Pilot Marine Patrolling and Policing Unit' consisting of Ex-Indian Navy and Coast Guard Personals at the top and middle level and local fishermen at lower level be considered with a special focus for marine habitat and biodiversity protection. This will ensure presence of people with enough marine habitat experience in field. This Unit is proposed to serve under the Wildlife Warden of the Marine National Park.

viii. Maintenance of data base on offenders

ix. Special incentives should be provided for patrolling squad and those who stay in islands for patrolling and monitoring. Free rations should also be provided to those stay at the Patrolling camps at island.

x. Scuba training needs to be provided to frontline staff who are part of the patrolling and monitoring activities.

Table Suggested head quarters and stations of the protection personnel of Gulf of Mannar Marine National Park

Sl. No.	Name of Division / Range	Head quarters of Division / Range	Forester's head quarters	Forest Guard's head quarters	Forest Watcher head quarters	Mali head quarters
1.	Wild Life Warden	Ramanathapuram	-	-	-	-
2	ACF (Protection & restoration)	Ramanathapuram				
4	Forest Ranger, Ramanathapuram (HQ)	Ramanathapuram	3. Ramanathapuram 4. Thondi	4. Ramanathapuram 5. Thondi 6. Uppar	-	2. Ramanathapuram
5	Forest Ranger, Kilakarai	Kilakarai	2. Kilakarai	4. Kilakarai 5. Earwadi 6. Periyapattinam	2. Earwadi 3. Sethukarain	-
6.	Forest Ranger, Mandapam	Mandapam	3. Mandapam 4. Rameswaram	4. Mandapam 5. Rameswaram 6. Utchipuli	2. Mandapam	-
7	Forest Ranger, Tuticorin	Tuticorin	3. Tuticorin	4. Tuticorin 5. Tuticorin 6. Vembar	-	-
8	Forest Rangers, Vembar	Vembar	1. Vembar 2. Sayalkudi			
9					Two in each island	

Management of Core Zone

Gulf of Mannar National Park

Chapter8

Species Recovery Programs

Gulf of Mannar harbours a diverse of life forms. If not all, most creatures still experience severe threats from different faces such as over exploitation of resources, habitat degradation, invasion of exotic, illegal extraction, indiscriminate fishing and pollution. Dugongs, Dolphins, Whales, Turtles, Corals species, sea horses, sea cucumbers, and several other organisms are worthy of the need of significant conservation measures. A list of fauna and flora of Gulf of Mannar Marine Biosphere Reserve has been given in Appendix. This list, in detail depicts their scheduled status under the Wildlife (Protection), Act 1972 and it's following Amendments. Their status on the IUCN Red Data Book and CITES Appendix is also given.

Government of India has recently published the India's third National Wildlife Action Plan for 2017-2031. The Plan is the future road map for wildlife conservation in India. The third National Wildlife Action Plan is unique as this is the first time India has recognised the concerns relating to coastal and marine biodiversity, climate change impact on wildlife and stressed on integrating actions that need to be taken for its mitigation and adaptation into wildlife management planning processes. Further, the Plan adopts a "seasca[e/landscape approach" in conservation of all wildlife that have an ecological value to the ecosystem and to mankind irrespective of where they occur. The Plan also gives special emphasis to recovery of threatened species and aquatic ecosystems. Further, the Action Plan emphasise the importance of integrated management of coastal and marine ecosystems in India.

National Board for Wildlife under the Chairmanship of the Hon'ble Prime Minister constituted two Sub-Committees comprising conservation experts for recovery of threatened Aquatic species including marine species in India. These Committees have already developed Guidelines for Threatened Species Recovery Plan. These recovery plans need to be used by the GOMBRF to develop detailed recovery plans for any threatened species, if require. These Committees after detailed deliberations have chosen Dugong, Whale shark, Giant clam, Horseshoe crab, Leatherback sea turtle, Hawksbill turtle, Sea cucumbers, Balanoglossus and coral reefs for preparation of recovery plan in the first phase. Recently, the MoEFCC has developed a National Level Recovery Plan for the Dugongs and their habitats in India and has entrusted the Wildlife Institute of India, Dehradun for its implementation especially the research, monitoring, education and awareness in Tamil Nadu, Gujarat, and Andaman and Nicobar Islands. This programme is already getting better outcome

from the Gulf of Mannar and Palk Bay region due to high level of participation of State Forest Department, Indian Coast Guard, Fisheries Department, NGOs and local communities. Similar approach is proposed for other threatened species of concern in this Management Plan including dugong so that GOMBRF would continue the dugong recovery programme once CAMPA-Dugong Programme ends in 2020.

It is important to enhance the stock of certain threatened, commercially and sustainably important marine fauna within the National Park. Spillover of these stock enhanced commercial species into the buffer zone of the Biosphere Reserve will be rationally and sustainably harvested, which ultimately improve the livelihood of coastal fishermen and the economy of these coastal districts of the Gulf of Mannar Biosphere Reserve. During current Management Plan period, the following species of conservation importance and sustainable utilization are required to be given special management attention. This stock enhancement programme will expected to be getting the confidence of the local people and hence their pressure on the bio-resources of the National Park would be minimized.

The two categories of conservation and management actions for species recovery/restoration/stock enhancement described are for:

A. Species recovery programs

Even though, several species of invertebrates and vertebrates within the Gulf of Mannar Biosphere Reserve and Marine National Park are in the Red Data Book of the IUCN and schedules of the Indian Wildlife (Protection) Act, 1972, it is proposed to initiate active species recovery and restoration of a few prioritized species. It is important to realize that such species recovery programmes require highly specialized and trained human resources and professional organizations. The small number of species recovery programme suggested below will also provide opportunities for capacity building of GOMMNP and GOMBR staff, educated youth, local NGOs and other institutions to formulate and initiate similar actions for range of other species, a range of which has been listed out.

1. **Dugong**
2. **Sea turtles**
3. **Holothurians**
4. **Lobsters**
5. **Sea horses and pipe fishes**
6. **Important Crabs**
7. **Sea snakes**
8. **Coastal birds**

B. Stock enhancement of species that are important for subsistence and economic importance to dependent communities.

Commensurate with the traditional dietary spectrum of the local inhabitants and the increasing evidence of a large number of marine fauna entering into the local, regional and global commercial market, there has been an over exploitation of many such resources. The current status of many marine resources are in a vulnerable state and an increasing number of species are being considered to be taken into the threatened and endangered category and to be provided strict protection. In a situation like this there is drastic decline in the number of species that can be harvested without any legal hindrance. It is, therefore, important that the 'stock enhancement option' for select group of harvestable resources are initiated. Such programmes are proposed to be taken up in the National Park limits where no fishing is permitted. This will provide the replenish stock to grow in a sheltered and protected situations and spill over into the Biosphere Reserve limits where controlled and sustainable harvest by users is permitted. The community at large will view this activity as an effort by the Biosphere Reserve Authority as a positive and supportive action rather than a ban on resource use. Fortunately, for a range of economically important and subsistence level use resources, the technology has been developed with fair degree of extension and technology transfer mechanisms in placed. A few species suggested to be included under this programme can be enhanced after the success of the pilot programmes. A range of species for which such programmes can be initiated is appended. A similar approach of creating livelihood opportunities involving propagation of indigenous marine flora and fauna that are not in the threatened and endangered category have also been suggested in the Eco-development plan chapter.

8.1 Dugongs

The Dugong (*Dugong dugon*) is one of the four surviving species in the Order Sirenia and it is the only existing species of herbivorous mammal that lives exclusively in the sea (Heinsohn, 1972). It is a large primary consumer and has considerable potential as a source of protein. The Dugong ranges along the coast of east Africa into the Red Sea, along the coast of southern Asia to as far east as the Solomon Islands, and along the northern coasts of Australia from southern Queensland to subtropical Western Australia (Marsh *et al.* 1999).

Figure Dugong

Dugongs are usually found in calm sheltered, nutrient-rich water less than five meters deep, generally in bays, shallow island and reef areas which are protected against strong winds and heavy seas and which contain extensive sea grass beds. However, they are not confined to only inshore water. There have been sightings near reefs up to 80 km offshore in waters up to 37 meters deep. Studies have suggested that there is a correlation between the sea grass and dugongs abundance (Das, 1996).

Dugong is considered to be rare over most of its range (Bertram & Bertram, 1968). Human exploitation has led to extirpation of the species in several previously inhabited archipelagoes, including Mascarene, Laccadive, Maldives, Barren, Narcondam, Cocos and Christmas Islands around the rim of the Indian Ocean and Lesser Sunda Islands in Indonesis east of Java. The species is listed as

vulnerable to extinction at a global scale (Marsh et al. 1999). However, Dugongs are still abundant in the shallow seas around tropical Australia, and it is likely that Australia may contain the main reservoir of dugongs in the world, after which comes the coast of United Arab Emirates.

Dugong population in the world is being threatened by human activities such as habitat destruction through coastal developments, pollution, accidental capture in fish nets and poaching (Marsh *et al.* 1999). Shark nets and gill netting are known to be responsible for the drowning of hundreds of dugongs worldwide. A less but major long-term problem is the disturbance in their feeding area by the noisy boat traffic.

In India, the dugong occurs in the Gulf of Mannar and Gulf of Kutch, the Palk Bay and in the Andaman and Nicobar Islands. All these areas have sea grass beds, which are good foraging ground for the Dugongs. The most favored dugong habitats are the Gulf of Mannar. In 1988, Helene Marsh, based on the data of Dr. Eric Silas and Mr. Bastion Fernando, indicates that 250 dugongs were illegally caught and butchered at the villages of Kilakarei and Peripattinum alone between April 1983 and August 1984. This information clearly shows that once the Gulf of Mannar had a good population of dugong but due to illegal off take of this species caused the species to be threatened with local extinction. Catches were higher in Palk Bay between Devipattanam and Pamban on Rameswaram Island than in the Gulf of Mannar between Musal and Appa Islands and the mainland (Marsh 1988).However, since 1988, the Tamil Nadu Forest Department initiated awareness campaigns to safeguard this species, which was first initiated by Mr. Balakathiresan, I.F.S. and later on it was carried forward. Though, the illegal off take of this species drastically reduced their population, information on current status and distribution is not known in detail.

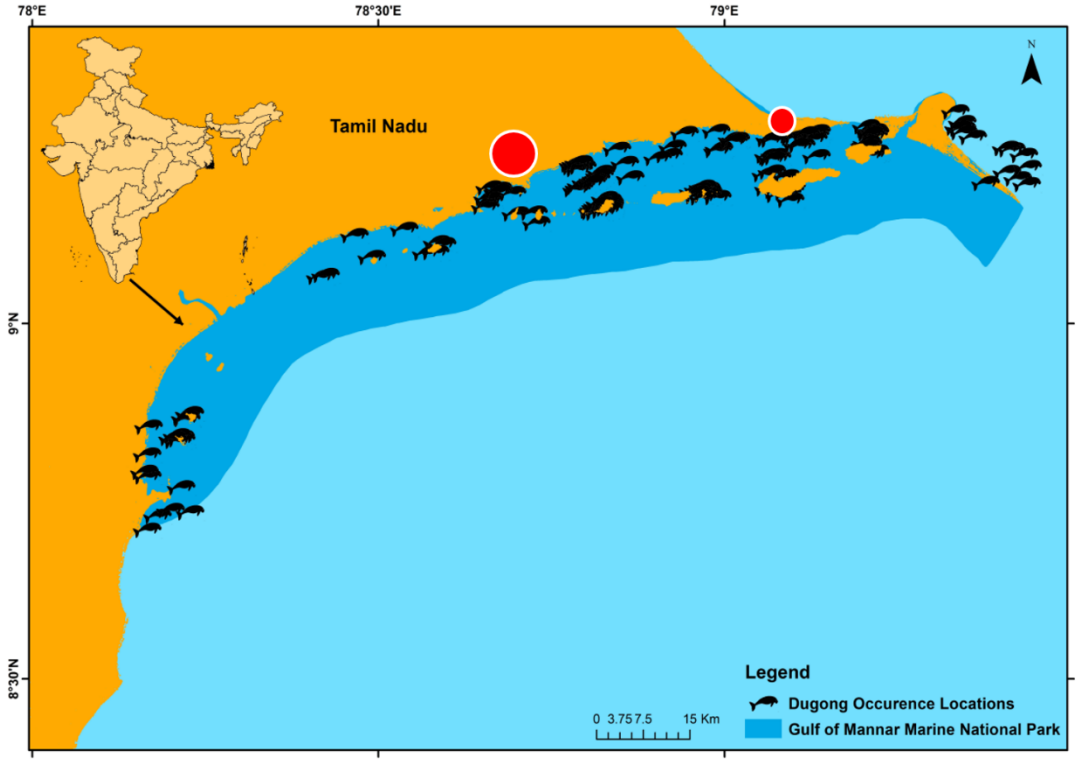


Figure Critical dugong habitats of Biosphere Reserve

The Gulf of Mannar area is the last refuge of any significance off the Indian coast where the most endangered mammal, Dugong (*Dugong dugon*) occurs. Here, the seagrass beds are the ideal feeding ground for the endangered marine mammal, Seacow (*Dugong dugon)*. Stormwater runoff drains both urban and agricultural areas, and carries with it household chemicals, oils, automotive chemicals, pesticides, animal wastes, and other debris into the sea which poses as destructive factors to seagrass beds. The Dugong feeds only on seagrasses and requires 30-40 kg of them every day. Seagrasses are also fed upon by various herbivorous animals including turtles, fishes, etc. Megaherbivores that depend on segrasses, control the community structure of the seagrass meadow by grazing. The meadows which are often grazed by Dugongs consists of fast growing species of seagrasses like Halophila and Halodule, which have relatively high nitrogen content to fibre content.

Killing of dugongs and dolphins (both these are locally called as “Avolia” and “Kadalpandir”) and turtles for sale for meat has reduced currently, owing to the implementation of the wildlife (protection) Act 1972 and the publicity given about the protection accorded to these mammals in the Act. However stray incidents of poaching and of incidental catches of these by the fishermen are known to still occur.

Recovery of Dugong in the Gulf of Mannar

Currently, there is no technology available to recover this species through *excitu* conservation methods. However, recovering their habitat i.e. sea grass beds and avoiding poaching will help this species to recover. There may be a migration of dugong between India and Sri Lanka through Palk Bay which is shallow water (Jones 1976). If we could restore the degraded seagrass beds in the Gulf of Mannar Biosphere Reserve then we may expect the arrival of dugong to the Biosphere Reserve. It is important to identify the critical dugong habitats and their status in the Gulf of Mannar. Encourage and support members to collate and document information on habitat disturbance and loss (e.g., seagrass dieback) and poaching. Education, including formal education, public awareness and training is critical for promoting sustainable development and improving the capacity of the people to address dugong conservation and management issues. Both formal and non-formal education is indispensable to changing people's attitudes so that they have the capacity to assess and address their dugong conservation concerns.

Management Prescriptions:

At present, CAMPA-Dugong Programme of Wildlife Institute of India and Dugong Recovery of Programme of TBGP of Tamil Nadu Forest Department has been integrated and implemented in the region with help of various stakeholders. Since several reasons have been attributed to their population decline, some of which include sea grass habitat loss and degradation, boat traffic, gill netting, disease, chemical pollutants, consumptive use, and poaching. Therefore, recovering dugongs in Biosphere Reserve entails targeted, multidisciplinary research that flows into management actions and advocacy for policy changes. Therefore, dugong recovery program aims at: (a) assessing and monitoring Dugong population and habitat status; (b) implementing site specific management actions to recover populations and restore critical habitats; (c) incentivizing participatory conservation efforts involving local stakeholders; and (d) improving the capacity of enforcement and management agencies to promote integrated protection and management of Dugong and associated species.

State level Stakeholders Consultation Workshops in Tamil Nadu was held and finalized the modalities related to implementation of Dugong Recovery Programme with actionable conservation measures on priority. The Indian Navy and the Indian Coast Guard have also supporting this programme. More than 20, 000 school children and fisherfolks have participated in awareness programs organized jointly by TNFD and WII. Because of these awareness programs, few fishermen in Tamil Nadu (Palk Bay), who could successfully rescue and release three dugongs entangled in their fishing nets, were honoured with incentives. A total of 60 frontline forest staff of Tamil Nadu Forest Department have been oriented towards conservation of dugong.

As part of 'Incentive for Conservation Programme', examinations have been conducted among school going children of fishermen community and selected 50 'Dugong Ambassadors' from Palk Bay region. Education of these 'Ambassadors' would be supported with 'Dugong Scholarship' i.e. Rs. 500/month for two years. Similar, sholarshiop programme required to be extended to Biosphere Reserve during this Management Plan period. Further, the Managent Plan suggest to conintue all the conservation actions of present Dugong Recovery Programme after 2020 that include the 'Dugong Schoarlship to School Going students of fishermen'.

Further,

1. A detailed mapping of sea grass beds with the information on the status of each species in the Biosphere Reserve is needs to be prepared using latest satellite imageries and it should be monitored requlary.
2. Efforts are required to manage the Critical Dugong Habitats inside the buffer zone of Biosphere Reserve. WII has already identified these habitats that need to be monitoring.
3. Assess the populations of dugongs using various census techniques and establishment of marine mammals rescue and rehabilitation facilities in all three states.
4. Prevent the further decline of sea grass beds by eliminating the causes of decline such as pollution, indiscriminate fishing etc.
5. Extending the present sea grass distributional limit to the historical distributional limit.
6. Prohibition of trawling fishing on the sea grass beds.
7. Awareness programme in the catchment area regarding the excessive use of pesticide and other chemicals and its impact.
8. Restoration experiments with the help of CSMCRI and Restoration technology adopted on a coastal lagoon in the North of Yucatan (Southeastern Mexico) may be consulted here. The agency which would be used for the restoration of this habitat is also requested to consult with 'Chapter 7. Seagrass: in Handbook of Ecological Restoration, Volume 2, edited by Martin R. Perrow and Anthony J. Davy, Cambridge University Press, 2002'.

8.2 Sea Turtles

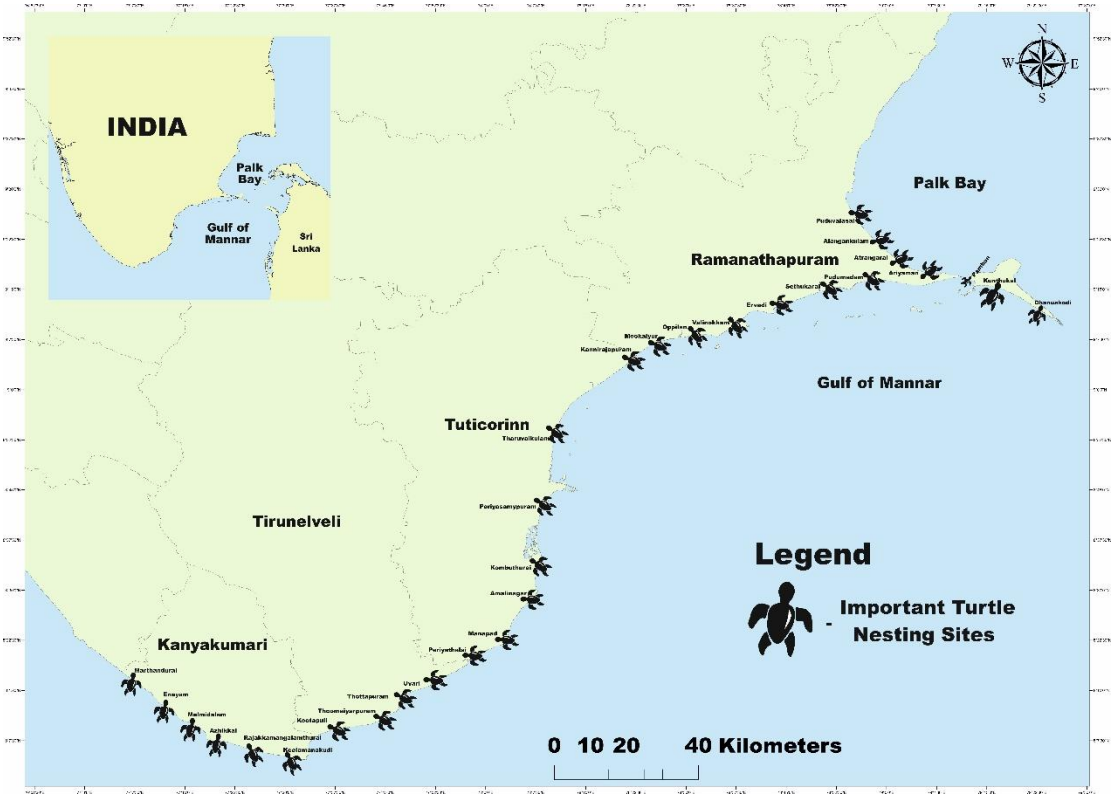
Four of the seven species of sea turtles found world wide are reported to occur in the Gulf of Mannar Biosphere Reserve. These are the olive ridley (Lepidochelys olivacea), green (Chelonia mydas), hawksbill (Eretmochelys imbricata) and leatherback (Dermochelys coriacea. All the four species of sea turtles that occur in these coastal waters are protected under Schedule I of the Indian Wildlife Protection Act (1972), as well as listed in Appendix I of Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) which prohibits trade in turtle products by signatory countries. At present there exists no commercial or international trade of marine turtles or turtle products in India. However, incidental capture in trawls is a well-known cause of mortality for sea turtles and have been reported all over the world and the Gulf of Mannar is not exceptional to this. Turtles are being harvested in the GOM area for meat near Tuticorin.

Figure Green turtle

During 1971-76 the percentage of green turtle and olive ridley caught in the Gulf of Mannar and adjoining areas was 89% and <10% respectively and during November 2001 it was 46% and 48% but in 2004 the percentage was 13% and 83% which shows that the proportion of green sea turtles catch declined in this region drastically. The reduction in the green turtle catch could be due to overexploitation as local people prefer this species to other species for food. Since the population of green turtle was smaller in size the people were forced to exploit the olive ridley in recent days. It is necessary to recover the green species population in the Gulf of

Mannar region as it has an important ecological role in the seagrass and coral reef ecosystems.

Figure Olive Ridley turtles



Recovery of sea turtles in the Gulf of Mannar Biosphere Reserve:

Beach erosion due to both man made and natural phenomena, have reduced the nesting habitats and resulted in a drastic decrease of sea turtle nesting in the Biosphere Reserve. Moreover, beach armouring with exotic plantations, artificial illumination and tourism are few other threats to the nesting beaches and hatchlings. Hence, it is recommended to continuously monitor the nesting beaches and avoid exotic plantation within 500 m from the high tide line and also manage vegetations on the beaches. Further, it is recommended to protect the beaches and turtles with help of 'Network of Turtle Watchers'.

Beach management and hatchery programmes are proved to be the better methods to recover the sea turtles around the world (GOI-UNDP Project Manual). The same programme may be tried in the Gulf of Mannar Biosphere Reserve both on islands and mainland coasts. A detail manual has jointly been prepared by MoEF (GOI), UNDP, WII and MCBT on this subject can be used. WII has already identified important turtle nesting areas in the Biosphere Reserve that need to be protected and monitored. Community based Turtle Tourism may also be tried (e.g. Malvan coast, India; and Sri Lanka). Wildlife Institute of India may be approached to help the Authority to initiate a programme of this kind in the Gulf of Mannar Biosphere Reserve.

8.3 Holothurians

Past and present, holothurian have been consumed as a culinary delicacy and as a high quality ingredient in many kinds of medicine, mostly exists in international trade in dried form, known as beche-de-mer (*iriko* in Japanese, *hai-som* in Chinese, or *trepang* in Indonesian). Sea cucumbers have continuously increased supply in international markets, both in tropical and temperate zones. Trends in fishery indicate that the number of producing countries and species in trade has recently increased worldwide and prone to overexploitation because of their limited mobility, late maturity, density-dependent reproduction, habitat preferences and low rates of recruitment. Around 30 species of sea cucumbers have been recorded in the Gulf of Mannar region, of these, 12 species are well known to fishermen .

Holothurians are naturaly large and sedentary organisms and fishing techniques do not require sophisticated equipment, these attributes attract the fishermen to harvest some high value species that is seen as a valuable source of income particularly to local fisheries communities in many developing countries. Present fishery systems seem to be open for sea cucumbers resource access and overfishing to supply the demand of commercial

merchandiser. Holothurians fisheries are commonly targeting the high value species, which taxonomicall are mostly identified in families Stichopodidae and Holothuriidae. Meanwhile, since certain populations of these high value sea cucumbers are in decline, new species are now being collected, adding to the number of commercial species. The Government of India banned the holothurians fishing due to drastic population decline that has been noticed in this group. The Gulf of Mannar once known for major holothurians fishing has lost a majority of its holothurians stock due to overexploitation. It is important to enhance the stock of the holothurians in the National Park because the excretions of holothurians are known to improve the populations of benthic fauna and flora which are important food for several commercially important fishes.

Stock enhancement of Holothurians

Currently, no aquaculture production of sea cucumbers has been reported to FAO by member countries but with current production trends, it can be assumed that sea cucumbers from aquaculture ventures may constitute a large portion of total world production.

Promoting research and development of restocking and stock enhancement in the Gulf of Mannar is urgently required to recover holothurians populations in this region. Most of aquaculturists and researcher work on *Apostichopus japonicus*. *Holothuria scabra* or sandfish seem to be the ideal tropical holothurian most suited to restocking in the western Pacific and Southeast Asian waters (FAO). The two main problems of sea cucumber restocking are the long farming period and the low number of seeds available from the wild. Mariculture for sea cucumbers exists in the Philippines, while a significant effort on resource management will have to be focused on the regulation of harvest, enhancing the natural stock with hatchery-bred individuals has become a feasible option. Same model may be tried in the Gulf of Mannar as a pilot programme with the help of professional agencies such as CMFRI, CASMS, Tuticorin Fisheries College, SDMRI etc.

8.4 Lobsters

A total of seven species of lobsters are harvested in different coastal areas of India. Of these, *Panulirus homarus* and *P. polyphagus* are the most commercially important and the main fishery of the Gulf of Mannar coasts (George 1968 and Deshmukh 1964). Stock enhancement and fattening of lobsters in this region is expected to improve the livelihood of the coastal fishermen who are fishing in the buffer zone of the Biosphere Reserve. It will ultimately allow the fishermen to understand the importance of the Marine National Park and its protection. Professional institutions such as CMFRI, TFCRI and SDMRI may be consulted for this programme.Artificial habitats designed for lobsters may be created in the buffer zone to

enhance the population and prevent fishermen from harvesting in the core zone.

8.5 Sea horse & pipe fishes

Seahorses are fish belonging to the Syngnathidae family, which also includes sea dragons, sea moths, and pipe fish. Most Seahorses are found in coastal waters, typically at depths of 1–15 meters, occurring in relatively sheltered environments among seagrasses, kelp beds, rocky reefs, mangroves and coral reefs. Unfortunately these are some of the most vulnerable of marine environments in the Gulf of Mannar, highly susceptible to disturbance caused by human activities. Seahorses feed on brine shrimp, tiny fish and plankton. Sea horses are primarily used in traditional Chinese medicine. They are said to cure asthma, skin ailments, relieve heatiness(acidity), joint and stomach aches, cleanse the blood, and strengthen the kidneys. Seahorse consumption is surprisingly common among Malay fishing communities. They frequently grill and fry their captured seahorses and eat them as crackers. They also believe that dried seahorses worn with string around the neck of newborns or toddlers or hung in their home, act as omens to dispel evil spirits. An aquarium and seahorse curio trade also exist but are difficult to monitor. Due to this the wild populations of sea horses in the Gulf of Mannar was overexploited and presently their status is endangered, therefore, they are protected by the IWPA (1972).

In the Gulf of Mannar, four species of sea horses are occur, most of the seahorses are landed as bycatch of shrimp trawling. In response to a significant increase in international demand, a target fishery for sea horses along the east coast of India in the Gulf of Mannar was started in 1992. India was one of the largest exporters of dried sea horses globally, exporting at least 3.6 tonnes (1.3 million sea horses) annually, and contributes to about 30% of the global sea horse trade. Sea horses are exploited both as an incidental catch (by-catch in trawl nets) and target catch, for export. Presently, the commercial exploitation of sea horses is totally banned in India.

Recovery of sea horse and pipe fishes

Because seahorses live in areas along the coast, the potential for impact from human activities is great. Very few studies have been carried out on wild seahorse populations and, as a result, scientists have no idea how many seahorses live in the wild and do not fully understand the basic biology of the creature. This lack of information makes it extremely difficult to predict how seahorse populations will be affected by exploitation. However, fishers and traders agree that, over a five-year period, exploited populations in Southeast Asia have declined by 15–50% (Vincent 1996). It is

believed that the populations of sea horse and pipe fishes in the Gulf of Mannar is under severe threat due to over exploitation. It is important to assess their stock and enhance the same in the National Park areas with help of professional institutions such as CASMS, Annamalai University and CMFRI. Technology for captive breeding of sea horses had been developed by these two organizations with the support of the Ministry of Environment and Forests, Government of India. The same technology may be utilized for the stock enhancement of sea horses in the Gulf of Mannar Marine National Park. Public awareness programme needs to be initiated and people needs to be told about the reason for the declining of sea horse due to over exploitation. Technology to breed the pipe fishes in captivity needs to be developed.

8.6 Important Crabs

A total of 38 crab species belong to 21 genera and five families occur in the Gulf of Mannar Biosphere Reserve, which is 5.6% of Indian crab germ plasm. Of the 11 important commercial crabs in India, six crab species occur in this region. Several species are considered to be becoming rare and threatened, or having reduced over all size because of over exploitation and their habitat destruction. Inter-tidal zone of Gulf of Mannar Marine National Park and the Biosphere Reserve are considered to be good habitats for these crabs in this region. It is important to enhance the stock of economically important crabs in this region i.e. in the core zone of the Biosphere Reserve, which ultimately spill over to the buffer zone where controlled and sustainable fishing is allowed. Professional agencies such as CMFRI and CASMS need to be involved in this programme.

8.7 Sea snakes

Sea snakes are considered to be the most successful marine reptiles in the world. 12 species of sea snakes have been reported in the Gulf of Mannar region. Of which, nine species are true sea snakes i.e. belong to the family Hydrophiinae. Studies shows that the sea snake population in Indian seas are declining. It is understood that, incidentally captured sea snakes are released back into sea but in several occasions the incidentally captured sea snakes are killed by the fishermen due to fear. In this connection, a public awareness programme for fishermen in the Gulf of Mannar region is useful to conserve these species using posters etc.

8.8 Coastal Birds

A total of 187 species of birds were reported from the Gulf of Mannar Marine National Park, of which 84 were aquatic species and the remaining are terestrial. The status, popoulation, arrival

and departure dates (for the migratory birds) of the waders, terns and gulls have been described species wise. The other aquatic birds are listed group wise and the terrestrial birds recorded are checklists. At Manali and Hare islands 223 species are migratory birds were found to over summer every year. Lesser sand piper, Curlew sandpiper, Little stint are abundent, Red knot, Eastern knot, Crab plovers Bar tailed Godwit, Broad billed Sandpiper, Dunlin, Longtoed stint, Rednecked phalarope, Little tern, Kentish plover, Stone plover, Stone curlew, Lesser crested sterna etc were recorded as regular visitors to this area. (S.Balachandran Journal, Bombay Natural History Society,Vol 92 (3), December 1995.Page no 303).

MELASELVANUR BIRD SANCTUARY:

This is an important area of breeding for many of the migratory birds coming from Europe and Australia during the winter months every year. Grey pelican and painted stork are among the birds visiting this place. Season: November-March/April.

Possibilities of Eco-tourism:

Given a proper publicity and necessary infrastructure, this has potential to attract many tourists from all over the country during the season. A watch tower and an interpretation center should be built. Poaching can be prevented by putting-up a fence around this area. If this is not feasible, a canal should be dug to prevent poachers and grazing animals to enter this area.

KANJIRANGULAM-CHITRANGUDI BIRD SANCTUARY:

This is situated at a distance of about 5KM from Mudukulathur (24KM from Ramanathapuram) in Ramanathapuram district. It covers an area of around 150Ha. Cormorants, Egrets, Herons, Teals, Pelicans etc., visit this area.

VETTANGUDI BIRD SANCTUARY:

This 38 Ha bird nesting area is situated at a distance of about 11KM from Thiruothathur in Sivagangai District.

A combination of islands with mud flats and mangroves habitats makes the BR an ideal waterfowl habitat. Large numbers of both migratory and resident birds have been recorded in this area. The panel would depict pictorially the migrant and resident birds and their behavior. Calls of birds would also be included in the panel to make it interactive for visitors and the children coming to the conservation education centre.

DANUSHKODI:

This is a fishing village situated on the northeastern tip of the Rameswaram Island, 40km from Rameswaram. Ruins of Church and other government buildings constructed during the British rule present here can be of archaeological value. The marsh here also harbors different migratory birds coming from Europe and Australia during October to January every year.

Possibilities of Ecotourism:

- A bird watching centre, with some basic infra structure like a watchtower and an interpretation centre can be established in Danushkodi.
- The ruins of old buildings can be declared as heritage site, which can attract a good number of tourists.
- A water sports complex like water skiing, speed boating etc., can be established in Danushkodi.
- Eco-friendly resorts along the Danushkodi beach can also be built with the involvement of local communities.

Table: Major actions required to recover certain marine species in the Gulf of Mannar Biosphere Reserve.

Sl. No.	Species	Increased awareness programme based on species status and problems	Enforcement and protection from species removal	Status survey and population estimation	Stock enhancement	Species recovery actions	Protected by	Professional Institutions needs to be consulted
1	Sea turtles	√	√	√		√	IUCN, IWPA, CITES	WII, MCB
2	Dugong	√	√	√		√	IUCN, IWPA, CITES	WII
3	Sea horses & pipe fishes	√	√	√	√		IWPA	CASMS, CMFRI
4	Lobsters				√			TFCRI, CMFRI, CFRI, CASMS
5	Holothurians	√	√	√	√		IWPA	CMFRI, TFCRI
6	Reef fishes	√		√	√			CMFRI, TFCRI
7	Balanoglossus	√	√	√				TFCRI, SDMRI
8	Sea snakes	√						WII
9	Commercially important crabs				√			CASMS, TFCRI, CMFRI

Chapter9

Habitat Recovery Programs

The coastal region of the Biosphere Reserve should required to be monitored and the pollution creating activities should be monitored and got rid of. The assessment of biodiversity, (corals, mangroves, sea grass etc.,) socio economic value of the coastal region, biological connectivity and its status should also be monitored. An integrated network among peoples is also much needed only after which the action will get public support. Demonstrative sites should build entire GOM region to assess all the status of entire coast.

The status of coral reefs of the Gulf of Mannar Marine National Park has been studied over the last decade by various institutions in India, but compilation of the data revealed that there were no concrete results to the current status of the reef or its trends in the past ten years, this was mainly because of inconsistent in methodologies used and sites studied which has varied from organization to organization. Therefore, an appropriate method to monitor the coral reefs from identified sites for a longer period is visualized. Long term monitoring on status and distribution pattern of corals on identified reefs would help us to the success of any management programmes.

9.1 Recovery of Coral reef ecosystem (Source: Patterson, SDMRI)

Present status and distribution of corals

Corals and coral reefs of Gulf of Mannar National Park form an essential ecosystem, which supports a variety of ecologically and economically important marine life. Coral reefs in Gulf of Mannar occur mainly around the 21 uninhabited islands encompassing an area of about 683 ha. The islands in Gulf of Mannar Marine National Park are divided into three groups namely, Mandapam group (7 Islands), Keelakarai group (7 Islands) and Tuticorin group (7 Islands). The islands of Mandapam group are Shingle, Krusadai, Pullivasal, Poomarichan, Manoliputti, Manoli and Hare; those of Keelakarai group are Mulli, Valai, Thalaiyari, Appa, Poovarasanpatti, Valimumai and Anaipar; and those of Tuticorin group are Nallathanni, Puluvinichalli, Upputhanni, Kariyachalli, Vilanguchalli, Koswari and Vaan. Among these 21 islands, Vilanguchalli in Tuticorin group and Poovarasanpatti in Keelakarai group have already submerged under the water a few decades ago. Coral mining had been the chief reason for this loss.

Fringing reef is the major reef type in Gulf of Mannar. Narrow fringing reefs are found at a distance of 100 to 350 m from the shore of the islands at depths ranging between 0.5 and 2 m. Patch reefs are also met with around the islands at depths between 2 and 9 m. These patch reefs are 1 to 2 km long, and about 50 m wide. Reef flat of Gulf of Mannar has been reported to be extensive (Pillai, 1971, 1977). Pillai (1986) reported that coral diversity in Gulf of Mannar comprises 94 species belonging to 37 genera. Edward et al. (2004) updated the list to 104 species and Edward et al. (2007) updated the list further to 117 species of corals belonging to 40 genera. The fast growing corals such as *Acropora* spp., *Montipora* spp. and *Pocillopora* spp dominate shallow waters of depth ranging between 0.5 and 2 m.. Boulders such as *Porites* spp., *Goniastrea* spp., *Favia* spp., *Favites* spp., etc. are dominant in depths between 3 to 9 m around the islands.

Threats / Management issues

Threats to corals may be broadly divided into two categories, namely natural threats and human-induced threats. Both natural and human-induced threats may be further divided into high intensity threats and low intensity threats.

Climate change

Global Climate Change has become a serious threat to all the living beings. As a consequence of Climate Change, the global average temperature has shot up to unprecedented levels during the past few decades. Corals are organisms which respond to variation in the

environmental parameters especially to temperature fluctuations. Coral bleaching is a general response by corals to increased sea surface temperature. Bleaching takes place when corals experience abnormally high sea surface temperatures. Coral bleaching is an annual phenomenon in Gulf of Mannar during summer; and corals tend to recover from this condition when the temperature gets back to normal levels. However, coral bleaching caused severe mortality among the corals in Gulf of Mannar during 2010 and 2016 because the gulf witnessed longer periods of elevated sea surface temperature.

During 2010, a significant 9.8% of corals died in Gulf of Mannar because of the prolonged spells of elevated temperature levels. During this bleaching period a temperature range of 32.2 to 33.2˚C prevailed for four months from April to July. The coral species affected during 2010 include *Pocilopora damicornis*, *Acropora formosa*, *A. intermedia*, *A. nobilis*, *A. cytherea*, *Montipora digitata, Montipora foliosa, Favia* sp. and *Echinopora* sp. However, the affected corals started to recover immediately because of the coral recruits which were not affected by bleaching. During 2016, Mandapam group of islands were the most affected by bleaching, with a mortality of 22.17%. The mortality was 17.15% in Keelakarai group, while a comparatively lower mortality of 9.19% was found in Tuticorin group of islands. The fast growing species *Pocilopora* spp., *Montipora* spp., and *Acropora* spp. faced severe mortality during 2016 whereas the boulders such as *Porites* spp., *Goniastrea* spp., *Favia* spp., *Favites* spp. were not affected.

Coral diseases and other health issues

Reports of disease outbreaks and consequent coral mortalities have become common in Gulf of Mannar. Severe disease outbreaks and mortalities have been reported from Vaan and Shingle Islands. Three types of typical coral diseases have been recorded from Gulf of Mannar: white syndrome, focal bleaching and growth anomalies. Of these the mean prevalence of white syndrome in Gulf of Mannar was 0.2%; that of growth anomaly was 0.13%; while focal bleaching accounted for 0.6%. White syndrome was found to infect the coral genera *Acropora* and *Montipora*, and growth anomaly was found to infect *Acropora*, *Porties*, *Turbinaria* and *Favia*.

Apart from these typical coral diseases, other natural health issues encountered in Gulf of Mannar are: predation by corallivore snails (0.34%), predation by corallivore fishes (1.41%), sponge overgrowth (0.69%), macroalgae competition (1.75%), worm infestation (1.16%), invertebrate gall (0.27%), coralline algae overgrowth (0.15%) and mucus sheathing (0.09%). Snail predation has been observed in *Montipora*, *Acropora* and *Porites*; fish predation has been observed in *Acropora, Porites, Goniastera, Favia* and *Platygyra*; sponge overgrowth has been observed in *Montipora, Acropora, Porites, Goniastera, Favia, Favities, Platygyra* and *Turbinaria*; macroalgae competition has been

observed in *Montipora, Acropora, Porites, Goniastera, Favia, Favities, Platygyra, Turbinaria, Symphyllia, Pocillopora* and *Ecinopora*; worm infestation has been observed in *Montipora, Acropora, Porites, Goniastera, Favia* and *Favities*; invertebrate galls have been observed in *Turbinaria*; coralline algae overgrowth has been observed in *Montipora, Acropora, Porites, Goniastera* and *Favia*; mucus sheathing has been observed in *Goniastrea* and *Favia*. Invasion of coral-killing sponge *Terpios hoshinota* has also been witnessed recently in Vaan Island of Gulf of Mannar.

Bio-invasion

*Kappaphycus alvarezii*is red seaweed native to the Philippines and is an invasive species in the non-native environs of Gulf of Mannar. The introduction of this exotic seaweed in Gulf of Mannar in 2005 as a maricultural measure to enhance the livelihood of the coastal people was carried out without conducting proper Environmental Impact Assessment. This alga is the source of sulphated polysaccharides commonly called "carrageenan", which is used in the food and the pharmaceutical industries. The alga is able to coalesce into the tissue of the coral, obtaining thereby a strong means of attachment, and thus surviving in high wave energy environments. It spreads mainly by fragmentation (pieces of seaweed float to new locations) and can overgrow and kill the coral by smothering and shading it from sunlight. It causes the shifting of a diverse coral reef into a seaweed-dominated, low-diversity reef; it changes the bottom structure of the reef; and reduces access to crevices and holes. Thus the habitat loss may impact the commercial and recreational fisheries.

The cultivation of this alga was started in places close to reef areas in 2005, and in 2007 bio-invasion was first observed in branching corals of *Acropora* sp. in Krusadai island of Gulf of Mannar. Within 24 months, reef areas of over 1.2 km^2, destroying over 500 branching and massive coral colonies of *Acropora cytherea, A. formosa, A. nobilis,Montipora digitata* and *Porites solida*, size ranging from small (< 20 cm) to larger (> 80 cm) colonies happened in Krusadai Island.

The overall area occupied by *K. alvarezii* in Krusadai Island was 1,524 m^2 during 2014, and it was 368 m^2 in Mulli Island while in Shingle Island it was 152 m^2. During coral bleaching in 2016, live coral cover in Gulf of Mannar was reduced considerably and significant mortality was recorded in the islands affected with *K. alverezii.* As the substrate (live corals) cover was reduced the *K. alverezii* cover was also correspondingly decreased. Now, except for a few fragments in Krusadai Island, *K. alverezii* has been completely wiped out from Gulf of Mannar for want of a continuous stretch of live corals. However, the left-over fragments of *K. alverezii* are capable of increasing their biomass in the event of their finding proper substrate through currents.

Terpios hoshinota is an encrusting cyanobacteriosponge that aggressively overgrows live coral and can undergo outbreaks causing significant declines in live coral cover. An outbreak of *T. hoshinota* on *Montipora divaricata* colonies in Vaan Island of Tuticorin region of Gulf of Mannar was recorded during 2015. This sponge is capable of causing huge mortality on corals and is likely to spread to other islands of Gulf of Mannar.

Sedimentation

Sedimentation caused by currents and waves tend to smother corals and kill them. Fresh water runoff during rainy season brings sediments from the land source resulting in sedimentation, especially in Tuticorin and Keelakarai regions. The extent of sedimentation tends to be higher during the onset of natural disasters like cyclones, storms and tsunami, which causes serious disturbance to corals. Sedimentation rate in Gulf of Mannar ranges between 19.51and 71.15 $mg/cm^2/day$.

Turbidity

High turbidity of water caused by currents and waves prevent the symbiotic algae from getting sunlight and thus disturb the corals. Turbidity is also caused by freshwater runoff especially in Tuticorin and Keelakarai regions. Generally turbidity ranges between 4 and 7 NTU in Gulf of Mannar. But in areas where sewage water mixes with sea water, turbidity has been recorded as high as 38 NTU.

Tsunami

During the onslaught of Indian Ocean tsunami in 2004, corals were found unaffected in Gulf of Mannar. Only a very little amount of branching corals were fragmented in that tsunami because of the high intensity waves along the coast of Gulf of Mannar. Coral species such as *Acropora cythrea*, *A. intermedia*, A. *nobilis* and *Turbinaria* spp. were found damaged by the strong waves.

Coral mining

Coral mining has been a major threat to the corals of Gulf of Mannar until the last decade because this activity directly damages the corals and decreases the live coral cover. Coral mining also jeopardizes the process of natural coral recruitment by reducing the amount of substrates suitable for coral attachment. Coral has been mined in Gulf of Mannar since 1960s for building material and for input for lime factories. Tuticorin and Mandapam were the two main bases for coral mining. Most of the buildings during that time were built using these mined coral blocks. About 25,000 tonnes of coral was mined

annually from Gulf of Mannar and Palk Bay together. Since there was no legislation to prevent coral mining during that time, some islands were even leased out as coral mines.

Declaration of Gulf of Mannar Marine National Park during 1986 by Govt. of Tamil Nadu and the declaration of Gulf of Mannar Marine Biosphere Reserve during 1989 by Govt. of India did not bring about any change in the level of coral mining as it was still continued. In 2001 corals were brought under Schedule I of the Wildlife Protection Act, 1972, of Govt. of India. Since then the strict enforcement by the Tamil Nadu Forest Department made the lime factories to shut and mining activities started reducing. However in Tuticorin region, illegal mining had been taking place in some villages such as Vellapatti, Thalamuthunagar and Siluvaipatti until 2004. Creation of awareness about the importance of corals has been carried out since 1990s and early 2000 by various Government and Non-Government organizations. After the Indian Ocean tsunami of 2014, the remaining coral miners from Tuticorin region came forward voluntarily to stop coral mining but demanded alternate livelihood avenues. This voluntary halt is attributed to the awareness created coupled with strict enforcement. Fishermen believed that corals are important to protect them from the natural disasters such as tsunami. However, small-scale mining of live corals for ornamental purposes still continues, predominantly in Keelakarai and Mandapam regions of Gulf of Mannar. This ornamental trade of coral skeletons is evident from the availability of corals for sale in the tourist places such as Kanyakumari and Mahabalipuram.

Destructive fishing activities

Shore seine

Shore seines are beach seines operated in inshore waters, commonly in use for ages. They are locally called 'karai valai'. Shore seine is employed in many fishing villages along the coast of Gulf of Mannar. In Tuticorin region alone about 600 fishermen are engaged in shore seine operation. The impact of shore seine on the marine resources is immense, as it involves bottom trawling. Whether mechanized or manual, bottom trawling is detrimental to the marine ecosystem. As the bottom trawl is designed to tow along the seafloor it crushes, kills and buries the benthic fauna and exposes them to predators. It causes physical and biological damages that are irreversible and extensive. In Gulf of Mannar, shore seine operation is practiced even in the prohibited islands where corals are found. Shore seine operation in the island areas eliminates the possibility of new recruits in the dragged area. Since dead corals, which form the base for new coral recruits, are dragged ashore, the area becomes unsuitable for coral recruitment.

Trap fishing

Trap fishing is a method by which reef fishes are caught by setting a bamboo-made trap in the reef area. This method, though a traditional one, has increased enormously in the last decade in Gulf of Mannar. The traps are set in the reef areas by damaging the corals by way of breaking them or disturbing them. Depletion of herbivorous fishes, which feed on the macro algae, is the other indirect harm. The killing of herbivorous fishes results in the proliferation of macro algae, which are serious competitors with coral for space.

Nowadays, there is an increase in the operation of fish traps by the artisanal fishermen in Gulf of Mannar. The fish traps are made of bamboo by an indigenous group of people. Normally the traps are 90 cm in length, 88 cm in width and 55 cm in height at the entrance point. The trap mouth is oval in shape and measures 55 cm x 35 cm. The lead-way from the mouth region extends to about 85 cm. The overall view of the trap is almost like a wing and the wing-like extensions on the side measure 25 cm.

About 6-10 fishermen carry 20-25 traps in a country boat (Vallam/Vathai) and set them close to the reef or in between reef covered area. To hide the traps in the reef, the fisher folk break off live corals especially the massive ones to cover them. The bait kept inside is generally discarded shrimp heads collected from processing plants. The entire crew starts for work around 5 am in the morning and set the traps in many places. After the traps are set, styrofoam is used as floats for marking and stones are used as sinkers to send the trap to the bottom. Every day the fishermen visit the site to collect the fishes trapped inside and leave the trap in the same place or change the place according to the abundance of fish population.

The peak season for the trap fishing in Gulf of Mannar is from October to January and from February to May, and the off-season period is from June to September. The targeted fish are Parrot fish, grouper, snapper, rabbit fish, sweet lips, wrasse, goat fish, and honeycomb eel. The non-targeted fish species are coral cat fish, squirrel fish, butterfly fish, razor fish, trigger fish, goby, puffer, surgeon fish, angel, banner fish. Uprooting of coral colonies and coral recruits, breaking off of coral branches, bleaching through shadowing, dislodgement of dead corals and other benthic organisms were the common damages in Gulf of Mannar (Jamila Patterson et al., 2016).

Push net operation

Push net operation is in practice throughout Gulf of Mannar. This involves bottom trawling using sails. This operation is resorted to by fishermen predominantly in the sea grass areas to catch prawns and it is also made use of in the sea grass areas near the islands. As

corals and sea grasses occur adjacent to each other near the islands, turbidity and sedimentation caused by this sort of trawling disturb the corals. There are about 300 boats being operated for push net operation in Gulf of Mannar.

Poison fishing

Poison fishing using cyanide has been in practiced in Gulf of Mannar since 1990s and early 2000. In this method, the fishes are stunned by a spray of cyanide, and are then collected by the fishermen. Poison fishing was mainly done by the collectors of ornamental fish. This method is no longer in vogue in Gulf of Mannar because of strict enforcement.

Dynamite fishing

Dynamite fishing started in Gulf of Mannar during early 1980s in Mandapam region and spread soon to Keelakarai and Tuticorin regions. With the use of gelatin sticks, wire and batteries, divers blast the reef area into rubbles to collect the shocked fishes. Reef fishes such as wrasses, parrot fishes, carangids, snappers, etc. are caught using this method. The impact caused by dynamite fishing is very severe as it damages the reef habitat and destroys the associated organisms. There are people in Tuticorin region who have lost their arms while doing this dynamite fishing operation. This activity was almost stopped in Gulf of Mannar in early 2000 with the strict implementation of the legal provisions. However, one hears of sporadic dynamite fishing from Mandapam and Keelakarai regions.

Ornamental fish collection

Ornamental fish collection in the reef area is regularly practiced over a decade. Though this unorganized trade is managed by commercial traders, the collection is done by poor fishermen. The peak season for this activity is between November and April when calm season prevails. The major locations are Mandapam, Ervadi, Keelakarai, Vembar and Tuticorin. About 40 to 50 fishermen in each location take part in the collection of ornamental fishes associated with reef and sea grass. About 8 to 10 small boats ('Vallams' or 'Vathais') are involved in each location. The collection is made using fish traps, Scoop net operation, and Skin diving. Fishermen earn from Rs. 6,000 to 7,000 per month depending on the size of catch, the season and the variety of fishes caught. The artisanal fishermen, while going for regular fishing, are also engaged in the collection of ornamental fish in the reef areas with a view to enhance the daily income (Jamila Patterson et al., 2016).

Seaweed collection

In Gulf of Mannar Marine National Park, both live and dead corals are found together around the shallow areas of the islands. The seaweeds (*Gelidiella acerosa*, *Gracilaria edulis*, *Sargassum wightii* and *Turbinaria conoides)* grow mainly on the dead corals. The dead corals also form suitable substratum for attachment of new coral recruits (coral larvae). The exploitation of seaweeds in the reef areas of marine national park at depth between 0.5m and 1.5m mainly by fisher women caused the following severe impacts to the reef ecosystem. Over 500 fisher women are involved in seaweed collection in the reef area for their daily livelihood (Jamila Patterson et al., 2016).

- The seaweed collectors mechanically pluck or scrap the seaweeds attached to the dead corals and so the collectors remove the entire seaweed along with dead corals. Due to the removal of seaweeds along with dead corals, the new coral recruits attached to dead corals are also removed along with seaweeds. This is affecting the coral growth and live coral cover.
- Since dead corals are removed from reef area along with seaweeds, there is substrate instability and so little chance for attachment of new coral recruit (coral larvae) in the affected area and this will lead to reduction of live coral area.
- Since dead corals are found along with live corals, the collectors while collecting seaweeds mechanically damage the nearby large number of live coral colonies too especially the branching corals.
- Breakage of corals leads to stress and it affects growth, survival and reproduction (spawning).
- Since seaweeds are plucked along with dead corals, the seaweed resources are drastically reduced with minimal possibility for proliferation and thus the species, *Gelidiella acerosa*,is almost locally extinct.
- Seaweeds are part and parcel of the coral reef ecosystem because they serve as very good feed for various associated herbivorous fishes. When seaweeds are removed and live corals colonies are damaged along with this removal, the associated fishery resources dependent on them vanish too from the reef area for want of food and habitat.
- Several people (more than 10 people) get involved in seaweed collection in an area at a time, and so the damage done to live coral is very severe; the collectors also disturb the reef environment by their activities, for example engendering increased levels of turbidity and sedimentation in the reef area. Higher levels of sedimentation on the live coral colonies leads to coral mortality.
- The seaweed collectors anchor their boat on the reef area, which causes very severe mechanical damage to the live coral reefs continuously.

Pollution

Along the coast of Gulf of Mannar, various small scale and big industries are found. However, no significant anomaly in the physico-chemical parameters has been observed in the Gulf waters. However the sewage outlets that drain into the Gulf remain a perennial source of sedimentation and turbidity along the coast of Gulf of Mannar. There are two major sewage outlets into Gulf of Mannar; one is in Tuticorin and the other is in Keelakarai. Apart from these two outlets, there are numerous small domestic waste outlets along the coast of Gulf of Mannar. Domestic wastes from these outlets are untreated and hence capable of causing microbial and nutrient pollution.

Mechanized trawling

Hundreds of large mechanized trawlers are being operated in Gulf of Mannar from Tuticorin, Ervadi, Keelakarai, Mandapam and Rameswaram. These mechanized trawlers are not supposed to trawl near-shore. But these trawlers sometimes trawl near the islands causing turbidity and sedimentation which in turn disturb the corals.

Surface supplied diving

Surface supplied diving for the sacred chank *Turbinella pyrum* in Tuticorin is a new threat to this region which is not subject to any kind of regulation. In this operation, sea floor is dug with metal scrappers up to two meters deep to collect dead shells; this causes severe sedimentation and it is likely that sediments would smother the nearby corals. Further, this process destabilizes the sea floor, thereby disturbing the natural coral recruitment. This operation is carried out only in Tuticorin region, where more than 2,000 fishermen are engaged. However, it is highly likely that it may spread to other regions of Gulf of Mannar.

Other fishing activities

Purse seine operation in the reef areas produces mechanical damages to the corals. The bottom settling gill nets such as crab net, lobster net, etc. harm the corals when they get entangled.

Coral status in Gulf of Mannar

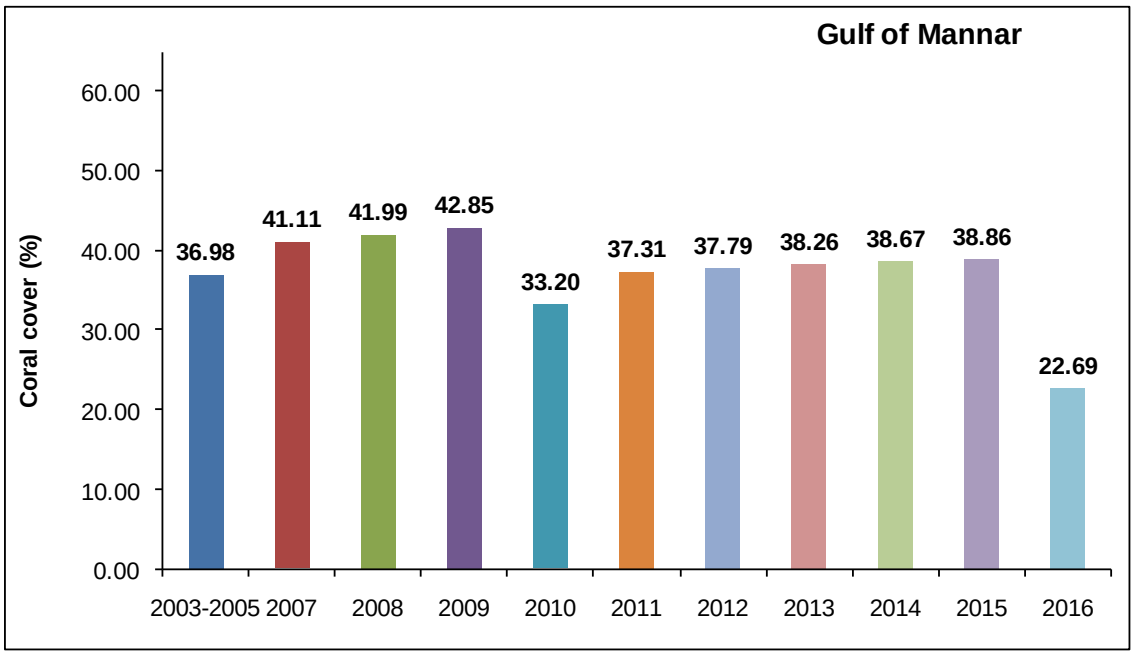
There had beenneither comprehensive baseline study undertaken nor data collected on the status of coral in Gulf of Mannar prior to 2003. During 2003-05, SDMRI conducted detailed baseline study and collected comprehensive data on the status of corals in Gulf of Mannar, especially on particulars like density, distribution, diversity and abundance. Intensive underwater surveys around the islands showed that live coral cover of Gulf of Mannar was 36.98% during

2003-05. Thereafter a regular monitoring activity is in place with permanent monitoring locations established from 2005 onwards. After the halt of coral mining in 2005, corals started recovering gradually as demonstrated by the significant increase in coral cover to 42.85% during 2009. In the absence of coral mining, adult and dead corals were undisturbed and this paved the way for successful coral reproduction and recruitment.

During 2010, a significant mortality of 9.8% was witnessed in Gulf of Mannar on account of the coral bleaching triggered by elevated sea surface temperature. Hence, live coral cover came down to 33.2% during 2010. At the same time the coral recruits remained unaffected by the bleaching during 2010, and so they started growing well and the recovery was good. The gradual increase in live coral cover sustained since 2010 brought about a live coral cover percentage of 38.86 during 2015. Severe coral mortality due to bleaching took place during 2016, reducing the coral cover to the lowest 22.69%. A mortality of about 16.2% live corals due to bleaching was recorded during 2016. Most of the affected species were fast growing coral genera such as *Pocillopora*, *Acropora* and *Montipora*. Boulders such as *Porites, Goniastrea, Favia, Favites*, etc. were not affected by the bleaching. By October 2016, the partially dead corals have started recovering and growing. It is expected that coral cover in Gulf of Mannar would increase gradually with the fast growing species if further mortality does not happen.

Apart from the reef-rich regions around the islands, there are several areas where corals occur in patches in Gulf of Mannar between mainland and the islands. A total of 9 such reef patches have been identified between Mandapam and Kanyakumari in Gulf of Mannar. The depth ranges between 0.5 to 8 m in these patch reefs. Mandapam and Keelakarai regions have one patch reef each; Vembar region has two patch reefs; Tuticorin region has three. These patch reefs look like the reef regions around the islands of Gulf of Mannar. Area cover of the patch reefs ranges between 0.7 to 16.8 km^2 and the live coral cover in these patch reefs ranges between 15.5 to 73.56%. *Turbinaria* is the dominant genus in patch reefs.

Excluding reef areas around the islands and the patch reefs, there are several other reef patches in Gulf of Mannar in deeper waters which are called “pars”. A total of 15 such pars have been discovered so far. These pars occur between 8 and 25 km from the shore and occur at depths ranging between 12-24 m. Of these 15 pars, 10 are in Tuticorin coast, 3 in Vembar coast and 2 in Keelakarai coast. These pars have hard sandy bottom with a few elevated rocks. Encrusting and massive types of corals are the dominant coral life forms in these pars and live coral cover ranges between 6.1 and 51.03 in these pars.



Coral status in Gulf of Mannar during 2003-2016 (2010 - 9.8% mortality & 2016 - 16.2% mortality due to bleaching caused by SST)

Coral reproduction and recruitment pattern

Successful coral reproduction followed by successful natural coral recruitment has been recorded in Gulf of Mannar. Multi-specific synchronous coral spawning in acroporans has also been recorded in Gulf of Mannar. Visible but immature gametes start appearing in acroporan colonies of Gulf of Mannar from January every year and they mature during March. Pigmented gametes are visible during March every year and they expel their reproductive products in March. After fertilization, coral larvae find suitable substrate to attach themselves to and grow. After the halt of mining, suitable substrates, which are dead coral rubbles, are available in Gulf of Mannar for the coral larvae to attach.

Conservation initiatives during 2007-2016

Coral rehabilitation

In India, research on coral restoration was first conducted in Gulf of Mannar by Suganthi Devadason Marine Research Institute (SDMRI), Tuticorin through the project entitled "Coral culturing and rehabilitation of degraded coral reef through transplantation of stag horn corals, *Acropora formosa* in Tuticorin", funded by the Ministry of Environment, Forest and Climate Change, Govt. of India [Ref.3/19/2000-CSC (M)] during 2002-2005.

The low-tech and low-cost viable transplantation technique to restore degraded reef areas was successfully standardized through this project.

The key findings include

- Standardization of key factors required to select suitable site for coral restoration
- Standardization of suitable artificial substrates like concrete frames and fish houses for transplantation of coral fragments.
- Suitable coral fragment size and position to fix on the substrates
- Suitable donor coral site
- Selection of various native species ratio to maintain heterogeneity
- Identification of climate change resistant and resilient coral species for restoration
- Protocol to monitor coral restoration sites

Further scaling up of the coral restoration activity in Gulf of Mannar was initiated by the Tamil Nadu Forest Department from 2007-08 onwards successfully. So far, coral restoration work was conducted in a degraded reef area of 8 km^2 around the islands in Gulf of Mannar with a survival rate of 80-85% on both branching and non-branching corals. The average annual growth was 12 cm for branching corals and 1.5 – 2.0 cm for non-branching corals.

Achievements

- The artificial substrates provided for coral transplantation also act as suitable substrates for natural coral recruitment in Gulf of Mannar, and hence live coral cover considerably increased (Earlier, due to coral mining, the substrates around islands become unstable and unsuitable for coral recruit attachment).

- Spawning activity was recorded in the restored coral sites after 4 years, which is a major indication of successful and healthy reef site.

- Though Gulf of Mannar had lost considerable live corals due to bleaching events caused by elevated sea surface temperature (9.8% in 2010 and 16.2% in 2016), coral restoration activity in Gulf of Mannar helped in the quick and steady recovery.

- Due to coral rehabilitation, there is considerable increase of associated biodiversity particularly the fish species.

- Based on the success of coral restoration activity in Gulf of Mannar and substantial increase of live coral cover, coral restoration was also experimented in Gulf of Katch in Gujarat. During 2014-2015, branching coral fragments from Gulf of Mannar was transported to Gulf of Katch by Zoological Survey of India for transplantation under a World Bank Programme.

- The successful transplantation technique in Gulf of Mannar was also successfully replicated in Malvan Coast in Maharashtra during 2014-2017 with technical expertise from SDMRI under UNDP-GEF Sindhudurg project.

Artificial reefs for biodiversity enhancement

Artificial reefs were deployed to study the biodiversity enhancement particularly coral recruitment through a research project funded under The Netherlands–India Coastal Cooperation Programme during 2002-2004 by SDMRI. The outcome of the project includes

- Standardization of suitable artificial reef module design for biodiversity enhancement, particularly coral recruitment
- Monitoring protocol for artificial reef sites

Similar artificial reef activity in Gulf of Mannar was initiated by the Gulf of Mannar Biosphere Reserve Trust with the same artificial reef module design during 2014-16 and by Tamil Nadu Biodiversity Green Project of Forest Department during 2016-17.

Achievements

- The artificial reef module design helped in the attachment of rich coral recruits.
- The deployed artificial reefs are still strong enough without any damage even after 15 years.
- The artificial reef modules also helped to increase other benthic assemblages and fish population
- The successful artificial module design in Gulf of Mannar was also successfully replicated in Malvan Coast in Maharashtra during 2014-2017 with technical expertise from SDMRI under UNDP-GEF Sindhudurg project.

Monitoring of reef areas

SDMRI has developed baseline data for the corals of Gulf of Mannar in 2003-05, and thereafter regular monitoring is in place in association with Forest Department. The following parameters are regularly monitored:

- Status of corals

- Impact of climate change on corals
- Coral diseases and health issues
- Impact of the exotic seaweed, *Kappaphycus alvarezii*, on corals
- Fish population associated with coral

Monitoring of coastal water quality and sedimentation

The water quality and sedimentation rate in the coastal area between Rameswaram and Tuticorin are regularly monitored.

Protection and restoration of Vaan island from erosion through coral rehabilitation and deployment of multipurpose artificial reef modules.

The Vaan Island is one of the 21 islands located at the southern end of Gulf of Mannar Marine National Park, and it comes under the Tuticorin group. This Island has been the most affected in the last 5 decades because of coral mining, which was completely halted in 2005. Erosion has been a serious threat to Vaan Island as it is shrinking in size over the years. As per the notification of the Gulf of Mannar Marine National Park (G.O.Ms.No.962, Forests and Fisheries, 10th September 1986), the Vaan Island had 16 hectares of area cover. Vegetation on the Island is not noteworthy as *Prosopis juliflora* is the dominant plant along with some small shrubs and salt marshes.

In May 2013, it was reported by the reef researchers from Suganthi Devadason Marine Research Institute (SDMRI) that the area of Vaan Island was reduced to approximately 5.7 hectares and has also been split into two portions, the south segment with an area of about 2.7 hectares and the north 3 hectares. During September 2014, the north segment was fully submerged and the south one was eroded fast and reduced to an area of about 1.53 hectares in Dec. 2015.

If the erosion had continued at the same pace without any intervention it is obvious that the Island would have sunk by now. The Government of Tamil Nadu provided partial funding for the proposal submitted by SDMRI to protect the island through coral rehabilitation and deployment of multipurpose artificial reef modules. A total of 10,600 artificial reef modules have to be deployed as per the results of the Wave Dynamic Study. Funding for 4,600 modules was provided by the Govt. of Tamil Nadu; the funding for the remaining 6,000 modules is from the Ministry of Environment, Forest and Climate Change, Govt. of India.

At present, the Vaan Island is protected from further erosion and island area is also increasing due to accretion.

Awareness building

Awareness building among all stakeholders through workshops and meetings are being conducted regularly by various organizations.

Capacity building of stakeholders

- Imparting of skill to conservation managers and frontline forest staff by way of training is being regularly conducted, with the focus on biodiversity identification, scuba diving, snorkeling and underwater monitoring techniques.

Strengthening the enforcement mechanism

- Strict vigilance against poachers and traders
- Making available more boats for patrolling

Management prescriptions

1. **A stricter Vigilance, Protection and Monitoring**- the current system of management and protection is not enough to guarantee the protection of the sensitive eco systems around the islands from exploitation by fisherman. There is an urgent need for increasing the number of protection guards on the island, there should be a permanent presence of at least two guards with 2 helpers at all times in each island and also the number and frequency of boats patrolling the marine area should be increased. The Area under the Marine National Park especially near and around coral reef areas should strictly be a No Activity Zone other than for protection, species/habitat restoration, research and monitoring.

2. **Natural Recovery monitoring**- Most of the sub-tidal ecosystems in the islands in the gulf of Mannar seem to be in relatively good condition, this is not to say that there have been no disturbances, but that the disturbances have been localised and relatively in a small scale. These include the islands of the Mandapam, Keelakarai and Vembar group and Karyachalli and Vilanguchalii of Tuticorin group. Most of the threats documented in the GOMMNP are due to direct anthropogenic effects such as “sea weed collection”, “destructive fishing” practises, “over fishing in island areas” and “coral mining”, with stricter vigilance of these islands to ensure that no more exploitation takes place; these ecosystems have a very high chance of recovering naturally to their original state. These areas also need to be constantly monitored for progress and

plans for a small scale in-house monitoring project on a yearly basis should be taken up for this purpose. A regular out-sourced monitoring project should be taken up for monitoring broad scale threats such as pollution(every year and also seasonally) and also for detailed mapping and diversity studies of corals ,say in a time frame of 3-5 years.

3. **Assisted restoration monitoring**- Scaling up of coral rehabilitation activity in degraded reef areas in all islands. Projects need to be taken up not only to restore the reefs through transplantation and re location but also artificial barriers be set up to protect the shore line of the islands. Regular maintenance and monitoring of rehabilitated coral sites are also equally important.

4. Development of artificial reef sites outside the Marine National Park Area for biodiversity enhancement particularly natural coral recruitment and fish production

5. Capacity building of officers and frontline staff towards marine biodiversity identification and monitoring with SCUBA diving and Snorkeling.
6. Coral reefs outside the marine national park- Reefs which are found outside the marine national park, but within the Biosphere reserve should be identified. A professional study into to extant of such reefs and their status need to be done based on satellite data and ground truthing, these areas can be designated as multiple use area and can be especially used for community based activities such as diving, snorkelling and reef watching through glass bottom boat. These reefs can be a good source of education and awareness building on coral reefs.
7. Marking permanent monitoring plots for in house monitoring once a year. The GOMBRT and GOMMNP management requires to mark permanent monitoring plots in all fringing reefs and patch reefs around the islands for in-house monitoring at least once a year , preferably during Jan - March
8. Outsourcing – a professional and scientific assessment of coral reef status , distribution and abundance , monitor pollution and prepare detail maps once in 5 years (e.g. DOD-ICMAMPD resource information system)
9. Co-ordinate and collate information into an open data database at the GOMBR research and monitoring laboratory.
10. Encourage and facilitate scientific research and monitoring of specific taxon, events and status by professional

scientific agencies with their data being documented within the GOMBR database.

9.2 Seagrasses Habitat recovery(Source: Patterson, SDMRI)

Introduction

Seagrasses constitute one of the most productive ecosystems, which provide food and shelter for many economically and ecologically important species. Seagrasses are the only marine flowering plants and are the only angiosperms that successfully grow in tidal and sub-tidal marine environment. Seagrasses belong to the families, Hydrocharitaceae and Potamogetonaceae; and they are not related to the terrestrial grasses of Poaceae. Seagrasses are capable of surviving underwater and are well-adapted to tolerate high levels of salinity. They have well-established anchoring system to withstand water movements and are capable of submarine pollination. Flattened leaves, elongated leaves, well-developed systems of root and rhizome are the chief adaptations of seagrasses to live in the marine environment. Seagrass ecosystems play important ecological roles in the marine ecosystem such as direct contribution to primary production, supplying surface for the epiphytic growth and providing shelter to a wide range of biodiversity. Seagrass meadows serve as the primary spawning, nursery and refuge habitats.

Seagrasses form one of the most predominant and specialized group of marine flora; yet in India they are known less than the other ecosystems such as mangroves and coral reefs. The major seagrass meadows in India exist along the southeast coast (Gulf of Mannar and Palk Bay) and in the lagoons of islands from Lakshadweep in the Arabian Sea to Andaman and Nicobar in the Bay of Bengal. The largest area of seagrass occurs along the coast of Gulf of Mannar and Palk Bay. Diverse group of animals such as sea horses, sea turtles, sea cucumbers, sea urchins, star fishes, gastropods, bivalves, ascidians, sponges, crustaceans etc. are abundant in the seagrass meadows making Gulf of Mannar a zone rich in biodiversity.

Distribution

The Gulf of Mannar coast and Islands have dense meadows of seagrasses, mainly between the mainland and the islands (shoreward from island), as well as towards the seaward sides of the islands. A total of 13 species of seagrasses have been documented in Gulf of Mannar. In the seaward sides of the islands, seagrasses are seen in patches. They extend to about 2 to 3 km from the Island shores towards the open sea. Little seagrass patches have been observed up to a depth of 18 m. Occurrence of persistent, strong waves in the seaward side is the primary reason for the relatively low percentage cover. Shoot density, biomass and diversity are higher in the shoreward side than the seaward side. Seagrass meadows around the islands of Gulf of Mannar form a significant grazing ground for the sea cow, *Dugong dugon*. *Thalassia hemprichii, Syringodium isoetifolium* and *Cymodocea serrulata* are the dominant seagrass species in Gulf of

Mannar. *Enhalus acoroides* is said to be an endemic species growing abundantly in the rich clay-toasted silt soil in Gulf of Mannar.

Management issues / threats to seagrasses

Threats to seagrass resources of Gulf of Mannar can be divided into human-induced and natural threats, which can further be divided into high intensity and low intensity threats.

Elevated sea surface temperature

Increase in the global average temperature has been unprecedented during the past few decades because of the Global Climate Change. The year 2015 became the hottest year on record by breaking the previous record held by 2014. Elevated sea surface temperature directly affects seagrass metabolism, photosynthesis and respiration, thereby acting as a limiting factor which decides the abundance and distribution of seagrass meadows. It is likely that temperature elevation has its impact on flowering and seed germination in seagrasses. Detailed studies on the impacts of elevated sea surface temperature have not been carried out in Gulf of Mannar. Coral reefs in Gulf of Mannar are significantly impacted by elevated sea surface temperature as evidenced by the severe coral mortalities during 2010 and 2016 through coral bleaching. In Gulf of Mannar the water temperature in summer tends to cross 33˚C, which is too high and would have its impact on seagrasses.

Sea level rise

The global rate of mean sea level rise has been estimated at 1.8 mm/year for the last century. It is expected to rise further as the Climate Change is getting severe. The major direct impact of sea level rise is the deepening of water column and the consequent reduction of light availability to the bottom. Rising sea levels reduce the light penetration to the bottom and limit the photosynthesis of seagrasses. Sea level rise also has its impact on tidal currents which in turn disturb the seagrasses by limiting light availability. The rise in sea level in Gulf of Mannar is obvious from the erosion seen along the coast. Because of the combined effects of sea level rise and coral mining, two of the 21 islands of Gulf of Mannar have submerged.

Waves and Currents

Though seagrasses are rooted firmly to the sea bottom, strong currents and waves are capable of uprooting them. During the period between September and January, tons and tons of seagrass blades are washed ashore by the action of strong waves and currents in Gulf of Mannar as evidenced by the accumulation of seagrasses throughout the coast of Gulf of Mannar.

Sedimentation and turbidity

Seagrasses are generally capable of maintaining water clarity by trapping the suspended sediments in the water column. The sedimentary particles then settle down on the benthic substratum, where they are stabilized by the roots of seagrass. But when sediment loading reaches a critically higher level, turbidity increases and sunlight penetration is hampered. Turbid waters thus disturb the process of photosynthesis. Higher sedimentation sometimes smothers the seagrasses and kills them. The rate of sedimentation in Gulf of Mannar ranges between 19.51 and 71.15 mg/cm^2/day. Turbidity in Gulf of Mannar ranges between 4 and 7 NTU, but in areas where sewage water mixes with sea water, turbidity has been recorded as high as 38 NTU.

Animal forage

The seagrass meadows in Gulf of Mannar host a large variety of animals which feed on seagrasses. The sea cow, *Dugong dugon*, feeds only on seagrasses and requires tons of them every day. Seagrasses are also fed upon by various herbivorous animals including turtles, fishes, etc. As animal foraging is a natural process in the food web, it does not affect seagrasses to a great extent.

Tsunami, cyclones and storms

The tsunami of the Indian Ocean in 2004 did not make a notable impact on seagrass meadows. The occasional cyclones and storms amplify turbidity and sedimentation in Gulf of Mannar, but no significant impact has been observed so far.

Eutrophication

Eutrophication sets in when the quantum of nutrients reaches to higher than the normal levels. Eutrophication promotes the proliferation of phytoplankton thereby enlarging their biomass. This results in the poor penetration of sunlight, which in turn induces the growth of opportunistic macro algae. Macro algae can grow fast and displace seagrasses. High concentration of nutrients is toxic to seagrass meadows. Further, eutrophication reduces the primary production of seagrasses through shading. Eutrophication has been reported from Gulf of Mannar during 2008 in Keelakarai region. Eutrophication has reportedly wrought remarkable damage to seagrass meadows in the shoreward sides of the islands Mulli, Valai and Thalayari.

Freshwater runoff

Flooding during extreme weather conditions causes increased turbidity and sedimentation. Drought and flooding have become common in Gulf of Mannar. Extreme flooding during 2015 caused excessive freshwater mix with the sea water, as a consequence of which salinity level dropped considerably to 14 ppt from 35 ppt. Though seagrasses were not significantly affected by this flooding, they are likely to be damaged by a prolonged period of low salinity.

Diseases

As any other plant, seagrasses are vulnerable to diseases. Though no study has been undertaken in Gulf of Mannar to understand the nature and prevalence of the diseases in the seagrass meadows, a typical disease called wasting disease has been witnessed.

Mechanized trawling

Bottom trawling endangers all the benthic marine life by damaging, burying and killing them. Bottom trawls are made to sweep the sea bottom where the delicate benthic organisms occur. Seagrasses are directly removed by bottom trawling and thus they suffer loss of biomass.. Hundreds of huge mechanized trawlers are being operated in Gulf of Mannar from Tuticorin, Ervadi, Keelakarai, and Mandapam up to Rameswaram. These mechanized trawlers are not supposed to trawl in the area between the mainland and islands where the main seagrass meadows occur. However, the patchy seagrass meadows on the seaward sides of the islands are damaged significantly by the mechanized bottom trawlers. Moreover, bottom trawling destabilizes the seafloor by continuous action and thereby reduces the chances of seagrass recovery. As technology improves, engines of higher horse power and upgraded bottom trawls keep the seagrass meadows disturbed.

Shore seine

Shore seines, locally called 'karai valai', are bottom trawls operated in inshore waters. They have been commonly used for long in many villages along the coast of Gulf of Mannar. In Tuticorin region alone about 600 fishermen are engaged in shore seine operation. The impact of shore seine operation on near-shore marine resources is massive, for it involves bottom trawling. Near-shore seagrasses are uprooted along with their epiphytic organisms by this method. Along with seagrasses, inhabitants such as sea anemones, sea cucumbers, star fishes, marine sponges, sea horses, juvenile fishes etc. are also dragged ashore.

Push net operation

Push net operation is another way of bottom trawling which is practiced throughout Gulf of Mannar. In this method, bottom trawling

is enabled with the help of wind driven sails. This operation is employed predominantly in the seagrass areas for catching prawns. There are about 300 boats being utilized for push net operation in Gulf of Mannar. Tons of seagrasses are swept along with the prawns and thrown back to the sea by the fishermen. But the uprooted seagrasses, though flung back into the sea, have no chance of any recovery and will be washed right back onto the shore.

Surface supplied diving

Surface supplied diving for the sacred chank *Turbinella pyrum* in Tuticorin region is a new threat to this region. In this crude diving method fishermen with a pair of metal scrappers dig the sea bottom up to 2 m in search of dead chanks which are settled in the seafloor. This indiscriminate digging renders the sea bottom unstable, which affects the bottom dwelling sessile organisms and seagrasses. Not only does this method directly affect the seagrass meadows by removing the seagrass but also indirectly influence them by stepping up sedimentation and turbidity. Although surface supplied diving operation is restricted at present to Tuticorin region it is highly likely that it would spread to other regions of Gulf of Mannar. Around 2,000 fishermen, who are not traditional chank divers, are engaged in this operation.

Pollution

Seagrasses are highly tolerant to organic and metal pollution. Anomalies in these parameters have not been recorded in Gulf of Mannar. Along the coast of Gulf of Mannar, various small scale and big industries are going on. Sewage outlets, especially the two major ones found in Tuticorin and Keelakarai regions, cause considerably larger scale of sedimentation and turbidity. Apart from these two bigger outlets, there are numerous small domestic waste outlets along the coast of Gulf of Mannar. Domestic wastes from these outlets are untreated and hence capable of causing microbial and nutrient pollution.

Bottom settling nets and Anchoring

Many bottom settling gears are used along the coast of Gulf of Mannar, which include crab net, lobster net, ray net, bottom gill net, etc. Bottom settling nets uproot a minimum amount of seagrasses while laying and collecting. As a major portion of fishery in Gulf of Mannar takes place in seagrass areas, hundreds of boats lay their anchor on seagrass meadows and damage them mechanically. Whenever an anchor is laid on seagrasses, it uproots a sizeable quantity of seagrass plants with it.

Seagrass status in Gulf of Mannar

The coast along and the islands in Gulf of Mannar have relatively denser growth of seagrass meadows. The bulk of seagrass meadows occur between the mainland and islands and the density decreases towards the seaward sides of the islands. Seagrasses in Gulf of Mannar have been witnessed at depths up to 18 m. Total seagrass cover in Gulf of Mannar Marine National Park is approximately 76 km^2. The following are the seagrass species recorded in Gulf of Mannar, *Cymodocea rotundata, Cymodocea serrulata, Enhalus acoroides, Halodule pinifolia, Halodule uninervis, Halodule wrightii, Halophila decipiens, Halophila ovalis, Halophila minor, Halophila stipulacea, Halophila becarii, Syringodium isoetifolium* and *Thalassia hemprichii.*

Seagrass area cover in Shingle Island is 2.03 km^2; Krusadai Island 2.36 km^2; Pullivasal Island 2.86 km^2; Poomarichan Island 2.8 km^2; Manoliputti Island 2.45 km^2; Manoli Island 2.7 km^2; Hare Island 4.53 km^2; Mulli Island 3.2 km^2; Valai Island 3.14 km^2; Thalayari Island 4.64 km^2; Appa Island 6.96 km^2; Poovarasanpatti Island 3.33 km^2; Valimunai Island 4.29 km^2; Anaipar Island 4.09 km^2; Nallathanni Island 4.18 km^2; Puluvinichalli Island 3.09 km^2; Upputhanni Island 3.38 km^2; Kariyachalli Island 3.87 km^2; Vilanguchalli Island 4.62 km^2; Koswari Island 3.55 km^2; Vaan Island 4. km^2. Seagrass percentage cover in Shingle Island is 42.19%; Krusadai Island 36.68%; Pullivasal Island 40.63%; Poomarichan Island 38.75%; Manoliputti Island 28.38%; Manoli Island 29.88%; Hare Island 32.03%; Mulli Island 28.5%; Valai Island 42.2%; Thalayari Island 27.9%; Appa Island 32.75%; Poovarasanpatti Island 29.85%; Valimunai Island 32.75%; Anaipar Island 29.15%; Nallathanni Island 38.4%; Puluvinichalli Island 38.4%; Upputhanni Island 38.25%; Kariyachalli Island 38.25%; Vilanguchalli Island 29.13%; Koswari Island 34.79%; Vaan Island 31%.

Seagrass meadows in Gulf of Mannar are also found outside the Gulf of Mannar Marine National Park. Survey carried out in four distinct areas outside the Park area revealed the following results: overall seagrass area cover (51.69%) was recorded in the area between Periyasamipuram and Vembar with 9.42 km^2; seagrass cover (51.78%) was 6.22 km^2 in the area between Vipar and Periyasamipuram; seagrass cover (44.78%) was 5.25 km^2 in the area between Valinokam and Erwadi; seagrass cover (45.11%) was 3.56 sq.km in the area between Koswari and Kariyachalli islands.

Conservation initiatives during 2007-2016

Development of baseline data

Seagrass rehabilitation

- Seagrass rehabilitation within 1 km^2 degraded area in Vaan Island during 2012-2014, supported by GIZ India through Dept. of Environment, Govt. of Tamil Nadu
- Seagrass rehabilitation within 1 km^2 degraded area in Koswari Island during 2013-2015, supported by IUCN India.
- Seagrass rehabilitation within 2 km^2 degraded area in Koswari Island during 2015-2017, supported by the Ministry of Environment, Forest and Climate Change under Climate Change Action Plan for Tamil Nadu
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Table . Distribution of sea grasses around different islalands of the Gulf of Mannar Natioanal Park.

		1	2		4	5	6	7	8	9	10	11	12
Sl. No		***Cymodocea rotundata***	***Cymodocea serrulata***	***isoetifolium***	***Halodule uninervis***	***Halophila ovalis***	***Halophila ovata***	***Thalassia hemprichii***	***Enhalus acoroides***	***Halophila stipulacea***	***Halophila decipiens***	***Halophila beccarii***	***Halodule pinifolia***
1	Shingle island	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
2	Krusadai island	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3	Manoli and Manoputti islands	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4	Musal island	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5	Mulli island	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
6	Valai and Tailari islands	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
7	Appa island		Y	Y		Y	Y	Y		Y	Y	Y	Y
8	Poovarasanpatti and Valimunai islands		Y	Y		Y	Y	Y		Y	Y	Y	Y
9	Anaipar island		Y	Y		Y	Y	Y		Y	Y	Y	Y
10	Nallathani islands	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
11	Puluvinichalli island	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
12	Upputhani island		Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
13	Karaichalli island	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
14	Vilanguchalli island	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
15	Kasuvar island	Y		Y			Y	Y		Y	Y	Y	Y
16	Van island		Y	Y		Y	Y	Y		Y	Y	Y	Y
	TOTAL AREA												

Management Prescriptions

1. Long term monitoring of sea grass beds with the information on status of each species using Remote Sensing Technology by the professional agencies is an immediate requirement. Based on the findings, few long-term monitoring plots on the sea grass beds need to be established so that the efficacy of the management actions can be evaluated for long term.
2. Check on pollutions which come from the all kinds of industries and other sources.

3. Prohibition of fishing on the sea grass beds, which falls inside the National Park areas.
4. Extending the present sea grass distributional limit to the historical distributional limit. Habitat restoration of the sea grass beds needs to be inititated with help of nearby professional organizations.
5. Awareness programme in the catchment area regarding the excesive use of pesticide and other chemicals and its impact
6. Seagrass rehabilitation within 1 km2 degraded area in Vaan Island during 2012-2014, supported by GIZ India through Dept. of Environment, Govt. of Tamil Nadu
7. Seagrass rehabilitation within 1 km2 degraded area in Koswari Island during 2013-2015, supported by IUCN India.
8. Seagrass rehabilitation within 2 km2 degraded area in Koswari Island during 2015-2017, supported by the Ministry of Environment, Forest and Climate Change under Climate Change Action Plan for Tamil Nadu
9. **Monitoring, evaluation and restoration**: Permanent monitoring plots in different islands need to be marked and the same need to be monitored for its biomass productivity and other associated species in that plots.Restoration experiments with the help of CSMCRI and Restoration technology adopted on a coastal lagoon in the North of Yucatan (Southeastern Mexico) may be consulted here. The agency which would be used for the restoration of this habitat is also requested to consult with 'Chapter 7. Seagrass: in Handbook of Ecological Restoration, Volume 2, edited by Martin R. Perrow and Anthony J. Davy, Cambridge University Press, 2002'.

9.3 Restoration of Mangroves(Source**:** Ramasubramanian, Selvam, Nagarajan, Anil Kumar, MSSRF)

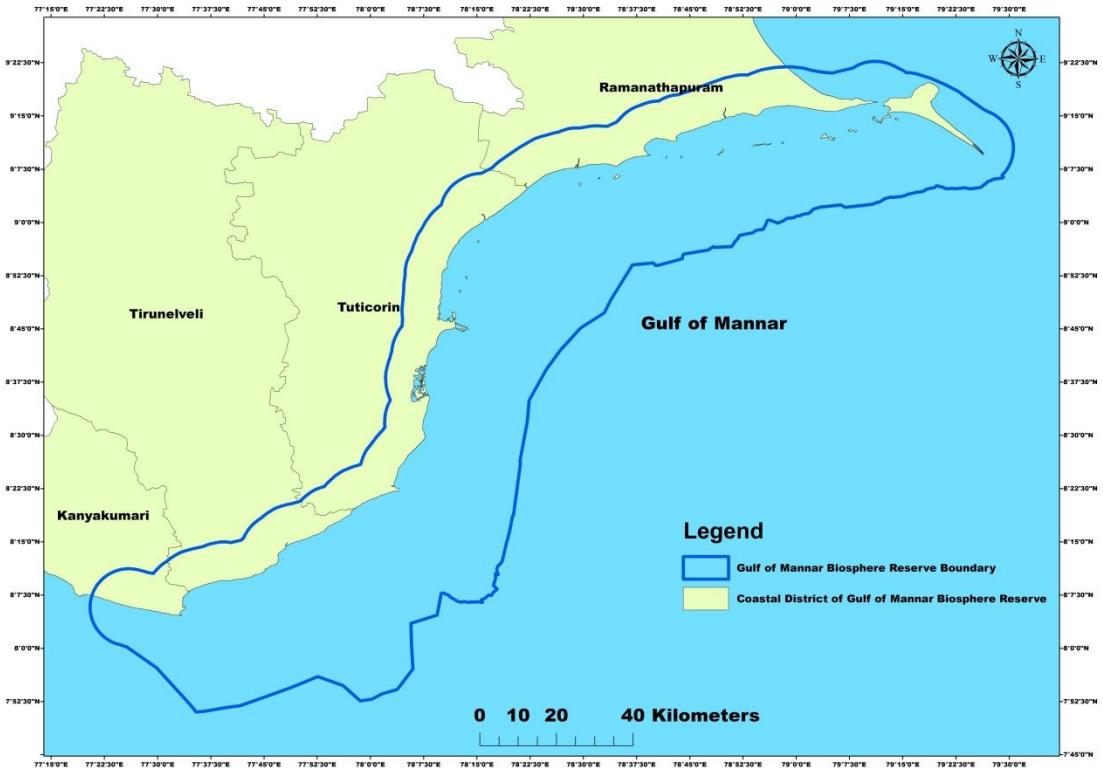
Current status of Mangroves in the Gulf of Mannar Marine National Park

The Gulf of Mannar is endowed with diversified ecosystems such as beaches, estuaries, mudflats, seagrass beds, coral reefs, algal beds, salt marshes and mangroves. It is rich in diversity and more than 3,600 species have been recorded. As the area supports many rare and endangered species, the government of India, has declared the Gulf of Mannar National Park in 1986 with 21 islands located between Tuticorin and Dhanuskodai (Fig. 1). The extent of the National Park is about 560 sq.km having larger coral reef and shallow water areas.

Later, Gulf of Mannar Biosphere Reserve (GMBR) was established in 1989 consisting of the Gulf of Mannar National Park and its 10 km buffer zone. It extends to a distance of 170 nautical miles running parallel to main coastline spreading over Ramanathapuram, Tuticorin and Kanyakumari districts of Tamil Nadu (Fig. 2). It is the first Marine Biosphere Reserve in South East Asia. The Gulf of Mannar Biosphere Reserve of Indian part is about 10,500 km^2 and is located between 8° 47' - 9°15' N and 78°12' to 79°14' E. Nearly one third of the coastal length of the State of Tamil Nadu is occupied by the Gulf of Mannar coast.

The biosphere reserve has 21 islands located between Rameswaram and Tuticorin which is unique in its biological wealth. The islands are situated at an average distance of about 8 km from the coastline of Gulf of Mannar. The total extent of islands is about 623 hectares. The islands are grouped as follows:

The Tuticorin group of islands has Vaan (16.00 hectares), Koswari (19.5 hectares), Vianguchalli (0.95 hectares) and Kariyachalli (16.46 hectares) islands.The Vembar group has 3 islands namely Uppu Thanni (22.94 hectares), PuluviniChalli (6.12 hectares) and Nalla Thanni (101 hectares). The Kilakarai group has the following seven islands: Anaipar (11.00 hectares), Vali Munai (6.72 hectares), Poovarasan Patti (0.50 hectares), Appa (28.63 hectares), Talaiari (75.15 hectares), Valai (10.10 hectares) and Mulli (10.20 hectares)The Mandapam group has seven islands: Musal (124.00 hectares), Manoli (25.90 hectares), Manoli Putti (2.34 hectares), Poomarichan (16.58 hectares), Pullivasal (29.95 hectares), Kurusadai (65.80 hectares) and Shingle (12.69 hectares)Only Krusadai, Musal and Nallathanni islands are inhabitated and other islands are uninhabitated.



A study was conducted by the Wildlife Institute of India, National Institute for Coastal and Marine Biodiversity Centre in 2006 to make and inventory of the mangroves and mangrove associated flora in the off-shore islands of Gulf of Mannar Marine National Park. This study also aimed to provide a detailed description of the present status of the entire mangrove ecosystem in the Gulf of Mannar region and to suggest the conservation, restoration and management requirements.

True mangrove flora:

In general, Gulf of Mannar islands possess some unique type of mangrove vegetation. In this study, a total of10 true mangrove species were identified belonging to 6 families of 6 order. The mangrove species *Avicennia marina* is recorded in 14 islands and *Pemphis acidula* is from 13 islands. *Pemphis acidula* is the only species found far interior of the islands where none or occasional drainage for sea water takes place. Both these species have grown luxuriantly all along the periphery and equally dominate each other. The species *Agiceras corniculatum* is found only in Krusadai and similarly *Bruguiera gymnorrhiza* is recorded only in Manoli. However these two species are found in these two islands in very low abundance. *Bruguiera cylindrica* and *Excoecaria agallocha* are shrubby and found mixed within the spaces of *Avicennia marina mangroves* in Mandapam group of islands.

The island Manoli ranks high in having 9 mangrove species and is followed by Krusadai, Pullivasal, Poomarichan and Hare Island respectively. The mangrove vegetation in Manoli is striking for its luxuriant growth and diversity. The islands Valai, Pullimunai,

Nallathanni, Upputhanni and Van islands have only one mangrove species each. When the diversity of mangrove vegetation is compared among the island groups, Mandapam group of islands ranked first in high diversity, followed by Keelakarai group. The Vembar and Tuticorin group of islands has very low diversity of mangroves.

Figure: 1. Off-shore mangrove sites of Gulf of Mannar Marine National Park

Plate: I. On-shore (island) mangroves of Gulf of Mannar Marine National Park

Table: 1. True mangrove flora recorded in Gulf of Mannar Islands during the study in the year 2006

Islands / Species	Shingle	Krusadai	Pullivasal	Poomaricha-	Manoliputti	Manoli	Muyal	Mullai	Vaaail	Thalaiyari	Appa	Puliarmunai	Anaipar	Nallathanni	Pulivinichal-	Upputhanni	Kariachali	Kaswar	Van
Aegiceras corniculatum	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Avicennia marina	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	-	✓	✓	-	✓	-	-	✓
Bruguiera cylindrical	-	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
Bruguiera gymnorrhiza	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceriops tagal	-	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
Excoecaria agallocha	✓	✓	✓	✓	✓	✓	✓	-	-	-	✓	-	-	-	-	-	-	-	-
Lumnitzera racemosa	✓	✓	✓	-	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
Pemphis acidula	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-
Rhizophora apiculata	-	-	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhizophora mucronata	-	✓	✓	✓	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-

Luxuriant growth of *Avicennia, Lumnitzera, Rhizophora* were seen only in Krusadai, Pullivasal, Poomarichan, Manoli and in Manoliputti islands. In these islands, *Avicennia* reaches maximum to 8m in height and *Rhizophora mucronata* to about 7m., but in general these trees are not very tall. Perhaps the height is curtailed due to strong winds lashing here perennially, with greater velocity during monsoons and periodical cyclones, etc. Interestingly, natural regeneration of *Avicennia marina, Rhizophora mucronata, Ceriops tagal* species by seed dispersal was observed in Krusadai, Pullivasal and Manoli islands of Mandapam group. In other islands though they do exist but have not flourished well.

Mangrove species diversity and associated species

In India, 39 true mangroves belonging to 19 genera and 14 families have been reported along with 86 mangrove associates under 73 genera and 44 families. In Tamil Nadu, 16 species of true mangroves and 23 mangrove associates along the Tamil Nadu coast were reported (Sakthivel et al., 2014). Daniel and Umamaheswari (2001) have made a detailed study in the entire area. Other studies are limited to few islands (Iyengar 1927; Rao et al., 1963; Lakshmanan et al., 1984;).

Iyengar (1927) recorded *Avicennia officinalis, Excoecaria agallocha, Bruguiera cylindrica, Ceriops tagal, Lumnitzera racemosa, Suaeda maritima, S. monoica* and *Sesuvium portulacastrum*in the Krusadai Island. Krishnamurthy et al. (1987) recorded 9 species of mangroves and 7 associated species of mangroves while Perichiappan et al.(1995) reported 13 species of mangrove and mangrove associates. The Mandapam group of islands has maximum number of species (Daniel, 1998).

Jeganathan et al. (2006) reported 10 true mangroves and 24 mangrove-associated species from the islands in the Gulf of Mannar. Gopal and Krishnamurthy (1993) have recorded only 4 mangroves species while Kathiresan and Rajendran (1998) have recorded 7 mangrove species. The diversity of mangroves and associates in Krusadai and Pullivasal was 11, followed by Manoli (10 species), Poomarichan and Hare island (9), Manoliputti (8) and Shingle (7). *Pemphis acidula* and *Avicennia marina* were recorded in 13 islands and *Sesuvium* in 15 islands. Mandapam group of island has rich diversity of mangroves. Krusadai, Poomarichan, Pullivasal, Manoli and Manoliputti Islands have large areas of mangroves of *Aegiceras corniculatum*, *Avicennia marina, Bruguiera cylindrica, Ceriops tagal, Lumnitzera racemosa, Rhizophora apiculata* and *R. mucronata*. Muyal and Shingle Islands, have only *Avicennia marina*, *Lumnitzera racemosa* and *Excoecaria agallocha*. In the Keelakarai group has *A. marina* and *Lumnitzera racemosa* in Talaiari Islands and *A. marina* and *Pemphis acidula* in Valai Islands. The Tuticorin group of Islands is very poor in mangroves. Upputhanni island has only *A. marina*. Kaswari Island had a small patch with *A. marina* and *P. acidula*. The associated species namely *Aeluropus lagopoides, Arthrocnemum glaucum, Atriplex repens, Clerodendrum inerme,*

Fimbristylis ferruginea, F. polytrichoides, Halosarcia indica, Ipomoea violacea, Pandanus fascicularis, Salicornia brachiata, Salvadora persica, Sesuvium portulacastrum, Sporobolus tremulus, Suaeda maritima, S. monoica, S. nudiflora and *Thespesia populnea* are found in the islands of Gulf of Mannar (Daniel and Umamaheswari, 2001). In general, mangrove diversity and also health is good in the Mandapam groups of islands when compared to Keezhakarai, Vembar and Tuticorin groups. In Gulf of Mannar, a total of 11 mangrove species and 17 mangrove associates were identified (Database on Gulf of Mannar Biosphere Reserve, 2015). *Ceriops tagal* in Pamban, *Pemphis acidula* and *Avicennia alba* in Palayakayal estuary are rare species found only in the Gulf of Mannar in Tamil Nadu. *Pemphis acidula* is endemic to Gulf of Mannar.

About 24 mangrove associated species were recorded from all the islands. The species *Salvadora persica* and *Sesuvium portulacastrum* were the dominant associate flora found in about 15 islands.

Similarly, the species like *Thespesia populnea* and *Scaevola taccada* have been recorded in 13 islands. *Caesalpenia*, *Dalbergia*, *Pandanus*, *Pongamia*, *Salvadora* and *Thespesia* were found distributed well away from the upper reaches of high tide. The grass species like *Aleuropus, Fimbristylis, Spinifex* and *Tamarix* were recorded at or near the upper reaches whereas halophytes *Salicornia, Scaevola, Sesuvium, Suaeda* occupies the gaps between the mangroves and in exposed areas in the mudflats. *Clerodendrum, Ipomoea,* and *Spinifex* covers the periphery of the islands.

An interesting observation is that in hypersaline areas (exposed areas where mangroves already degraded) the halophyte *Salicornia brachiata* is found occupying to maximum extant. Since they are salt loving species, their colonization in these areas is an indication of the nature getting itself repaired

Table: 3. Mangrove associated flora recorded in Gulf of Mannar Islands during the study in the year 2006

Islands / Species	Shingle	Krusadai	Pullivasal	Poomaric	Manolipu	Manoli	Muyal	Mullai	Vaaail	Thalaiyar	Appa	Puliarmu	Anaipar	Nallathan	Pulivinic	Upputhan	Kariachal	Kaswar	Van
Aleuropus lagopoides	✓	✓	-	-	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
Caesalpenia cristae	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caesalpinia bondoc	-	✓	-	✓	-	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-
Clerodendrum innerme	-	✓	✓	✓	✓	✓	✓	-	-	✓	✓	✓	-	-	✓	-	-	-	-
Dalbergia spinosa	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-
Dendropthe falcate	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ipomoea pes-caprae	✓	✓	✓	✓	✓	✓	✓	-	-	✓	-	-	-	✓	✓	-	-	-	-
Fimbristylis ferruginea	-	✓	-	✓	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
Ipomoea tuba	-	✓	✓	-	✓	✓	✓	-	-	✓	-	-	-	-	-	-	-	-	-
Pandanus tectorius	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pongamia pinnata*	-	-	-	-	-	-	✓	-	-	-	-	-	-	✓	-	-	-	✓	✓
Salicornia brachiata	-	✓	-	-	-	✓	✓	-	-	✓	-	-	✓	-	-	✓	-	-	-
Salvodora persica	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	-	✓
Sarcolobus carinatus	-	✓	✓	✓	-	✓	✓	-	-	-	✓	✓	-	✓	-	✓	-	-	-
Scaevola plumieri	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scaevola taccada	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓
Sesuvium portulacastrum	-	✓	✓	✓	-	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Spinifex litorea	✓	✓	-	✓	-	✓	✓	-	-	✓	✓	-	-	✓	-	-	-	✓	✓
Suaeda maritima	-	✓	✓	-	✓	✓	-	✓	-	✓	-	-	-	✓	-	✓	✓	-	✓
Suaeda nudiflora	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
Tamarix troupi	-	✓	-	✓	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
Thespesia populnea*	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	-	✓	✓	-	-	-	✓
Wattakakka volbulis	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Species have also been introduced in islands under Social Forestry Scheme

Threats to the Island mangroves:

Our observation documents that presently there is no direct profound threat to mangrove ecosystem in the off-shore Islands. Traces of human settlements are found on Pullivasal, Poomarichan, Manoliputti islands but are not permanent.Expansion of salt pans in and around Tuticorin is another factor leading to the shrinkage of mangroves (Kathiresan, 2008; Kathiresan et al., 2008b; Daniel and Uma Maheswari, 2001) Activities such as docking of small boats, cooking adjacent to the vegetation were also observed but they pose very little damage. Mangroves in Muyal and Pullivasal islands were harvested by the local community for their firewood needs .Natural degradation of mangroves has been observed in few islands.

The flooding stress, increased anaerobic conditions, hyper salinity and sulfide stress at water-logged area over a period of time has killed mangroves in Poomarichan, Manoli and Thalayari islands. Similarly in the planted mangrove area, due to blockage at the openings of the trenches made a layer of salt crystal have been observed on the soil surface. Mining of corals resulted in submergence of Vilanguchalli, in the Thoothukudi group, and Poovarasanpatti Island, in the Kilakarai group resulting in loss of biodiversity including mangroves (Venkataraman, 2000). Sea level rise is expected to aggravate inundation; storm surges and erosion affect the mangroves along the fringes of the island Dead stumps of *Avicenna marina* in water-logged area of Thalaiyari have also been observed.

Degraded mangrove (see dead stumps) at Thalaiyari island

Possible natural mangrove degradation pathway in islands

In addition, both soil erosion and accretion were observed in all the islands; especially at the shoreline the *Avicennia marina* experiences suffocation of pneumatophore due to accretion (south of Upputhanni) and *Pemphis acidula* have been uprooted due to erosion (South of Shingle).

Management Plan for Mangrove conservation in Gulf of Mannar

Gulf of Mannar is a special place in the Indian Ocean. The region is special because not only of the conglomeration of diverse small islands, but each exists with unique flora and fauna, rare or endemic and threatened species surrounded by a protected marine environment, and playing some critical ecological and biological functions. The already available scientific evidences show that the region qualifies many of the criteria that were proposed by Convention on Biological Diversity (CBD) in 2008 to qualify an "Ecologically or Biologically Significant Area" (EBSA) of an ocean environment.

The criteria describe EBSA are (i) uniqueness or rarity of area with reference to the species/populations/communities; habitats or geo-morphological or oceanographic features; (ii) special importance of life history stages of species (area needed a population to survive); (iii) importance for threatened species and habitats; (iv) vulnerability, fragility or sensitivity of the habitats/species/populations; (v) area with higher biological productivity; (vi) biological diversity rich in all the three different forms –genetic, species and ecosystem; (vi) naturalness with comparative high degree of naturalness due to less human influence. The Gulf of Mannar Marine National Park (GOMMNP) can be identified as a critical EBSA of the Indian Ocean.

Apart from keeping this management option proposed by the CBD, the provisions under other biodiversity related conventions such as (i) the

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); (ii) the Convention on Migratory Species (CMS); (iii) Ramsar convention; and (iv) Convention on world cultural and natural heritage also need to attract commitments from the part of national and state governments to better design and implement the management plan for the GOM Marine National Park and Biosphere Reserve (GOMMNP&BR).

We propose the Mangrove management plan of GOMMNP&BR under the following heads:

Promote Research vis-à-vis the EBSA criteria

It is important to undertake long-term research and monitoring studies of the mangrove ecosystems of GOMMNP with reference to the critical EBSA parameters like uniqueness or rarity, the vulnerability and fragility of the system, importance for threatened, endangered or declining species and/or habitats; and the biological diversity and productivity of the system.

The need for a mechanism that will help the Forest Department to identify the priority research in the sustainable management of both the NP and the Reserve is critical, and it demands a collective action by involving few credible research and management institutions in the area of dynamic conservation of mangrove ecosystem and genetic resources. It is unavoidable to have pooled and updated information to know the status of all forms of biodiversity associated with mangroves from the protected and open region.

Integration of traditional knowledge, innovations and practices of the local fishermen community can contribute significantly in the description and management of the mangrove ecosystems of the island and the shore. Documentation of such knowledge and practices would help the department of effectively engage the local community in the forest management.

The Forest Department may invite Expression of Interest from competent Research Organizations across globe to undertake target species and ecosystem services specific and Traditional Knowledge oriented long term research programme.

Promote Assisted Natural Regeneration of Mangroves

Activities that aim to accelerate natural regeneration of desirable mangrove species need to be promoted by taking into consideration of the ecological and biological characteristics of each of the island of the National Park and other key locations of the Reserve. Some of the barriers to natural regeneration of mangrove species such as soil degradation and competition with weedy species like *Prosopis* in the

present case that hinder the natural succession process, which to be reduced by undertaking carefully designed assisted natural regeneration (ANR) techniques.

It was observed that the forest department has initiated mangrove plantation mostly by planting only the species of *Avicennia marina*. This species has been planted in the restoration sites as monoculture. Science based mangrove restoration practices such as selection of species, propagation techniques and planting techniques should be evolved before scaling up of plantation in the entire area. *Pemphis acidula* is seen grown luxuriantly in the entire region, protocols need to be developed to plant *Pemphis acidula* rather than planting *A. marina* alone. *Avicennia marina* and *Ceriops tagal* have already been planted by applying canal-banking method in Thalaiyari and Muyal islands. Since there is no freshwater source, there is a lack of proper sedimentation which is the basic need to augment the mangrove growth. Further due to the blockage at the opening of canal, there is no proper drainage pattern exist and also due to prolonged evaporation the canal substratum were covered by thick salt-crystal layers. Thus the growth rate and survival of the planted mangroves aside these canal has lower probability of success.

Since there exists no perfect zonation of mangrove species distribution in these islands, the colonization of propagule and natural regeneration were found irregular. For example *Pemphis acidula* is found both at the sea-front and far interior of the islands; *Lumnitzera racemosa,* however was present only in few islands and its locality is found to unusually compete with some terrestrial flora .This distribution pattern makes it difficult to identify and determine the sites suitable for certain species. Our thorough observation reveals that *Avicennia marina, Rhizophora mucronata* and *Ceriops tagal* were the most suitable species for restoration because of their luxuriant growth and customized adaptability to these island environs. That is, there is no need to allow any newer species to occupy; instead, the native species can be established in order to assist the process of natural regeneration.

- The Forest department may be in association with the national institutions like NIOT and INCOIS can effectively use the tide and sea level data and climate change predictions to design and implement the necessary activities that directly benefit to mitigating, and adapting with climate vulnerabilities.

- Mapping of the degraded locations across the National Park and the Reserve has to be immediately undertaken with reference to both natural and man-made barriers and threats to ecosystem like salinity intrusion, soil degradation, grazing, and over harvesting. This has to be done by combining both remote sensing techniques and on the ground monitoring studies.

- Planting in the intertidal mudflats (where mangroves present historically) with most suitable mangrove species of the region has to be taken up in partnership with local community. Involve the trained local youth in planning, implementing and monitoring the mangrove plantations;

- Invasion of *Prosopis* has to be assessed and appropriate strategy has to be evolved to eradicate the species

The indicators for effective management of the GOMMNP and the Biosphere Reserve shall include (i) coverage and quality of protected mangroves; (ii) trends in area size, quality and management efficiency of the mangrove ecosystem in the Park as well as in the community conserved areas; (iii) trends in rarity and threat status of species and other genetic resources, associated with mangrove ecosystem; and (iv), number of specialists, projects and networks that are in operation with the aim of enhancement of the ecological and biological services of the protected and buffer sites.

Afforestation programs in islands:
Mangrove afforestation programs have been undertaken in islands like Muyal and Thalayari by the Tamil Nadu Forest Department from 1987-1998. The species like *Avicennia marina* and *Ceriops tagal* were planted by making long trenches. The planted mangroves and the dredged trenches were left as such without regular monitoring and due to this the trench openings have got blocked. Inspite of this, Ramachandran (2001) documented that for over a period of 11 years (1987-1998) 14.01 ha area of mangrove increased due to afforestation programs. Under Social Forestry Scheme the species like *Albizia, Pithecellobium, Pongamia, Phoenix*, *Thespesia, Borassus,* Tamarind, Coconut, Casuarina and Mango etc. have also been planted in few islands by the Department of Forest, Ramanathapuram. Since *Thespesia* and *Borassus* were native to the island they flourished well, but only few individuals of *Albizia*, *Pithecellobium*, *Phoenix* were found surviving at present. Our observation also conforms that the planted Mango trees failed to survive.

Capacity development of the Key stakeholders

Achieving simultaneously the triple objectives of CBD needs to be the top priority agenda, which requires high end capacity development of the human resource connected with mangrove resources conservation and enhancement. The needed capacity for effective management of the mangroves includes two critical areas, firstly, creation of awareness and education, especially targeting the key stakeholders like youth, mass media personnel, elected representatives, educationists, local political and other social/cultural/religious

leaders onthe value of mangrove ecosystem and its various services; secondly, mainstreaming the principles and values of conservation and sustainable use of mangrove ecosystem in planning, and developing policies and projects of the state government as well as the district/ local administrations.

However, a pre-requisite for mainstreaming mangrove biodiversity is scientifically credible evidences about the known and potential values and importance of this resource system. As part of the capacity development programme, we recommend undertaking a participatory biodiversity assessment of the mangrove ecosystem in every five years by involving knowledgeable individuals (TK holders and practitioners) from both the local and scientific communities.

Some of the important questions to be addressed by the State Forest Department are: Can we engage the local communities in the priority setting of mangrove resource management? How do we empower the Biodiversity Management Committees to safe guard the mangrove biodiversity? Is the current human resource capacity of the Forest department is adequate to understand the complexity of mangrove biodiversity management? The capacity development of forest officials, especially the ground level staff should be attempted by keeping these questions, and developing the programmes covering all aspects related to sustainable forest management.

The major outcome indicator of capacity development of the forest officials and the other key stakeholders will be India's achievement of the targets number 1, 2, 3 and 6 of the National Biodiversity Targets by 2020 and thereby contributing to the Global Biodiversity Strategy Plan and Aichi Biodiversity Targets.

On-the Ground Action

The current global trend in Biodiversity conservation is to work directly with local communities rather than only through the state run institutions. This has resulted in going for Dynamic conservation efforts, which offer strong opportunities for income security to those steward communities of biodiversity by getting them involved through market-driven eco-enterprises including eco-tourism.

The Mangrove Conservation Programme of the department in the GOMMNP and in particular the Biosphere Reserve should aim for practicing dynamic conservation where conservation and livelihood benefits are optimised. Biodiversity management needs to be promoted by giving concurrent attention to adaptation and mitigation dimensions of *Climate Change*, which will prove an effective and holistic strategy for mangrove conservation.

How to prioritize the needed projects for Mangrove ecosystem conservation in the region for the next five to ten years? All those projects need to be tailored towards achieving the relevant goals in the National Biodiversity Targets, and should have following four categories of activities.

C**ategory 1-**Activities where sustainable and equitable utilization of biodiversity that have direct socio-economic benefits, especially income generation;
Category 2-Activities where mangrove conservation directly benefit to mitigating, and adapting with climate vulnerabilities;

Category 3-Activities that increases awareness on mangrove ecosystem's value and thus benefiting mangroves itself, especially its rare and threatened group of species and varieties;

Category 4-Activities related to access to traditional knowledge that benefitting the local communities who possess unique knowledge about various uses of mangrove genetic resources.

The current implementation facilities for the mangrove conservation and coastal livelihood development such as departments of forests, fisheries and agriculture should get coordinated for achieving the goal of dynamic conservation, which will help the Forest department to build some core competency in the area of joint mangrove management. Some core management strategies to achieve this goal need to be building the capacity of the Biodiversity Management Committees, and building up a "community gene fund" as stipulated by the Indian Biodiversity Act 2002.

Partnership
Evidence for synergy and coordination between the existing institutions working on Mangrove ecosystem in the GOMMNP and the Biosphere Reserve or the state as a whole is currently invisible. Lobbying, Advocacy and Actions for Mangrove management would be possible only when there are avenues for scientists/experts to engage in consistent dialogue with the conservation plan implementation officials, policy makers at different levels-state, local, national and global. There are many major legislations and policy framework related to Biodiversity management like the Biodiversity Act 2002, Wild Life (Protection) Act of 1972 and Amendment, 1982; Coastal Zone regulation Act 1991, Wetland (conservation and management) rules 2010, operational in the state that benefit the mangrove conservation, but organizing regular interfaces on the implications of these Acts on protection of ecosystem services or the livelihoods and sustainable use of biodiversity is missing.

The need for meaningful partnership building with the Forest Department, Forest Research Organizations and NGOs working for the sustainable forest management appears urgent. Such a partnership and coordinated efforts will help to generate more funds on a regular basis from appropriate funding institutions in India and abroad.

Natural-cum-Assisted mangrove regeneration:

The natural regeneration of mangrove may be assisted to facilitate the colonization of seedlings/propagule in such a way not congregating at one area. This can be achieved by creating series of mounds in the existing mudflats (where mangroves present historically) perpendicular to the shoreline.

Minor topographical alterations at mudflats existing near the mangrove, opening of already dug-out trenches will facilitates the distribution of propagule upto the upper reaches. This also reduces the salinity at the sites where mangroves have degraded due to water-logging and hypersalinity. The available area, suitable locations, its elevation (based on field observation), the need of topographic alteration and the monitoring mechanism have been given below.

POTENTIAL AREA IDENTIFIED	**AVAILABLE AREA (HA)**	**SUITABLE AREA (MUDFLATS)** (where mangroves present historically)	**RECOMMENDED SPECIES**	**SITE ELEVATION**	**TOPOGRAPHIC ALTERATION**	**MANAGEMENT NEED AT SITES**
Krusadai	15-20	Adjacent to the north-west portion of island	*Avicennia marina, Ceriops tagal, Rhizophora mucronata*	Little (±0.5m)	Leveling the elevation	Low level (because of natural recovery)
Pullivasal	5-10	Northern shoreline	*Avicennia marina, Ceriops tagal, Rhizophora mucronata*	Little (±0.5m)	Leveling the elevation	Low level (because of natural recovery)
Muyal	>30	Northern portion of island	*Avicennia marina, Ceriops tagal, Rhizophora mucronata*	High (±1m)	Opening of inlet	Need for proper drainage in canal
Thailari	15-20	West - Centre portion of island	*Avicennia marina*	High (±1m)	Opening of inlet	Need for proper drainage in canal
Upputhani	10	South-eastern part	*Avicennia marina*	Little (±0.5m)	Leveling the	Low level

					elevation	

Note: The available area mentioned is the approximate values based on visual estimate and need to resolve using Remote Sensing, Survey maps and physical measurement.

The above mentioned sites were identified based on the standard criteria prescribed listed out in FAO (1994) mangrove management guideline. Regarding the topographic alterations it was suggested here to go for leveling the elevated parts and irregular surfaces to a gentle slope and opening of inlets to allow drainage.

Being in National Park area, these sites after restoration may not need stringent protection against anthropogenic disturbance. But boards and labels may be established to make aware of the local fishermen who sometime try to dock around these islands. The sites may need a regular monitoring toward the proper drainage in canal, clearance of temporary sand mounds due to wave actions, removal of wrasses etc. will facilitate a better restoration result.

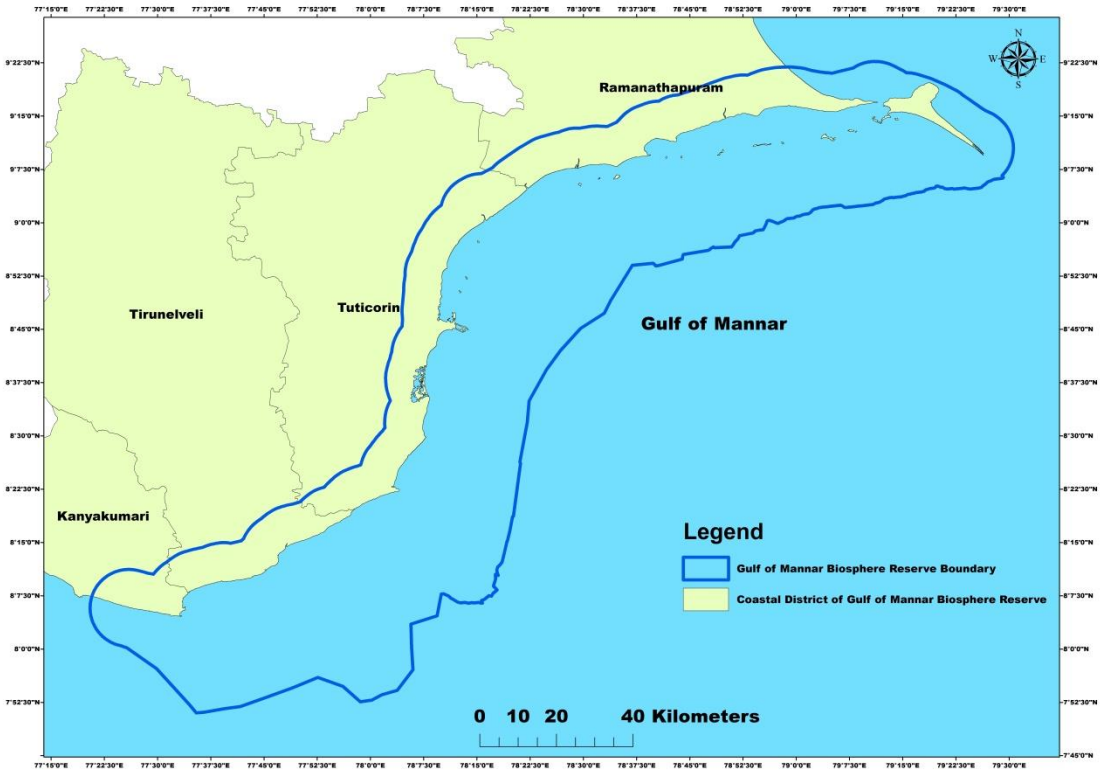
Mangrove Restoration effort journal, on the lines of forestry plantation journal to be maintained in addition to site based boards and labels so as to provide a visual was well as documented monitoring process.

Management of Biosphere Reserve
(Buffer zone)

Buffer Zone of the Gulf of Mannar Biosphere Reserve is proposed to be permitted for local people's use such as fishing and fisheries related activities in a sustainable manner. The seascape surroundings the islands beyond the limits of the National Park will form the buffer zone i.e. up to 20 m depth in seascape around the National Park and the coastal areas (10 km from the high tide mark to landward side) will form the buffer zone of the Biosphere Reserve. As per the Notification of the Gulf of Mannar Biosphere Reserve, the total area of the Reserve is 10500 sq. km, which extend from Dhanuskodi Island to Cape Comorin.

Activities in this zone:

1. Eco-developmental activities
2. Tourism
3. Permitted eco-compatible fishing
4. Maritime navigation
5. Artisanal fisheries
6. Sea weed collection
7. Shell collection using traditional methods
8. Restoration of habitats/species
9. Mariculture using native species.



History of conservation and Management of Buffer Zone of Gulf of Mannar Marine Biosphere Reserve

After the concurrence of the Tamil Nadu Governemnt (Telex message NO.75612 / FRV / 88 –3, dated the 24th January 1989) to the proposal of the Government of India for setting of a Marine Biosphere Reserve in Tamil Nadu, the Government of India vide their Notification No. No. 1/6/80-Mannar, dated 4th April 1989, declared the Indian part of the Gulf of Mannar region covering an area of 10500 sq. km as the Gulf of Mannar Biosphere Reserve (GOMBR). Suggesting the Tamil Nadu Government for preparation of detailied maps of the Biosphere Reserve and to initiate management of the BR as per the Government of India Guidelines. However, there have been no management plan for the GOMBR though the management of the BR was under the direction of the CWLW, TN and implemented by the Wildlife Warden under the supervision of the Southern Regional Wildlife circle at Madurai and later under the supervison of Conservator of Forests, Virudhanagar circle as designated as the Director, GOMBR.

Since the GOMBR surrounding the Marine National Park is the area where the local communities are dependent for their livelihood, the Tamil Nadu Government established the Gulf of Mannar Biosphere Reserve Trust (GOMBRT) under the Tamil Nadu Society Registration Act, 1975 vide TN G.O. Ms. No. 263, E&F-FR (V), dated 18.12.2000 as a special purposed vehicle to coordinate and ensure effective inter sectoral coordination and facilitate mainstreaming of biodiversity conservation issues into the productive sector and policy development. Government of Tamil Nadu sought support and assistance of the GEF-UNDP through a project 'Conservation and sustainable use of the Gulf of Mannar BR coastal biodiversity'. The GEF-UNDP approved this seven year project in the year 2002 at the cost of Rupees 140 crores, of which, the GEF-UNDP contribution was tune of Rupees 40 crores and co-funding from the Government of Tamil Nadu, Government of India and others to the tune of Rupees 100 crores.

Therefore, in addition to the Wildlife Warden, GOMMNP and the Director, GOMBR, the Director, Gulf of Mannar Biosphere Reserve Trust are responsible for protection, management and development of the GOMBR.

The Tamil Nadu Government with help of GEF-UNDP has earlier established the Gulf of Mannar Biosphere Reserve Trust, a special purpose vehicle to co-ordinate project implementation in order to effective inter-sectoral co-ordination and facilitate mainstreaming of biodiversity conservation issues into the productive sector and policy development. The Trust is registered under the Tamil Nadu Society Registration Act, 1975. However, the management and activities of the Gulf of Mannar Marine National Park is governed by the

Conservator Forests, Virudhunagar Circle and implemented by the Wildlife Warden of the National Park. The Principal Chief Conservator of Forests and the Chief Wildlife Warden guides both the GOMBRT's Director as well as the GOMMNP's Director. And hence, in a way the Chief Wildlife Warden is the statutory head for the GOM Conservation Area, the GOMBRT has statutory authority to play a focal role in the implementation of the project providing the institutional framework and to work with Government to strengthen the over all policy framework and to enable other governmental agencies for better co-ordinate and collaborate in the enforcement of Coastal Zone Regulation and biodiversity conservation.

It is now felt that the GOMBRT to be merged with **GoMBRF** not only for unified control and management of all activities of the core area of the Biosphere Reserve i.e. the Marine National Park and the buffer and the multiple use area i.e. Biosphere Reserve but also for better coordination and synergy with all other stakeholders agencies who will play an important role in the management of Reserve. The new Authority in such a situation will have better co-ordination between the management of the Marine National Park as well as the Biosphere Reserve through its own staff i.e. the Wildlife Warden, the Eco-development Officers and the suggested to coordinated with other line departments to seek the help of sociologist, biologist, fisheries and tourism officials to deal with human dimensions, research and monitoring unit, fisheries and eco-tourism aspects as well as eco-compatible and sustainable marine resource utilization activities.

The ten year composite integrated management plan for the period 2007-2016 for the Gulf of Mannar Marine National Park and Gulf of Mannar Biosphere Reserve has been developed in the year 2007 by the Wildlife Institute of India facilitated by the GOMBRT and the FIRST Management Plan for the buffer zone of the Biosphere Reserve.

Chapter 10

Management of Pollution

(Source: Murugesan, MSU)

10.1 Introduction

Since the new Tuticorin port became operational, the coast of Gulf of Mannar Biosphere region is experiencing an accelerated growth in the rate of industrialization especially in the districts of Tuticorin and Tirunelveli. Due to bloom in the culture fisheries activities which gradually replaced the traditional salt pans in this region has also changed the ecology and morphology of the coasts which has caused serious damage to the maintenance of water quality, traditional fishing, and loss of coastal habitats and benthic life (Easterson, 1998).

The utility of benthos in pollution monitoring to ascertain the health of estuarine and marine environment has been in vogue since the classical study by Wilhelmi (1916). There are several reasons why the benthos are used as indicators of ecosystem change. Firstly, the life history of benthos especially their longevity provides long term exposure to toxic substances, secondly, they live in close contact with sediments which enhances their intimacy with many pollutants and lastly the infaunal organisms reflect the situations not only at the time of sampling but also during yesteryears. These view points have been highlighted well by Kolkwitz and Mansson (1908), Forbes and Richardson (1913) and Gaufen and Tarzwell (1952). These investigations led to the development of the indicator organism concept which is the presence of a particular species or a group of species in a given locality that reflects the state of a particular environment. Among benthos, the well studied group polychaetes qualify the most of the traits of an ideal indicator organism since they constitute well over half of the organisms in and on the bottom and thus give a good indicator of benthic conditions.

Pollution can affect an estuary in four major ways: 1) oxygen depletion (e.g. from sewage), 2) chemical accumulation (e.g. toxic organic compounds, petroleum products, heavy metals), 3) spills (e.g. oil. spills) and 4) thermal pollution (e.g. heated effluent from power plants). (Ganapathi, 1975).

Almost all the estuaries/rivers in the four districts of Gulf of Mannar Biosphere Reserve opens into the sea and influenced by the tidal water of Gulf. None of them belongs to perennial water source. Most of the river mouths in the Gul of Mannar remain closed during dry seasons, especially May to August. Due to lack of continuous flow of freshwater, the entire river mouth and its adjacent mudflats are

dominated by the tidal flush and hence heavily influenced by high salinity conditions.

Reclamation of the coastal habitats for developmental activities, dumping ground for garbage, conversion of salt pans into aquaculture farms, in addition to the anthropogenic disturbances, the setting up of shrimp farms along the coast of estuaries in GOM has also become a matter of great concern. Due to delicious taste, universal acceptance, high unit value, quick growth rate, short culture period, high returns on investment and insatiable demand, shrimp farming had spread its root in India. With the recognition by Government of India as an extreme focus sector and with the patronage of government agencies and financial institutions, shrimp farming picked up fast. But due to lack of planning, there was unregulated growth leading to social resistance and outcry by environment groups regarding degradation of habitats and erosion of livelihood opportunities. It was reported that due to shrimp farming, the biota has changed and many species have disappeared (Johnston, 1976; Varshney; Amaral & Costa, 1998 and Govindan, 1995). The aftermath of industrialization, urbanization and increase in population resulted in the release of discharges to the immediate ecosystem, which causes the deleterious effects as one of the exigent and perplexing problems of the coastal environment (Folke and Kautsky 1992; Pillay, 1992 and Gajbhiye, 1995). Coastal waters of Gulf of Mannar has also reportedly become polluted due to activities in ports and harbors, sewage discharge from human settlements along the coast and industrial effluents. Disposal of wastewater and industrial effluents into the estuaries and oceans has also increase the organic pollutant load in the coastal environment (Jayamani,2002).

A major outcome of increasing industrial water use has been the increase in conflict between local communities and the industry on issues ranging from water pollution to water scarcity. In areas where there is water scarcity, industries are under tremendous pressure from community and government alike to reduce water use (Murugan, 1989). Depletion of groundwater by industries, supply of water meant for irrigation to industries, preferential treatment given to industries by the government are some of the major reasons for the conflict between industry and community over water use (Zingde and Desai, 1980; Zingde and Sabnis, 1994).

Some chlorinated compounds used in herbicides and pesticides are toxic to marine organisms and may be bio-accumulated in the coastal food chain. Pathogens such as faecal coliforms and viruses may pose a human health issue for swimming and the consumption of seafood. Hotspots include areas around sewage outfalls, industrial areas, intensive agriculture and areas that are poorly flushed by tides such as coastal lakes and lagoons (Kennish, 1992 and Frouin, 2000).

Anything that happens to a river in its catchments can have an impact on the estuary. A river flowing through farmlands can become polluted by pesticides, herbicides and nutrients from fertilizer. Soil eroded from badly farmed or overgrazed lands will also be washed into estuaries after heavy rains. This excessive silt load has the effect of filling up the estuary and in some cases resulting in the estuary mouth closing. Silt smothers animals and reduces light penetration so that plants are unable to grow except in very shallow water (Stone and Reish, 1965; Senthilnathan, 1990).

10.2 Threats or Conservation Issue

Marine Pollution

Marine pollution is a major problem on the Earth. Most sources of marine pollution are land based. The major sources of ocean pollution are classified as point and non-point sources. Point source pollution is the direct discharge of industrial wastes into coastal environment. Non-point pollution includes runoff from farmland discharge such as fertilizers, manure and industrial runoff, heavy metals, phosphorous and urban runoff such as oils, salts, various chemicals and atmospheric fallout of airborne pollution.

Oil Pollution

Oil is discharged in to the sea in various forms as crude oil and as separate fractions. Sources of chronic oil pollution include discharges of oil from marine vessels, runoff, and accidental spills and operational discharges from offshore oil and gas activities (National Research Council 1985, 2003). Most of the oil fractions are biodegradable. An oil spill releases a liquid petroleum hydrocarbon into the environment due to human activity. The oil may be a variety of materials, including crude oil, refined petroleum products (such as gasoline or diesel fuel) or by-products, ships' bunkers, oily refuse or oil mixed in waste. Spills take months or even years to clean up. The spilled oils cause more devastation to the marine environment. Petroleum oils are very complex mixtures containing large numbers of hydrocarbons, with trace amounts of sulphur, nitrogen, oxygen and different metals . Oil spillage seriously affects the life cycle of coral reefs thriving in the ocean. The oil spilled in the ocean could clog up the gills of fishes, thereby preventing respiration. Because oil floats on the top of water, less light penetrates into the water, limiting the photosynthesis of marine plants and phytoplankton. This in turn affects the food chain in the ecosystem.

Sewage Pollution

Sewage is yet another major source of marine pollution. Sewage is discharged into the oceans from all over the world mostly from urban settlement. The main sources of sewage are the coastal outfall located near the cities. The increasing shipping activities also add higher

concentration of sewage in to the harbour and shipping routes. Moreover many rivers also transport sewage from the inner regions of the land. In open coast, the effect of sewage is difficult to detect due to higher mixing up of tidal, wave and current actions. Addition of sewage into the marine leads to enhancement of nutrients. The raw sewage contains higher concentrations of organic particulate matter, home washings, detergents, small amount of oil, higher concentration of nutrients, toxic heavy metals and so on. Besides these, it also contains higher concentration of bacteria and viruses, which includes harmful pathogenic forms.

Garbage Pollution

Garbage disposal is another major form of ocean pollution. The world's oceans are a virtual dumping ground for trash. Sometimes the garbage includes junked out fishing nets, plastics, general household garbage and even like bulbs. In one case, an island 300 miles from the nearest inhabited island had 950 pieces of garbage ranging from plastics to tin cans. Garbage in the oceans are a serious issue as fish entangle themselves in fishing nets and animals sometimes eat trash products and die. There are numerous examples of dolphins, sharks and whales entangling themselves in fishing nets and dying from oxygen starvation. It is possible to clean garbage from the oceans if humanity quits using it as a garbage dump. Marine garbage can often enter into animal gut; plastic pop tab rings accidentally strangle animals and so forth. Controlling this form of pollution is important to maintain a healthy ocean ecosystem. Simple plastic bags can have large pollution impacts of the ocean. In one case, a deceased sperm whale was found to have a party balloon blocking its digestive system. The whale died from inability to process its food and died of starvation. Plastics can also have negative impacts to boats if they accidentally plug water intake lines.

Heavy Metals Pollution

Normally the metals having the atomic weight more than twenty are considered as heavymetals. The term “heavymetals” is used to denote elements with specific weight higher than those of Iron (Fe) and mainly Lead (Pb), Mercury (Hg), Copper (Cu), Cadmium (Cd) and Chromium (Cr). Coal combustion, electric utilities, steel and iron manufacturing, fuel oils, fuel additives, and incineration of urban refuse are the major sources of oceanic and atmospheric contamination by heavy metals. Heavy metal contaminated runoff from the land, rain of pollutants from the air, and fallout from shipwrecks pollute the ocean with dangerous metals.

Lead affects human central nervous system A common air contaminant due to use of bad fuel in the auto industry, now being phased out through the introduction of lead-free petrol; also in air in the vicinity of industrial plants using lead where precautions are not taken. It is a carcinogen of the lungs and kidneys. From the point of

view of industrial poisoning, inhalation of lead is much more important than is ingestion. Lead is a cumulative poison. Increasing amounts build up in the body and eventually a point is reached where symptoms and disability occur. Lead can cause irreversible behavioral disturbances, neurological damage and other developmental problems in young children and babies.

Cadmium is toxic to humans by inhalation and other routes. It can enter through ingestion, intraperitoneal, subcutaneous, intramuscular and intravenous routes. Cadmium is highly toxic to freshwater and marine organisms. It is bioaccumulative through the food chain. Increased exposure can increase risk of lung cancer. Cadmium was responsible for the "Itai-itai" disease in Japan. Hexavalent chromium in high dosages has been implicated as the cause of digestive tract cancers, cutaneous and nasal mucous membrane ulcers and dermatitis. Certain chromate salts, i.e. calcium chromate are carcinogenic, at least when inhaled.

Zinc is human skin irritant and produces pulmonary system effects. The difficulty arises from oxidation of zinc fumes prior to inhalation or presence of impurities such as cadmium, antimony, arsenic and lead. Zinc however is a needed micronutrient for humans. It is needed in agriculture. It is used in galvanising industry. The real problem is of its association with heavy metals like lead. Arsenic is toxic by subcutaneous, intramuscular and intraperitoneal routes and reported to produce systemic, skin and gastrointestinal effects. It is also a human carcinogen and experimental teratogen.

Mercury is a potent neurotoxin, capable of causing severe brain damage in developing foetuses and mild tremors and emotional disturbances in exposed adults. Implicated in the occurrence of Minamata disease in Japan, largest source of mercury contamination is through aquatic animals in which it accumulates and gets bio-transferred to organo compounds, e.g. methyl mercury. Mercury and lead poisoning cause brain damage and behavioral disturbances in children. Copper is also dangerous to marine organisms and it has been used in marine antifouling paints. Because of the pollution, the bio resources of the Gulf of Mannar are highly affected and the quality of marine water and sediments may be changed.

10.3 Pollution hotspots and their location

S.No	Place	Location	
		Latitude	Longitude
1.	Tuticorin	8.7641661	8.7641661
2.	Punnakayal	8.6241168	78.0729591
3.	Kombuthurai	8.5806855	78.1339798
4.	Thiruchendur	8.503902	8.503902
5.	Kulasekarapattina	8.3988908	78.0523610000000

	m		2
6.	Kudankulam	8.179771900000002	77.705144300000003
7.	Kanniyakumari	8.0883064	77.5384507
8.	Vaipar	9.023936199999998	78.246360200000003
9.	Valinokkam	9.20107088614095	78.561172485351556
10	Ervadi	9.2191566	78.710773099999998
11	Keelakarai	9.2343379	78.783602700000007
12	Mandapam	9.277039199999999	79.1252174
13	Pamban	9.2797601	79.229105500000006
14	Rameshwaram	9.2876254	79.312929100000002

Tuticorin

Tuticorin town is one of the major industrial pollution hotspot. There is a vast number of industries including Sterlite, SPIC, TAC, heavy water plant, etc. are located in the fort city Tuticorin. Further, there are also major thermal power plants along the coastal region including TNEB, NLC and Coastal Energen. In addition it also contains many major and minor fish processing units. Sea water of GOM region is disturbed by the VOC Port, old port and fishing harbor in Tuticorin town. Moreover there is a major domestic waste canal in Thirespuram village of Tuticorin. This untreated domestic wastes and solid wastes mix with the seawater of GOM region.

Punnakayal

There is a major river mouth in Punnakayal village. Along with the river water, agriculture wastes also mix with the marine water of GOM region.

Kombuthurai

Kombuthurai fishing village near Kayalpattinam is another prone area for pollution. The major source for pollution in this area is mainly due to the industrial effluents from various small and large industries including DCW industry.

Thiruchendur

Thiruchendur coast of Gulf of Mannar is disturbed by the activities of devotees and by the domestic waste water.

Kulasekarapattinam

Seawater in the Kulasekarapattinam village is disturbed by the activities of the devotees, especially during Dusera festival.

Kudankulam

In Kudankulam shore of Gulf of Mannar KKNNP occurs. Regular monitoring for pollution is warranted.

Kanniyakumari

Seawater in Kanniyakumari region is disturbed by fishing harbor wastes, domestic pollution and tourism.

Vaipar

There are aqua farms near Vaipar fishing village and the waste water from the farms mix with the seawater.

Valinokkam

There are aqua farms near Valinokkam fishing village and the waste water from the farms mix with the seawater.

Ervadi

Seawater in Ervadi region is disturbed by fishing harbor wastes, domestic pollution and tourism.

Keelakarai

Keelakarai coast of Gulf of Mannar has a big domestic outlet by which untreated domestic wastes and solid wastes mix with the seawater

Mandapam

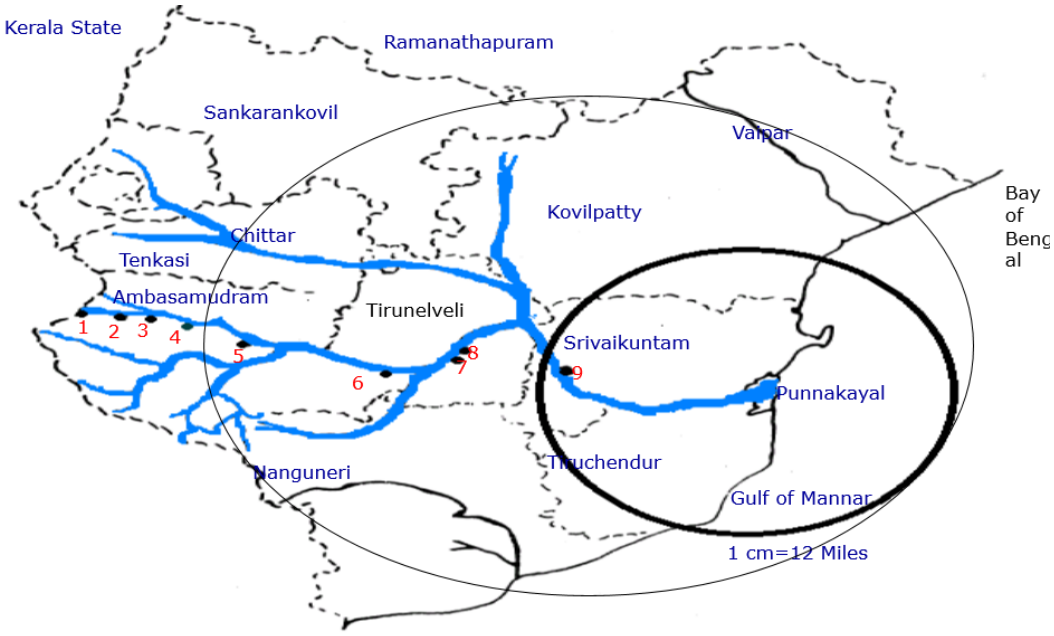
Fishing harbor wastes and processing unite wastes mix with seawater in Gulf of Mannar part of Mandapam village.

Pamban

Fishing harbor wastes and processing unite wastes mix with seawater in Gulf of Mannar part of Pampan village.

Rameshwaram

Keelakarai coast of Gulf of Mannar has a big domestic outlet by which untreated domestic wastes and solid wastes mix with the seawater



10.4 Benthic organisms as pollution indicators

Benthos - Benthic invertebrate communities are integral components of all kinds of aquatic ecosystems. The benthos – those organisms that live on or within sediments – influence sediment and bottom-water chemistry, alter sediment organic content and structure and serve as major prey species for crustaceans and fish. Although freshwater and estuarine benthos perform similar ecological functions but their composition is quite different. Estuarine benthos typically includes polychaete worms, amphipods, crustaceans and molluscs.

Benthic organisms have long been recognized as an integral part of coastal ecosystems and have been used as biological indicators of water quality for assessing the effects of industrialization and urbanization in various parts of the world (Pearson and Rosenberg 1978). As many as research works has been done on benthic organisms as an indication of various pollution in both the water and soil substratum. Because of their intact life system with these media and of its sedentary life style, they very well suite to this typical studies. Most of the studies concluded the presence and dominance of certain benthic species is an indication of relevant pollution threat in particular site. Levin (2000) describes the concept of indicator species is an attempt to use the presence and or dominance of certain species on the basis of the indicators taxon concept in a sample or area to characterize the degree of community change or pollution effects. Indicator species may belong to polychaetes, crustaceans, molluscs or to any other animal groups promptly represented in the samples.

Often polychaetes are used as an indicator species (Levin, 2000) because they are often exposed to high concentration of pollutants both in their food and in the ambient milieu. Polychaetes in general are more opportunistic in their potential to colonize stressed environments (Rhoads and Morse, 1971; Pearson and Rosenberg, 1978).

Most of the studies conducted in India are on polychaetes whereas studies on molluscs and crustaceans as biological indicators of pollution is lacking. Even though research on some benthic communities of Uppanar, Vellar, Coleroon do exists along Tamil Nadu coast, studies especially on pollution indication is negligible.

The basic concept of utilizing the indicator species to gauge pollution status is described below. Indicator organisms are used primarily to identify rather than to measure environmental changes. The cause for these changes may be the result of varying mixture of pollutants or of unknown causes. Under stress, the more sensitive organisms will get eliminated and successful species will increase in numbers to dominate the community. These species while indicating pollution help in evaluating the effect of pollution.

Determination of pollutant status in the estuaries using benthic organisms as indicators in the Gulf of Mannar Biosphere Reserve coastal areas

The purpose of this study was to document the existing benthos (benthic organisms) of the estuaries, creeks and lagoons of Gulf of Mannar coast in order to monitor the pollution status.

Fig. Estuarine/river sampling sites of GOMBR coastal areas, Tamil Nadu

Sampling sites and site descriptions

District	**Sampling site: Estuary/river**	**Position**	**Status of estuary mouth**	**PP**	**AR**	**IS**	**DS**	**AF**	**SP**	**SM**
Ramanathapuram	Kanjirangudi estuary	N09°14'712" E078°49'985"	Open	N	N	N	Y	Y	N	Y
	Vallinokkam estuary	N09°10'189" E078°38'275"	Closed	N	N	N	N	Y	Y	N
	Vembar river	N09°04'754" E078°22'887"	Closed	N	N	N	Y	Y	Y	Y
Tuticorin	Vaipar river	N09°01'787" E078 °15'015"	Closed	N	N	N	N	Y	Y	N
	Pazhayakayal estuary	N08°39'593" E078°06'846"	Open	Y	Y	Y	Y	N	Y	Y
	Punnakayal estuary	N08°38'237" E078°07'418"	Open	Y	Y	Y	Y	N	N	Y
	Veerapandi Pattinam estuary	N08°30'240" E078°07'530"	Closed	N	Y	N	Y	N	N	Y
Kanyakumari	Nambiyar river	N08°14'886" E077°48'249"	Closed	N	Y	N	Y	N	N	Y

Note: Y- Yes, N – No

PP - Power Plant AF - Aquaculture Farm AR - Agriculture run-off
IS - Industrial SewageDS - Domestic Sewage SP - Salt Pans
SM – Settlements

Source of pollutants in estuaries/rivers along the Gulf of Mannar Biosphere Reserve

Estuaries/Creek	Pollution type	Source
Kanjirangudi	Organic	Aquaculture effluent
Valinokkam	Organic and brine water	Aquaculture effluent and Saltpan
Vembar	Brine waters	Saltpan
Vaipar	Brine water	Saltpan
Pazhayakayal	Brine water	Saltpan
Punnakayal	Organic	Agricultural runoff
Veerapandipattinam	Organic	Sewage
Nambiyar	Organic	Agricultural runoff

Univariate statistics of the estuarine areas

Sample sites	Total species	Total individual	Species richness	Evenness	H' diversity index
Kanjirangudi	44	1420	5.924	0.9371	3.546
Valinokkam	28	1460	3.706	0.8663	2.887
Vembar	20	1300	2.65	0.9099	2.726
Vaipar	20	1160	2.693	0.8651	2.592
Punnakayal	55	1860	7.173	0.9258	3.71
Pazhayakayal	56	1840	7.316	0.8808	3.546
Veerapandipattinam	46	1660	6.069	0.8846	3.387
Nambiyar	23	1220	3.096	0.8542	2.678

Table . List of kinds polluting industries along sampling sites in four districts along the Gulf of Mannar coast

District	**Sampling site: Estuaries**	**Status: Estuarine mouth**	**Pollutant sources from Catchments area**	Indicator species - Benthic polychaetes	Heavy metal content of polychaete indicator species	Dominant polychaete indicator species in polluted area	Level of pollutants
Ramanathapuram	Kanjirangudi estuary	open	AF, DS	*Heteromastus similis, Lumbriconereis latreilli, Lumbriconereis simplex, Nephthys polybranchia, Nereis* sp. *Pulliella armata, Thalehasapia tenuis*	*Lumbriconereis* sp. *Nephthys* sp. – Organic materials	*Lumbriconereis* sp. *Nephthys* sp.– sewage pollution	Low
	Vallinokkam	closed	SP, AF	*Eunice* sp. *Heteromastus similis, Nephthys polybranchia, Nereis* sp. *Pulliella armata, Thalehasapia tenuis*	*Eunice* sp.- Magnesium	*Eunice* sp. .– Salt pans	Low
	Vembar river	closed	SP, DS, AF	*Eunice* sp. *Lumbriconereis simplex, Nephthys polybranchia*	*Nephthys* sp – Chloride	*Nephthys* sp.– Salt pans	Low
Tuticorin	Vaipar river	closed	SP, AF	*Lumbriconereis polydesma, Lumbriconereis simplex, Nephthys polybranchia, Eunice* sp.	*Lumbriconereis* sp. – Potassium, Magnesium	*Lumbriconereis* sp. – Aquaculture farm	Low
	Pazhayakayal estuary	open	PP, DS, SP, IS, AR	*Lumbriconereis simplex, Eunice* sp., *Nephthys polybranchia, Sternaspsis scutata, Nereis* sp.	*Sternaspsis scutata* – Zinc, Nickel and Cadmium	*Nereis* sp., *Sternaspsis scutata* – Industrial area	Medium

	Punnakayal estuary	open	PP, DS, AR, IS	*Heteromastus similis, Nephtyhs* sp. *Nereis* sp. *Prionospio polybranchia*	*Nereis* sp., - Chromium, Copper	*Nereis* sp., *Prionospio* sp., - Agriculture run-off	Mediu m
	Veerapandipat tinam estuary	closed	DS, AR	*Lumbriconereis latreilli, Prionospio polybranchia, Nereis* sp. *Sternaspis scutata, Thalehasapia tenuis, Pulliella armata*	*Lumbriconereis* sp. *Nephthys* sp. – Organic materials	*Lumbriconereis* sp. *Nephthys* sp.– sewage pollution	Mediu m
Kanyakumari	Nambiyar river	closed	DS, AR	*Heteromastus similis, Lumbriconereis simplex, Nephthys polybranchia*	*Lumbriconereis* sp.– Organic materials	*Lumbriconereis* sp. *Nephthys* sp.– sewage pollution	Low

Note:

PP - Power Plant; AF - Aquaculture Farm; AR - Agriculture run-off; IS - Industrial Sewage; DS - Domestic Sewage

Source: Abdul Azis and Nair (1982); Remani et al. (1983); Raman and Ganapathi (1983); Sunilkumar and Antony (1994); Ajmal Khan et al., (2004) and Ajmal Khan and Murugesan (2005

Species recorded in Valinokkam indicates no pollution threats observed. In Pazhayakayal, areas having high density of crustacean populations are an indication of presence of tolerant species to some pollutants such as agricultural fertilizers and to some organic effluents. Whereas in Vaipar, and Vembar having comparatively very low individuals of crustaceans species. Pazhayakayal areas represents having high densities of molluscan species is also an indication that these species do occur in polluted areas.

On comparing the polychaete and crustacean species recorded in highly polluted areas with that of present study reveals that some other species may also tolerates in the high pollution levels. The presence of polychaete species such as *Diopatra neapolitana, Eunice sp, Glycinde oligodon, Heteromastus similis, Lepidonotus tenuisetosus, Prionospio pinnata, Pulliella armata, Thalehasapia tenuis, Tharyx sp*. and crustacean species *Ampithoe ramondi, Calanus sp, Clibanarius sp. Eriopisa sp. Grandidierella sp.Quadrivisio bengalensis, Tanaeus sp*, molluscan species such as *Cerithedia cingulata, Katelysia opima, Meretrix meretrix*, *Modiolus metcalfi* and *Umbonium vestiarium* may also be taken into consideration to categorize the sites based on pollution. Even though *Cerithidea* sp. and *Meretrix* sp. are found abundantly in mangrove regions, it was reported to be tolerant for various pollutants. Absence or low diversity in certain areas is not an indication of non-polluted areas. Rather, it is possible that the animal would not be able to withstand the higher pollution limits. Hence such areas should be considered as polluted areas as well.

10.5 Management actions for pollution control and abatement

1. A policy level decision to ban untreated industrial pollutants and sewage release into the Gulf of Mannar Biosphere Reserve is proposed to be taken up with the State Pollution Control Board. All industries including Ports in the Gulf of Mannar region should be addressed and facilitated to prepare, submit and implement an Environmental Management Plan (EMP). Identify highly causative polluting industries in the region and necessary actions required for developing Environmental Management Plan for review and implementation. This needs to be taken up with the State Pollution Control Board.The coastal region should be announced as protected area and the pollution creating activities should be monitored and got rid of. The assessment of biodiversity, (corals, mangroves, sea grass etc.,) socio economic value of the coastal region, biological connectivity and its status should also be monitored. An integrated network among peoples is also much needed only after which the action will get public support. Demonstrative sites should build entire GOM region to assess all the status of entire coast.

2. It is proposed to prepare an ecological hotspots and fragile heritage maps along the coast of Gulf of Mannar Biosphere Reserve using the information provided in the Management Plan and to suggest a) no industry zone and b) permitted kind of industry zone.

3. Liaise with Tamil Nadu Pollution control Board and hasten the development of regulations for discharge of industrial effluents into the coastal waters with respect to
    a. Regulation of volume of effluent discharge (treated) – where effluents can be treated.
    b. Regulation of volume of effluent discharge (untreated)
    c. Control the number of the industries
    d. Control the volume of effluents per industry

River Tamirabarani itself carries household wastes, garbage, industrial wastes and corporation debris. Creating activities regarding minimizing the pollution in river Tamirabarani also creates effective results in GOM region. Activities of industries in and around Tirunelveli and Tuticorin district should monitored.

4. It is proposed to initiate plantation around polluted saltpans for desalination: *Salicornia* sp.,/*Avicenia* sp. may be considered for this purpose.

5. The acid wash from shell craft industries, solid and waste water from ice factories and sea food processing centers are now considered as localized pollutants in Gulf of Mannar areas, however, these pollutants may become a major one if no regulation on such kind of industries and their waste discharges.

6. The fishing activities should be ecologically effective in manner. Licensing and permissive system is essential to all fishermen. Each and every individual who is involved in fishing activities should know the bad impact of over or non-permissible fishing activities. Surveillance is needed for those activities. For this setting of ecologically sustainable level of use. Minimize the catching of non – target species. (Control the fishing net mess size). Eliminate subidies that encourage over fishing.

Some of the key points to consider

- Conduct survey and interview among fishermen to obtain the field data.
- Develop 'no fishing' zone.
- Regulate the closed fishing season for the effective manipulation of species.
- Sticking the guidelines in entire coastal region.
- Licensing system to fishermen

7. Since intensive aquaculture farm would bring localized ecological changes due to high output of nutrients like nitrates, phosphates and organic matter which in turn limit long term production and closure of the farm, detailed assessment of potential adverse ecological effects and carrying capacity of aquaculture farms and of the ecosystem into which the effluents are discharged needs to be assessed.

8. Proposed RMC of the Authority should be equipped with capability to monitor pollution levels and establishment of sampling station and share information with the TNPCB and polluting industries in every six months time period.

9. Managing the coastal area with the help of local community itself will give better results. Establish and empower community based estuary management committees, councils, agencies and enhance the community to identify a variety of issues and problems. People should be aware of coral reefs, sea grass and catchment development. Within the pollution hotspot areas an integrated EIA is very much essential to control the coastal pollution.

10. The raising of public awareness of importance of coastal region and threats to entire gulf. For this, the production and publication of awareness material especially using electronic media, broachersm AV CD's and other media is essential. Development of teaching materials and providing them to colleges, schools, universities and community colleges.
    Some more Key points to consider
    - Creating Public awareness about the importance of Coastal/ Marine environment
    - Mass Cleaning programmes to prevent entry of solid wastes
    - Enforce to strictly follow standards for effluent discharge
    - Minimal use of pesticides- Switch to organic farming
    - Strict implementation of polluter pays principle
    - Strict implementation of laws pertaining to pollution prevention & coastal zone management before establishing new industrial units/ Construction near the coast
    - Erection of continues monitoring system at critical locations
    - Ensure Zero discharge in fish processing industries
    - Announce the coastal region as Zero plastic zone
    - To ensure pukka sewage treatment plants in all the panchayats and municipalities
    - To conduct an integrated EIA along the GOM region

- Monitoring of contaminated sea food for the available of potential threats like viruses, bacteria and toxic chemicals including pesticides
- Eco Tourism – advise and encourage to announce the beach area
- Monitoring the mortality of marine organisms such as turtles fish, sea birds etc.,

11. Sometimes ships also create pollution to coastal region such as i) ship or boat collision, grounding in coastal lane, ii) discharge of seawage from ship, iii) boat/ship solid waste, iii) oil spills iv) illegal disposal of toxic wastes.

13. Study regarding the pollution and risk assessment, EIA, Species distribution and other monitoring studies shall be given to universities, colleges and to other agencies. Some of the key studies to consider

- Biodiversity
- Environment & ecosystem properties
- Monitoring of flora and fauna
- Environmental impacts of (natural and man maid)
- Fisheries
- Economic valuation of GOM region

And in collaboration with various research organizations and TNPCB, develop a Pollution Abatement Plan for this region.

Fig. 2. The grab sampling at a mangrove region

Fig. 3. Kanjirankudi Estuary

Fig. 4. Vallinokkam Estuary

Fig. 5. Vaipar Estuary

Fig. 6. Veerapandipatnam Estuary

Fig. 7. Nambiyar Estuary

Fig. 8. Sieving

Chapter 11

Species Recovery Programs in Buffer Zone

The buffer zone of the Gulf of Mannar Biosphere Reserve supports several globally important species such as the critically endangered Dugong (sea cow), all protected sharks (IWPA, 1972) including whale shark, sea horses, balanoglossus, green and hawksbill sea turtles, dolphins, lobsters, pearl oyster, corals, sea cucumbers, star fish, sea grasses and sacred chunks including several endemic species such as the Balanoglossus, sea grass, crabs and mangroves.

11.1 Dugong

Restoration and management of sea grass ecosystem of the Gulf of Mannar Biosphere Reserve.Dugong conservation is nothing but seagrass habitat conservation and management in the Gulf of Mannar Biosphere Reserve. Since the major portion of the sea grass beds are located in the buffer zone where multiple use is also permitted, the fragile sea grass habitats has already been damaged heavily due to indiscriminate fishing activities. It is proposed to initiate action to restore those degraded sea grass habitats in the Biosphere Reserve and simultaneously it is also proposed to take up conservation awareness programme among fishermen communities addressing the value of sea grass habitats with respect to fin and shell fish breeding as well as dugong. The scope of the CAMPA-Dugong Recovery Progamme needs to be extended and strengthened in the buffer zone of BR. GoMBRF has to continue the all management actions intiated by CAMPA-Dugong Project after 2020.

Management Prescriptions:

1. A detailed mapping of sea grass beds with the information on the status of each species in the Biosphere Reserve is needs to be prepared using latest satellite imageries.
2. Prevent the further decline of sea grass beds by eliminating the causes of decline such as pollution, indiscriminate fishing etc.
3. Extending the present sea grass distributional limit to the historical distributional limit.
4. Prohibition of trawling fishing on the sea grass beds.
5. Awareness programme in the catchment area regarding the excessive use of pesticide and other chemicals and its impact.
6. Restoration experiments with the help of CSMCRI and Restoration technology adopted on a coastal lagoon in the North of Yucatan (Southeastern Mexico) may be consulted here. The agency which would be used for the restoration of this habitat is also requested to consult with ‘Chapter 7. Seagrass: in

Handbook of Ecological Restoration, Volume 2, edited by Martin R. Perrow and Anthony J. Davy, Cambridge University Press, 2002'.

Recovery of Dugong in the Gulf of Mannar

Currently, there is no technology available to recover this species through *ex situ* conservation methods. However, recovering their habitat i.e. sea grass beds and avoiding poaching will help this species to recover. There maybe a migration of dugong between India and Sri Lanka through Palk Bay which is shallow water (Jones 1976). If we could restore the degraded seagrass beds in the Gulf of Mannar Biosphere Reserve then we may expect the arrival of dugong to the Biosphere Reserve. It is important to identify the critical dugong habitats and their status in the Gulf of Mannar. Encourage and support members to collate and document information on habitat disturbance and loss (e.g., seagrass dieback) and poaching. Education, including formal education, public awareness and training is critical for promoting sustainable development and improving the capacity of the people to address dugong conservation and management issues. Both formal and non-formal education is indispensable to changing people's attitudes so that they have the capacity to assess and address their dugong conservation concerns. Professional institutions such as WII, MKU, SDMRI and CMFRI may be consulted for this programme.

Poaching of Dugongs, dolphins and Turtles

Killing of dugongs and dolphins (both these are locally called as "Avolia" and "Kadalpasu") and turtles for sale for meat has reduced currently, owing to the implementation of the wildlife (protection) Act 1972 and the publicity given about the protection accorded to these mammals in the Act. However stray incidents of poaching and of incidental catches of these by the fishermen are known to still occur.

11.2 Sea turtles:

Four of the seven species of sea turtles found world wide are reported to occur in the Gulf of Mannar Biosphere Reserve. These are the olive ridley (*Lepidochelys olivacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and leatherback (*Dermochelys coriacea*. All the four species of sea turtles that occur in these coastal waters are protected under Schedule I of the Indian Wildlife Protection Act (1972), as well as listed in Appendix I of Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) which prohibits trade in turtle products by signatory countries. At present there exists no commercial or international trade of marine turtles or turtle products in India. However, incidental capture in trawls is a well-known cause of mortality for sea turtles and have been reported all over the world and the Gulf of Mannar is not exceptional to this. Turtles are being harvested in the GOM area for meat near Tuticorin.

During 1971-76 the percentage of green turtle and olive ridley caught in the Gulf of Mannar and adjoining areas was 89% and <10% respectively and during November 2001 it was 46% and 48%but in 2004 the percentage was 13% and 83% which shows

that the proportion of green sea turtles catch declined in this region drastically. The reduction in the green turtle catch could be due to overexploitation as local people prefer this species to other species for food. Since the population of green turtle was smaller in size the people were forced to exploit the olive ridley in recent days. It is necessary to recover the green species population in the Gulf of Mannar region as it has an important ecological role in the seagrass and coral reef ecosystems.

Recovery of sea turtles in the Gulf of Mannar Biosphere Reserve:
Beach management and hatchery programmes are proved to be the better methods to recover the sea turtles around the world (GOI-UNDP Project Manual). The same programme may be tried in the Gulf of Mannar Biosphere Reserve both on islands and mainland coasts. A detail manual has jointly been prepared by MoEF (GOI), UNDP, WII and MCBT on this subject can be used. Wildlife Institute of India may be approached to help the Authority to initiate a programme of this kind in the Gulf of Mannar Biosphere Reserve.

11.3 Holothurians

Holothurian Fishing
Fishing for holothurians has gained importance during 1980s although the industry is ancient and reported to have been established about hundred years ago. The two commercial important species that are collected by fishermen are *Holothuria scabra* and *Holothurai spinifer* which are processed and exported to Singapore and Hong Kong. The fishermen collect the holothurians by diving in shallow waters of 2 to 10 metre depth. Fishermen from Chinnapalam, Vadalai, Mandapam, Periapattinam, Kilakarai and Tuticorin are engaged in this kind of fishing. Annually 60 tons of Holothurians valued at Rs. 90 lakhs were collected from Ramanathapuram district of which 50% are estimated from the Gulf of Mannar area. Due to the over exploitation of the holothurians their population have drastsically declined, therefore, the Government of India banned Holothurians fishing, henceforth also in the Gulf of Mannar Biosphere Reserve.

Past and present, holothurian have been consumed as a culinary delicacy and as a high quality ingredient in many kinds of medicine, mostly exists in international trade in dried form, known as beche-de-mer (*iriko* in Japanese, *hai-som* in Chinese, or *trepang* in Indonesian). Sea cucumbers have continuously increased supply in international markets, both in tropical and temperate zones. Trends in fishery indicate that the number of producing countries and species in trade has recently increased worldwide and prone to overexploitation because of their limited mobility, late maturity, density-dependent reproduction, habitat preferences and low rates of recruitment. Around 30 species of sea cucumbers have been recorded in the Gulf of Mannar region, of these, 12 species are well known to fishermen .

Holothurians are naturaly large and sedentary organisms and fishing techniques do not require sophisticated equipment, these attributes attract the fishermen to harvest some high value species that is seen as a valuable source of income particularly to

local fisheries communities in many developing countries. Present fishery systems seem to be open for sea cucumbers resource access and overfishing to supply the demand of commercial merchandiser. Holothurians fisheries are commonly targeting the high value species, which taxonomicall are mostly identified in families Stichopodidae and Holothuriidae. Meanwhile, since certain populations of these high value sea cucumbers are in decline, new species are now being collected, adding to the number of commercial species. The Government of India banned the holothurians fishing due to drastic population decline that has been noticed in this group. The Gulf of Mannar once known for major holothurians fishing has lost a majority of its holothurians stock due to overexploitation. It is important to enhance the stock of the holothurians in the National Park because the excretions of holothurians are known to improve the populations of benthic fauna and flora which are important food for several commercially important fishes.

Stock enhancement of Holothurians

Currently, no aquaculture production of sea cucumbers has been reported to FAO by member countries but with current production trends, it can be assumed that sea cucumbers from aquaculture ventures may constitute a large portion of total world production.

Promoting research and development of restocking and stock enhancement in the Gulf of Mannar is urgently required to recover holothurians populations in this region. Most of aquaculturists and researcher work on *Apostichopus japonicus. Holothuria scabra* or sandfish seem to be the ideal tropical holothurian most suited to restocking in the western Pacific and Southeast Asian waters (FAO). The two main problems of sea cucumber restocking are the long farming period and the low number of seeds available from the wild. Mariculture for sea cucumbers exists in the Philippines, while a significant effort on resource management will have to be focused on the regulation of harvest, enhancing the natural stock with hatchery-bred individuals has become a feasible option. Same model may be tried in the Gulf of Mannar as a pilot programme with the help of professional agencies such as CMFRI, CASMS, Tuticorin Fisheries College, SDMRI etc.

Stock enhancement of commercially important species

Core zone at present have a good representation of the various marine ecosystems component and are fairly in good condition which need to be strictly protected without major management activities. Research and monitoring, habitat restoration (mangrove restoration, coral reef restoration, seagrass beds restoration, stock enhancement of critically endangered species such as sea horse, holothurians etc., removal of invasive species) and protection are the only three activities proposed to be taken up inside the National Park. Plantation of exotic species is to be strictly prohibited on the islands and removal of these exotic species is also prescribed with proper planning.

Except research, monitoring of biodiversity and restoration, no other activities is proposed to be permitted in the core zone. The strict protection given to the core zone will result in spillover and migration of the faunal wealth to the buffer zone and will be available and can be harvested in a sustainable manner by the people who are directly depend on these resources for their livelihood, especially those who live in the terrestrial buffer zone. It will also help in the economic development and a source of revenue to these coastal districts.

Core zone area at present has a good representation of the various marine ecosystems components and are fairly in good condition which need to be strictly protected without major management interventions. Research and monitoring, habitat restoration (mangrove, coral reef, seagrass beds and stock enhancement of critically endangered species such as sea horse, holothurians etc., removal of invasive species) and protection are the only three activities proposed to be taken up within the National Park. Plantation of exotic species is to be strictly prohibited on the islands and removal of these exotic species with proper planning is also prescribed.

The core zone of the Biosphere Reserve i.e. the Marine National Park and its biodiversity need to be protected strictly from any kind of anthropogenic activities except the activities related to habitat and species restoration and research and monitoring. Therefore, it is important to strengthen the protection force of the Biosphere Authority by having Forest Watchers Headquarters in each island, which is in addition to the existing protection force. Minimum of two forest watchers should be posted in each of the island with a motorboat and communication systems. People who are posted on the island needs to be given special incentives and their stay on the islands should not harm the biodiversity at any level. Minimum accommodation facilities (eco friendly protection huts) may be created in each larger island. Responsibilities of the proposed protection force under the control of the Wildlife Warden need to be extended to other zones of the Biosphere Reserve too. Any violation of the Indian Wildlife Protection Act, 1972 and the Management Plan of GOMBR, any where in the Biosphere Reserve should not be allowed. This should be the responsibilities of the protection force under the Wildlife Warden of the National Park and also by the other staff of the Biosphere Authority

Stock enhancement of species that are important for subsistence and economic importance to dependent communities.

Commensurate with the traditional dietary spectrum of the local inhabitants and the increasing evidence of a large number of marine fauna entering into the local, regional and global commercial market, there has been an over exploitation of many such resources. The current status of many marine resources are in a vulnerable state and an increasing number of species are being considered to be taken into the threatened and endangered category and to be provided strict protection. In a

situation like this there is drastic decline in the number of species that can be harvested without any legal hindrance. It is, therefore, important that the 'stock enhancement option' for select group of harvestable resources are initiated. Such programmes are proposed to be taken up in the National Park limits where no fishing is permitted. This will provide the replenish stock to grow in a sheltered and protected situations and spill over into the Biosphere Reserve limits where controlled and sustainable harvest by users is permitted. The community at large will view this activity as an effort by the Biosphere Reserve Authority as a positive and supportive action rather than a ban on resource use. Fortunately, for a range of economically important and subsistence level use resources, the technology has been developed with fair degree of extension and technology transfer mechanisms in placed. A few species suggested to be included under this programme can be enhanced after the success of the pilot programmes. A range of species for which such programmes can be initiated is appended. A similar approach of creating livelihood opportunities involving propagation of indigenous marine flora and fauna that are not in the threatened and endangered category have also been suggested in the Eco-development plan chapter.

Table: Major actions required to recover certain marine species in the Gulf of Mannar Biosphere Reserve.

Sl. No.	Species	Increased awareness programme based on species status and	Enforcement and protection from species removal	Status survey and population estimation	Stock enhancement	Species recovery actions	Protected by	Professional Institutions needs to be consulted
1	Sea turtles	√	√	√		√	IUCN, IWPA, CITES	WII, MCB
2	Dugong	√	√	√		√	IUCN, IWPA, CITES	WII
3	Sea horses & pipe fishes	√	√	√	√		IWPA	CASMS, CMFRI
4	Lobsters				√			TFCRI, CMFRI, CFRI, CASMS
5	Holothurians	√	√	√	√		IWPA	CMFRI,

								TFCRI
6	Reef fishes	√		√	√			CMFRI, TFCRI
7	Balanoglossus	√	√	√				TFCRI, SDMRI
9	Commercially important crabs				√			CASMS, TFCRI, CMFRI

Chapter 12

Conservation of protected sharks in Gulf of Mannar National Park and Biosphere Reserve

(Source: Shoba, Manojkumar, Remya, Ranjith, Zacharia – CMFRI)

12.1 Introduction

The relevance of the Gulf of Mannar ecosystem to shark species and diversity cannot be overstressed. The pristine coral reef habitats in the Gulf of Mannar ecosystem provide the perfect aggregation grounds for breeding and feeding populations of several fish groups, including sharks. The park includes estuaries, mudflats, beaches and forests of the near shore environment. It also includes marine components such as coral reefs, seaweed communities, sea grasses, salt marshes and mangroves, all of which are critical and key habitats that promote such aggregations. There are several records of the earliest sightings, strandings and landings of different species of sharks along this coast. Raje et al. (2007) has noted that the Gulf of Mannar is rich in elasmobranch diversity and sharks were being regularly exploited in this region. Although consumption and grade were on a low scale in early years, increase in market demand in recent years have promoted while body utilisation of sharks, including trade for shark oil.

Both, the GoM MNP and the GoM BR are already under the ambit of good fishing and seafaring regulatory policies defined by the TN MFRA and region-specific regulations. However, periodic review of the status of critical resources is always warranted. Sharks are at present a highly threatened group which have come under the global scanner. There is a widespread move to bring as many shark species as possible and necessary under the protection of different conservatory measures. Being a major shark fishing nation, India too has implemented several regulatory measures on shark fishing and trade.

Diversity of sharks in the GoM National Park and Biosphere Reserve

Shark catch along Tuticorin coast are mainly supported by the families Carcharhinidae, Echinorhinidae, Hemiscyllidae, Alopidae, Sphyrnidae and Squalidae. The family Carcharhinidae alone represented 45.1% of shark catch and family Hemiscyllidae represented 30.6% of shark catch (Abdussamad *et al.*, 2006). In the Pamban region of Gulf of Mannar about half a dozen species of sharks are commonly reported from the catches by drift nets at 20-60 metres of which the most important are *Sphyrna zygaena*, *Carcharhinus limbatus* and *Scoliodon laticaudus*. Occasional and accidental catches of the tiger shark and whale shark are also recorded in this area. The carpet shark *Chiloscyllium* spp. is often caught with bottom-set gillnets operated in the Gulf of Mannar region.

The deeper areas of Gulf of Mannar off Pamban have been observed to be good potential fishing grounds for a number of sharks, especially for the hammer-head (*S.*

zygaena), which is observed to breed in this area. Sudarsan *et al.* (1988) identified the existence of potentially rich grounds for pelagic sharks off the Gulf of Mannar. The incidence of non-conventional species of deep-sea shark species has also been reported from the Tuticorin region of Gulf of Mannar by the deep-sea trawlers (Devadoss, 1996). Nair and Mohan (1973) reported deep sea sharks such as, *Halaelurus hispidus*, *Eridacnis radcliffei* and *Eugaleus omanensis* in the Gulf of Mannar region at the depth of 200 fathoms. The landing of whale shark (Kasinathan *et al.* 2006; Ranjith *et al.* 2014) and thresher sharks (Ranjith *et al.*, 2014; Gowthaman *et al.*, 2013) have also been reported from Tuticorin waters of Gulf of Mannar.

12.2 Current status of shark fishing in the GoM

There is no exclusive or regular targeted shark fishery in the GoM, and sharks are usually brought in as a bycatch of many multispecies gears like trawls, hook and lines and the drift gillnets. Sharks are exploited in the region by both mechanised and non-mechanised vessels. Major trawl landing centres are Mandapam south, Mandapam north, Rameswaram, Valinokkom, Tuticorin and Chinna Muttom. Other landing centres where both the trawlers and traditional vessels also land sharks are Pamban, Keelakkarai, Chinna Ervadi, Vembar, Veerapandianpatinam, Thiruchendur, and Cape Comorin. Among these, Virapandianpatnam and Mallipattinam are the most important centres where the mechanised gillnetters from Ramnad and Tuticorin districts migrate and camp, at Virapandianpatnam during April-September and at Mallipattinam during September-January. They use special large mesh (170–190 mm) drift gillnets to harvest sharks and other pelagic species.

In the recent years, Tharuvaikulam, Threspuram and Punnakayal coastal villages in Tuticorin have emerged as important landing centres where sharks are often landed as bycatch along with the tunas and other large pelagic fishes caught by mechanised gillnetters and large meshed drift gillnet (paruvalai) and hooks & lines operated from traditional fishing craft (vallam) (Kannan *et al.*, 2013; Ranjith *et al.*, 2013; Sivadas *et al.*, 2013). The fishermen of Kombuthurai fishing village in Tuticorin who had migrated from Kanyakumari a decade ago, targeted sharks by hook and line fishing but later shifted to pelagic resourcess like carangids, seer fishes, baraccudas etc. Murugan and Durgekar (2008) have observed that trawlers are employed from Tharuvaikulam and Arkatuthurai for operating drift nets (*udu valai, sella valai, paru valai*) targeting tuna, seer fish, sharks and carangids. While drift nets and hook & lines are mainly used in the southern part of the Gulf of Mannar (from Tharuvaikulam and Threshpuram respectively), *thirukaivalai* (bottom set gill nets) are used in the northern part to catch rays.

During the period 2012-16, the total landing of sharks in the GoM region across the districts of Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari was about 27283.5 t, of which 72% was landed by trawlers, 23% by mechanized and motorized gill nets and 3.5% by hook s& lines. The bulk of the landings (75%) was recorded from Ramanathapuram and Kanyakumari (Fig. 1).

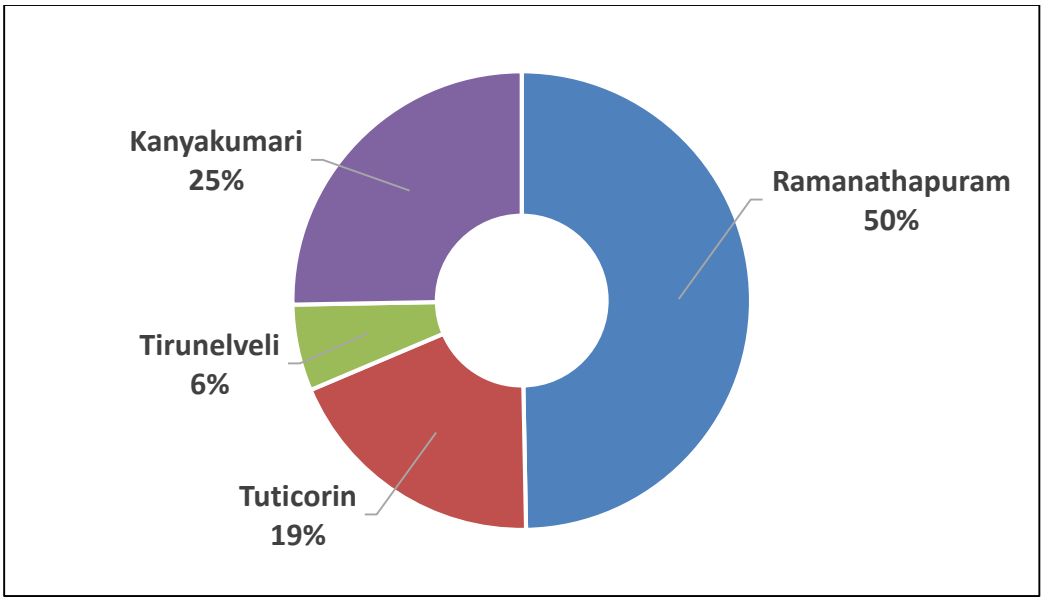


Fig. Percentage share of different districts to shark landings in GoM during 2012-16

In Tuticorin district where the landings are more or less exclusively from the Gulf of Mannar waters, the total shark landings during 2012-16 was about 5163 t. The landings showed a steady trend (Fig. 2). About 49% of these landings were by mechanized trawlers, 35% by motorized gill netters, 10% by mechanized gill netters and 5% by motorized hook & line operators.

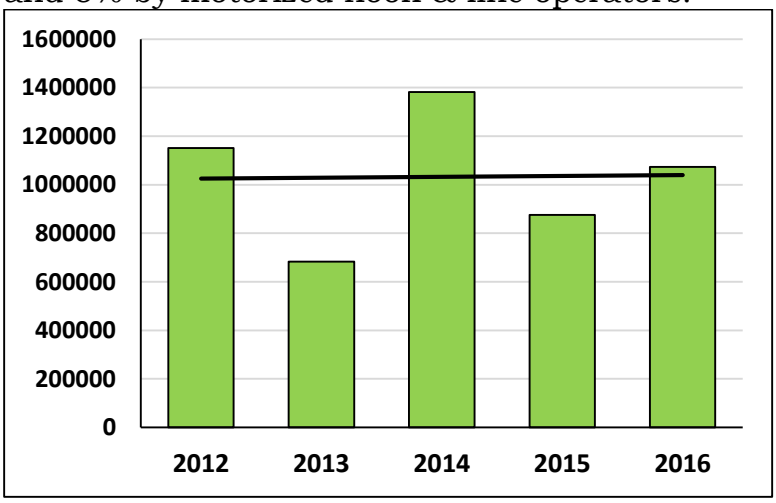


Fig. Shark landings in Tuticorin during 2012-16

In 2015, the shark landings were dominated by rays. Guitarfishes formed a very megligible part of the landings. (Fig. 3).

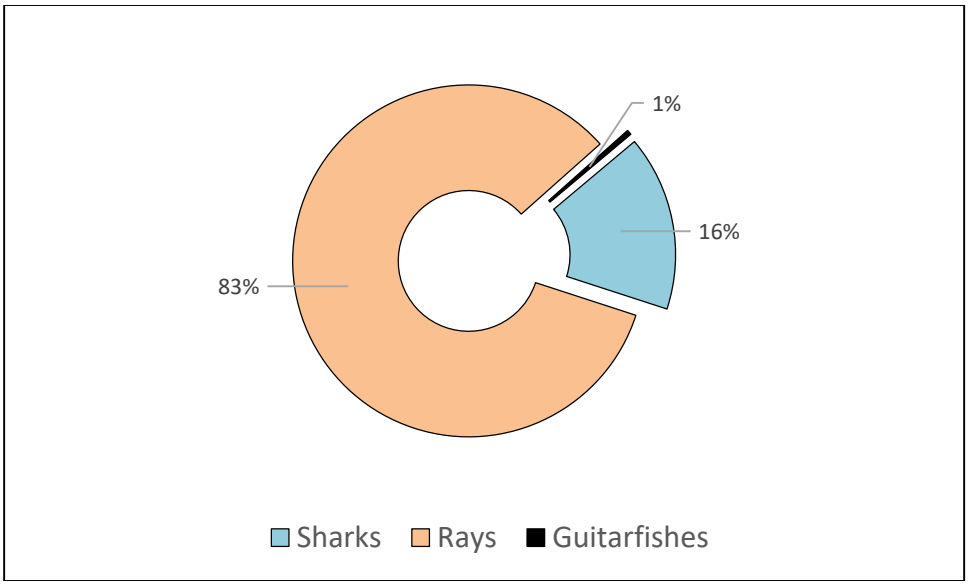


Fig. Share of sharks, rays and guitarfishes in total shark landings in Tuticorin during 2015

Eleven species of sharks and 10 species of rays were prominent in the landings (Table 1.). 11

Table Composition of shark landings in Tuticorin during 2015

SHARKS	% contribution
Thresher sharks	46%
Milk sharks	4%
Spade-nose sharks	6%
Hammerhead sharks	3%
Carcharhinid sharks	26%
Bamboo sharks	15%
RAYS	% contribution
Devil rays	33%
Whiptail sting rays	51%
Cow-nose rays	9%
Eagle rays	6%
Butterfly rays	1%

Abandoned targeted gillnet fishery of sharks at Chinnapalam, Gulf of Mannar

The shark fishery along the Gulf of Mannar side of Ramnad district was supported by both trawl net and gill nets during the period 2000-06, with the major contribution being from the gill nets. The fishermen in the Chinnapalam area of Gulf of Mannar (GoM) were engaged in the operation of a type of gillnet, locally called as '*thirukaivalai*' during this period, specifically targeting rays. The fishing ground (sandy bottom off Chinnapalam to off Danushkodi) is 5-10 km away from the shore at a depth of 15-23m.

The operation of *thirukaivalai* had slowly dropped over the years due to low price of rays, increasing cost of fuel and higher demand for other resources like crabs and lobsters. The fishing operations in the area were eventually diverted to exploitation of crabs and other finfishes. At present, only a single boat only is operating gillnet by four fishers.

Table 2 . Characteristics of gillnet fishery at Gulf of Mannar over the years

Sr. No.	Particulars	Fishery up to 2006	Fishery during 2016
1	Total boats	30-35	1
2	No. of Thirkkaivalai	1500-1750	100
3	Catch/boat (kg)	500-1000	40-100
4	Price/kg (Rs.)		
	A. narinari & *A. ocellatus*	10	60-100
	H. bleekeri	3-5	70-150
5	Other gillnets (%)	few	99.5

Existing management practices/issues/lacunae and suggestions

As all the 21 islands come under the Marine National Park sphere, tourism and other related activities are NOT allowed. Fishing regulations in place within the GoM MNP & BR are equally effective in curtailing undue exploitation of sharks, particularly protected or endangered species in this region. The protection of 10 species of sharks (4 sharks, 2 rays, 1 guitarfish and 4 sawfishes) under the Wildlife Act, 1972 in the year 2001, created an initial outcry in the fishing industry. However, with enforcement measures falling in place gradually, alongside awareness generation movements by Central and State Government agencies and NGOs, has led to acceptance and compliance along the Indian coast, including the GoM area. Further, the total ban on shark fin trade declared in 2014 and the inclusion of several species under the CITES during 2014 and 2017, have helped to tighten the reins on undue exploitation for sharks through targeted fishing. However, there still exists a gap between the fished, the traded and the reported, and the need of the hour is to bridge this gap in order to put in place effective regulatory and management plans for conservation of the protected and endangered resources. In general, the fisher communities are characterized by low literacy rate, lack of awareness of environmental issues, low income and a resulting reluctance among fisher folk to take up livelihood options other than fishing (Patterson et al., 2007).

12.3 Management prescriptions

1. Immediate documentation of current fishing grounds on a spatio-temporal basis with respect to shark resources – this can be done on a participatory approach. Data sharing between fishers and government research/implementation agencies can be made mandatory through educating the fishers about the biological vulnerability of shark resources. Such data can be used to identify seasons and grounds of shark aggregations for feeding and breeding and can be more effective in determining closed seasons, closed grounds and gear restrictions.

2. Defining the availability of resources within the GoM waters – this can be done either with the help of fishermen or through exploratory surveys. The latter is time consuming and entails utilisation of manpower and funds which can prove constraining. Hence, a participatory approach is called for. Correct information on fishing grounds can be obtained from fishers who operate in both GoM waters and in nearby fishing grounds to the north of GoM and further along the south-west coast of India. Landings in Kanyakumari and Ramanathapuram district are often a mix of resources from widespread waters and therefore can be misleading while interpreting them for managing the resources in the GoM.
3. Occurrences (sightings and incidental catches) of protected species, particularly the whale shark, pondicherry shark, all sawfishes, giant guitarfish and porcupine ray, and the CITES listed species – hammerhead sharks, oceanic white-tip shark, manta rays, thresher sharks, silky shark and devil rays, must be mandatorily reported to the monitoring agencies. Wherever possible details regarding grounds, gear, weight of catch, numbers caught etc. must be recorded and shared.
4. While the GoM MNP is under strict regulation, seafaring activities like shark ecotourism can be encouraged in the GoM BR, to reduce shark fishing and offer alternate livelihood means for the fishers. Spotting and swimming with the whale shark can be promoted along the lines followed in countries like Australia and South Africa.
5. The impact of habitat degradation in the GoM BR due to anthropogenic and natural factors can be mitigated by deploying coral embedded artificial reefs to increase the coral reef spread.
6. There should be a widespread awareness campaign in the region and fishers and locals should be educated about vulnerable shark resources ad the need for conservation and management. Posters, pamphlets and handouts can be distributed for generating awareness. Research agencies like CMFRI and NGOs can play a major role in these campaigns.
7. Continuous monitoring of shark occurrences and landings must be done to establish a strong database that will easily reflect changes in fishing and landing patterns as well as trade and utilisation, following the implementation of regular action plans which can be altered according to the status of the resource.
8. Strong linkage must be made mandatory between different agencies including research bodies, legislative and management implementing authorities, monitoring agencies, NGOs, fishermen associations, trader associations etc. with all the agencies working towards a common goal which protect the habitat, he resource and the interests of the primary stakeholders without affecting their livelihood.

Chapter 13

Management of Molluscan Diversity in Biosphere Reserve

(Source: Stella Chellaiyan, DOCAS, AU)

13.1 Introduction

Molluscans are important for maintaining the integrity of marine ecosystem and its functioning. Gastropods are either grazers, predators of invertebrates or scavengers. They control the excessive algal growth by grazing the rock surfaces and check the outbreaks of nuisance invertebrates. The gastropod, giant triton (*Charonia tritonis*) is one of the species that feeds on the crown-of-thorns starfish (*Acanthaster planci*), which can cause massive destruction to the coral reefs. Even though *C. tritonis* is a potential *A. planci* predator, its effect of predation on populations of *A. planci* has been questioned.

Top shells (*Trochus spp*) are mainly herbivorous, feeding on fleshy algae and algal films that typically develop on live rock; they are also known to forage on organic detritus. Helmet shells (*Cassis cornuta* and *Cypraecassis rufa*) checks the outburst of sea urchins that graze on the soft lime stone rocks and corals when feeding on algae. Marine mollusks such as Bivalves are important filter feeders of marine ecosystem and they convert large quantities of organic matter into protein.

However, there was no detailed information about such important taxa especially their ecology, status, distribution and threats available with respect to Gulf of Mannar Biosphere Reserve. But, historically the Gulf of Mannar is known for its pearl oyster collection and this oyster species became very rare due to over exploitation. The dependency on marine resources has gone beyond fulfilling the daily needs and crept into exploiting it beyond healthier fractions thereby endangering these resources critically affecting the marine ecosystem. WII study reveals that legally protected marine molluscan species are exploited in alarming amounts and traded as curios across coastal tourist and pilgrim centers of Tamil Nadu. High market demand coupled with lack of awareness and inadequate enforcement is the major driving force for illegal marine curio trade.

The investigation of the littoral fauna of Krusadai Island in the Gulf of Mannar was undertaken by Frederic Henry Gravely (1927). Satayamurthi (1940) his noteworthy publications are on the Molluscs of Krusadai island in the Gulf of Mannar“ Amphineura and Gastropoda”Vol.1(Satyamoorthy, 1952,56,The pioneering work on gastropod molluscs of Tamil nadu was by Melvill and Standen (1878) which was followed by Crichton (1940,1941) and Gravely (1942). The only major investigation on the bivalves is by Crichton (1941) and Gravely (1941).. Satyamurthi (1956) carried

out a detailed study on the material of Scaphapoda, Pelecypoda and Cephalopoda from Krusadai Island. Bivalves and gastropods of the Indian seas reported by Ganapati and Sarma (1972). Mahadevan and Nayar (1974) Pearl oyster resources in India.India has a large variety of molluscan resources in the coastal waters and in the estuaries and backwaters reported by Alagarswamy and Meiyappan, (1988). Appukuttan and Ramdoss (2000) reported the commercial important of gastropods in export and handicraft trade and also it gives the distribution details, abundance and habitat of ornamental gastropods along Indian coast. CMFRI Ann. Rep,(2003-2004) reported a total of 84 different species of gastropods belonging to 26 families and 32 genera were tentatively identified from the trawl landing centers of Mandapam, Kollam and Cochin. The CMFRI scientists were conducted survey and assessment of bivalve and gastropod resources in Gulf of Mannar area in the year 2004. Recent work by Subba Rao (2003) and SubbaRao and Day (2000) deal with distribution of most of the molluscan fauna occurring in Indian coast including Tamil Nadu.

13.2 Status and distribution of molluscans in Mandapam And Keelakarai Islands

Study by the Alagappa University, provide present status, distribution and threats of scheduled Molluscs in Mandapam and Keelakkarai group of islands(Table 1&Fig 1).

In Single island , 6 species of Scheduled molluscs and 61 individuals of Scheduled molluscan species were recorded and identified ,namely *Placenta placenta (34) , Fasciolaria trapezium(18) ,Lambis chiragra (4), Lambis truncate (2),Lambis scorpius (2) and Tudicila spirilus (1).* The scheduled species of *Placenta placenta* were showed maximum number of individuals when compared with other scheduled species. The percentage composition of scheduled molluscs in Single Island was recorded 5.54% and the status and distribution of associated fauna in Single Island it was recorded more than 48 species were identified and the quantitative analysis of this molluscan individuals in both Intertidal area as well as the under water observation, it was recorded 9. 97No/$m^{2.}$

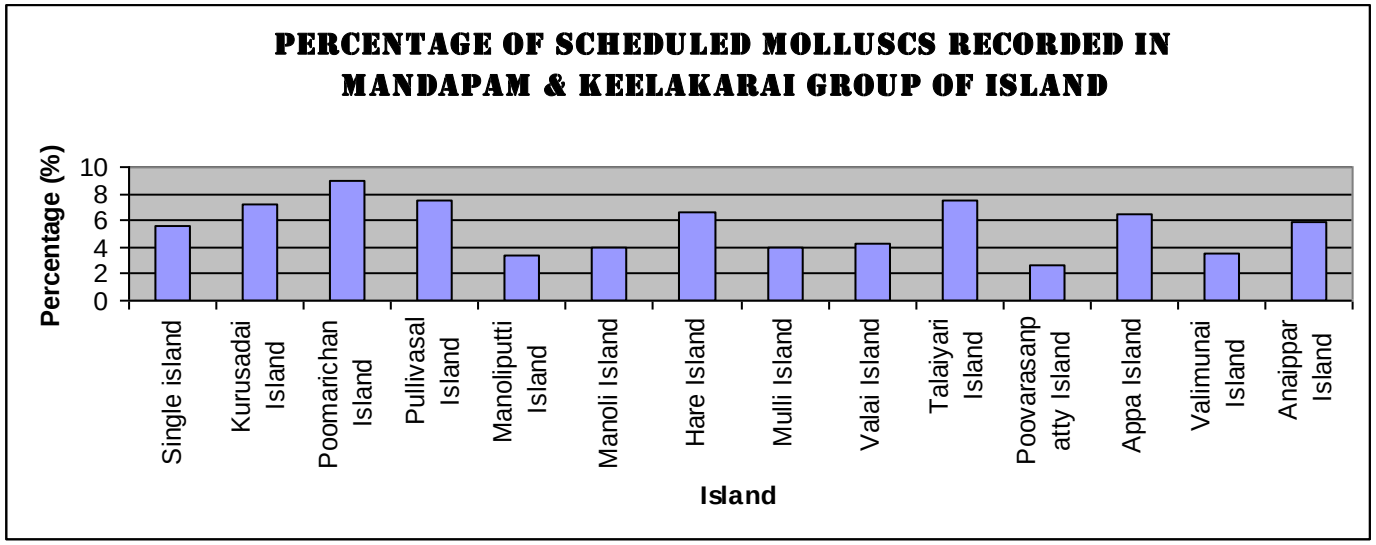
Table .1. Percentage of Scheduled Molluscs, Density and total number of species identified in Mandapam and Keelakkarai group of islands

S.No	Name of the Island	Total no of Species Identified	Density No/m2	Percentage(%)of scheduled molluscs
1	Single Island	48	9.97	5.54
2	Kurusadai Island	52	12. 31	7.20
3	Poomarichan Island	44	12.61	8.90
4	Pullivasal Island	48	11. 07	7.45
5	Manoliputti Island	44	9. 96	3.36
6	Manoli Island	41	8. 53	4.0
7	Hare Island	57	12. 6	6.63

8	Anaipar island	44	10. 50	4.0
9	Vali Munai	47	7. 56	4.2
10	AppaIsland	54	9. 98	7.5
11	Poovarasan Patti	36	8. 73	2.6
12	Talaiyarai island	64	10. 52	6.45
13	Vali island	47	9. 93	3.6
14	Mulli island	44	9. 93	5.90

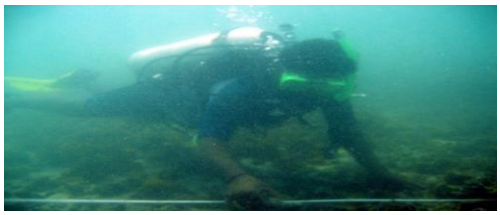
In Kurusadai island , 6 species of Scheduled molluscs and 80 individuals of Scheduled molluscan species were recorded and identified, namely *Placenta placenta (52) , Fasciolaria trapezium(19) ,Lambis chiragra arthitica (2), Lambis truncata (5),Lambis crocea(1) and Cassis cornata(1).* The scheduled species of *Placenta placenta* were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Kurusadai Island it was recorded 7.2%. In Kurusadai Island, the more than 52 species were identified and recorded and the quantitative analysis of this molluscan individuals in the Intertidal area and the under water observation, it was recorded 12.31 No/m^2.

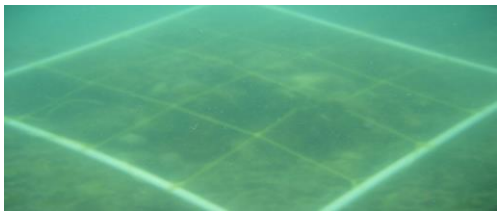
Fig 22.1 Percentage of scheduled mollusks recorded in Mandapam and Keelakarai group of Island



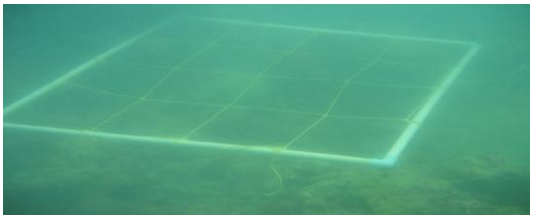
INTERTIDAL SURVEY


UNDERWATER SURVEY






Intertidal survey

Underwater survey




In Poomarichan island , 5 species of Scheduled Molluscs and 82 individuals of Scheduled molluscan species were recorded and identified , namely *Placenta placenta (59) , Fasciolaria trapezium(13) ,Lambis chiragra arthitica (3), Lambis truncata (6)and Lambis crocea(1)* . The scheduled species of *Placenta placenta* were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Poomarichan Island it was recorded 7.45%.In Poomarichan Island, more than 48 species were identified and recorded and the quantitative analysis of this molluscan individuals in both Intertidal area as well as the under water observation, it was recorded 11.07 No/m^2.

In Pullivasal island , 8 species of Scheduled molluscs and 98 individuals of Scheduled molluscan species were recorded and identified , namely *Placenta placenta (62) , Fasciolaria trapezium(23) ,Lambis chiragra (4), Lambis truncata (3),Lambis crocea(3) , Lambis scorpius (1),Strombus plicatus (1)and Tudicila spirilus(1).* The scheduled species of Placenta placenta were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Pullivasal Island it was recorded 8.90%.In Pullivasal Island, more than 44 species were identified and recorded and the quantitative analysis of this molluscan individuals in the Intertidal area and the under water observation, it was recorded 12.61 No/m^2.

In ManoliPutti island , 5 species of Scheduled Molluscs and 37 individuals of Scheduled molluscan species were recorded and identified ,namely *Placenta placenta (23) , Fasciolaria trapezium(10) ,Lambis chiragra arthitica (1), Lambis truncata (2) and Lambis crocea(2.* The scheduled species of Placenta placenta were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Manoliputti island it was recorded 3.36%. In Manoliputti Island, more than 44 species were identified and recorded and the quantitative analysis of this molluscan individuals in both Intertidal area as well as the under water observation, it was recorded 9.96 No/m^2.

In Manoli island , 6 species of Scheduled Molluscs and 44 individuals of Scheduled molluscan species were recorded and identified ,namely *Placenta placenta (29) , Fasciolaria trapezium(8) ,Lambis chiragra (1), Lambis truncata (3),Lambis scorpius (3) and Lambis millipeta (1).* The scheduled species of *Placenta placenta* were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Manoli Island it was recorded 4.0%. In Manoli Island, more than 41 species were identified and recorded and the quantitative analysis of

this molluscan individuals in the Intertidal area and the under water observation, it was recorded 8.53 No/m^2.

In Hare island , 6 species of Scheduled molluscs and 73 individuals of Scheduled molluscan species were recorded and identified ,namely *Placenta placenta (55) , Fasciolaria trapezium(13) ,Lambis chiragra (2), Lambis scorpius(1),Lambis crocea(1) and Lambis chiragra arthitica(1).* The scheduled species of Placenta placenta were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Hare Island it was recorded 6.63%. In Hare Island, more than 57 species were identified and recorded and the quantitative analysis of this molluscan individuals in the Intertidal area and the under water observation, it was recorded 12.6 No/m^2.

In Mulli island , 5 species of Scheduled Molluscs and 44 individuals of Scheduled molluscan species were recorded and identified ,namely *Placenta placenta (32) , Fasciolaria trapezium(9) ,Lambis chiragra (1), Lambis truncata (1) and Lambis scorpius(2).* The scheduled species of Placenta placenta were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Mulli Island it was recorded 4.0%. In Mulli Island, more than 44 species were identified and recorded and the quantitative analysis of this molluscan individuals in both Intertidal area as well as the under water observation, it was recorded 9.93 No/m^2.

In Valai island , 7 species of Scheduled Molluscs were identified and recorded ,namely *Placenta placenta (29) , Fasciolaria trapezium(11) ,Lambis chiragra (3), Lambis truncata (2),Lambis crocea(1), Lambis chiragra arthitica(1) and Lambis scorpius(2).*Totally 47 individuals of Scheduled molluscan species were recorded . The scheduled species of Placenta placenta were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Valai island it was recorded 4.2%. In Valai Island, more than 47 species were identified and recorded and the quantitative analysis of this molluscan individuals in both Intertidal area as well as the Under water observation, it was recorded 9.93 No/m^2.

In Thalaiyari island, 7 species of Scheduled Molluscs were identified and recorded, namely *Placenta placenta* (48), *Fasciolaria trapezium* (21), *Lambis chiragra* (6), *Lambis chiragra arthitica* (2), *Lambis truncata* (3),*Lambis crocea* (2) and *Lambis scorpius* (1).Totally 80 individuals of Scheduled molluscan species were recorded . The scheduled species of Placenta placenta were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Thalaiyari island it was recorded 7.5%. In Thalaiyarai Island, more than 64 species were identified and recorded and the quantitative analysis of this molluscan

individuals in both Intertidal area as well as the Under water observation ,it was recorded 10.52 No/m^2.

In Poovarasanpatty island , 5 species of Scheduled Molluscs were identified and recorded ,namely *Placenta placenta (23) , Fasciolaria trapezium(2) , Lambis chiragra (2), Lambis chiragra arthitica (1) and Lambis crocea(1).*Totally 29 individuals of Scheduled molluscan species were recorded . The scheduled species of Placenta placenta were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Poovarasanpatty island it was recorded 2.6 %. In Poovarasanpatty Island, more than 36 species were identified and recorded and the quantitative analysis of this molluscan individuals in both Intertidal area as well as the Under water observation, it was recorded 8.73 No/m^2.

In Appa island , 6 species of Scheduled Molluscs were identified and recorded ,namely Placenta placenta (43) , Fasciolaria trapezium(19) , Lambis chiragra (3), Lambis chiragra arthitica (3), Lambis truncata (2) and Lambis crocea(1).Totally 71 individuals of Scheduled molluscan species were recorded . The scheduled species of Placenta placenta were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Appa island it was recorded 6.45%. In Appa Island, more than 54 species were identified and recorded and the quantitative analysis of this molluscan individuals in both Intertidal area as well as the under water observation, it was recorded 9.98 No/m^2.

In Valimunai island , 7 species of Scheduled Molluscs were identified and recorded ,namely Placenta placenta (21) , Fasciolaria trapezium(12) , Lambis chiragra (2), Lambis chiragra arthitica (2), Lambis truncata (1),Lambis crocea(1) and Lambis millipeta(1).Totally 40 individuals of Scheduled molluscan species were recorded . The scheduled species of Placenta placenta were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Valimunai island it was recorded 3.6%. In Valimunai Island, more than 47 species were identified and recorded and the quantitative analysis of this molluscan individuals in both Intertidal area as well as the under water observation, it was recorded 7.56 No/m^2.

In Anaipar island, 8 species of Scheduled Molluscs were identified and recorded ,namely Placenta placenta (39) , Fasciolaria trapezium(17) , Lambis chiragra (3), Lambis chiragra arthitica (1), Lambis truncata (2),Lambis crocea(1), Lambis scorpius(1) and Cassis cornata (1).Totally 65 individuals of Scheduled molluscan species were recorded . The scheduled species of Placenta placenta were showed maximum number of individuals when compared with other scheduled species and the percentage composition of scheduled molluscs in Anaipar

Island it was recorded 5.90%. In Anaipar Island more than 44 species were identified and recorded and the quantitative analysis of this molluscan individuals in both Intertidal area as well as the under water observation, it was recorded 10.50 No/m^2.

From this survey in Mandapam group , The maximum number of scheduled species of molluscs were recorded in Pullivasal (8)and in minimum number it was recorded in Poovarasanpatty island (5) . The maximum numbers of individuals of scheduled species were recorded in Pullivasal (98), Poomarichan (82), Kurusadai (80) and Hare islands (73) and in minimum number of individuals of scheduled species were recorded in Manoliputti island. In Keelakkarai group of island ,the maximum number of scheduled species of molluscs were recorded in Anaippar island (8), Valai island(7) , Thalaiyari island(7) and Valimunai island(7) and in minimum number of scheduled species were recorded in Poovarasanpatty island. The maximum numbers of individuals of scheduled species was recorded in Thalaiyari (83) and Appa Island (71) and in minimum number of individuals of scheduled species were recorded in Poovarasanpatty Island.

In all the 14 islands the maximum numbers of scheduled species were recorded in Pullivasal and Anaippar Island and in minimum number it was recorded in Poovarasanpatty .The maximum numbers of individuals of scheduled species were recoded in Pullivasal and Thalaiyari Island. The minimum numbers were recorded in Manoli Island and Poovarasanpatty Island. In percentage composition of individuals of scheduled species, the maximum numbers were recorded in Poomarichan Island (8.90) and in minimum numbers were recorder in Valimunai Island (3.6). In distribution pattern reveled (GIS mapping) that the maximum numbers of scheduled species were observed in both Mandapam and Keelakkarai group of islands and the distribution of individuals of scheduled species were recorded in Mandapam group of islands when it compared with Keelakkarai group of islands.

The distribution pattern of Associated fauna of scheduled molluscs showed that the maximum number of molluscan species of gastropods and bivalves were recorded in Hare island (57) and minimum number were recorded in Manoli island (41) in Mandapam group of islands and in Keelakkarai group of island, the maximum number of molluscan species were recorded in Thalaiyari island (64) and in minimum number it was recorded in Poovarasanpatty (36). The maximum number of density were recorded in Kurusadai (12.31 no/m^2) and Poomarichan island(12.61no/m^2) in Mandapam group and the minimum number it was recorded in Valimunai island(7.56no/m^2)of Keelakkarai group. In the present observation, in Mandapam group showed the maximum number of diversity as well as density of molluscan species of both gastropods and bivalves when it compared with Keelakkarai group of islands,

In Mandapam group, the Kurusadai and Hare Islands showed higher density of molluscan Individuals when compared to other islands and in Keelakkarai group of islands, the Appa and Thalaiyari Island showed higher density when compared to other Islands. In both, Mandapam and Keelakkarai group, the Mandapam group showed higher density when compared to Keelakkarai group of islands. In the present survey, the maximum number of species diversity was recorded in Hare Island of Mandapam group and Thalaiyari island of Keelakkarai group and in minimum number of species diversity was recorded in Manoli and Vali Munai when compared to other islands. In all the 14 islands, the Gastropods diversity was higher when compared to Bivalve diversity. From the observation of the survey work, so far a 132 species of gastropod from 25 families and 3 orders and 90 species of Bivalves from 19 families were recorded and identified. In bivalves, out of 90 species, 30 species were newly recorded.

India has a large variety of molluscan resources in the coastal waters and in the estuaries and backwaters. The clam resources consisting of *meritrix, katelysia, paphia, Anadara, villorita* and others have been exploited by fisherfolk from time immemorial for food and also for their shells.. *Placenta* is restricted in its distribution but is well exploited (Alagarswamy and Meiyappan, 1988). Out of 55 species of bivalve molluscs collected from Gulf of Mannar, 49 species belonging to two subclasses, four orders and eighteen families were identified and classified. Littoral fauna of Krusadai Island in the Gulf of Mannar was done by Chennapayya (1927). The survey was indicated that the main use of these bivalves as food, source of lime and for ornamental purposes (Jayaseeli and Murugan, 2003). Generally the gastropods fishery along the villages in Gulf of Mannar area was mainly associated with lobster fishery (Ayyakkannu, 1992). All catches of the gastropods were considerate as by- catches and hence if lobster fishery was affected by any factor, it ultimately affected gastropods fishery. Now days this situation was changed by using of separate net for the collection of gastropods during fishing and after the northeast monsoon, the gastropod fishing is being carried out regularly by skin diving almost in all the area in the Gulf of Mannar region. Nearly 200 to 400 divers were engaged in diving to collect the commercially important gastropods. Considerable landings of *Fasciolaria trapezium, Xancus pyrum* and *Chicoreus ramosus* were noticed. In all villages the daily earning of each divers ranged from Rs. 500 – 2500/- based on the season and fishing.

The commercially important gastropods are collected mainly for shell and operculum. These shells are collected by trawler, while trawling bottom finfishes and shellfishes or by lobster netting or hand picking by diving. The collected shells are sold at fish landing centers by the fishermen. These shells are purchased by middle man living in and

around the villages .The shells purchased by middle man are stored in their house and brought to a purchaser located near coastal areas. This purchaser will again sell these to the shell industries for export. In general observation of the present survey work in Mandapam and Keelakkarai group of islands were showed that the threats of scheduled molluscs and their associated fauna were Over exploitation, by-catches and skin diving. In all the areas, the maximum number of scheduled species and the other molluscan forms were observed and recorded in fish landing when compared with other two areas this may due to over exploitation and by-catches. Generally in Mandapam and the adjacent Islands to maintain a rich molluscan diversity than the other areas. Now the present data on the survey work showed a depleting trend on the Molluscan diversity in the Gulf of Mannar when compared with earlier records.

13.3 Management Prescriptions

1. Inventorization of molluscan diversity of the Gulf of Mannar Biosphere Reserve with reference to pollution and economic importance.

2. Mapping and monitoring of all critical mollucan beds of the Biosphere Reserve

3. Legally protected molluscans are exploited in and illegally traded as curios across coastal tourist and pilgrim centers of Tamil Nadu. High market demand coupled with lack of awareness and inadequate enforcement is the major driving force for illegal marine curio trade. Therefore, adequate awareness programs need to be conducted.

4. Patrolling on critical molluscan beds on regular basis

5. Necessary laws should be enforced by the wildlife/forest officials, along with educational and awareness programs and also promoting alternate resource of livelihood for seashell/coral collectors can curb the illegal marine curio trade

Chapter14

Habitat Recovery Programs in buffer zone of Biosphere Reserve

The mangroves, coral reefs and sea grass ecosystems are the three important and sensitive ecosystems in the coastal zone. The GOMBR possesses all these unique ecosystems and has become significant because of the presence of other associated resources such as fishes, sponges, gorgonids, holothurians, pearl beds, chank beds, sea horses, turtles and the sea cow, *Dugong dugon*.

Coral reefs are vital components of ocean ecosystems, providing shelter to nearly one quarter of all marine life forms. They are the breeding and nursery ground for many fin and shellfishes. There are more than 793 - recorded species of corals in the world support enormous life forms. Reef ecosystems can be compared to rain forests in terms of their biodiversity and density of living organisms. They serve as atmospheric carbon dioxide sinks and act as historical climate recorders. The coral reef ecosystems play an important role in global biogeochemical processes and in the production of food resources in the tropical region. These systems are very sensitive to external impacts both natural and manmade that violate their homeostasis.

The floral components comprises of economically viable species of seaweeds such as *Gracilaria* sp., *Gelidiella* sp., *Caulerpa* sp, *Sargassum* sp. and *Turbinaria* sp. The sea grass communities of this region tops the list of marine flora of India with the highest number of sea grass species recorded, providing important feeding grounds for the endangered *Dugong dugon*.

Many commercial shoaling fishes like sardines, mackerels, anchovies, snappers and pelagic fast swimming forms like Tuna, Billfish, Sailfishes are found abundant in this region and these form a major fishery. Information regarding environmental settings of the Gulf of Mannar Biosphere Reserve has been mainly gathered from a study on Gulf of Mannar Biosphere Reseve by Anna University, Chennai.

14.1 Conservation, restoration and management of corals of on-shore region of the Gulf of Mannar Biosphere Reserve

It is important to map all on-shore corals reefs of Biosphere Reserve and monitor them. These corals including reefs around the Rameshwaram Island can be used for eco-tourism provide these reefs are restored and protected.

Projects need to be taken up not only to restore the reefs through transplantation and re location but also stabilizing the shore line of the islands by placement of artificial barriers to act as natural reefs . These barriers can serve the purpose of acting as a substrate for transplantation, habitat enhancement for marine life but also for shore line protection. International organisations like Reefball (www.reefball.org), have a high reputation and have worked on many of the reefs in the world, they can be approached for any sort of technical guidance to restoration in this region in collaboration with local organisations such as SDMRI who already have some experience in the field of restoration of coral reefs. Moulds for restoration can be made off coral boulders which have been seized or under govt ownership; coral debris from demolished old houses can also be used. Though the use of coral slabs to study recruitment is known, it is suggested that a study be made on weather such moulds can be made stable enough for restoration work.More information on the restoration techniques used globally for coral reefs can be obtained from " Handbook of Ecological Restoration, Volume 1&2, edited by Martin R. Perrow and Anthony J. Davy, Cambridge University Press, 2002."

14.2 Conservation, restoration and management of seagrass habitats of buffer zone of Gulf of Mannar Biosphere Reserve

The coast along and the islands in Gulf of Mannar have relatively denser growth of seagrass meadows. The bulk of seagrass meadows occur between the mainland and islands and the density decreases towards the seaward sides of the islands. Seagrasses in Gulf of Mannar have been witnessed at depths up to 18 m. The following are the seagrass species recorded here: *Cymodocea rotundata, Cymodocea serrulata, Enhalus acoroides, Halodule pinifolia, Halodule uninervis, Halodule wrightii, Halophila decipiens, Halophila ovalis, Halophila minor, Halophila stipulacea, Halophila becarii, Syringodium isoetifolium* and *Thalassia hemprichii.*

Seagrass meadows in Gulf of Mannar are also found outside the Gulf of Mannar Marine National Park. Survey carried out in four distinct areas outside the Park area revealed the following results: overall seagrass area cover (51.69%) was recorded in the area between Periyasamipuram and Vembar with 9.42 km^2; seagrass cover (51.78%) was 6.22 km^2 in the area between Vipar and Periyasamipuram; seagrass cover (44.78%) was 5.25 km^2 in the area between Valinokam and Erwadi; seagrass cover (45.11%) was 3.56 sq.km in the area between Koswari and Kariyachalli islands.

Management Prescriptions

10. Mapping of sea grass beds with the information on status of each species using Remote Sensing Technology by the professional agencies is an immediate requirement. Based on the findings, few long-term monitoring plots on the sea grass beds need to be established so that the efficacy of the management actions can be evaluated for long term.

11. Check on pollutions which come from the all kinds of industries and other sources.

12. Extending the present sea grass distributional limit to the historical distributional limit. Habitat restoration of the sea grass beds needs to be inititated with help of nearby professional organizations.

13. Awareness programme in the catchment area regarding the excesive use of pesticide and other chemicals and its impact

14. **Monitoring, evaluation and restoration**: Permanent monitoring plots in different islands need to be marked and the same need to be monitored for its biomass productivity and other associated species in that plots.Restoration experiments with the help of CSMCRI and Restoration technology adopted on a coastal lagoon in the North of Yucatan (Southeastern Mexico) may be consulted here. The agency which would be used for the restoration of this habitat is also requested to consult with 'Chapter 7. Seagrass: in Handbook of Ecological Restoration, Volume 2, edited by Martin R. Perrow and Anthony J. Davy, Cambridge University Press, 2002'.

14.3 Conservation, restoration and management of mangrove habitats in the on-shore region of the Gulf of Mannar Biosphere Reserve

Reports on the mangroves and its associated vegetation of Gulf of Mannar Islands and on-shore are very limited. Rao et al (1963) noticed only small patches of mangroves in Pamban. Perhaps this is the oldest document on mangroves of this area. Blasco (1975) reported that existence of large patches of mangrove along Tamilnadu coast about 100 years ago which also includes the on-shore area of this Biosphere Reserve. Similarly, Jayaseeli and Murugan (2002) pointed out the presence of large patches of mangroves in Punnakayal some decades back. No other literature is available regarding mangrove existing along this Reserve but few records of mangroves adjacent to some polluted sites along the Gulf of Mannar coastline does exist (Manikandavelu and Ramadhas, 1991; Senthil kumar and Patterson Edward, 2002).

A study was conducted by the Wildlife Institute of India, National Institute Coastal and Marine Biodiversity Centre at Kanyakumari to inventorise the on-shore mangrove vegetation and habitat in the Gulf of Mannar Biosphere Reserve. This study also aimed to provide a detailed description about the present status of the mangrove habitat with supplementary information about potential areas for development, conservation and management.

A detailed survey was conducted all along the coastline of Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari of Gulf of Mannar Region for a period of two months (March 2006 to April 2006). The coastal areas were identified using locally available district maps. All type of on-shore wetlands such as river mouths, estuaries, salinas and backwaters have been marked out referring the available sources and accessed. Each sites were explored by walked along the shoreline and far interior up to the maximum reaches to locate existing or relics of mangrove vegetation. Since all the sites were mentioned (in literature) as having monospecifc stand of *Avicennia marina* no line transect or any other method was followed but explored to a distance from 100-200m to document the nature of distribution and the health of the existing mangrove patches. An assessment of the anthropogenic pressures, impact and the prospect of mangrove restoration in these areas were also assessed.

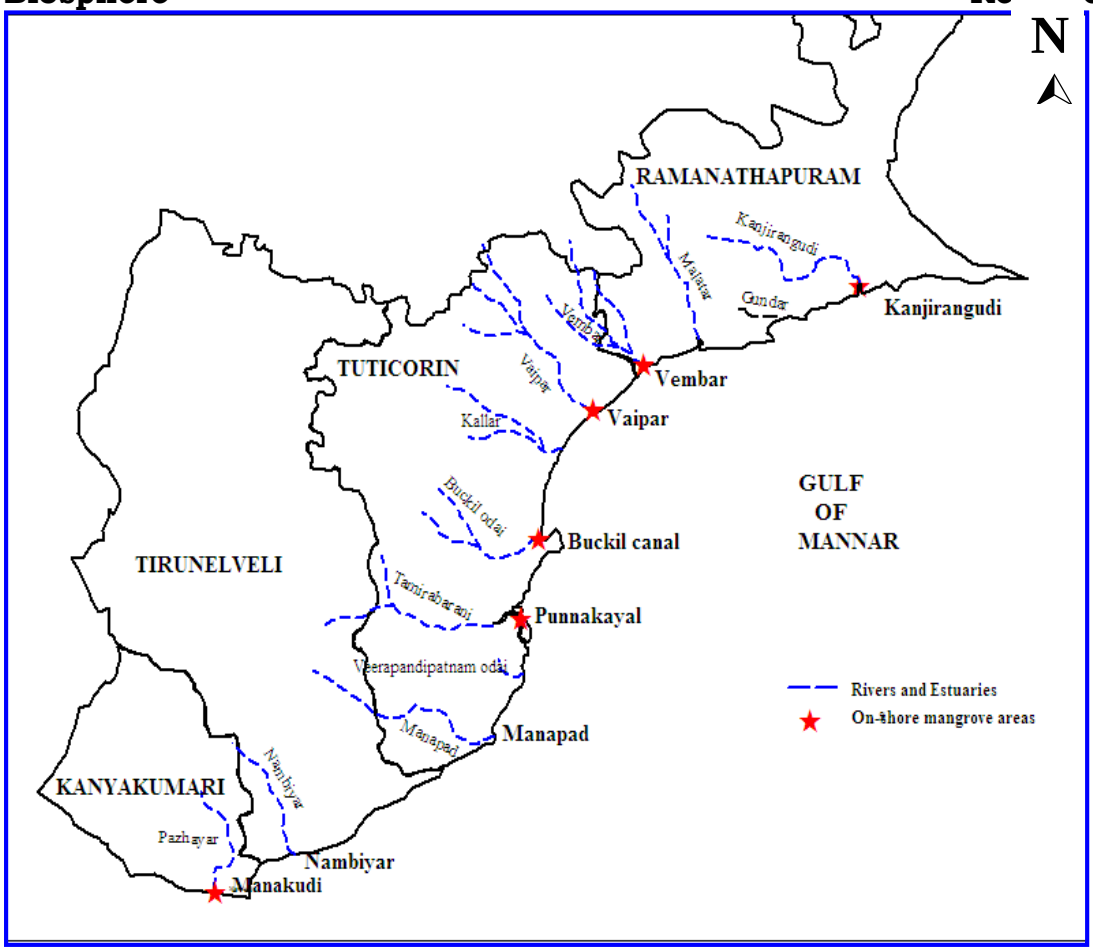
Riverine-estuarine areas of Biosphere Reserve:
About 13 typical riverine-estuarine and canal have been recorded along coastline of the Biosphere Reserve. Among them only Kanjirangudi of Ramnathapuram; Vaipar, Buckil odai, Punakayal-Pazhayakayal complex of Tuticorin and Manakudi of Kanyakumari district had water flow whereas the remaining were found dried (during the study period). The Guddar, Mallatar, Vembar, Vaipar, Manapad and Nambiyar were found to be rain-fed, but it was reported there had been water flow before two decades. At present, in Nambiyar

and in Manapad there is very little flow of water due to rainfall in monsoon.

On-shore rivers, estuaries and canals of Gulf of Mannar Biosphere Reserve

1. Kanjirangudi
2. Gundar
3. Mallatar
4. Vembar
5. Vaippar
6. Kallar
7. Buckil odai
8. Pazhayakayal
9. Punnakayal
10. Veerapandipattinam
11. Manapad
12. Nambiyar
13. Manakudi

Rivers, estuaries and on-shore Mangroves areas along the Biosphere Reserve:



Map not to scale

Almost all the rivers of four districts of Gulf of Mannar Biosphere Reserve opens into the Bay of Bengal except Manakudi (opens into

Arabian Sea). Only Punnakayal estuarine complex and Manakudi has the perennial water source and the remaining were drained annually during monsoon. Most of the river mouths will be remain closed during dry seasons, especially May to August. Due to lack of continuous flow of freshwater, the entire river mouth and its adjacent mudflats of open sites are dominated by the tidal flush and hence heavily influenced by high saline conditions.

On-shore Mangroves of Biosphere Reserve:

Among four coastal districts of Gulf of Mannar Biosphere Reserve, as aforementioned, Ramanathapuram, Tuticorin and Kanyakumari districts have mangrove distribution. Along these districts patches of mangroves were observed in Kanjirangudi, Vaipar, Buckil odai, Punnakayal-Pazhayakayal complex and in Manakudi estuaries. In all these sites, *Avicennia marina* is the dominant species. Also patch of *Pemphis acidula* in Punnakayal-Pazhayakayal complex of Tuticorin, *Rhizophora mucronata* and *Acrostichum aureum* were recorded in Manakudi of Kanyakumari district. The distribution of mangroves present on-shore of these districts were described in details below

Pamban – *Kundukal point*: a small patch of mangroves was recorded at the western part of the Rameswaram, near Pamban in Ramnathapuram district. The existing mangrove is on an open back swamp with mudflat at the seafront. The mudflat is frequently inundated with very low energy tidal waves. *Avicennia marina* is naturally distributed along this mudflat.

Kanjirangudi estuary: This is an open mouth estuary located near Sethukarai in Ramanathapuram district. Freshwater flows only during monsoon but because of open mouth the entire area was influenced by tidal inundation. The estuarine waters have largely been utilized for aquaculture practice nearby. *Avicennia marina* is the only mangrove species found along the muddy shoreline of the estuary and its distribution extents upto a1.5 km distance from the coast.

Vaipar: The location is at far north of Tuticorin district. The historical background of this area reveals that once the river receives continuous freshwater flow. Presently, water can be seen in only in the split areas of about a kilometer distance from sea. The existing mouth is very wide with two split ends but is being closed by a thin streak of sand bar. It was observed that during spring tides tidal water seeps into the river. *Avicennia marina* is the only mangrove vegetation found with stunted growth. One of the split riverine channels has been converted into the saltpan and the high saline brine was discharged out aside the river. This has changed the substratum hard and unfit for the growth of vegetation. Present status of mangrove at this site is critically endangered due to lack of tidal inundation.

Buckil odai: This is the backwater area in Tuticorin coast with several patches of *Avicennia marina* fringing along the shoreline.

However the vegetation is denser, the trees were with stunted growth. Various reasons may be attributed for this stunted growth. The watercourse receives brine discharge from saltpans and sewage from the nearby settlements. Similarly, mixing of industrial effluents and dumping of ETPP wastes have also been observed. All these detrimental pollutants might have a cumulative influence on the growth; however the exact cause should be determined before it is too late.

Punnakayal-Pazahayakayal estuarine complex: It is an important estuarine area located at 15km south of Tuticorin coast. Several forked-split branches of river Tamirabarani opens into the Gulf of Mannar leaving many small isles of slightly elevated mudflats. The estuarine complex presently has two open mouths and a thin strip of sand bars interfering temporarily. Comparatively very thick mangroves have been recorded here fringing the shoreline of the mudflats. Trees to a height of 4-5m have also been recorded only in the northern portions. Interestingly, the mangrove *Pemphis acidula* is found distributed at the southern parts of Punnakayal. No records are available so far regarding the occurrence of this species in the mainland. Similarly this is the only area in the mainland having seagrass beds inside the estuarine waters.

Manakudi: Manakudi estuary lies just 9 km west from Kanyakumari, receives freshwater from Pazhayar regularly through out the year. Along with *Avicennia marina*, this site has a thick patch of *Rhizopora mucronata* and *Acrostichum aureum* just interior. *Rhizophora mucronata* is said to be introduced during 1994-95 (Ravikumar *et al.* 2003).

Mangrove afforestation programs along the coastline:

Mangrove afforestation programs have been undertaken at four sites in three districts of this coastline. The sites, total area planted, parties involved, species used, methods followed and the current status were given in details below.

Table: 1. Mangrove afforestation efforts along the coast of Gulf of Mannar Biosphere Reserve

Mangrove afforested sites	Year	Department/NGO	Area (ha)	Species	Method	Current status
Kundakal point	2005	Tamil Nadu Forest Department	~5	*Avicennia marina, Ceriops tagal, Rhizophora mucronata*	Parallel canal banking	Only few saplings of *Rhizophora mucronata* survives
Kanjirangudi	2005	Tamil Nadu Forest	>1	*Ceriops tagal*	Parallel canal	Only few saplings

		Department			banking	survives
Punnakayal	2004-2005	Tamil Nadu Forest Department	30	*Avicennia marina*	Fish bone canal	>25% success with stunned growth
	2006	PAD	~20	*Avicennia marina*	Fish bone canal	Very recently planted
Manakudi	1994-1995	Unknown	2	*Rhizophora mucronata*	On elevated mudflat	Well flourished

The planted *Ceriops tagal* and *Avicennia marina* were almost found dead in the Kundukal point, whereas *Rhizophora mucronata*stand still with 2-3 pair of leaves, this might due to the capacity of the propagule which can support its own life for a year in any type of substratum. Other interesting observation is that at this site, stagnation of inundated water is frequent and very often the seedlings were submerged. Because of the length, the *Rhizophora* seedling escapes from desiccation. Similarly, the reason for the failure of *Ceriops tagal* establishment in Kanjirangudi can be attributed to the higher elevation of canals which were not drained even during highest high tides. Very recently in Punnakayal, the Department of Forest underwent *Avicennia marina* plantation to about 30ha at the elevated sites following Fish-bone canal method. At present only ~30% of the planted mangrove was thriving and the remaining were found dead due to the desiccation. Blockages were found at most of the corners of canal, due to over siltation and sliding of heaped mud which were dredged previously.

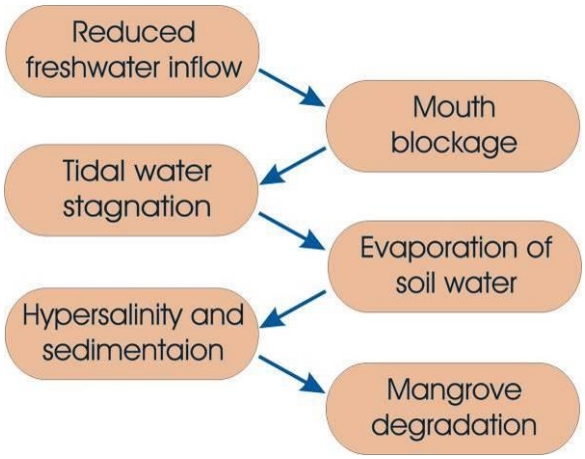
Silt deposition, soil erosion, root exposure of growing *Avicennia marina* sapling in dredged canal at Punnakayal

The PAD (NGO) very recently (2006) started planting *Avicennia* using same method and proposed to monitor the site for a longer period for its successful establishment.

The present status of natural mangrove habitats:

The off-shore mangroves are of monospecific *Avicennia marina* stands with stunted growth (average height of 1.5m) in all the sites. In general the on-shore mangrove ecosystem is also found degraded in some areas. Dead stumps and relics of mangroves were recorded at many study sites such as Kanjirangudi and in Vembar (already degraded). Manikandavelu and Ramadhas (1991) documented the mangroves situated near Thermal Power Station in Tuticorin area is polluted with nitrogenous nutrients. The available nitrogen, phosphate level were recorded higher amounts. Similarly, Senthil kumar and Patterson Edward (2002) found the mangrove waters of both Tuticorin and Punnakayal were polluted, also the Punnakayal waters have been highly contaminated with sewage discharge. Other than these pollution factors, formation of high-salinity in the low lying area between the exposed mangrove patch are the other reasons for further degradation. In addition, lack of tidal flushing and blockage of the mouth due to increased rate of sedimentation may be the other reasons. Solid waste dumping, discharge of Municipal sewage and industrial effluents were observed in Tuticorin mangroves whereas in Vaipar, brine water from the saltpans were released directly into the nearby mangrove area.

Mangrove degradation pathway in riverine-estuarine areas



Along this coast, there has been a reduction of fresh water flow over a period of time, which has had a telling impact on the growth and survival of mangroves. Reduction in freshwater flow also led to the reduction of sediment supply and in turn on nutrient. In due course of time, entire geomorphology and topography of this region would have been changed in such a way not to support or suitable for growth and survival of mangroves. Other than chemical properties, physical factors such as topographical alteration, elevation of mudflats due to blockage near mouth, silt deposition due to runoff immediately after the monsoon are detrimental to the mangrove ecosystem. As a consequence of temporary blockage of mouth, the mangroves in Punnakayal thrived for certain period and in due course of time would have degraded gradually. Similar case would have had

happened both in Vembar and in Vaipar, where relics of mangroves were observed at far reaches.

On-shore mangrove restoration and management:

Establishment of mangroves at the on-shore regions of Gulf of Mannar Biosphere Reserve can be presumed with an approach of protection and substantial production. Even though mangroves do exists, our observation reveals there is a need for development of mangrove ecosystem. Whatever may be, the prime intention is to increase the mangrove cover all together in the jurisdiction of Biosphere Reserve.

Based on some of the important factors which were prescribed in the standard criteria (FAO, 1994) to identify the potential area for mangrove restoration, 5 such areas have been identified suitable for mangrove restoration.

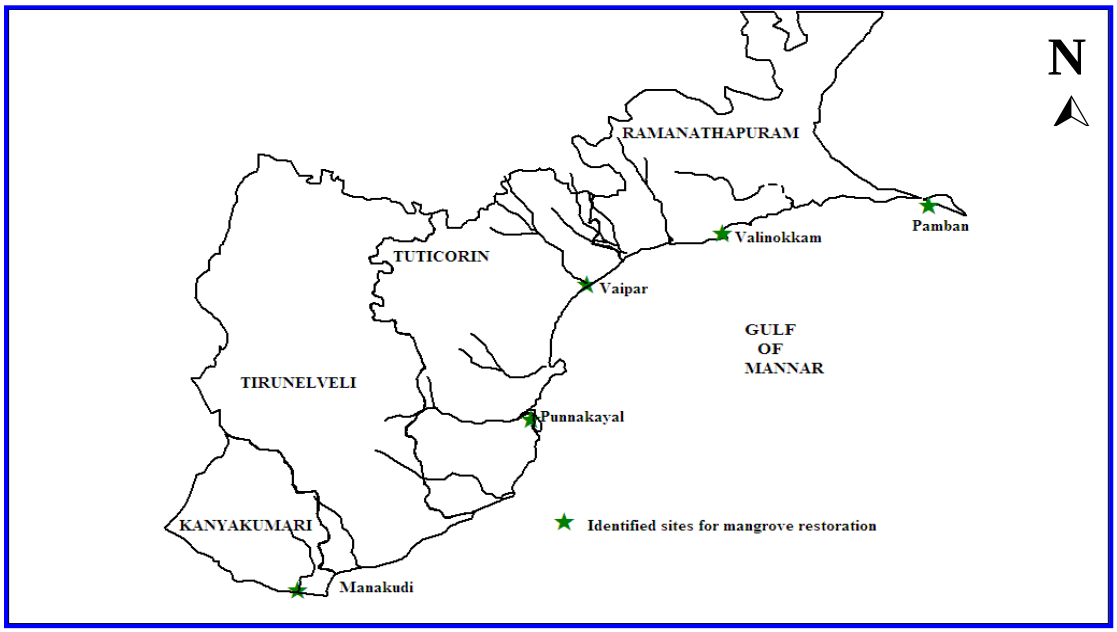
POTENTIAL AREA IDENTIFIED	**AVAILABLE AREA (HA)**	**SUITABLE AREA (MUDFLATS)**	**SITE ELEVATION**	**TOPOGRAPHIC ALTERATION**	**MONITORING**
Kundukal point	5	Entire backswamp	No elevation	Need – raising mounds	Need to maintain mound height
Valinokkam	10-15	Periphery of the stream	No elevation but closed	Inlet opening	Regular for inlet closure
Vaipar	15-20	Periphery and in islet mudflat	No elevation	Mouth opening	Regular for inlet closure
Punnakayal	>30	The periphery of islets and mudflats	High elevation (±1m)	Need for leveling elevations	Need to maintain canal slopeness
Manakudi	>20	Interior to the estuary	No elevation	No need	No need

Note: The available area mentioned is the approximate values based on visual estimate and need to be resolved using Remote Sensing, Survey maps and physical verification by the concerned coastal Forest Divisions and Ranges.

Among the identified area, Vallinokam is a coastal wetland, lying 35km south of Keelakarai. Traces of mangrove relics have been identified at the periphery of the wetland. Presently, it is used as the

temporary pond to store pumped sea water for solar saltpan. The other is Vaipar, which already have mangrove patches but in very critical condition. The mouth needs to be opened immediately to bring back the growth normal; otherwise the existing patch will go off very soon. The areas which have already been dredged needs little alterations and other areas need intensive topographical grading such as canal dredging with suggested modifications.

Identified areas for mangrove restoration along the coast in the Gulf of Mannar Biosphere Reserve



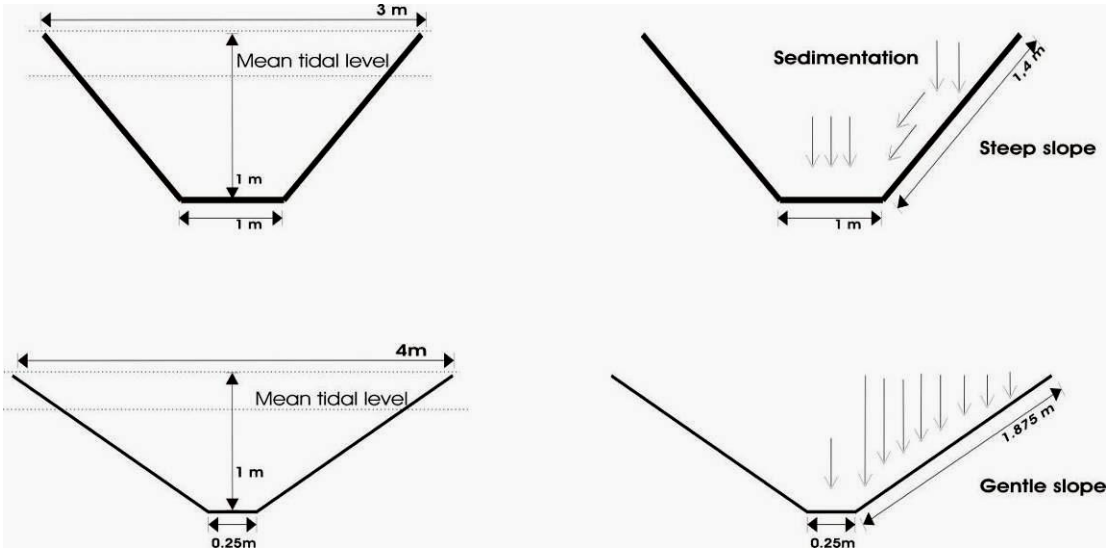
Map not to scale

Here in Gulf of Mannar region the sea is very calm in most of the seasons and even the kinetic energy of the wave is comparatively optimal and similarly, the tidal height is in range between 0.6-1.2m. Normally, here the amplitude reaches 0.85m in spring tide and reaches to the minimum of 0.2m in neap tide. In addition to this, entire coast experiencing the diurnal tidal cycle, thus will keep the identified/proposed restoration area wet. The wave energy, the tidal amplitude and tidal cycle are favorable factor suitable for mangrove restoration even near the seafront mudflats such as near Pamban and in Punnakayal if proper methodology prescribed below is followed. Since there is no regular freshwater flow, canal-banking method would not be supportive to the growth of mangroves in Kanjirangudi, whereas in Punnakayal estuarine complex, it will work well if the freshwater flow is diverted to drain the canals properly. It was suggested here to go for minor alteration such as reduction of elevation by removing the dumped soil between the feeder canals in Kanjirangudi will reduce the salinity gradient in due course. This would probably facilitate the distribution of the native species found fringing along its shoreline.

Suitable species:
As far as on-shore is concerned, *Avicennia marina* is found in almost at all mangrove areas of the Biosphere Reserve. Due to absence of pristine mangrove ecosystem, sturdy species such as *Avicennia* will be suggested at this stage. Introduction of species new to this region may invites some strange situation like species invasion and related problems in near future or it may not withstand the newer environment and finally leads to the failure of the restoration program. After successful establishment of the native species, the soil substratum will be stabilized and then the other prescribed species can be introduced. But, species like *Rhizophora* and *Ceriops* have recently been introduced in in Pamban and Kanjirangudi respectively. If above mentioned practice were followed both the *Rhizophora* and *Ceriops* can be used for restoration at the majority of the sites. However, a prior thorough assessment of the site with regard to various environmental characteristics in addition to the requirements of the species to be introduced may avoid failures. In most of the restoration project, the proposed sites were allowed to colonize by the halophytic herbs for a period of several months or even for two years. Since these salt-loving herb species, extracts enough salt and reduces the salinity of the soil. This reduction in soil salinity facilitates the developing mangrove in future.

Needed trench modifications:
By the observations made in already trenched canals and by various other details recorded, some modifications while trenching and its consequences have been discussed hereunder. Canals should be dredged in degraded areas to facilitate the flow of tidal water to bringing down the soil salinity and to create favorable conditions for planting. Usually the feeder canals were made with the dimension of 1:1:3m in bottom width, depth and surface with respectively. Similarly for the distribution canal the dimension is little lesser the abovementioned values. In both the condition the slope is very steep and the area available for plantation is susceptible to slide down to the bottom. Due to availability of enough flat bottom, steep inclination of the sides results in siltation and the canal bottom need to be de-silted frequently. This siltation may also in due course of time reduced proper flushing and sometime even gets block near loose soil areas. In this dimension, the surface area for plantation is being reduced than that of originally available area, i.e., if a canal dredged to a length of 10m, then the surface area available for plantation will be 28.8sq.m.(total area dredged=30sq.m).

Dimensions of canal in use and modification to be made to minimize the problem



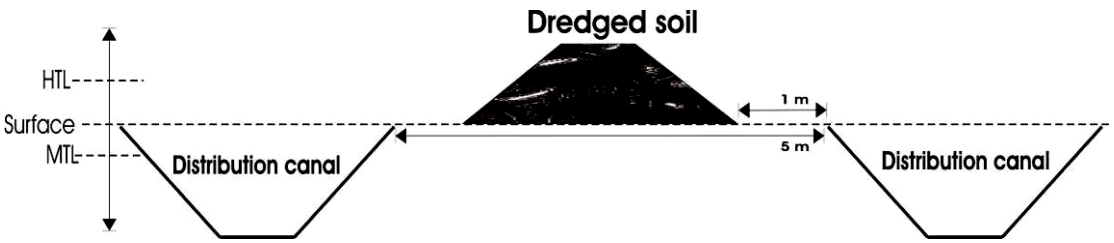
Rather, some modifications have been suggested here to increase the surface area, to reduce the rate of sedimentation and to avoid the soil-slip etc. The bottom width needs to be minimized to 0.25m, this allows the canal to have a gentle slopeness of the sides and increase the surface from top to bottom. The slant sides provide enough area for plantation and also results in even deposition of silt. Comparatively, the available rooting medium will also be increased and this facilitates the growth of the planted seedlings. Most importantly, colonization of soil-dwelling organisms will be more in gentle slant substratum than very steep.

Benefits of the modification of canal dimension:

- Gentle slopeness suitable for plantation
- Increased surface area availability
- Facilitated area faunal recruitment
- Reduced erosion due to slopeness

Usually the dredged soils were heaped at the surface edges of the canal itself. This soil often washed during spring tides and settle down back in to the canal. This makes the whole effort of canal dredging to dissipate. It was suggested here to heap the soil at least 1m away from the edge or if possible far away from the site.

Suggested mode of disposal of dredged soil



On-site nurseries:

It is advisable to set a nursery to raise the mangrove propagules near or adjacent to the proposed restoration site. Long strip of mounds in the inundated area running parallel to the creek may be created using the dugout soil substratum should be treated as nursery beds. Both, sowing the propagules or plunging them into the substratum may be practiced for this type of nursery establishment. These on-site nurseries foresee the details about adaptability and growth of the developing seedling at the site. Similarly, if it is proposed to use already raised seedlings from outside, the seedling to be planted may be kept adjacent to the site for 2-3 weeks where regular inundation takes place. Keeping the seedlings (in polybags) which were nursed outside the proposed site will make the seedling to adapt to the newer environs. For example, the wave energy, tidal amplitude, the nutrient flux and so on will facilitate the seedling to prepare to that environment.

Mangrove plantation:

Direct plantation of propagules and transplantation of the raised seedling needs special attention. Usually mangrove plantation should be carried out during onset of monsoon because; availability of freshwater will facilitate the growth of the planted seedling. As far as our study area is concerned, November and December months are very suitable. Plantation program should always coincide with and within fruiting seasons of the mangroves located nearer to the proposed site. It would be better if the planting program was scheduled during the time of maturity of the seeds of the selected species. This is in contrast with the fact that the right season will be very-well read by the parent trees best for seed dispersal.

***Monitoring and maintenance of sites after restoration**:*

Several immediate actions are needed once after the proposed sites have been restored. The important actions are..

- Monitoring the growing mangrove species as a function of time to know the status of successful establishment and suitability of the sites selected.
- Monitoring the growth characteristics such as seedling density, diameter increment, height, node production and stem structure etc. provide enough evidence in relation to the impact of that environment on developing species.
- Recording the failure of seedlings, weed infestation, pests, diseases and debris accumulation provide scientific reason for failure and facilitates the remedial actions to minimize or completely tackle the problem in the future restoration programs.
- The restored sites need to be maintained from grazing, cutting, fishing etc. at least to a period of complete establishment by fencing entire or required areas.

Pictures of on-shore mangroves

Mangroves of Kanjirangudi

Mudflat and adjacent mangrove in Vaipar

Mangroves in Tuticorin backwater

Mangroves in Punnakayal

Previous on-shore mangrove restoration at different sires

***Ceriops tagal* plantation in Kanjirangudi**

Canal banking plantation in Pazhayakayal

Parallel canal banking tried in Pamban

Chapter 15

Integrated and Sustainable Management of fisheries in Gulf of Mannar Biosphere Reserve

15.1 Introduction

Gulf of Mannar, located in the southeast coast of India, is a distinctive marine ecosystem bestowed with rich biodiversity. During 19th century, the fisheries was the only source of sustenance for a segment of the population living in the coastal region. Fishing in general was a profession carried on from generation to generation with almost all the members of the family taking part in it to varying degree. The socioeconomic condition of fishermen was very poor. The fishermen belonged to the lowest stratum of society and fishing was generally regarded as one of the meanest of all trades and profession.

In 1907 two cruises in search of trawling grounds were undertaken by Mr. James Hornell and Cribb when in the employ of the Ceylon Pearl Fishery Company with the company's trawler Violet, in the course of which an extensive trawling ground of five thousand square miles (Wadge Bank) off Kanyakumari and other smaller banks adjoining Thanjavur Coast were discovered. Apart from this, survey with trawls along Malabar coast with SS Margarita in 1908, fishing off Cannanore and off Thoothukudi with Sutherland and *Turbinella* during 1908-11, fishing experiments by with Sea Scout during 1922-24 and exploratory fishing with vessels Lady Nicholson, T.R.8, Lady Goschen, Sea Scout and Leverett during 1927-30 were the earlier activities. Eight motor fishing vessels were used for shark fishing and as mother vessel for towing canoes and catamarans to the fishing ground in 1946. Experimental fishing with hand lines on the Wadge Bank and for flying fish off Nagapattinam was conducted in 1949. During 1945, a special unit under Mr.E.K.Madhavan was organized in the department for designing and building small-motorised boats. After the successful operation of the first motorized boat Ajit in Adiramapattinam in 1948, eleven more boats were built. Fishing demonstrations using long lines, surface gill netting and boat seines were made at specific centers.

The GOM is also historically known for its pearl *(Pinctada fucata)* and chank (conch shells, *Xancus pyrum*) fishery. From the earliest recorded times the Paravars were fishers, seamen and maritime traders specializing in seasonal harvesting of pearl oysters and chank, both of which were significant exports from southern India by the first century AD. The pearl diving season usually lasted 20 – 30 days, around March.

The earlier fishing boats large open vessels with masts as well as oars; the sails were made with cotton, stiffened by boiling with roots and cow dung, and the fishing nets were made from coconut fiber. There is uncertainty regarding whether or not the present boats called *vallam* are similar to the

ones described 500 years ago. Hornell's report of 1920 described the single-masted vallam in use around that time at being about 9 meters (30 ft) long and with a cargo capacity of around 2 tons. In 1914 he had described a larger three-masted boat, called the dhoni, which was used for pearl fishing and ferrying between anchored ships and Tuticorin harbour, as well as coastal journeys. The dhoni may owe its origin to Arab designs but could equally be indigenous.

For fishing boats similar to catamarans (tied tree) were used. An 1895 traveler describes them as a hollowed-out tree trunk up to 20 feet (6.1 m) long which is connected to a smaller trunk acting as an outrigger using lashes and two arched lengths of bamboo. The voyager and explorer William Dampier had described seeing them in 1699.

Synthetic twine, first introduced in the late fifties, has now almost totally replaced cotton twine for making fish nets (BoBP, 1983). At that time, fishing hardly extends beyond the 40 m depth line.

During 1980s' the district of Ramanathapuram had the largest number of mechanised craft, while Kanyakumari district has the largest number of kattumarams. The mechanised boats constructed are of six size groups viz. 7.6 m, 9.1 m, 9.7 m, 11 m, 11.5 m and 13.2 m. The 7.6 m boats were originally designed for gillnetting, but were later modified by fishermen for trawling. The construction of these boats was discontinued from 1974. Similarly, nearly 1,200 boats of the 9.1 m size originally constructed for gillnetting-cum-stern trawling. Later they were used only for stern trawling. The fishermen also tried to modify their boars as per their convenience since shrimp trawling proved more profitable than gill-netting.

Chanks fishing was recorded as early as 88 AD chank fishing was recorded (Arockiaraj, 2016). The chank and pearl divers of Thoothukudi are known for their ability to dive into the deeper depths of the sea without the help of any modern equipment. In 1962, the pearl fishery was stopped due to declining population. There were about 80 pearl banks in this region. These banks varied in depth from 10-20m. Maximum numbers of pearl banks were along Thoothukudi coast. Apart from industrial pollution and intensive bottom trawling, settlement of the heavy load of silt and clay has been identified to adversely affect the habitat and population of pearl oyster and chank.

Presently, there are no pearls to be fished out, and these divers eke out a living by dredging up leftover chanks from the depths of the Gulf of Mannar. "As chanks are found in shallow areas of the sea bed, we travel as far as 20 nautical miles, in search of shallow patches. The fishermen usually keep measuring the depth of the water by dropping a stone into it to find a shallow stretch, and send the divers to a depth of 15-20 meters to comb for chanks. . The chank divers also laments that today chanks are hard to come.

The Government of Tamil Nadu provides licenses to fishermen for the chank fishery in the area. Sea cucumbers, locally called attai, found in abundance in the GOM region, constituted an important fishery until 2001. The intertidal regions near the islands are an important source of sea cucumbers, which are exported as beche de mer. The Holothurians (all species of sea cucumbers) were listed in Schedule I of the WLPA in 2001, leading to a ban on their collection and trade.

Some of the nets introduced in part of Tamil Nadu.

- Use of the vaalaivalai- a cotton drift net with a two inch mesh, used for mackerel and wolf herring. During 1978, the net had largely been replaced by more effective gill net varieties made up of synthetic twins.
- Tamil Nadu fisheries department encouraged to use synthetic material for net making during 1960s. A section of people opposed the use of paddu nuul (Tamil for synthetic twines) to make valai particularly in some parts of coramandal coast.
- Introduction of set bottom net along with trawl net during late 1960s'.
- Government of Tamil Nadu as early as 1964 had issued an order giving exclusive rights to the artisanal fishermen within three miles from the coast.
- Introduction of trammel net a three layered gill net during 1983.
- Tamil Nadu Marine Fishing Regulation Act, which was passed in 1983 (Bavinck 2001)
- Introduction of modern ring seine during 1990s'.
- Tamil Nadu State government has banned the use of purse seine net and miniature version of the net known as ring seine for fishing during 2008 as they would cause damage to biological processes of fish population.

The FAO Code of conduct for responsible fisheries (FAO, 1995) with management measures and their applications (Cochrane, 2002) was used as the reference documents to evaluate the present status and to prepare a sustainable fisheries management plan for Biosphere Reserve.

Outline of Sustainable Fisheries Management Plan (SFMP):

	Step	Planning Process
Preliminary study	1.	The present status of fishing villages, landing centres, and markets
	2.	The employed fishing crafts, gears and their mesh sizes, operation duration, target catch, catch per haul and days engaged in fishing activities
	3.	Assessment of fish diversity in the creek

	4.	Status of documentation of fishing information, discards and waste (garbage/plastics)
	5.	Evaluation of creek fisheries management
Implementation of management plan	6.	The stock assessment and status, including ecosystem interactions with implementation of precautionary approach
	7.	Economics of the fishery, including the socio-economic profile and market status
	8.	Management issues, including depleted species concerns, habitat considerations, and gear impacts
	9.	Short- and long-term sustainable fisheries objectives for stock conservation
	10.	Management measures for the duration of the plan, including control and monitoring of the harvest, decision rules, licensing, and habitat protection measures
	11.	Performance review of management objectives

15.2 Fishing practice of Gulf of Mannar:

Gulf of Mannar is one of the critically important habitats. The fishery forms a livelihood opportunity for the coastal people. Over 30,000 were directly dependent on marine fishery resources of Gulf of Mannar. This region produces nearly 20% of the Tamil Nadu marine capture. The fishery is multi-species as well as multi-gear based. Fishing practice is also diverse.
Fishing villages:

The Gulf of Mannar has more than 225 fishing villages and 150 fish landing centers. Fishermen in the coastal district have been exploiting mainly the fishery resources along the coast for centuries.
Table: District-wise costal length

Sl.No	Name of the District	Gulf of Mannar (km)
01	Ramanathapuram	141.0
02	Thoothukudi	163.5
03	Tirunelveli	48.9
04	Kanyakumari	11.5
		364.9

Table: Marine Fishing landing centers in Gulf of Mannar

Sl.No	District	No of Fish Landing Centre		
		Major	Minor	Total
01	Ramanathapuram	5	63	68

02	Thoothukudi	2	25	27
03	Tirunelveli	1	7	9
04	Kanyakumari	3	44	46
	Total	**11**	**139**	**150**

Fishing crafts employed

The report indicates that there is a continual growth of fishing crafts in this region. Both mechanized and artisanal fishing practices co-exist in the region for long. Mechanization was initiated way back in 1954 under Indo-Norwegian program by the Indian Government (Piyami, 2017). Before this time, fishing was done with country crafts cruised by sails, paddles and oars. Mechanized boats, Non-mechanized boats, motorized boats and shore seines are now operated in this region for fishing. The traditional Catamaran has been drastically reduced and almost vanished from the region except in Kanyakumari. However, majority of the catches are landed by mechanized boats only. This is followed by non-mechanized, motorized and shore seines. Fishing is normally done up to the depth of 20 to 50 m. in the area of 5500 m^2 .

Fisheries resource of Gulf of Mannar mainly consists of sardines, anchovies, tuna, silver bellies and perches. The reef associated fauna are heavily landed in this region. Rameswaram trawlers fish only three days a week (Tuesday, Thursday and Saturday) on account agreement with the local traditional fishermen who fish on other four days (Vivekanandan, 2004)

Number of Fishing crafts reported as per 2010 census

District	Trawler	Gill netter	Liners	Ring seiners	Others	Total			Total
						Mechanised	Motorised	Non-motorised	
Ramnad	1995	2622	-	57	116	4790	372	1926	7088
Thoothukudi	333	1097	-	-	90	1520	1699	294	3513
Tirunelveli	-	-	-	-		0	1111	205	1316
Kanyakumari	645	25	380	-		1050	6672	2597	10319
	2973	3744	380	57	206	7360	9854	5022	22236

Fishing gears employed

Fishing is one of the major economic activities in Gulf of Mannar. As far as fish species are concerned, of the 2,200 fish species distributed in Indian waters, 804 species (including elasmobranchs) have been recorded in Gulf of Mannar. The gears that are commonly used for fishing in this region are trawl net, Gill net, seine net, tangle net, surrounding net, lift nets and line fishing. Among the several types of gears employed, most of the catches are

landed only by trawl net, followed by gill net. District wise fishing gears employed in Gulf of Mannar is given below.

District	Gill net	Trawl net	Shore seine	Boat seine	Long line	Trap	Others	Total
Ramnad	6902	1598	221	538	1292	150	1279	11980
Thoothukudi	3442	135	73	2	650	1	497	4800
Tirunelveli	1758	0	0	0	82	0	189	2029
Kanyakumari	4263	460	114	130	2589	21	1699	9276

(Source: Marine Fisher Census Year 2010 Tamilnadu, Tamilnadu State Fisheries Department)

Fishing is the major livelihood option for the coastal fishermen community and it has to be managed sustainably. The fish landing pattern has been heavily changed for the last twenty years and the depleted resource niche are occupied by newer species. The increasing production, due to capture of small fishes and capture from new deeper fishing grounds mask the resource degradation and depletion.

15.3 Status of fishery resources:

The GoM produces about 20 percent of the marine fish catch in Tamil Nadu. Of the 2 200 fish species distributed in the Indian waters, 1182 species belong to 144 families and 39 orders are reported from Gulf of Mannar alone. (Joshi, et al., 2016). Fishing is done intensively in 5 500 sq. km nearshore coastal waters in the depth range of 50 to 200 meters. The fishery is multi-species as well as multi-gear with diverse fishing practices. Trawl nets form the dominant gear, followed by gill nets and long line

Analysis of various net catches revealed that nearly 435 species are caught in trawl net followed by gill net (286 species) and long line (194 species). The analysis of the fishes indicated that nearly 465 bony fishes are used as food fish in Gulf of Mannar region. 176 could be used as potential marine ornamental fishes and 146 fishes are thrown as trash fish. The trash fishes are mostly utilized for preparing poultry feed.

Past analysis of fisheries from this region revealed that there are 734 bony fishes and 68 elasmobranches (Venkataramani and Jawahar, 2010). Recent updated check list of Gulf of Mannar indicated that there are 1,182 fishes found in the Gulf of Mannar (Joshi et al., 2016). and for their status revealed that 241 bony species are common, 51 species are abundant, 302 species are rare and 107 species are indeterminant and thirty- three species are in vulnerable list Venkataramnai and Jawahar, 2009) . The exact nature of other individual fish status could not be assessed due to lack of base line data.

The pelagic group of fishes like sardines, anchovies, engraulids and mackerel were mainly caught by smaller meshed gillnets and shore seines. The pelagic seer fish and tuna group of fishes were exploited by surface gill net, drift gillnet and long line. Among the pelagic group the capture of *Sardinella longiceps, Sardinella gibbosa, Sardinella albella, Sardinella sirm, Stolephorus commersoni, Stolephorous indicus and Euthynnus affinis* were dominant. The other species *Dussumiera, Hilsa, Chirocentrus* were occasionally caught and form minor fishery. The catch of oil sardine, *Sardinella longiceps* is increasing in this region due to climate change.

The demersal catch from Gulf of Mannar is highly diverse. It is highly represented with Leiognathids, Carangids, Lethrinids, Lutjanids, Acanthurids, Haemulids, Mullids, Serranids, sciaenids, barracudas and some elasmobranches. Demersal catch beyond 50m depth range has been increasing. The increasing horse power (i.e. up to 500) by trawl owners help to reach the fishing ground more quickly. It also makes most of the fish unfit for edible purpose and turns into trash fish.

The catch composition shows that the drift gillnet fishery at Tuticorin, Chinna Eruvadi and Mandapam coast is a multispecies fishery, mainly composed of *Hilsa toli, Pampus argenteus, Parastromaetus niger, Scomberomorus guttaus, Chirocentrus dorab, Scoloiodon laticaudus,Rhizoprionodon acutus, Trichiurus lepturus etc.*, The higher catch rate in the beginning of the fishing season, i.e., during September-October was mainly due to better catches of pomfrets and in the end of the fishing season i.e., during May-June.

Ornamental fish diversity

Venkataramani et al. (2004) reported 113 species of ornamental fishes while Kumaraguru (2005) reported 115 species of coral fishes belonging to 53 genera and 28 families from the GoM. The marine ornamental fishes are caught by shore seines, trawl nets and traps. Some of the common ornamental fishes of the region include *Amphiprion sebae, Dascyllus trimaculatus, Abudefduf vaigiensis, Chaetodon collare, C. octofasciatus, C. vagabundus, Pomacanthus annularis, P. semicirculatus, Labroides dimidiatus, Thalassoma lunare, Zebrasoma veliferum, Scarus gobban, Zanclus cornutus, Lutjanus fulviflamma, Platex teira, Siganus javus* and *Gymnothorax favagineus.*

Sea cucumber

The sea cucumbers are an interesting group of purely marine animals. They are a delicacy in far east Asian countries and are consumed in fresh, chilled, frozen, dried and in processed forms. They find an important place in traditional Chinese medicines. Since sea cucumbers do not offer resistance at the time of capture, they are easily over- exploited. Nearly 200 species are available in Indian waters of which fifteen are used for processing. Some of the important species of the GoM include *Holothuria scabra, H. atra, H.spinifera* and *Stichopus varigatus.* Fishing on sea cucumber is banned in India.

15.4 General fishing trend:

Research papers are available on biology of limited species (Annexure I). Literatures on the fishery and stock assessment are also limited from this region (Annexure II). With the existing knowledge, current status could not be established. The fishing pressure on individual length group has to be established. But the general trend could be indicated as follows.

- Overall capture of Oil sardine is increasing and it is contributing highly to the fishing in the region.
- The contribution of lesser sardine and silver bellies are stagnating.
- Capture of anchovies are varying dependent on environment variability.
- The catch of juvenile and lower value fish have been increasing in the catch. The low value fishes like *Odonus*, balistids and leiognathids are increasing in the catch.
- The length at first capture of most of the fishes including commercial groups like lethrinids, lutjanids, serranids, scombrids are coming down. The average size of the fish captured has been decreasing.
- The catch per unit effort has been coming down. The trash fish/ bycatch coming from this operation is also high.
- The total capture of particular fish group also coming down. Fishermen are spending more fishing hours to reach the fishing ground to capture the fishes. Fishermen are trying to find new fishing grounds especially far off places. The number of fishers traveling far off fishing grounds also increased. The fishing grounds also moved away from the shore especially at a depth of 300 to 500 m.
- Use of fine-mesh nets particularly, the cod end size of around 10-20 mm in some gears almost sweeps all the fishes.
- Fishing boat should also been also modernized with more sophisticated instruments. Global positioning system has been introduced in all the vessels going for fishing. Horse power of trawler has increased from 40 to 200 & 500 hp. This helps to increase the speed of vessel so as to reach the fishing ground quickly and do long hours of trawling. The depth of operation of fishing has been increased to 30 m to 150 m. Modern mechanical and electronic innovations like echo sounders, loran, and hydraulics have improved fishing efficiency immensely. Deeper and deeper resources are being tapped and capture of deep sea fish/ crustacean resources are increasing.
- Smaller boats especially catamaran, FRP and vallam are fixed with inboard engines or outboard engines to reach the ground quicker.
- The capture of benthic organism and sharks has been drastically coming down. The capture of demersal species like Lobster, Elasmobranches, chank, crab and *Scomberomorus* were drastically coming down.
- Enormous increase in fishing effort since the 1970s has resulted in the decrease in per capita area per active fishermen and per boat in the inshore fishing grounds and also in the Catch per Unit Effort,

which, in turn, has given rise to conflicts among different categories of fishermen, especially artisanal and mechanized sectors.

- Excessive bottom trawling results in degradation of the sea-bed ecosystem and its biodiversity. Large number of non-target groups comprising juveniles and sub-adults of economically important finfishes and shellfishes and also benthic organisms are caught by this non selective fishing gears. Some of the destroyed individual's species may have little edible value but occupying key positions in the marine food web.
- Nearly 20% of the catch is discarded. Managerial measures need to be devised for onboard collection/preservation of discards and their value addition to prevent economic wastes.
- Deep water shrimp (*Heterocarpus* sp) are fairly abundant in depths of 200-700 m of southern part of Gulf of Mannar and steps have to be initiated to harvest these resources.
- Most of the fisheries resources are either already overexploited or approaching level of over-exploitation due to uncontrolled fishing pressures. Some of resources such as shrimp and lobsters have crossed the level of sustainability due to over fishing and it is feared that their potential may collapse in near future.
- From the available data on fish landings we could not make decision on individual species fishing nature. Survey with fishermen (Vivekanandan, 2010) indicated that the species like Sharks, saw fish, skates, Black rays, Rainbow sardine, Tiger prawns, Sea bass, Catfish and lobsters are depleted in their fishing grounds. Whereas the species like *Thunnus*, *Chirocentrus*, Eel, Parrot fish, Red mullet, catfishes and Perches catches are declining. With the field observation, it could be indicated that overfishing is happening in Gulf of Mannar
- Increased pressure on coastal resources is rampant in many parts of the Gulf of Mannar. Uncontrolled expansion of trawling has led to a decline in not only shrimp catches but also most of the fishes in the Gulf of Mannar. These vessels compete with artisanal fishermen whose gears get damaged, and conflicts are common. The legal framework providing for fisheries management and development is weak in this area.
- Mechanised boats often damage the fishing gear of traditional fishermen, causing financial loss to them;
- Mechanised boats also pose danger to the safety of the traditional fishermen: due to collisions between mechanised boats and country boats, traditional fishermen get injured; and
- The expanded reach and indiscriminate nature of trawling downgrade the marine resources, lowering catch and income of the traditional fishermen and endangering sustainability of the resource.

Based on the common indicators of overfishing, (proposed by DENR et al, 2001) it could be observed that overfishing is happening in the Gulf of Mannar.

Sl. No	Indicator	
1.	Changes in species composition	Yes
2.	Marked increase in the catch and sale of trash fish (lower-value fish)	Yes
3.	Rapid growth in the population and catch of squids	No
4.	Bigger volumes of smaller-sized fish being caught and sold	Yes
5	Decreasing catch of targeted species such as groupers, snappers (Lutjanidae) , breams, and flatfish (Psettodidae)	Yes
.6.	Fewer sightings of specialty species such as stingrays (Dasyatidae), manta rays,sharks and others	Yes
7.	Decrease in fish age and size at maturity	In most fishes.
8.	Increased catch of small-size individuals (less than 20cm) of typically large-backed fish such as jacks or groupers	Yes
9.	Significantly lower total fish catch compared to five years ago	No data on individual species. But fishermen indicating the fish catchers are coming down.
10.	Fishers going out farther to fish	Yes
11.	Fishers needing more time to catch the same amount of fish that they did five years ago	Yes
12.	Decrease in catch determined using informal or formal data sets of catch records over at least 10 years	Data not available
13.	Change in CPUE	Yes- Decreased
14.	Decline in average income of fishers	Yes
15.	Fewer boats going out to sea or less frequent use of boats for fishing	Yes
16.	Increase in the number of fishers in the area due to migration or lack of employment	Fishermen population is increasing.
17.	Absence of seabirds hunting for schools of fish	Yes
18.	Marked increase in the establishment of fish aggregating devices	Initiated to establish fish aggregating devices.
19.	Increased use of fine-mesh nets to catch fish	Yes
20.	Marked increase in illegal fishing and use of destructive fishing methods;	Yes. Particularly pair trawling, purse seines
21.	Increasing conflicts between traditional and commercial fishers;	Yes
22.	Increased encroachment of commercial fishing boats on territorial waters;	Yes

23.	Large increases in the price of first and second-class fish	Yes
24	Increasing number of fishers traveling to distant fishing grounds (even to other countries EEZ) to catch fish they used to be able to catch locally	Yes

The study by various scientists revealed that nearly 65% of the commercially important varieties are overfished. This uncontrolled open access fishing will leads to undesirable consequences like Fishery collapse, Economic inefficiency, Loss of employment and Habitat loss or decreases in the abundance of rare species.

15.5 Threats

The Gulf of Mannar area is prone to severe anthropogenic pressures from the coastal fisher population. The major threats prevailing in the area are;

a) High fishing capacity:

b) Over exploitation of Marine Resources/ Depletion of fishery stocks of commercial species:

c) Higher and unsustainable exploitation rate:

Nearly 65% of the stock assessed had over 0.5. in most of the case, the fishing effort exceeded fmsy.

d) By catch: By catch analysis revealed that the by catch was found to be high in trawl net followed by bottom set gill net. It has already been pointed out that ever so many other species of fishes are getting destroyed in the avaricious attempts to catch the shrimp and other bottom resources.

e) Habitat destruction:

Due to heavy fishing and coastal pollution, the fish habitats are affected. The pollution from Thermal and other industries located in Thoothukudi region has serious threats to the critical habitats like coral reef, estuary, mangroves and sea grass beds. The sea grass beds are also affected by heavy fishing. Studies reveal that an artificial reef established in various parts of Gulf of Mannar has enhancing the fishery resource. So, sufficient funding, training and encouragement are needed to restore and to protect the coastal habitats particularly coral reefs and associated biodiversity of Gulf of Mannar. The marine ranching work should be encouraged in the region particularly to enhance the depleted marine fishery resources of Gulf of Mannar.

f) Use of prohibited fishing practices and banned gear:

Bottom trawling, purse seining, etc, and the usage of mesh size below 20 mm in any type of gears are banned in Gulf of Mannar region as per the Tamilnadu Fisheries Act & Rules. Studies on gears indicated the banned gears and fishing (pair trawling) practices are still prevalent in some parts..

The effective enforcement of these laws is needed to protect the fishery resources.

g) Capture of endangered organisms:

The species like seahorse, sea cow, whale shark, marine turtles, holothurians and certain chank species are reported as by catch from trawlers and gill nets. Status surveys of illegal trade of these organisms are still in progress in certain parts of Gulf. Dugong capture has been found to be in the northern part of Gulf of Mannar whereas the capture of marine turtles are found to more near southern part of Thoothukudi. Other species are incidentally caught from all along the coast.

h). Marine pollution:

This results due to untreated sewage dumping in the nearshore areas. Localized pollution were observed in Thoothukudi regions and the sewage dumping sites. Due to this harmful algal blooms are occurring frequently in Gulf of Mannar.

i). Climate Changes

Marine fisheries are an important global food supply source. Pressure on marine fish population comes from many sources including global warming or climate change. Climate change is one of the most important factors that can affect marine fisheries, Due to climate change the open water wetlands that are critical habitat of many species would be replaced by damp land although some form of vegetation would remain there. Lower water table would also leave some areas that currently have some form of wetland vegetation, dry for a longer period that would reduce biological productivity and in some cases would leave the land too dry to consider it as a wetland.

Climate change induced shifts in temperature will have a disastrous effects on fish populations (e.g., thermal stress), especially if shallow water or long distances prevents the fish from finding a thermal refuge. It also affects at molecular (e.g., heat-related damage to vital enzymes; Somero, 1995) to systemic (e.g., cardiac insufficiency, Cech et al., 1975) level.

15.6 Fisheries Resource Management

Necessary resource management and conservation initiatives are needed to arrest the decline of marine natural resources. Marine fisheries is basically harnessing a natural resource and therefore its management must be anchored on knowledge- based interventions generated through close monitoring of their distribution, abundance, exploitation, population dynamics and fluctuations of fish stocks in relation to natural factors and anthropogenic interventions (Pillai et al., 2007)

The resources are conserved in two ways. One is called in-situ (on-site) conservation, the other ex-situ (off-the-site) conservation. The governments departments, NGOs, communities, research institutions and

many others are working to conserve and manage the fisheries resources. Some major international organizations involved in this work are the IUCN, the World Wide Fund for Nature (WWF), the United Nations Environment Programme (UNEP) and the United Nations Educational Scientific and Cultural Organisation (UNESCO). In 1971, the UNESCO began the Man and the Biosphere Programme to establish at least one biosphere reserve in each of the earth's 193 bio-geographical zones. The idea is to protect the plants and animals that characterize each bio-geographical zone in their natural setting. Gulf of Mannar is one of the important biosphere reserve established under this programme

Some of the International agreements help to manage the fisheries resources are listed below.

- The Convention on Biological Diversity
- The Convention on International Trade in Endangered Species of Wild Flora and Fauna (flora: plants, fauna: animals)
- The World Heritage Convention, a UNESCO mission to protect cultural and natural heritage. India has five natural world heritage sites—Keoladeo National Park (Rajasthan), Manas and Kaziranga National Parks (Assam), Nanda Devi National Park (Uttarakhand) and the Sunderbans (West Bengal)
- The Convention on Wetlands—India has 19 wetlands protected under this convention.

Conservation initiatives in Gulf of Mannar/ India:

India has several laws aimed at protecting the environment, including plants and animals. It has also launched several plans and programs to conserve biodiversity. Let us take a brief look at some programs and organizations related to conservation in India.

Laws related to wild resource conservation and management.

i. The Forest Act, under which reserved, protected and village forests are managed
ii. The Forest (Conservation) Act, which regulates non-forest use (e.g., mining) of forest land
iii. The Wildlife (Protection) Act
iv. The Fisheries Act, which bans the use of explosives and poisons for fishing.
v. Indian Biological Diversity Act, 2002
vi. The Marine Fisheries Regulation Act (MFRA) is the most important legal instrument in fisheries management followed by the Wild Life Protection Act. The Directorate of Fisheries is responsible for implementing the provisions of the MFRA Act. The Act and Rules have a number of regulatory provisions, including the following:
    - All fishing vessels are required to register and get a license to fish in the waters of the State.
    - The Act prohibits fishing gear of less than 10-mm mesh size from knot to knot.

- The Act prohibits mechanized and deep-sea fishing vessels from undertaking fishing operations within three nautical miles of the coastline.

The Rules, as amended in 2000, prohibit bottom-trawling operations within three nautical miles of the coastline; prohibit the use of gillnets with a stretched mesh size of less than 25 mm from knot to knot; of shrimp nets with a stretched mesh size less than 37 mm at the cod end; and of fish trawl nets with a stretched mesh size less than 75 mm at the wings and 40 mm at the cod end.

According to a notification issued under the Act, dated 25 March 2000, fishing using pair trawls or fishing with purse-seine nets by any fishing vessel/craft, whether country craft or mechanized boat, irrespective of its size and power of the engine, is prohibited along the entire coastal areas in the territorial waters of Tamil Nadu, to conserve the fishery resources.

A closed season (monsoon ban) is in place, whereby mechanized fishing vessels are not allowed to fish in the territorial waters for a period of 45 days during the monsoon season, starting from 15 April to 29 May every year. In 2017, Government of Tamil Nadu announced the closed season of 60 days starting from April 15 to June 14.

- Implementation of this act is patchy and change according to district and local convenience.
- Night fishing by mechanized boats is banned in Thoothukudi while it has been allowed in other parts of GoM.
- Rule governing order in which shore seines can be used given that all cannot be simultaneously operated
- Restrictions on fish landings by outsiders. This often applies even to fishing harbors officially under DoF control
- Prohibits fishing by mechanized fishing vessel, motorized country craft and those using mechanized fishing techniques in the radius of 5 nautical miles around the potential turtle nesting grounds during the breeding time (1 January to 30 April).

Each family of traditional lobster fishermen has exclusive rights to specific lobster grounds and these rights are inherited by sons and lead to sub-division of “property” as on land

The 3 day - 4 day rule in the Palk Bay, by which trawlers can fish on three days a week and the artisanal boats the remaining four days, came into being as a result of an agreement brokered by the District administration in Pudukottai and was then adopted by the other districts. Since this was in 1978 when the MFRA was not in place, this regulation is in force through a local administrative order. It can be considered the most successful and the longest standing of marine fishing regulations by state authorities in TN. Around 30,000-40,000 fishermen of TN are governed by this. It even has influence on the fishing in Sri Lanka as local fishermen take evasive action on the days on which trawlers are permitted to operate in India.

Apart from that the following acts/ rules exists for regulating the fishing activity in the region.

Existing Act/ rules	Salient Features
• Environment Protection Act (EPA), 1986 • Coastal Regulation Zone Notification, 1991 • Coastal Zone Management Plans (CZMPs) • Hazardous Waste Management Act,1989 • Environmental Impact Assessment Notification, 1994	• An umbrella Act under which industries cannot be set up near areas protected for conservation. • Under this act, all development projects have to get an environment clearance from the government. • Regularizes the various activities in coastal zone • Supreme Court Intervention that all the Coastal states prepare their CZMPs by 1996 • This Act provides guidelines for hazardous waste management and also for the import and export of hazardous waste in country. • The objective of this act is to conserve and protect the environment
• Water (Prevention and Control of Pollution) • Act,1974,Amended in 1988	• Control of pollution from land-based sources • Pollution Control Board was constituted under this act
• Indian Ports act,1908	• Enactment relating to ports and port charges. • Provides for rules for the safety of shipping and conservation of ports
• Major Port Trust Act, 1963	• The Act makes provision for the constitution of port authorities for certain major ports in • India and to vest the administration, control and management of such ports in such authorities and for matters connected therewith.
• Merchant Shipping Act,1958	• Control of pollution from ships and off-shore platforms
• Indian Fisheries Act,1897	Offers protection to fisheries against explosives or dynamites
• Marine Fishing Regulation Act, 1978	A model act, which provides guidelines to the maritime states to enact laws for protection to marine fisheries by

	regulating fishing in the territorial waters. The measures include: regulation of mesh size and gear, Reservation of zones for various fishing sectors and Also declaration of closed seasons Laws framed and Amended from time to time by different maritime states

Fisheries Resource Management

The management should aim to increase the social, environmental and economic benefit by harvesting the natural fisheries resources. It also reduce the negative impacts that affect the sustainable development of fisheries. Further, a stock should be

- exploited sustainably
- should maintain reproductive biomass
- should harvest growing population to avoid growth over fishing and recruitment over fishing
- fished with its biological health status`.

Moreover, India is a signatory to various International instruments and conventions related to the marine environment, notable of which are the UNCLOS, IWC, CBD, CMS, Tuna Commission, International oceanographic Commission, Antarctica treaty etc. and therefore, has an obligation to develop proper conservation and management of the marine habitat and its management.

The existing management regime could not able to control over fishing capacity and reduce exiting fishing fleet size to the natural carrying capacity. Under these circumstances the management options available for sustainable fisheries in Gulf of Mannar

1. Fisheries Legislation:

The depleted coastal resources and overfishing are the symptoms of the lack of effective management of fishing capacity in the region. There are several regulations by both central and state governments but there is no stringent legislation and strict vigil to stop illegal fishing, destructive fishing and mesh size regulation.

A review of existing legislations like the Fisheries act, Wildlife Protection Act, Environment Protection Act, continental shelf, and other Maritime zones of India Act, Maritime Zones of India (Regulation of fishing by foreign vessels) 1981, Offshore Mineral Development Act, National Biodiversity Act 2000 etc. of both center and states and other enactments impinging on marine biodiversity should be done with a view to amend them or introduce legislation in respect of areas affected or in respect of practices that harm marine fishery resource to the extent not so far covered.

The Protected Areas Network in marine areas should be expanded to cover critical deep sea areas. The fisheries/ forest departments in the states should be strengthened and upgraded to handle this better.

2. Creation of Awareness:

The awareness on Gulf of Mannar resource has been increasing. More efforts are need to sustain these precious resources. Monitoring of stock status is relatively difficult as the number of small vessels are very high. To enhance the level of understanding about the GoM resources, regional level awareness program should be launched in all the districts of Gulf of Mannar. The coastal villagers are sensitized on the need for sustainable/wise use of coastal and marine resources. Public awareness programme should be undertaken with different forms of print and audio-visual media. Good quality films on the subject area should be made.

3. Proper implementation of Responsible fisheries management principles:

The FAO formulated the code of conduct for responsible fisheries management. These are model codes used to conserve and sustainably utilize these aquatic resources. This is the right time to take firm decisions to implement the code to protect the precious resources of Gulf of Mannar. The code should be implemented strictly among the people who are benefitted from government subsidies for their fishing vessel and other benefits like Fisheries Welfare schemes.

4. Proper exploitation of underutilized resources:

The capture of hitherto underutilized deep sea resource should be encouraged. Series of resource survey should be conducted to find out the potential fishing grounds in Gulf of Mannar. Sufficient training to the fishermen should be given viz Chart reading, ecofriendly fishing, tuna long lining, proper handling of fishes, engine maintenance. The suitable modification of boat has to be encouraged. The deep-sea resources such as tunas and cephalopods which are not tapped should optimally be utilized. The resources like octopus, tuna, deep sea shrimp and deep sea fishes are under exploited.

- Octopus fishing – encourage- Helps to reduce the natural mortality of small fishes and coral associated fishes
- Utilize by catch effectively- like Sardine, Leiognathus. ribbon fishes and *Odonus niger*
- There does not seem to be any reason to reduce the present levels of offshore fishing effort although suggestions for any increase should be carefully considered.
- The fishing of ornamental fishes, ornamental invertebrates may also be encouraged. Organized capture of this will give livelihood option. The technology should be demonstrated.
- Taping of Deep-sea fisheries resources:
    - The capture of hitherto underutilized deep sea resource should be utilized. Series of resource survey should be conducted to find

out the potential fishing grounds in Gulf of Mannar. Sufficient training to the fishermen should be given. The suitable modification of boat has to be encouraged incentivizing the fishermen who come forward for conversion of existing fishing craft. So the deep-sea resources such as Tunas and Cephalopods should optimally utilized.

5. Reducing the pollution:

The coastal areas of Gulf of Mannar are the ultimate reservoirs of wastes generated by the modern civilization. The studies on impact of pollutants on marine resources are limited. However, literature indicated that the increased levels of heavy metals in the region are becoming a severe threat, which may pose hazards to the aquatic living resources. The non-biodegradable pollutants especially the heavy metals and pesticides alter the marine eco-system to a considerable extent.

No effluents, solid waste or untreated sewerage should be discharged into the sea without treatment which brings it in conformity with standards fixed by Central Pollution Control Board. In the case of metropolitan urban settlement on the coast, plan should be drawn up for treatment of effluents for discharge into the sea and for this purpose a project should be taken up on the model of the National River and Lake Action Plan.

The industrialization in the southern part of Thoothukudi is increasing. Nearly 30 industries are located along the coast of Gulf of Mannar. Sewage and other waste disposal locations along the coast are draining into Gulf of Mannar. In regions like Therespuram, Thiruchendur, Keezhakarai and Mandapam area, the domestic sewage pollution is high. The high levels of organic load further enhance the coastal productivity and induce algal bloom. Severe fish kill was observed near Keezhakarai due to *Noctiluca* bloom which affected the total reef ecology. Harmful algal blooms are occurring frequently in Gulf of Mannar.

About 35,789 metric tonnes of chemical fertilizers were used in 1995-96, out of which more than 60% constitutes the nitrogenous fertilizers. The usage of chemical fertilizers, bio-fertilizers and dust and liquid pesticides were 65702 tonnes, 2,08,670 pockets and 2,79,500 kg and 29548.10 liters respectively in the years. Their usage much be reduced. Industrial sewage discharge of 1025 m^3/d is estimated to be dumped into the coastal water of Thoothukudi district.

6. Community based resource management

Nearly 0.3 million fishermen are dependent on Gulf of Mannar for their day to day livelihood. Their involvement is very much essential to conserve the precious resources. Community based coastal resources management programme in Gulf of Mannar is needed in order to develop, manage and sustain the fishery resources and to uplift the socio-economic conditions of fisher folk.

7. Underutilization of mariculture potential:

The potential for marine and brackish water aquaculture and ornamental fisheries are not adequately tapped. Cage farming is picking up as a

diversified form of aquaculture in many parts of the Gulf of Mannar. The lobster fattening, crab fatting and seaweed farming may help the fishermen to diversify their activities and help to utilize the resources and reduce the dependence of marine resources. This activity has to be encouraged to its full potential as employment generation and alternate livelihood option for fishermen. . This could help to meet current seafood demand in the regio**n.**

8. Strengthen the research and monitoring of fisheries management:

The data on marine fisheries is limited in Gulf of Mannar. These ultimately affect the management officials to take appropriate decisions. So the Government and various funding agencies should encourage interested scientists with adequate funding for long term studies on fisheries resource and coral reef studies.

9. Generation of Alternative employment:

The dependence of marine natural resource by the coastal people has to be reduced. The following activities may be considered for diversification based on the resources available in the region.

- Marine Ornamental Fish Culture

There are a wide variety of ornamental fishes in the vast water bodies and coral reef ecosystems along the Gulf of Mannar coast, which if judiciously used, can earn a sizeable foreign exchange. Hatchery technology for clownfish (*Amphiprion chrysogaster*), damsel fishes (*Pomacentrus caeruleus*, *Neopomacentrus nemurus* and *N. filamentosus*) and the sea horse (*Hippocampus kuda*) has been developed, which can be scaled up for mass production of these species. Suitable policy has to be formed for the use of listed animal for aquariculture purpose.

- Seaweed Culture

Around 60 species of commercially important seaweeds with a standing crop of one lakh tonne occur along the Indian coast of which, nearly 880 tonnes dry agarophytes and 3,600 tonnes dry alginophytes are exploited annually from the wild (Kaladharan and Kaliaperumal 1999). Seaweed products like agar, algin, carragenan and liquid fertiliser are in demand in global markets and some economically viable seaweed cultivation technologies have been developed in India.

- Molluscan Culture
  - Edible Oyster Farming
  - Mussel (*Perna viridis, Perna indica*) Farming
  - Pearl Oyster Farming and Pearl Production
  - Clam Culture
- Lobster Farming/Fattening
- Crab Farming/Fattening
- Charcoal Making and Palm based small scale units:
- Tourism:

10. Improving the coastal fishery resource of Gulf of Mannar.

Based on the available literatures the fishery resources currently exploited in the Gulf of Mannar indicates don't offer any scope for expansion of the fishing activity except some underutilsed resources. To sustain the resources it is right time to diversify 10 to 20% of the fishermen in fisheries related activities like mariculture, value added fishery products development, fishery tourism, conservation activities and developmental activities related to coastal region.

Creation of new fisheries by allowing the fishermen to far off seas to capture hitherto under exploited octopus fishery are the need of the hour. It appears that effective monitoring and corrective management are very important for the future sustainability of nearshore coastal resources. The officers have to be empowered to strictly implement the rules. Steps should be taken to conserve these resources. Use of massive destructive gears should be banned in the interest of small scale fishers. Further the use of trawl net should be revisited and modification like midwater and pelagic trawling may be thought of to exploit sustainably the resources.

Economic incentives, loan and subsidies should be curtailed for destructive fishing practices. At the same time subsidy and loan should be given for ecofriendly fishing gears like line fishing, drift gill net, surface gill net and off bottom trawling and mid water trawling.

The under-utilization of various resources needs to be addressed from a regional perspective. The capture of octopus, deep sea resources (like Tuna, bill fishes, pelagic sharks, oceanic squids, deep sea crab and prawn) and other under- utilized ornamental invertebrates should be initiated.

Utilization of trawl bycatch resources is a necessary option, as bycatch utilization and/or reduction are becoming increasingly important considerations within the trawl fisheries. There is a need to utilize these resources as almost all bycatch organisms die after capture. If the facilities to process these resources are not available then measures to reduce bycatch are necessary such as inclusion of bycatch reduction or exclusion devices in the fishing gears. Reduce fish by catch by enforcing ecofriendly fishing gears and properly regulating the mesh size.

The fishery resources could be protected and sustainably utilsied by marine conservation, habitat protection and sustainable fisheries. It is very much essential to protect the unique Gulf of Mannar environment. As per the Goal no: 14 directs conserve and sustainably use the oceans, seas and marine resources for sustainable development. Further, sustainable and productive fisheries and aquaculture improve food and nutritional security, increase income and improve livelihood, promote economic growth and protect our environment and natural resources (Worldfish, 2017). To protect this precious resource the following management plan may be proposed.

Management measure	Issue	Mode of implementation
Reducing overcapacity	Excess fishing effort -The current fishing effort is overexploiting the near shore waters	• Freeze the existing fishing effort/ number of boats • Reduce the effort by number of fishing boat/ days

	(up to 50m depth) resources	• Remove the excess fishing vessels from fishery by buy back or translocation. • Divert part of the fishing vessel to deep sea fishing or other related occupations like tourism / eco watching • Reduce subsidy
	Scientific data on stock assessment is poor	• Strengthen the sampling protocol and develop stock assessment models for species available in Gulf of Mannar • Prioritize top twenty species stock assessment and develop management plan • Developing and employed rapid fish stock assessment methods.
	Destructive fishing methods are employed	• Strictly enforce the law. Provide adequate man power for patrolling • Create awareness on the destructive fishing methods.. • Replace the existing destructive gear with ecofriendly gears by buy back mechanism. • Encourage non-destructive fishing gears like long line – Kombuthurai like fishing methods
Reducing bycatch	Non selective fishing is employed.	• Strictly enforce the law. • Freeze the existing fishing capacity and longer run reduce / modify the destructive fishing gears • Develop ecofriendly gear with scientists.
	Non targeted biomass and smaller fish capture by some of the fishing methods are alarming.	• Introduce square mesh cod end in trawl nets. • mesh size regulation in all gears employed.
		• Create awareness on selective gears and ecofriendly gears.
		• Reduce the fishing gear which brings more by catch • Increase the seasonal and spatial

		closure (like fishing holiday).in two periods ie. one during breeding time and other during the recruitment time. • Develop PSA index and study the risk of individual species based on gear
	Listed and endangered animals are captured by the gear	• Create awareness among the stakeholders. • Support captive breeding program for endangered species •
	Reduction in commercially important species like spiny lobster, shrimp etc.,	• Strengthen the stock enhancement activity of the Fisheries Department, Regional centers and Central Research Institutes.
Maintaining fishery to its sustainable level	Sustainability level could not be assessed due to multispecies and multi-fleet fishery	• Available data is inadequate to take decision and impact of gears on fishery is unknown. So, generation of basic data to estimate MSY is needed.
		• Strengthen the vessel monitoring program
	Increasing horse power by these mechanized boats severely affecting the resources.	• Horse power of vallam and trawlers has to be regulated and fixed.
Reduce the Habitat loss	Reduction of coral cover, mangrove forest and seagrass beds due to pollution as well as fishing.	• Conduct survey on habitat loss and degradation due to fishing and pollution
	No data on fish habitat and spawning aggregates	• assess the critical habitat / fish breeding congregates and enhance the protected area to another 5% of GoMBRT • Increase survey on ecosystem and spawning aggregates
	Currently used fishing gears are not ecofriendly fishing	• Provide subsidy to convert ecofriendly fishing practice • Provide incentive for responsible fishing by eco-labelling and better marketing infrastructure

		• Creation of buffer zone for biodiversity conservation
Rebuilding fishery resource through habitat restoration	Existing fishery habitats are affected by fishing practice and pollution.	• Create awareness on responsible fishing • Develop ecology based fisheries management model for GoM. • Initiate habitat rehabilitation program for seagrass, coral and install fish aggregation device in open sea. • Protect the Chank Beds and Pearl Banks
	No data on fish habitat and spawning aggregates	• Assess the critical habitat / fish breeding congregates and enhance the protected area to at least 10% of the marine and coastal environment as per Aichi Target 11.
	Land derived waste are affecting the near shore waters productivity	• Strict implementation of environment law • Treatment of wastes • Establishing common effluent treatments at key locations. • EIA of the existing industries and commercial activities along the coast.
	Ecosystem based approach are not initiated.	• Involve various stakeholders on need for EBA approach in fisheries management • Strengthen co-management concept in fisheries resource management
	Enhancement of seaweed covers over coral reef area.	• Ranching of herbivorous and key ecotone species like *Siganus, Scarus,* Sea urchin in the degraded coral reef area.
Creation of alternative livelihood	Fishermen depend only fishing for their livelihood.	• Provide alternate livelihood option • Provide adequate skill development program • Seaweed, fish and shrimp culture may be encouraged among the fishermen. • Culture of other marine organisms like oysters/ mussel and even listed organisms may also be explored.

Summary of Recommendations:

1. Communication gap between primary stakeholders (fishers) and Biosphere Reserve Authority should be minimized.
2. An inter-institutional collaborative management programme i.e. between Department of Forest and Department of Fisheries, Government of Tamil Nadu and other institutions can strengthen the conservation objectives into reality.
3. The critical fish breeding distribution area in the Biosphere Reserve needs to be mapped and informed to fishermen accordingly for sustainable fishing over there.
4. Documentation of the catch and fishing operations should be made mandatory.
5. Awareness programs should be organized for minimizing catch of juveniles and other bycatch using slightly increased mesh size.
6. Strict enforcement of State and Indian Fisheries acts that promote the sustainable fisheries in the region.
7. With help of CIFT, Kochi, an appropriate gear and craft need to be developed for Biosphere Reserve region to minimize the bycatch and damage to corals, seagrass and oyster beds. These gears may be offered to fishermen at the discounted rate by the BR authority.
8. Enforcement of closed season on important breeding grounds can ensure the long term sustainability of fishery resources. Appropriate compensation required to be provided to fishermen during the closed season.
9. Ranching of suitable candidate species needed for stock enhancement inside the National Park (core zone). Spill over populations of these species in the Biosphere Reserve (buffer zone) may be harvested by the fishermen.
10. The alternative livelihood opportunities such as crab fattening, mussel culture, seaweed farming, fish rearing in floating cages and existing near shore natural ponds can be provided. Only native fishes and weeds need to be used in this programme.
11. Encourage the fishermen youths to participate in the proposed ecotourism activities which can generate the extra income for their livelihood.
12. The research should be promoted on the environmental and social impacts of fishing nets and their impacts on biodiversity and Biosphere Reserve fishing communities.

The management plan suggested is only of indicative nature. Various options are available. Necessary guidelines for resource protection and enhancement may be further refined with wider consultation. .

Fishing pattern of Gulf of Mannar

Particulars	Ramanathapuram					Thoothukudi						Tirunelveli						Kanyakumari			
	1977	1980	1996	2008	2010	1977	1980	1987	1996	2008	2010	1977	1980	1987	1994	1996	2010	1977	1980	1996	2010
No. of fishing villages	67	80	99	184	178	-	-	-	19	21	32	26	32	-	-	7	9	42	46	44	46
No. of landing centres	72	64	78	75	90	-	-	-	22	22	27	26	28	-	-	8	9	62	45	45	46
No. of marine fishermen	33795	71143	77510	148876	193413	-	-	40171	47289	88200	82560	30491	43793	18608	20952	21905	24639	88275	99051	135255	156595
Fishing crafts :-																					
Catamaran	155	370	178	-	52	-	-	-	1682	-	61	2345	2584	-	0	-	94	10817	11527	6728	1274
Country craft	-	-	7092	-	-	-	-	-	2768	-	-	-	-	-	0	-			-	2831	-
Mechanized boats	-	-	2180	-	4790	-	-	-	416	-	1520	-	-	-	-	-	0		-	1366	1050
Plank built boat	-	4074	-	-	87	-	-	-	-	-	7	140	958	-	-	-	0	-	692	-	23
Masula boat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-
Canoe	-	626	-	-	74	-	-	-	-	-	7	-	3	-	-	-	3	163	537	-	31
Vathai	881	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-		-	-	-	-
Thoni	303	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-		-	-	-	-
Vallam	189	-	-	-	-	-	-	-	-	-	-	424	-	-	-	-		308	-	-	-
Trawler	-	981	-	-	1995	-	-	-	-	-	333	-	103	-	-	-	0	-	226	-	645
Gillnetters	-	27	-	-	2622	-	-	-	-	-	1097	-	5	-	-	-	0	279	-	-	25
Others	-	45	-	-	116 + 57 (RS)	-	-	-	-	-	90	-	1	-	-	-		-	6	-	-
Motorized boats	-	-	-	-	372	-	-	-	-	-	1699	-	-	-	-	-	1111	-	-	-	205
Non-Motorized boats	-	-	-	-	1926	-	-	-	-	-	294	-	-	-	-	-	6672	-	-	-	2597
TOTAL	1528	6123	9450	-		-	-		4866			2917	3654	-	0	-		11288	13267	10924	-
Fishing Gears:	-	-	-	-																	

Boat seine	-	3,029	-	-	537	-	-	-	-	-	2	1033	-	-	-	-	0	2099	-	-	105
Gill net	24306	35,048	59232	-	6362	-	-	-	24076	-	3198	23513	-	-	32576	-	1571	13342	-	9327	3828
Shore seine	373	1523	583	-	200	-	-	-	176	-	72	10	-	-	-	0	0	577	-	591	79
Boat seine Changed to Ring seines	-	24	-	-	62	-	-	-	-	-	26	-	206	-	-	-	3	-	2070	-	142
Trawl nets	-	3029	3539	-	1457	-	-	-	640	-	130	-	217	-	-	0	0	-	524	415	307
Line fishing	615	5362	1399	-	1284	-	-	-	980	-	628	354	487	-	0	-	71	2934	2516	2904	2087
Bag net	12	737	-	-	0	-	-	-	-	-	3	-	12	-	-	-	0	-	109	-	9
Drift gill net	1041	35048	-	-	719	-	-	-	-	-	252	3716	14338	-	-	-	105	801	16832	-	853
Bottom set gill net	65	-	-	-	0	-	-	-	-	-	0	905	-	-	-	-	0	1776	-	-	0
Drag net	3016	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	0
Scoop net	-	22	-	-	2	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	0
Traps	-	3312	2412	-	148	-	-	-	1174	-	1	-	-	-	-	0	0	-	1370	164	19
Others	2261	1168	5720	-	275	-	-	-	146	-	6	23	-	-	-	48	50	261	-	2211	10
TOTAL	31689		72885			-	-	-	27192	-	-	29554	-	-	-	32622	-	21790	-	15612	-

Biological parameters of commercial important finfishes of Gulf of Mannar coast

Sl. No	Name of the Species	Location	L_∞	K/Yr	T_0	M	Z	F	U	a	b	L_{MAX}	E = F/Z	Exploitation
1.	*Encrasicholina devisi*	East Coast	103.5	1.6										
2.	*Stolephorus waitei*	East Coast	134.5	1.2										
3.	*Megalaspis cordyla*	East Coast	410	0.52		0.84	3.08	2.24	0.73	1.2463^{-05}	2.9404		0.7272	Overexploited
4.	*Caranx carangus*	Tuticorin	498	0.7689	-0.0455	1.18	6.54 trawl	5.36		-4.3555	2.8577		0.8196	Overexploited
		Tamil Nadu & Pondicherry					3.92 Gill	2.74					0.6989	Overexploited
5.	*Selaroides leptolepis*	Tuticorin	213	1.4283	-0.0151	2.19	6.10 Trawl	3.91		-3.5058	2.3732		0.6409	Overexploited
		Tamil Nadu & Pondicherry	202	0.82	2.1 to 3.7 yr	1.35	4.88	3.52	0.72	1.7119^{-05}	2.89319		0.7213	Overexploited
6.	*Decapterus russelli*	East coast	221	0.71	2.1 to 6.6 yr	1.35	2.83	1.48	0.52	5.2715^{-06}	3.11072		0.5229	Overexploited
7.	*Otolithes ruber*	Tuticorin	469	0.47		0.71	2.45	1.74	0.65				0.7091	Overexploited
		Chennai	315	0.65										
8.	*Pannahia macrophthalmus*	Mandapam	260	0.98										
9.	*Pennahia anea*	Gulf of Mannar	233	1.26	-0.08 to 0.84	2.24	4.27	2.00					0.4983	Optimally exploited
10.	*Nibea maculata*	Mandapam	284	0.85		1.07	2.74	1.67	0.37				0.3901	Under exploited
		Tuticorin	314	0.72										
11.	*Nibea maculata*	Tuticorin	26.78	0.81	-0.20									
12.	*Kathala axillaris*	Chennai	220	0.86										
13.	*Scomberomorusguttatus*	Chennai	73	0.72										
		Mandapam	109.2	0.85										
		Rameswaram										38		
14.	*Auxis thazard*	Tuticorin	49.0 M 51.2 F	1.30 1.30	-0.003 -0.004					0.000003	3.51			
15.	*E. affinis*	Tuticorin					10.63	8.7					0.8184	Overexploited
16.	*Scomberomorus commers*	Off Tuticorin		0.00027		0.43	1.28	0.91					0.7109	Overexploited
17.	*Leiognathus bindus*	*madras*	153	0.90		1.98	5.22	3.24	2.20	-4.777	2.96182	155	0.6206	Overexploited
18.	*L. jonesi*	*Rameswaram*	155	0.70		1.67	5.36	3.69	2.38	-5.20211	3.2167	152	0.6884	Overexploited
19.	*L. dussummieri*	*Pamban*	162	1.20		2.35	6.70	4.35	1.96	-5.02993	3.1136	161	0.6492	Overexploited
20.	*Secutor insidiator*	*Madras*	125.5	1.22		2.55	5.67	3.12	2.09	-5.73713	3.43654	120	0.5502	Overexploited

21.	*L. jonesi (Venkatraman et al. 1981)*	*Mandapam*	161.20	0.528	0.111	2.28	3.20	0.92					0.2875	
22.	*L. jonesi (Karthikeyan et al. 1989)*	*Mandapam*	146.62	0.917		1.25	5.26	4.01					0.7623	Overexploited
23.	*Lutjanus lutjanus*	*Off Madras*				0.44	0.71	0.27					0.380	Under exploited
24.	Elasmobranchs	Tamil Nadu								-6.3719				
25.	*Sphyraena obtusa*	Tuticorin					2.83	1.24					0.4381	Under exploited
26.	*Portunus pelagicus*	Tuticorin	199.4	1.56								195.0		

Chapter16

Rescue and Rehabilitation of Marine Animals

16.1 Background

Stranding of marine animals such as whales, dolphins, dugongs, turtles, etc have been observed frequently in the Gulf of Mannar Biosphere Reserve. Mostly, due to lack of adequate facilities and capacity, those stranded animals either let die or released back without any first aid but with injuries. However, stranded marine mammals have long attracted public attention. Those that wash up dead are, for all their value to science, seldom seen by the public as more than curiosities. Animals that are sick, injured, orphaned or abandoned ignite a different response. Generally, public sentiment supports any effort to rescue, treat and return them to sea.

Losing their way from their deep sea migratory paths due to natural or manmade
ocean disturbances is believed to be among the probable causes of marine mammals beaching. However, not much scientific study has so far been done to assess the behaviour, habitat and adaptability of these giant marine mammals.

The mass stranding of nearly 80-100 piolet whales along Tuticorin coast between January 12 and 13 was worst stranding of all. Though, the National Park authority could save some of stranded whales with help of district administration and local communities but many died due to lack of capacity and logistics. Earth quake under the sea near Indonesia was suspected for this mass stranding. “The vibration of seabed and overlying water could have posed an adverse impact on the sensory system of whales that probably disoriented their direction of migration. Nearly 75 whales were found beached near Mandapu village in Tuticorin district in Tamil Nadu shortly after the incident. The whales are social animals, moving in groups. They have poor visibility and communicate with each other through echolocation or sound made by them to stay in touch with each other during migration.

Due to disturbances in the sea water created by the movement of warships, thundering, cyclone etc., echolocation of certain individual whale may get disrupted, turning it haywire. In the process, such individuals tend to get washed ashore. Other factors — including climate change, tectonic movements of sea beds caused by sub oceanic volcanoes or earthquakes — also impact the overlying ocean water, which in turn can influence the whales as well.

Further, disturbances in the form of Active SONAR (sound navigation and ranging) may also affect certain species of whales. SONAR emits

varying frequencies of sound vibrations under water and used to detect marine vehicles. The immense pressure of such waves may cause internal bleeding in the ear and brain tissues, killing or disorienting whales, including infants from their mothers.

Moreover, injured whales, dolphins and dugongs due to fishing or navigating boats are also strand including sea turtles. Rescuing, treating and rehabilitate them required unique capacity and facilities. Therefore, it is recommended to establish a 'Marine Animals Rescue and Rehabilitation Facility' at Gulf of Mannar Biosphere Reserve.

16.2 Roles of Biosphere Reserve Authority

The Forest Department is legally responsible for enforcing the Wildlife (Protection) Act , 1972. This means that TNFD is in charge at marine mammal stranding events. As the lead decision maker, TNFD's responsibilities include:

- Protecting the welfare of stranded animals
- Disposing of any dead marine mammals
- Ensuring the health and safety of staff, volunteers, and the public
- Enabling cultural protocols – this involves consulting with local s through every step of the stranding, including rescue, euthanasia, sampling and disposal
- Enabling research, e.g. through the collection of scientific samples.

Major actions required to rescue and rehabilitate certain marine animals in the Gulf of Mannar Biosphere Reserve.

- **Immediate care**

  Aim: To prevent more animals dying, reduce stress, and increase chances of survival

  Any animals found stranded the stay clear of the tail as this can cause injury. In suitable conditions (i.e. not too windy), cover animals with wet sheets and begin gently bucketing water onto them. Do not cover the blow hole or pour water into the opening (to prevent this, wait until the animal has taken a breath before pouring). Concentrate on flippers and flukes (tail). If an animal is on its side: try to get the whale upright by digging a shallow trench parallel to the belly, remove sheets, and gently roll the animal into the trench. Ideally use at least 4–6 people. Keep flippers tucked downwards into sides, and once the whale is upright, dig small holes for the flippers to hang freely into. If the

whale is too big or suctioned into wet sand, do not over-exert or cause injury to yourself or others.

- **Moving**

  Aim: To move animals to deeper water, and to bring scattered animals together

  Ensure all people are aware to avoid the tail and the mouth over the next stages, as these are powerful and can cause injury. Moving the animals generally begins when water is about knee deep or more around the animals. Only people with wetsuits should be involved from this stage on. Coincide your re-floating efforts with waves for increased buoyancy. Tarpaulins, slings or pontoons may be used to shift smaller animals, under the guidance of DOC. Avoid moving animals over rough surfaces when not fully buoyant. Do not tow animals by fins, flippers or tails.

- **Reorientation**

  Aim: To prepare the animals for release and decrease the chance of re-stranding

  Once in waist-deep water begin gently rocking the animal from side to side. Have at least 2 people per animal. This should be carried out for as long as possible to allow the animal to familiarise itself with movement in water. Bring all animals together so the pod can be released together. Wait until the last animal is ready for release. Reorientation time will vary depending on the condition of the animals but can take an hour or more. Subject to conditions, each animal should have had at least 30 minutes. Assess whether the animal can: f Surface to breathe unassisted f Orientate and stay upright in the water f Self-right if rolled onto its side

- **Release**

  Aim: To release all of the animals in one group

  Release animals in water deep enough for them to swim but shallow enough for helpers to walk. Do not release until given the go ahead from rescue crew. A co-ordinated release will greatly increase the chances of a successful refloat. Any whales showing aggressive behaviour are to be avoided and identified to the person coordinating the release.

- **Monitoring**

  Aim: To prevent re-strandings

  You may be asked to form a human chain parallel to the shore, creating a barrier between the animals and the beach. If you are, ensure you remain in a comfortable depth of water, and not above shoulder height when standing. Stay in line in the human chain. At this stage, animals may become defensive of the pod and may become agitated or aggressive if approached. This may be displayed as tail slapping, swimming close by, or open-mouthed lunging. Striking metal objects or slapping the water's surface can deter animals from returning to shallow water. DOC boats may be used to help herd animals offshore. Be aware that animals can be groggy, disoriented, and can be very determined to return to shore. Do not jeopardise your own safety to stop the animals returning.

16.3 Establishment of A Marine Animal Rescue and Rehabilitation Facility (MMRRF)

A Marine Animal Rescue and Rehabilitation Facility (MMRRF) has been suggested to establish at Mandapam in collaboration with CMFRI. All marine animals stranded alive may be treated here and released back safely to the sea. It is not advisable to bring all stranded alive animals to the rehabilitation centre. Only injured animals required to be transported to MMRRF and after treatment they should be released back. All marine mammals and sea turtles can be treated here. Other marine animals are treated here if require. This centre need trained veterinarians and a rescue team with adequate training and logistics.

Chapter 17

Management of Invasive Species in the Biosphere Reserve

17.1 Introduction

Invasive Alien Species (IAS) is one of major factors for the loss of biodiversity including species extinctions and their habitats in India including in the Gulf of Mannar Biosphere. It is also threatening the economic or environmental conditions of the Biosphere Reserve. These invasives are widely distributed in all kinds of ecosystems throughout the India, and it may be found in all taxonomic groups from prokaryotes to the higher plants and animals. These species have also been observed causing dramatic ecological changes due to landscape transformations that reduce the adaptability and competitiveness of more desired native species. Biological invasions by these invasive species are largely facilitated by environmental changes and habitat destruction arising due to development, trade and travel. In terrestrial environments, plants, mammals and insects comprise the most common types of IAS. Identification, monitoring and management of all IAS in Biosphere Reserve is a major challenge that would be taken up on priority basis but in a phased manner.

So far, a total of 1599 alien plant species, belonging to 842 genera in 161 families have been identified. Alien plant species in India is constitute 8.5% of the total vascular flora found in the country. Major invasive alien plants in India are *Lantana camara, Prosopis juliflora, Parthenium hysterophorus, Argemone mexicana, Eupatorium adenophorum, Eupatorium odoratum, Mimosa* spp., *Ageratum conyzoides, Mikania micrantha, Ageratum* spp., *Galinsoga parviflora,Chromolaena odorata, Cytisus scoparius, Cuscuta* sp., etc. Several aquatic invasive alien plant species such as *Eichornia crassipes, Salvinia molesta, Ipoemia carnea*, *Microcystis, Caulerpa, Cladophora* etc. have become a nuisance for aquatic ecosystems.

Many fresh water and marine algae including species of *Kappaphycus, Microcystis, Caulerpa, Cladophora*, etc. causing extensive damage to the ecosystems and affect aquatic biodiversity adversely in India. The invasion *Carijoa riisei*was found in Andaman and Nicobar Islands, Gulf of Mannar and Gulf of Kachchh. A recent report on the Occurrence of the spider crab *Acanthonyx euryseroche*, a seaweed associate along the Central West Coast of India suggest that the epidemic outburst of such population might be dangerous to native marine biodiversity in India.

Introduction of marine organism alien to local ecosystem through ship hulls and ballast water – has serious consequences to native biota, fishery and general coastal ecosystem. Over 80% of the world cargo is mobilized transoceanically and over 12 billion tones of ballast water it filled at one part of the ocean and discharged at the other. These

ballast waters offer conductive situation for bacteria, viruses, algae, dinoflagellates and a variety of macro – faunal larval/cyst stages to translocate to alien region, usually along the coasts of the continents. As an example, there are 18 species of animals and plants documented along the Indian coasts as those that might have got invaded and established. They can cause deleterious effects to local flora and fauna through their toxigenic, proliferative and over-competitive charactersistics. However little information exists from indian marine ecosystems regarding the presence and the impact of alien species.

It is widely known that island ecosystems are particularly vulnerable to AIS, and that their impacts are especially severe (Veitch & Clout 2002). Island species are especially vulnerable to human-induced changes due to their isolation from other landmasses. This is because island endemics are often less able to adapt to the presence of AIS than species that are more-widely spread. AIS have been identified as one of the main causes of ongoing declines and extinctions on islands. For example, the accidental introduction of the *Prosopis juliflora to the islands of Gulf of Mannar National Park seems to be responsible for the degradation of island terrestrial habitats.*

The primary focus of concern over the role of introduced species within the Gulf of Mannar Marine National Park ecosystem, especially from the flora point of view are the processes of disturbance and competition. Evaluation of the consequences of introductions requires the formulation of evidence of the affects these processes have. This assessment is difficult due to the lack of historical data. However, it is presumed that species introduced during the 19th and 20th centuries are interacting with native biota. Thus, potential impacts are difficult to discern due to this interaction. Additionally, the island ecology of the Gulf of Mannar has continually changed as a result of intensified land use and modifications due to human pressure in past. These changes alter the conditions of the dynamic relationships between the introduced and native species interactions especially on terrestrial ecosystems. The status of invasive species in both aquatic and terrestrial ecosystems is not known except *Prosopis juliflora, Acacia spp., Parthenieum (which occurs on almost all islands) and Kappaphycus alvarezii.*

17.2 Current status and impacts of *Prosopis juliflora* on islands biodiversity

National Park Authority could successfully initiate the eradication of this invasive species in most of islands and replaced this species with native plants. But, Prosopis juliflora, is still abundant, and has become a serious problem on the Gulf of Mannar islands. The carrying capacity of other species on many islands seems to be seriously reduced due to its tremendous increase of Prosopis. In olden days,

fishermen use to graze their cattle in these islands. Dissemination of the seeds in cattle dung has been an important factor in this invasion. P. juliflora pods are relished by all livestock, which, unlike most other pea pods, do not shed their seeds. The invasive species, *Prosopis juliflora* is found in 13 islands. It was found that there seem to be a competition between the existence of *Acacia* and *Prosopis*. It was also observed that both these species were found growing with an interaction. During private ownership of islands Krusadai, Muyal and Nallathanni, cattle were allowed to graze on the grass and other palatable vegetation payment. It was said that both these species have emerged only after the islands were opened for cattle grazing. Similarly, some of these islands have been inhabited. It was also believed that anthropogenic intervention and frequent visits could also have brought some other terrestrial vegetation into these island habitat (Neelakandan, 1999).

17.3 Current status of Kappaphycus alvarezii, alien invasive aquatic plant in GOMNP

*Kappaphycus alvarezii*is red seaweed native to the Philippines and is an invasive species in the non-native environs of Gulf of Mannar. The introduction of this exotic seaweed in Gulf of Mannar in 2005 as a maricultural measure to enhance the livelihood of the coastal people was carried out without conducting proper Environmental Impact Assessment. This alga is the source of sulphated polysaccharides commonly called “carrageenan”, which is used in the food and the pharmaceutical industries. The alga is able to coalesce into the tissue of the coral, obtaining thereby a strong means of attachment, and thus surviving in high wave energy environments. It spreads mainly by fragmentation (pieces of seaweed float to new locations) and can overgrow and kill the coral by smothering and shading it from sunlight. It causes the shifting of a diverse coral reef into a seaweed-dominated, low-diversity reef; it changes the bottom structure of the reef; and reduces access to crevices and holes. Thus the habitat loss may impact the commercial and recreational fisheries.

The cultivation of this alga was started in places close to reef areas in 2005, and in 2007 bio-invasion was first observed in branching corals of *Acropora* sp. in Krusadai island of Gulf of Mannar. Within 24 months, reef areas of over 1.2 km^2, destroying over 500 branching and massive coral colonies of *Acropora cytherea, A. formosa, A. nobilis,Montipora digitata* and *Porites solida*, size ranging from small (< 20 cm) to larger (> 80 cm) colonies happened in Krusadai Island.

As per the SDMRI study, the overall area occupied by *K. alvarezii* in Krusadai Island was 1,524 m^2 during 2014, and it was 368 m^2 in Mulli Island while in Shingle Island it was 152 m^2. During coral bleaching in 2016, live coral cover in Gulf of Mannar was reduced considerably and significant mortality was recorded in the islands

affected with *K. alverezii.* As the substrate (live corals) cover was reduced the *K. alverezii* cover was also correspondingly decreased. Now, except for a few fragments in Krusadai Island, *K. alverezii* has been completely wiped out from Gulf of Mannar for want of a continuous stretch of live corals. However, the left-over fragments of *K. alverezii* are capable of increasing their biomass in the event of their finding proper substrate through currents.

The invaded area of Kappaphycus in islands were shallow (less than 2 m depth) and the dead coral area in Kurusadai and Mulli Island is now overgrown with *K. alvarezii* and other, native algal species *Chaetomorpha sp., Enteromorpha sp., Ulva sp., Caulerpa sp., Turbinaria sp., and Padina sp.* About 20 m away from the affected sites, scattered coral colonies of *Acropora nobilis, A. formosa, A. cytherea, M. digitata, M. divaricata, Pocillpora damicornis, Porites sp., Favia sp.* and *Favites sp.* are present, and no invasion of *K. alvarezii* has been noticed (Source SDMRI).

17.4 Management Prescriptions

1. Eradication of P. juliflora and other AIS plants from the National Park:
    a. Uprooting and burning plants before fruiting is the best method. This method is quite possible in these islands and hence it is recommended.
    b. Since the seed of this species has higher dormancy period, it is essential to monitor the seedlings for the period of minimum five years after eradicating all available plants in any given islands. The hard seed may remain dormant for many years and new plants may appear in previously infested areas.
    c. After initiating the eradication programme the *P. juliflora* Management Areas needs to monitored regularly and if required then the eradication programme needs to be continued.
2. Eradication of *Kappaphycus alvarezii***:** Though the extent of this aquatic weed is less in the Mandam group of islands, it may spread fast, therefore, this weed needs to be eradicated as soon as possible. Manual removal is the only option available at present. Weeds need to collected manually and then burned on the shore of the mainland coast but not on the coast of islands. This process should be continued till all the weeds are eradicated. It is also important to eradicate the same weed from the buffer zone of the Biosphere Reserve simuntaneously.
3. The impact of invasive species on insular fauna & flora is more sever than on the mainland. The Research and Monitoring Center of the Biosphere Reserve Authority is to take up a policy decision on the management of AIS in the Gulf of Mannar Biosphere Reserve whenever required and implement those actions. The RMC will also facilitate the development of a

database on AIS for planning and executing programmes on management of invasives in islands. This database will provide information on exotics introduced in different islands and their impact on the natural ecosystem. It will also provide useful information on the spread of exotics in islands, crucial for evaluating further proposals on impacts of such introductions elsewhere. The RAC of RMC will also evaluate any proposals on introduction. However, the RMC should not allow the introduction of any known AIS into the Biosphere Reserve and they may consider any re-introduction proposal of species, which are naturally occurring, non-invasive and major interest of public.

4. Preventing the introduction of alien invasive species is the cheapest, most effective and most preferred option and warrants the highest priority.
5. Rapid action to prevent the introduction of potential alien invasives is appropriate, even if there is scientific uncertainty about the long-term outcomes of the potential alien invasion.
6. Identify and manage pathways leading to unintentional introductions. Important pathways of unintentional introductions of invasive species to the Gulf of Mannar Biosphere include fisheries, aquaculture, forestry, tourism, trade, shipping, ballast water and construction projects.

7. **Management of other invasive species:**

    a. Both the Ministry of Environment, Forest and Climate Change (GoI) and Tamil Nadu Forest Department supported SDMRI to carry out studies on Kappaphycus ecology and its management in islands. However, a long term monitoring study on Kappaphycus is essential to monitor its spread, so that it can be controlled better.

    b. Regular manual removal and monitoring by the National Park Authority has helped to control the invasion of *K. alvarezii* at Krusadai Island, while in Mulli Island most corals have not so far been affected. The removal of the seaweed has also helped to control a further invasion at Shingle Island. In addition, the cessation of *K. alvarezii* cultivation for over 18 months, due to the occurrence of 'ice-ice disease' on the alga, has also helped in controlling the invasion. However, the rapid regrowth of the alga after removal poses a big challenge to conservation managers in protecting the corals in the GoM from the invasion of *K. alvarezii*, because regular removal and monitoring uses a considerable proportion of yearly budgets. But, fund constraint should not be an excuse for allowing this species to spread in Biosphere Reserve and destroy the overall biodiversity. Therefore, it is suggested to monitor and

remove the Kappaphycus on priority basis with help of Self Help Groups.

b. Removal of all major invasive species especially Prosopis from the sea turtle nesting beaches.
c. Removal of all invasive species from the National Park area, before that, a detail study is required on the diversity, status, and distribution pattern of invasive species in this region.
d. Biosphere Authority with the help of local people the removal operations can be taken up. This will generate the employment opportunities to local communities.
e. While removing the invasive species from the sensitive habitats there should not be any damage to the native fauna and flora and also for local communities.
f. There should not be any introduction of exotic species in the region even the commercially important exotic fishes.
g. It is also suspected that there are occurrences of some more invasive species in coral reefs and seagrass bed ecosystems, which need to be studied immediately, if any.
h. After initiating the eradication programme the Management Areas needs to monitored regularly for invasive species and if required then the eradication programme needs to be continued

Chapter 18

Disaster Management

18.1 Introduction

Indian subcontinent has always been vulnerable to natural disasters on account of its unique geo-climatic conditions and floods, droughts, cyclones, tsunami, earthquakes and landslides have been a recurrent phenomena. About 60% of the Indian landmass is prone to earthquakes of various intensities; over 40 million hectares of landmass and prone to floods; about 8% of the total area is prone to cyclones, 68% of the area is susceptible to drought and the entire coast of India prone to tsunami. In India, about 30 million people are affected by disasters every year. The loss in terms of private, community, public assets and wildlife has been astronomical. At the global level, there has been considerable concern over natural disasters. Even as substantial scientific and material progress is made, the loss of wildlife and its habitat due to disasters seems to not decrease. In fact, the human toll and economic losses have mounted but so far there has been no detail study on the impact of disasters on Indian wildlife. However, in recent years studies in the Nicobar islands have proved that there was a significant adverse impact on wildlife caused by the 2004 tsunami. It was in this background that the United Nations General Assembly, in 1989, declared the decade 1990-2000 as the International Decade for Natural Disaster Reduction with the objective to reduce loss of lives and property and restrict socio-economic damage through concerted international action, especially in developing countries. Planning the disaster management programme for wildlife habitats is much more difficult than the human habitation as it involves a lot more preparedness, especially in rescue of wildlife and its habitat from any natural disasters.

The Gulf of Mannar Biosphere Reserve comes in the “Semi-Arid” under the classification of the bioclimatic zones of India. Therefore, it is prone to drought. It comes under the ‘East-Coasts (8B)’ zone in the bifurcation of the different biogeographic zones of India classification by Rodgers et.al. (2002) and biogeographic province of Deccan Peninsula-Deccan South (6E).

The Gulf of Mannar Marine National Park and Biosphere Reserve located at the southernmost tip of India along the Bay of Bengal in Tamil Nadu is a vulnerable Marine Protected Area from natural disasters, particularly originating from the marine environment such as cyclonic storms, tsunami and flood. Being in a low rain fall zone, the area is also subjected to recurrent droughts. The other disasters due to human errors in the coastal and marine environment expected in the region are fire, oil spillage, accidental capsize of marine vessels with chemical hazards etc. In this background, the GOMBR

management plan has included this Disaster Management plan for the period 2018 -2027.

18.2 Objectives

The objective of this plan is to

1. Identification of various possible disasters that may occur in this region
2. Establish a preparedness' protocol for disasters management
3. Prescribe disaster management actions

Possible Disasters expected for the Biosphere Reserve & National Park

1. Cyclone
2. Drought
3. Fire
4. Flood
5. Oil Spillage
6. Accidental capsize of shipping vessel with hazardous chemicals
7. Tsunami
8. Earthquake

18.3 Disaster Management Prescriptions

Setting up of Disaster Management Cell: Mitigation, preparedness and response are multi-disciplinary functions, involving a number of Departments. Mitigation and preparedness measures go hand in hand for vulnerability reduction and rapid professional response to disasters. Institutional mechanisms which would facilitate this inter-disciplinary approach are required put in place. It is proposed to create a **Disaster Management Cell**, with representatives from the relevant Departments to bring about this coordinated and multi-disciplinary effort with experts covering a large number of branches. The cell could be headed by the Director of the BR Authority with representatives from Departments of Health, Water Resources, Agriculture, Defense, Chemicals, Science & Technology, Telecommunication, Urban Employment, Poverty alleviation, Rural Development, Indian Meteorological Department, police and fire service Members. Members of the cell should meet as often as possible to review the preparedness for any disaster management.

Cyclone Mitigation: The Government of India has constituted a National Core Group on Cyclone Monitoring & Mitigation. Experts from Indian Meteorological Department, National Centre for Medium Range Weather Forecasting, Central Water Commission, National Remote Sensing Agency and Indian Space Research Organisation have been made the Members of this Core Group, besides administrators from the relevant Ministries/Departments and State Governments vulnerable to cyclones. The Group has been assigned the

responsibility of looking at warning protocols for cyclones; coordination mechanism between different Central and State Ministries/Departments/ Organisations; mechanism for dissemination of warning to the local people and; cyclone mitigation measures required to be taken for the coastal States. The Group will also suggest short-term and long-term measures on technology up-gradation. The cyclone warning formats have been revised to Disaster Management in India. A project for Cyclone Mitigation (estimated cost Rs.1050 crore) has been drawn up in consultation with the cyclone prone States. This project envisages construction of cyclone shelters, coastal shelter belt plantation in areas which are prone to storm surges, strengthening of warning systems, training and education etc. This project has also been given inprinciple clearance by the Planning Commission and is being taken up with World Bank assistance. The Authority's Disaster Management Cell has to prepare a cyclone mitigation plan for the Gulf of Mannar Biosphere Reserve with consultation of this National Core Group.

Handling of Hazardous Materials from ships accident / coast based industries: Traffic of cargo shipping vessels is expected to increase after the completion of the Sethusamutharam canal. In the light of global and regional experience, there is a likely chance of accidents occurring to ships especially those carrying hazardous chemicals. Some of the industries located on the coastal region of the BR are also handling various chemicals which may be harmful for the biodiversity. Disaster Management Cell of the Biosphere Reserve Authority has to prepare a detailed disaster preparedness plan to cope with hazardous materials including oil spillage.

Oil Spill Related Disaster: With the existence of Tuticorin Port and establishment of Sethusamuthram Canal, the chances of chronic oilspill and possible acute oilspills in the region is very high. Also the recent oil exploration activities and possible strike of hydrocarbon in the offshore areas of Gulf of Mannar will increase chances of hydrocarbon related disasters. The Biosphere Reserve Management therefore, is to set in place a mechanism and protocol for facing such eventualities in consultation with the Indian Coast Guard (Nodal agency in India for Oilspill Management), Tuticorin Port Trust and the Sethusamuthram Canal Management Authority.

Tsunami preparedness and mitigation: Tsunami which occured on 26 December 2004 originated from the Sumatra coastal earthquake and traveled to Tamil Nadu coast in about two hours which is the first time in the recent history of India. Although Tsunamis are predicted to occur every 15 years in the Pacific ocean , this interval may be larger in the Indian ocean. Compared to other parts of Tamil Nadu and the Andaman & Nicobar islands, the adverse impact of tsunami

on the Biosphere Reserve was minimum due to the presence of the Sri Lankan island which actually acted as a Barrier. However, it would be better to prepare a 'Tsunami preparedness and mitigation protocol for the Gulf of Mannar Biosphere Reserve which hold unique biodiversity assemblages never seen anywhere else in the region. Since the adjoining districts have already had experiences and mitigated the impacts recent tsunami, the same model protocol may be reviewed and adopted for BR, if required, changes can be made in the existing tsunami preparedness and mitigation plan of the Tamil Nadu state for this unique region.

Flood Preparedness and response: In order to respond effectively to floods, Ministry of Home Affairs has initiated National Disaster Risk Management Programme in all the flood-prone States. Assistance is being provided to the States to draw up disaster management plans at the State, District, Block/Taluka and Village levels. Awareness generation campaigns to sensitize the all the stakeholders on the need for flood preparedness and mitigation measures. Elected representatives and officials are being trained in flood disaster management under the programme. BR Authority can consult this National Disaster Risk Management Programme for flood preparedness and response in the Gulf of Mannar Biosphere Reserve.

Earthquake Risk Mitigation: A comprehensive programme has been taken up for earthquake risk mitigation. The Bureau of Indian Standard (BIS) has laid down the standards for construction in the seismic zones, these should be followed in any infrastructure development in this region. Normally, the building construction in urban and suburban areas is regulated by the Town and Country Planning Acts and Building Regulations. In many cases, the Building regulations do not incorporate the BIS codes. Even where they do, the lack of knowledge regarding seismically safe construction among the architects and engineers as well as lack of awareness regarding their vulnerability among the population led to most of the construction in the urban/sub-urban areas being without reference to BIS standards. In the rural areas, the bulk of the housing is non-engineered construction. The mode of construction in the rural areas has also changed from mud and thatch to brick and concrete construction thereby increasing the vulnerability. The increasing population has led to settlements in vulnerable areas close to the river bed areas which are prone to liquefaction. The Authority's Disaster Management Cell have to address these issues.

Strengthening of Fire Services: In order to further strengthen the capacity for response, the fire services are recommended to be developed into multi hazard response units in the all adjoining districts of the Biosphere Reserve. Fire service stations in this region should be well equipped with to meet fire hazards either on islands or

on the mainland coastal region. In this connection, staff of these fire stations need a special training.

Setting up of Search and Rescue Teams in the Biosphere: The BR Authority are advised to set up their own Specialist Teams for responding to disasters. Members of this team need to be sent to the Training Centers for training in Search and Rescue in the States or at **CPMF** training institutions.

Chapter 19

Climate Change Adaptation Plan

19.1 Introduction

The earth's climate has changed notably over the past century because of anthropogenic greenhouse gas emissions, with an increase of 0.85 °C in mean global temperature recorded between 1880 and 2012. Projections by the Intergovernmental Panel on Climate Change (IPCC) indicate further warming of 1.1-2.6°C under a relatively mild greenhouse gas emissions scenario, and 2.6-4.8°C under a strong emissions scenario by the period 2081-2100 relative to the period 1986-2005 (IPCC 2014).

Gulf of Mannar region has already suffering due to coastal flooding of high sea tides, erosion of islands (Van Island), prolonged drought, loss of livelihoods etc. It is commonly accepted that the global average surface air temperatures have risen by 0.74 0 C (0.56 0 C to 0.92 0 C) over the last 100 year from 1906 to 2005. Eleven of last twelve years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature. Rising temperature in the atmosphere causes sea level rise and affects low lying coastal areas and deltas of the world.

Climate change is expected to make major impacts on global biodiversity through drivers such as carbon dioxide fertilization of plants; changes in fire frequencies; insect and pathogen attacks; latitudinal and altitudinal shifts in species distributions; and altered community interactions resulting in changes in species abundances. Climate change models also project increase in sea levels and in sea surface temperature, in addition to oceanic acidification, with consequences for coastal and marine biota. Freshwater ecosystems such as rivers, lakes and inland wetlands would also be impacted.

As a megadiverse country, India with over one-fifth of the land under forest cover and a long coastline can thus be expected to experience significant impacts of climate change. In the Indian context, we thus need to evaluate the impacts of climate change on a variety of aquatic ecosystems such as mangroves, intertidal zones, coral reefs, rivers and streams, marsh lands, lakes and so on. The spread of invasive alien species (IAS) and changes in fire regimes could further exacerbate the situation. Tamil Nadu coasts also has a large human population with growing needs for energy and natural resources for the economic wellbeing of a substantial proportion below the poverty line. Therefore, an adequate understanding of the likely impacts of future climate change on these coastal ecosystems is imperative to plan for strategies to promote climate change adaptation and resilience in natural ecosystems to change, as well as undertake mitigation measures.

Climate change adaptation (CCA) is defined as 'adjustment in natural or human system in response to actual or anticipated climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities'. The adaptation options include changing human consumption patterns and life styles; taking recourse to technology or engineering interventions for protection against climate impacts; adopting risk management strategies such as early warning systems; developing financial instruments such as insurance; and promoting ecosystem-based practices. Disaster Risk Reduction (DRR) is a systematic approach to preventing and reducing the damage from natural hazards. It is essential for working with CCA and is one of the best links for promoting biodiversity conservation and sustainable environmental resource management. Mitigation specifically refers to reduction in carbon emissions as, for instance, using clean energy from wind, solar, water and atomic sources; carbon offsets for balancing emissions with absorption, and by carbon trading.

The most natural way of building adaptive capacity of natural ecosystems is to ensure that species of plants and animals are able to disperse to more suitable habitat niches in tune with a changing climate. Gulf of Mannar Biosphere Reserve has been designed in the past when climate change was hardly a criterion for wildlife conservation, and this is the time to make judicious changes based on a more robust understanding of climate change impacts. In this context, Palk Bay region could play a major role in this regard provided both Palk Bay and Gulf of Mannar regions are linked with unified comprehensive seascape climate change adaptation plan in future. Therefore, it is important to recognize the biological significance of Palk Bay and start conserving them for the betterment of future generations of fishermen community.

Since, any alteration as a result of climate induced changes may affect the plankton dynamics in sea, this in turn could have a long lasting impact on other faunal populations such as corals, sea grasses, reptiles, fishes, oceanic birds and mammals, which are directly or indirectly linked to the availability of certain species of plankton. Moreover, possible increase in sea level probably due to climate change also cause of concern as it eroding or sinking both coastal and off-shore islands as well as mainland coasts in Tamil Nadu. Apart from this, climate change also rapidly affecting the socio-economic condition of coastal communities which also again adding more pressure on the marine bio-resources. Demographic changes also witnessed among coastal communities due to constant inflow of people due to drought in adjoining coastal habitats probably due to climate change.

If sea level rises due to climate change than it will affect sea shore regions of National Parka and Biosphere Reserve, which include sea

turtles nesting beaches, seagrasses and coral reefs, and migratory birds too because due to sea level rise there feeding ground in Mannar would affect. Further, coastal fishing communities would also affected due to loss of their livelihoods and space.

Adaptation and mitigation are two options for Gulf of Mannar National Park and Biosphere Reserve. Of which, the first one is region specific, or even local specific, but mitigation demands collective efforts of global communities. Development of adaptation policies for different sectors will help the GoMNP to face the crucial hazards of sea level rise.

Climate change and sea level rise have various significant impacts on economy, environment and security not just for GoMNP and BR but also for worldwide coastal ecosystems and if these impacts are not integrated in the regional development plans of coastal districts starting from Kanyakumari to Thanjavur, it will fail to attain sustainability. In this context, the following strategies are suggested;

i. Activity in the National Park and the Biosphere Reserve should be closely monitored and regulated such that no alteration or dilution is carried out on the existing zone of influence (buffer zone) so as to buffer the National Park and thereby conserve the biodiversity of the area. Thus, GoMBRT should be strengthened with extending its activities till Kanyakumari and also along Palk Bay coast in near future.

ii. Maintenance of a Mangrove plant nursery, so that if somehow mangrove plants on island and along coast die due to climate change or disease. In this condition we can manage the green cover.

iii. Strengthening the people participation in the management of Buffer Zone

iv. Promote drought resistant crops in these coastal districts.

Climate change and the Gulf of Mannar NP and BR: Taking action

It is important to build ecosystem resilience program, where we have to build on the targeted knowledge of climate-related risks to identify and test resilience-building strategies. Driven by the imperative to also adapt our own policies and approaches, this new management plans, and developed frameworks for assessing and responding to acute and chronic risks from climate change. Through collaborations with key partners such as the fishing industry, Port, tourism, other developmental sectgors etc, an integrated citizen-science program needs to be developed that will increase opportunities for stewardship to help build resilience to climate change.

19.2 Partners in adaptation

Traditional Owners and other Indigenous groups with interests in GoMNP & BR are no strangers to change. Key groups are working closely with the GoMNP to understand the implications of changing conditions, such as extreme weather events and a shifting climate, for their management strategies and traditional use of marine resources. The communities living throughout the NP&BR catchment are key players in efforts to protect and sustain wise use of the National Park and Biosphere Reserve. Through the National Park Guardians program, councils and schools are leading local communities in understanding and adapting to the implications of climate change for the Gulf of Mannar. Management of the National Park is achieved through a formal partnership between the Tamil Nadu Forest Department and other departments of Government of Tamil Nadu and Government of India in the region. Under this arrangement, the GoMBRT and GoMNP Authority need to be worked closed to the effective implementation of this Management Plan. As the day-to-day managers of the National Park at the front line in dealing with implications of climate-related events. Partnership with GoMBRT and other line agencies would enable valuable advances in adaptation, especially in the development and testing of strategies for building ecosystem resilience.

19.3 Ecosystem based Approach

The GoMNP & BR recognises the importance of biodiversity and ecosystem services to marine based industries like fishing industries, tourism, port, shipping, local communities, and the broader public. The connections between people and the Marine ecosystem are especially important in the context of climate change. A healthy National Park and Biosphere Reserve enhances the resilience of the ecosystem to adverse impacts of climate change; a resilient ecosystem reduces the vulnerability of fishing industries and communities that depend on the Biosphere Reserve.

Focusing on reducing non-climate stresses

Reducing ecosystem degradation is a 'no regrets', 'win-win' approach to adaptation. Ecosystem-based adaptation strategies should minimise other anthropogenic stresses that have degraded critical ecosystems and thereby undermined their resilience to climate change. Such stresses include unsustainable harvests, habitat degradation, non-native species and pollution.

19.4 Involving local communities

Ecosystem-based adaptation measures are more successful when the local population participates in both planning and implementation. Therefore, it is suggested to involve local communities, school and

colleges, religious groups and working class to help in creating better involvement of all groups and better understanding among themselves the value of National Park and Biosphere Reserve not for them but also for their upcoming generation. Enormous amount of efforts in this regard has already been put by both GoMBRT and NP Authority during the last Management Plan period, that created an excellent awareness among the communities but it needs to be continued further.

Multi-partner strategy development

Ecosystem-based adaptation presents a tangible opportunity to solve climate change problems by aligning conservation, development and poverty alleviation interests. Benefits are shared through the collaboration between local communities, conservationists, natural resource managers, private sector stakeholders, and the various levels of government and non-government institutions involved in social development and conservation issues.

Building on existing good practices in natural resource management

The most effective ecosystem-based adaptation strategies apply established best practices in land, water and natural resource management to some of the new challenges posed by climate change. Using the ecosystem approach for the integrated management of resources is particularly appropriate to ecosystem-based adaptation.

19.5 Adaptive management approaches

Ecosystem-based strategies should facilitate opportunities to identify and test adaptation options and accelerate their implementation. Climate impacts and ecosystem based adaptation measures should be monitored carefully so that management actions can be adjusted in response to changing conditions.

Integrating ecosystem-based adaptation with wider adaptation strategies

Successful adaptation depends on integrating ecosystem based adaptation initiatives with other risk management components, such as early warning systems and awareness-raising, and in some cases with physical infrastructure. It is important to encourage and enable technology transfer and dialogue between planners and practitioners with expertise in hard engineering and in ecosystem management.

Communicating and educating

Successful ecosystem-based adaptation depends on knowledge transfer, capacity building, integrating science and local knowledge

and raising awareness about climate change impacts and the benefits of sound ecosystem management. Local school, Colleges and other institute are constitutionally involving in bringing young generation close to nature and add positivity to their lives. Also how they can help in adopting various way to decrease carbon footprint and help in reducing climate change negative impact.

Core objectives

These objectives are central to delivering adaptation outcomes for the Gulf of Mannar National Park. They specifically aim to reduce risks and build resilience of different components of the marine ecosystems.

A resilient Biosphere Reserve ecosystem

The resilience of the corals and seagrass habitats is central to its ability to cope with future stress and avoid the worst impacts of climate change. A core objective of the Adaptation Strategy of National Park is to improve the capacity of managers to build the resilience of the various marine ecosystems of National Park and Biosphere Reserve ecosystem. In this context, objectives will be met by activities that focus on reducing or offsetting risks, and developing tools to support management decisions.

Action on climate change

The outlook for the National Park ultimately depends on the concentration of greenhouse gas emissions in the Earth's atmosphere over the coming century. A core objective of our Adaptation Strategy is to encourage action that reduces the rate and extent of climate change. This objective will be met through activities that ensure policymakers have access to information about the implications of climate change for the National Park and livelihoods of people who live around the Park.

Strategic science

Effective action to improve the outlook for the Marine National Park in the face of climate change requires timely and pertinent information. A foundational objective of our Adaptation Strategy is targeted science that supports management decisions and adaptation planning. This will be met by activities that address key knowledge gaps for management of the corals, seagrass, mangroves etc more broadly, and provide knowledge specifically to support management efforts in the critically important inshore areas of the National Park and Biosphere Reserve.

Effective communication

Communication plays a critical role in nearly every aspect of climate change adaptation. A foundational objective is effective communication to support implementation of our Adaptation Strategy. Therefore, it is suggested to improve the accuracy, availability and

delivery of communication materials to support climate change adaptation of Gulf of Mannar Marine National Park.

Stakeholder partnerships

Collaboration with local communities, educational group, industry groups and other organizations that influence or are influenced by the Marine National Park will be essential in successfully carrying out activities to support the strategy objectives. These collaborations create the opportunities for raising awareness, sharing experiences and building capacity that are the core ingredients to effective adaptation. Collaborations will be strengthened and expanded through existing forums such as National Park Authority and GoMBRT i.e. proposed GOMBRF. It is important to continue to foster the constructive working relationships with various departments and peak industry bodies that have been established over many years and advanced through the National Park and Biosphere Reserve programs. The close working partnership between the National Park Authority and Districts Administrations need to be continued and strengthened further so that livelihoods of people and ecological services of National Park are not adversely affected due to climate change.

Research collaborations

It is important to substantially build the collaborations with key knowledge providers to ensure all stakeholders, have access to the information and insights required for effective adaptation. In particular, it is essential to work through the National Environmental Research Program to support multi-year research programs designed to deliver direct benefits to management of the National Park. It is also suggested to maintain and strengthen the partnerships with the various Indian Educational Institute, Department of Science and Technology (DST), Ministry of Environment, Forest and Climate Change and other research organizations to harness Indian research capacity for an improved outlook for the Gulf of Mannar Marine National Park.

Chapter 20

Interpretation, Education, Eco-Tourism and Visitors Management Action Plan

20.1 Introduction

Eco-tourism known to promotes the National Integration and Internatioanl understanding and also creats awareness among people about the importance of biodiversity and their ecological services. The World Conservation Union [IUCN] defines ecotourism as "environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate the nature (and any accompanying cultural features-both past and present) that promotes conservation, has low negative visitor impact, and provides for beneficially active socio-economic involvement of local communities. Therefore, this Management Plan prescribes various actions that would mutually beneficial for both National Park and People through 'Eco-Tourism' inside and outside the National Park.

The coastal landscape and seascape in the Gulf of Mannar Biosphere Reserve with multifarious tourist attractions and historically has been a major tourist destination of South India and in Tamil Nadu in particular. Of the four coastal districts in which BR is located, the northern most district of the Ramanathapuram and southern district of Kanyakumari attracts the largest number of tourists, a majority of which are religious tourist. Most of the tourists visiting Kanyakumari are interested in the 'tri-sea confluence' at the Cape Comorin. And, the tourists who visit the Rameswaram are interested in the Ramanathaswamy Temple and nearby temples. However, the four districts along the Biosphere Reserve has a lot of tourism interest resources which are placed at Annexure at the end of this chapter.

Tamil Nadu is ranked first in both domestic and foreign tourist arrivals in 2014 and 2015 consecutively in the country. In last four years starting from 2012 to 2015, an average of 2755 lakhs of tourists per year visited the Tamil Nadu. Of these, an average fo 42 lakhs international tourists visited Tamil Nadu every year. More than, 20 lakhs tourists visit the Ramanathapuram district every year who're mostly visiting the district for the Ramanathaswamy temple in Rameswaram and few other temples around this place followed by Kanyakumari and Tiruchendur with yearly average of 15 to 10 lakhs tourists respectively.

The coastal and marine habitats of the Gulf of Mannar and Palk Bay have also been favourite visiting sites for academic purposes by students, researchers and scientists studying biology, marine

sciences, ecology, oceanography, geography and coastal geomorphology. After the creation of the GOMMNP, which encompasses the offshore islands and surroundings coral reef systems, was not used for tourism due to its vulnerability during the previous Management Plan period that ended in 2017. However, all eco-tourism prospect assessments have recommended reef based tourism as the highest opportunity in the Gulf of Mannar (MSSRF-UNDP-GEF study, 1988). Therefore, it is now recommended to permit the marine based eco-tourism in phased manner that too with a lot of caution and only in the tourism zone earmarked in the Plan i.e. Khurusadai Island and its sorroundings.

Interpretation and imparting Conservation Education on the importance of coastal and marine environments and its biodiversity for visitors and local communities of the Gulf of Mannar Biosphere Reserve is consider to be an important activity of the Management Plan. Only through a clearer understanding of the importance of coastal and marine ecosystem, the citizen, planners, administrators, younger generation and stakeholders will ensure and suppor conservation and protection of the Gulf of Mannar Biosphere Reserve and the Gulf of Mannar Marine National Park. For this, a comprehensive interpretation, extension, education and awareness conservation programme is proposed for the GOMBR and GOMMNP. This will include setting up of State of Art Interpretation Center, Information Centers, way side information kiosks, state of art marine aquarium, information signages, hoardings, brochures, leaflets, films, audio-visuals, innovative and interactive, unattended and attended services and use of print, electronic, traditional and time tested extension and educational media through competent and trained professional educated interpreters.

The proposed state of the art **Marine Conservation Interpretation cum Education Center(MARCONI)** and Information centers were recommended in the previous Management Plan too but it was not implemented probably due to logistic constraints. But, they are still relavant and required, therefore, it is herewith recommended to establish MARCONI and information centers at important entry points as well as at urban sites that will provide the visitors and other users a safe, visually coherent, appropriately sequenced and enjoyable experience with a focus on conservation education through exhibits and self guided activities. Idle site for MARCONI is near Mandapam, which is close to the Kurusadai Island (Tourism Zone). Signs and exhibits, when designed, fabricated and installed in such centers will welcome, orient and educate visitors to the facilities and the resources of the Biosphere Reserve and National Park. Through the signage's, exhibits, brochures, leaflets and other medias, the visitors will be better informed about how to enjoy their visit and how to manage their activities within the geographic limits and beyond the Biosphere

Reserve without impacting the ecological integrity of the area. Most visitor questions and expectations needs to be anticipated and answered by the interpretive facilities and programmes so that personal contact with the Interpreters and Educators of the Biosphere Reserve Management are minimal. Only through such comprehensive interpretive programme the visitors will respect the purpose and objective of the GOMBR and GOMMNP.

SWOT Analysis for development for tourism:

SWOT analysis shows that the existing flow of tourist in the region (about 20 lakhs tourists per year) as a huge market, the biodiversity, wildlife, islands, beaches, heritage sites, warm climate, good road networks and religious sites of National importance as some of the major strengths. The study also identified long standing national and state research institutions as well as creating of the GOMBR as an added strength. The traditional seafaring local community and their handicrafts, tourism infrastructure including connectivity by air (Tiruvananthapuram, Madurai, Tuticorin), rail (Madurai, Tuticorin, Ramanathapuram, Rameswaram, Kanyakumari, Tiruchendur, Nagercoil) and huge network of roads are also biggest strength for tourism promotion. Further, this region is being identified as one of the globally Important Marine Mammals Areas by IUCN.

Civic and industrial pollution in relatively monotonous landscape, high volume of biological sample collection related vandalism, untrained human resources and safety standards, lack of tourism protocol and management, interpretive facilities and infrastructure from the Gulf of Mannar Biosphere Reserve Management as well as dought situation in the region is considered as the weakness of the region from tourism point of view.

Development of eco-destinations, restoration of habitats and prospect of eco-tourism products based on natural attributes in the region along with the available markets locally, regionally and globally has been identified as opportunities. The increased attention of the state, country for infrastructure development has also been considered as an opportunity and need to be strengthened.

The study considers increased industrial and civil pollutions, depletion of biodiversity, ground water, untrained man power, lack of logistic facilities for marine tourism and unplanned development in the region as major threats for tourism promotion.

For purposes of eco-tourism development in the Gulf of Mannar Biosphere Reserve region, the geographic scope has been extended up to a 50 km limit from the coast and one island (Kurusadai) inside the National Park.

20.2 Objectives

Gulf of Mannar Bisophere Reserve is always considered as 'Paradise of Marine Biologist' due to its rich biodiversity and has a lot potential to create awareness among people to educate about the importance of marine ecosystem and its biodiversity. Further, promoting eco-tourism in the region would benefit local communities whose socio-economic conditions is comparatively low in the region. In this context, this Management Plan recommend various actions with following objectives;

a. To promote wildlife education
b. To promote conservation awareness
c. To enhance the socio-economic status of local communities
d. To gather public support and lobby for the National Park and Biosphere Reserve.
e. To promote the species conservation programme
f. To generate employment opportunities for those who lost employment due to protected area.
g. Off setting tourism pressures from other protected areas.

20.3 Ecotourism Participants

For efficient and harmonious tourism i.e. wherein the relationship between the Biosphere Reserve Authority, Tourism Department, the local community and the visitors is maintained without jeopardy to the environment or any individual it is necessary to involve all stakeholders that are dependent on the Biosphere Reserve indirectly or directly.

The participants for the same would include:

A] **Local communities** i.e. mainly fishermen who can serve as guides for the area and provide insight into the biodiversity and structure of the National Park and Biosphere Reserve and this would also boost their economic status. Youths of fishermen communities would act as scuba diving guides, etc.

B] **The officers or the personnel recruited by the Forest and Tourim Departments,** who would serve as the first line of defence in case of any anomaly or new activity in the Biosphere Reserve. They would be the first to observe any change that is occurring in the area due to tourism and its related activities.

C] **Non-Government organisations** would also play a major role in generating eco-tourism in the area with the advent and widespread coverage of social media they can promote awareness of the sanctuary and also provide a means for communication with a lot of people.

D] **Tourism Operators**, would play a major role in establishing and managing marie related eco-tourism such as operating glass bottom boats, snorkelings, scuba diving, sea walk, water sports etc in the earmarked areas with guidance from the Biosphere Reserve Authority.

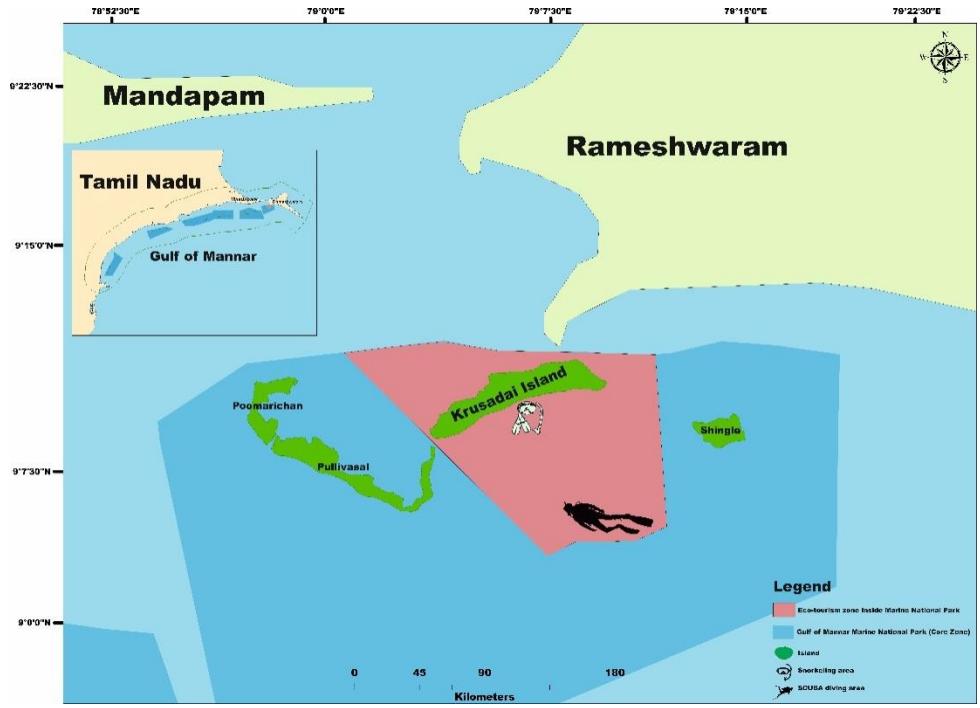
E] **Educational and Research Institutes** they will be able to contribute and increase our existing knowledge of the area by research activities. School and college educational trips would also help instil the need for conservation among young minds and thereby form an important part of ecotourism too.

20.4 Strategies

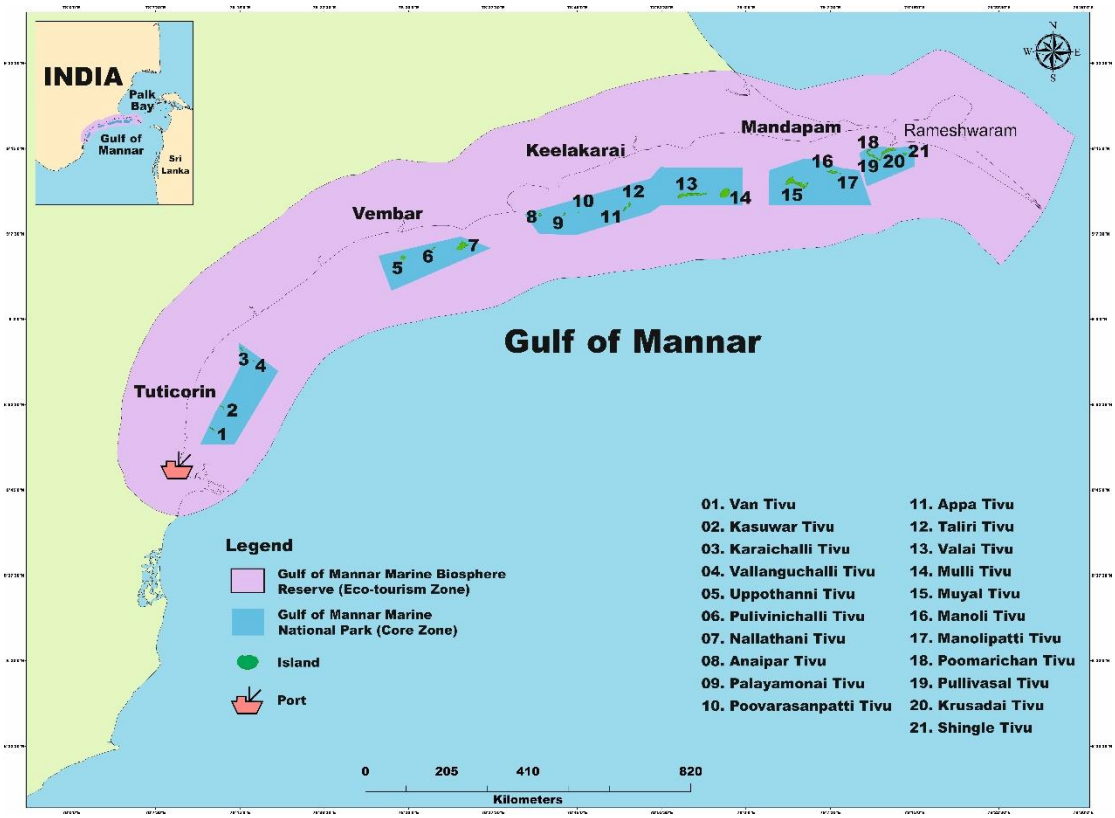
Zoning

It is the principle method used to deploy visitors and hence it is critical in achieving the appropriate combination of concentration and dispersal. It involves decisions about the type of recreational opportunity that would be provided and in which area of the Biosphere Reserve. It can also be temporal i.e. an area set aside for different uses at different times seasonally. Zoning is an essential part of all protected area management plans, from the tourism point of view resourse use should be based on the use levels of each zone and its conservation importance, it would be better to use the buffer zone of the of Reserve for tourism. Important tourism places have been identified and described below. These identified places can be developed and used for tourism and tourism related activities. In addition to the above mentioned places, the coral reef area around the Rameshwaram Island can be used for coral viewing and other marine related reecreatinal tourism activities. Mandapam can be developed as an important tourism site from where these coral reefs can be assessed by glass bottomed boats.

Kurusadai Island and its surrounding sea areas as mentioned in the map (below) is the only area inside the National Park has been identified for tourism zone inside the National Park. All eco-tourism activities need to be resitricted only inside the tourism zone i.e. Kurusadai Island, buffer zone (Biosphere Reserve) and reefs around the Rameshwaram Island.



Entire tourism zone should be a plastic free zone and there should not be any concrete structure established for tourism on the Kurusadai Island except two watch towers, one at eastern most point and another at western most point of the island. One patrolling and monitoring camp need to be established for the forest staff using fibreglass materials as a porta cabin. All facilities for tourists such as changing rooms, cafeteria, toilets, etc should be made by the bio-degradable materials largely using plant products. Tourists should be allowed inside the Kurusadai between 6 am and 4 pm.



20.5 Carrying Capacity

Kurusadai Island Tourism Zone

1. Five glass bottom boats with capacity of 10 persons/boat (each sortie will lost for 15 minutes on chargeable basis. Maximum 5 sortie permitted per boat per day)
2. Snorkling – maximum 200 peoeple/day
3. Discovery Scuba Diving – maximum 50 people/ day
4. Open water Scuba Diving – maximum 50 people /day
5. Sea walk – maximum 50 people/ day
6. Visit to Island – 500 people /day

Tourism in Buffer zone of Biosphere Reserve

1. Twenty glass bottom boats with capacity of 10 persons/boat. Maximum five boats per entry point such as Tuticorin, Keelakarai, Ervadi, etc.
2. Snorkling – maximum 300 peoeple/day (cumulative number from all entry points to Biosphere Reserve)

3. Discovery Scuba Diving – maximum 200 people/ day(cumulative number from all entry points to Biosphere Reserve)
4. Open water Scuba Diving – maximum 50 people /day(cumulative number from all entry points to Biosphere Reserve)
5. Sea walk – maximum 100 people/day
6. Visit to Buffer zone – maximum 1000 people /day (for water sport, angling, etc)

Marine Tourism around Rameshwaram Island

1. Five glass bottom boats with capacity of 10 persons/boat
2. Snorkling – maximum 200 peoeple/day
3. Discovery Scuba Diving – maximum 100 people/ day
4. Open water Scuba Diving – maximum 50 people /day
5. Sea walk – maximum 50 people/day
6. Visit to Island – maximum 500 people /day

There was no planned tourism activity in place at Biosphere Reserve earlier, therefore, there was no baseline data available to carry out systematic carrying capacity analysis. However, based on area available for tourism zone and other available logistic potential, these above numbers have been arrived with reference to carrying capacity studies conducted in similar conditions such as at Mahatma Gandhi Marine National Park, Andaman and Malvan Sanctuary, Maharashtra. It is strongly recommended to revisit these number after three years of this Management Plan with proper carrying capacity study that should be conducted by a renowned instituition with adequate capacity to conduct such kind of studies.

20.6 Finance

Budgeting is a very essential part of any organized activity. Tourist flows and activities should be organized while entering the reserve. On entering the reserve boundaries, visitors should be made to register

themselves by paying a nominal entrance fee, which could be used for maintenance and procurement of infrastructure etc.,

Assuming about 4000 tourists visit the Biosphere Reserve per day and they were charged an amount of Rs.50.00 each towards entry fees, it will generate an annual income of about Rs. 7 crores. Further, 5% of diving fee from people who do diving will also come to the Biosphere Reserve Authority. This could be used for maintenance and procurement of tourism related equipment and infrastructure. Among such equipment, few can be given to tourists for hiring. This equipment includes snorkelling gear, scuba gear, swimming gear etc., for divers, binoculars for bird watchers etc. Income to the reserve can also be generated through boat fares and other entry fees for various tourist spots where applicable.

Funding for initial establishment of tourism related infrastructure like accommodation complexes, roads, boat jetties, procurement of boats etc., can be acquired from the Department of Tourism, Tamil Nadu. A part of the investment can also be acquired by lending few places where recreational centers could be established on lease to private entrepreneurs.

20.7 Interpretation cum Education Center

Main topic of the interpretation center: 'Window to the Gulf of Mannar Biosphere' anchored by the Dugong as the focal species of the Reserve.

The interpretation cum conservation education centre needs to be located at one of the important locations of the Biosphere. Mandapam would be appropriate site for such a centre. The centre would serve the education and awareness needs of both the visitors to the Gulf of Mannar Biosphere and for the villagers living in and around the Biosphere. At present there are only a few visitors to the Biosphere Reserve, however, in future, the visitors can be school children, wildlife enthusiast, college students, pilgrims, researchers, bird watchers, coral watchers, scuba divers, teachers, adventurers, water sports lovers, and casual visitors.

The interpretation cum education centre exterior design and placement should welcome visitors and set the tone for the experience inside. The placement should make it visually obvious but not obtrusive to the visitors. The building exterior should visually complement the natural surroundings.

Upon entering the conservation education centre, visitors will be greeted at the reception desk in the alcove. Behind the desk on the wall would be the location map of the Gulf of Mannar Biosphere

Reserve with different zones, which would give the visitors a clue as to where they are. Leaving the alcove, the visitors would enter the larger exhibit room through the right entrance, where exhibits are on display. The text in the panels would be minimum and would be bilingual i.e. Tamil and English.(hindi should also be included cause currently most of the tourist are pilgrims from the northern part of India)

Some of the following sub-themes have been recommended in the Interpretation cum education center. Each panel may be having one theme within it. However, it is up to the concerned agency that will be establishing this center, to decide and finalize the themes.

Theme 1: Biophysical setting of the Gulf of Mannar Biosphere Reserve

The panel would depict the various ecosystems of the Gulf of Mannar Biosphere Reserve like coral ecosystem, seagrass ecosystem, mangrove ecosystem, terrestrial ecosystem etc. Ecological processes associated with BR like precipitation, mean monthly minimum and maximum temperature, monsoon types, evaporation rate, minerals cycles etc, need to be demonstrated in this panel.

Theme 2: Aquarium

Although a separate scientific aquarium is proposed for the Biosphere, it is suggested to have a small aquarium in the Interpretation center too. The live exhibit would include reef fish and other flora and fauna of Gulf of Manna Biosphere Reserve. The area is rich in marine biodiversity. Around 170 species of ornamental fishes have been recorded in this region, of these a few fishes can be kept in the aquarium at the conservation education centre. The importance of fish fauna in this region and the prospect of fisheries would also be depicted so that the local people are aware of why and how to protect this region so that they can continue their fisheries activities forever.

Theme 3: Mammalian and reptile fauna

Endangered fauna found in the area would be depicted and their habitat requirements and threats to the species would be discussed. The panel would also discuss about dugong, whales, other cetacean and sea turtles and sea snakes and importance of their conservation and methods adopted for conservation,.Information like how to keep safe distance from poisionous sea snakes etc can also be included

Theme 4. Flora

Gulf of Mannar is rich in both aquatic and terrestrial flora. For example, importance of sea grasses, sea weeds, mangrove etc can be discussed in this panel.

Theme 5: Unique fauna and flora of the Gulf of Mannar

There are several endemic fauna and flora occur in this region which need to be discussed in this panel. For example, balanoglossus, endemic mangrove species, endemic sea grasses etc should be mentioned with their unique importance of not being found anywhere else in the world

Theme 6: Culture

The area is surrounded by villages with fisherman communities, agriculture farmers. The panel would depict the local people's dependency on the BR and would also suggest alternates to counter the severe anthropogenic pressure. This panel would be in the form of diorama.

Theme 7: Avifauna

A combination of islands with mud flats and mangroves habitats makes the BR an ideal waterfowl habitat. Large numbers of both migratory and resident birds have been recorded in this area. The panel would depict pictorially the migrant and resident birds and their behavior. Calls of birds would also be included in the panel to make it interactive for visitors and the children coming to the conservation education centre.

Theme 8: Historical account on the GOMBR

Historical account of this region can be kept in this panel. Relationship between the '*Ramayana*' and GOMBR, information about Sethu Kings etc.

Theme 9: Important places in and around the GOMBR

Important places in and around the Biosphere Reserve can be discussed in this panel. For example, Rameswaram temple, Thanuskodi, Tuticorin etc.

Theme 11: Association between local community and Biosphere Reserve

Theme 10: Management

The panel would describe the management issues and also describe the initiatives taken by the Biosphere Authority.

Interactive Display

In the centre of the hall there would be an interactive display on Geo hydrology and Water Quality. Effluent from the industries located nearby is drained into the sea. The display would depict the water quality and also talk about what happens to the ecosystem when the water is contaminated and how it affects humans and the biodiversity of the area.

Video
The centre would have a Plasma wall mounted display screen on which films on the BR and other related issues are on screen for the audience.

Entrance/Orientation Kiosk
The entrance sign kiosk will house a detailed map of the BR, showing boundaries, indicating "you are here" and pointing out major points of interest. The kiosk will also list the rules to be followed while on the visit to the BR.

The kiosk will be so placed that all visitors to the BR will have to pass through the kiosk. Thus the kiosk can also be the site for entry permit and holding area for the visitors.

Signages
In order to regulate the flow of visitor's pathway directional signs should be placed at regular intervals so that the visitors are aware which way to go. The signs should lead them to all the major facilities that are available for the visitors such as toilets, drinking water, boat ghat, conservation education centre and the exit.

Professional organizations such as CEE, WWF-India, WII or CPR Foundation may be approached to establish the interpretation cum education center at GOMBR.

Most importantly, the National Highways Authority may be requested to place direction board with distance details at the Rameshwaram junction on the Kanyakumari-Chennai NH. Minimum five signages on the National Highways would be beneficial to tourists to know about the Marine National Park who travel to Madurai, Kanyakumari and Rameshwaram by roads.

Publications
All publications should have a masthead so that the viewer can know which department has produced it. This would also a means of publicity for the area and the department. All the publication must be in bilingual i.e. Tamil and English. Following publications for the area are proposed:

* Park Brochure
- Checklist of Birds
- Checklists of various marine animals
* Plant identification guide
* Posters
* Outreach Material

Publications can be priced and the money generated can be ploughed back through village eco-development committee. The revenue can be used for replenishing the stock of publications and also maintaining the conservation education centre.

Park Brochure

The brochure would consist of all the information that would be required by a visitor for planning the visit and also what one can expect to see in the area. The brochure would also have the Things to remember i.e. what one is allowed to do on the trip within the BR and what is prohibited. It would also give information on the timings and the period when the BR would be open for visitation.

Outreach Material

Since all kinds of visitors are expected to visit the BR, therefore it is important to reach out to them through publications and other means.

These materials can be used during special events day such as Annual Day of BR (18th February), World Environment Day 5th June, Wildlife Week 2-8th October and Wetland Day 2nd February. Special events increase public awareness of an environmental issue and motivate people to participate by focusing their attention on a particular issue.

The materials can be activity booklets like draw and color, sheets or cards. The material produced has to be in Tamil and in easy to understand language. The activity booklets can be used by school children and on successful completion of the activity they can be given a '*Certificate*', which would motivate the children to learn more about their surrounds. *Environment clubs* or *National Green Corps* too can be formed in schools and colleges located around the BR and activities can be undertaken in the clubs.

Audio-Visual

Films are an important media of mass communication and it works well in rural settings where very few people are literate. Series of 20 minutes film on the BR, its importance, threats and its mitigation can be prepared with strong visual content. The commentary can be in Tamil for use in the villages but English commentary can be superscripted for use in the Conservation Education Centre. The film should be professionally done on DG Beta Pro Formats and sound recorded on DAT (Digital Audio Tape). The DVD is easy to handle and maintain. Not only this, now most of the rural areas one can find DVD players through which the films can be shown on television screen for small audience and through LCD projector for large audience. This documentary film on GOMBR in Tamil can also be telecasted through

local cable TV networks, State Tourism Hotels TV networks, Private Hotels TV networks, etc.

Visitor Centers

It is proposed that information centers for visitor of the Biosphere Reserve need to be established in following five places.

1. Kanyakumari
2. Tuticorin
3. Ramanathapuram
4. Madurai and
5. CWLW- Chennai

All the information centers should have a larger display of the Biosphere Reserve map. Information center should provide all the necessary information to visitors regarding how to reach the BR, different facilities available for the visitors at BR. and Information regarding biodiversity of BR etc. All publications related to Biosphere Reserve should be kept in these information centers. If necessary, these information centers may be attached with district tourism information center but it should be in the above mentioned locations only.

Table 5.1: Media message matrix for interpretation and conservation education.

Activities	Information center	Interpretation center	Hoardings	Tran slides	Way-side Kiosk	Brochures, posters, stickers, post cards, leaflets	Orientation Films & Audiovisuals	Touch and Feel Explorations (students)	Nature Guides	Outreach programmes	Field guides	Organized safaris	Marine aquarium & museums	Organized cruise	Quizzes, competitions, seminars etc	Nature trails & beach walk	Board walks	Watch towers	Check lists	Website (www.gombr.com)	Others (Souvenir shop, Environmental Day etc)
Informing and Welcoming visitors to facilities and activities within Reserve	√	√	√	√	√	√	√		√		√		√							√	√
Making visitors understand the ecological process and importance of flora and fauna	√	√			√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√

Do's & Don'ts & to be a eco-visitors	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Land, people, customs and Traditions	√	√			√				√												
Visitors and tourism resources	√	√			√	√	√		√		√		√	√				√		√	√
Assistance in visitation planning	√	√				√			√		√		√	√						√	√
Conservation orientated activities	√	√			√	√	√		√		√		√	√						√	√
Visitors survey and feedback	√	√																		√	√
Nature club, Green club and Nature camps activities	√	√				√	√													√	√

Table 5.2: Deployment of various interpretive materials at important locations

	Hoardings	Tran slides	Electronic display	Information Kiosk	Brochures, posters & leaflets	Information on visitor resources	Copies of orientation films (CD)	Advertisements	Audiovisual programme	Website link	Television clipps
New Delhi		TN Bhawan & TN State GH		TN Bhawan, TN State GH	TN Bhawan, TN State GH		TN Bhawan, TN State GH				
Chennai		Airport		CWLW Office	CWLW Office, GOI Tourism Office		CWLW Office		CWLW Office		
Madurai	BRA Director Office, Railway station	BRA Director Office, Airport	BRA Director Office	BRA Director Office	BRA Director Office, TN Tourism Information Center	BRA Director Office	BRA Director Office		BRA Director Office		
Ramanathapuram		WLW Office, EDO	Railway Station	WLW Office, EDO	WLW Office, EDO	WLW Office, EDO	WLW Office, EDO		WLW Office, EDO		

		Office, Railway Station		Office	Office	Office	Office		Office		
Tuticorin	Railway station & Bus stand	Airport		Information Centre (IFC)	ACF and EDO Offices, IFC	ACF and EDO Offices, IFC	ACF and EDO Offices, IFC		IFC, EDO Office		IFC
Kanyakumari	Bus stand	Railway station	TN Tourism Office	Information Centre (IFC)	TN Tourism Office, IFC	IFC	IFC				IFC
Tirunelveli	Bus stand	Railway station									
Virudunagar					CF Office						
Tiruchendur	Temple										
Rameshwaram	Temple				TN Tourism Office						
Mandapam	Interpretation Centre (IC), CMFRI	IC	IC	IC	IC, CMFRI	IC	IC, CMFRI	IC	IC	IC	IC, CMFRI
Kilakarai	RMC		RMC	RMC	RMC	RMC	RMC		RMC	RMC	RMC
Pamban	Aquarium (AQM)	AQM	AQM	AQM	AQM	AQM	AQM	AQM	AQM	AQM	AQM

Trivandrum		Airport			Airport Tourism Desk						
Tourism Information centers of TN and GOI					√						
National Dailies, magazines, Television, AIR								√			
Other National & International NGOs										√	
Incredible India, TN Government Website, All tourisms websites, NIC, WII & MoEF website, UNDP website										√	

20.8 Eco-Tourism and Visitors Management

Classification of Tourists who visit the Gulf of Mannar region:

The Department of tourism, Tamil Nadu have classified tourists visiting Tamil Nadu as:

a) **Leisure Tourists** These tourists have only one aim; to enjoy the vacation. They normally come along with their families to visit hill stations, Beach resorts and wildlife sanctuaries.

b) **Pilgrim Tourists** The trip of pilgrim tourists to Tamil Nadu is solely meant for fulfilling certain spiritual aspirations. After achieving this, they do not hesitate to visit nearby Tourist centers. They are mostly Senior Citizens.

c) **Heritage Tourists** Tourists of this category restrict their visits to Historical sites, Heritage monuments and the like.

d) **Adventure Tourists** The tourists in this category are normally youth who love to go on trekking or play air/water sports.

e) **Business Tourists** Executives from leading private firms, public sector undertakings, multinational companies, etc. visit Tamil Nadu throughout the year to attend seminars, conferences, conventions or General body meetings. Once the business session is over, these executives take a break and visit tourist centers.

f) **Medical Tourists** These tourists are normally drawn from other states in India and abroad. Attendants accompany them. After getting discharged from the hospitals, they visit tourist centers for recuperation.

g) **Academic Tourists** The tourists in this category are generally students and research scholars from educational institutions who combine their study tour with tourism. Tourism Department extends concession in entry fee for students visiting Poompuhar Tourist Complex, Sound and Light Show, Madurai and Kattabomman Memorial Fort, Panchalankurichi.

h) **Social Tourists** This category of tourists visit Tamil Nadu to celebrate festivals with their kith and kin, participate in or organize fairs and festivals and attend to social functions. Such tourists make it a point to visit tourist spots after fulfilling their main objective.

Tourism Resources in the Region:

Out of 35 identified places of tourist interest, 21 are Religious places (15 temples, 5 churches and 1 mosque), 7 are

Archaeologically/Historically important, 12 beaches (recreational), 6 places important for Wildlife tourism (Sanctuaries), only 1 place suitable for adventure tourism, 1 place for health tourism, 6 museums etc.,

Significance of these places is discussed here, looking into the possibilities of ecotourism in those places.

Tourism Resource Inventory:

Various places of tourist interest in the four districts bordering the Gulf of Mannar Biosphere Reserve (falling within 50KM from shore land-ward side) are listed in the tables.

Table 5.3. Tourism resource checklist for Ramanathauram District along the coast (50KM landward) of Gulf of Mannar Biosphere Reserve.

RMD	Ramanathaswamy Temple, Rameswaram **Place Code: RMD/Rel/1**	Oruyur **Place Code: RMD/ Rel/8**	Earwadi Dargha **Place Code: RMD/Rel/9**	Ruins of British buildings, Danushkodi **Place Code: RMD/HH/1**	Keelaselvanur-Melaselvanur Bird Sanctuary, Keelaselvanur **Place Code: RMD/WL/1 ***	Mental Asylum, Earwadi **Place Code: RMD/Hea/1**	Glass bottomed boating, Mandapam **Place Code: RMD/Rec/1 *#**	Marine Aquarium ,CMFRI, Mandapam **Place Code: RMD/MA/1**	Pamban Rail scissors bridge, Pamban **Place Code: RMD/ Oth/1**
	Kodandaraman Temple, Rameswaram **Place Code: RMD/Rel/2**			Sethupathy Raja Palace, Ramnad **Place Code: RMD/HH/2**	Vettangudi Bird Sanctuary, Vettangudi **Place Code: RMD/WL/2 ***		Danushkodi beach **Place Code: RMD/Rec/2 *#**	Marine Aquarium , TNFDC, Mandapam **Place Code: RMD/MA/2**	
	Darbasayanam, Thirupullani				Chitrangudi bird		Kushi beach,		

	Place Code: RMD/Rel/3				sanctuary **Place Code: RMD/WL/3 ***		Ariyaman **Place Code: RMD/Rec/3 ***		
	Sethukarai **Place Code: RMD/Rel/4**						Pudumadam beach **Place Code: RMD/Rec/4 *#**		
	Uttarakosamangai **Place Code: RMD/Rel/5**						Valinokkam beach **Place Code: RMD/Rec/5 *#**		
	Navabhashanam, Devipattinam **Place Code: RMD/Rel/6 ***								
	NainarKovil								

	Place Code: RMD/Rel/7								

Suggested Eco-tourism destinations for community involved tourist activities.

Table 5.4. Tourism resource checklist for Tuticorin district along the coast (50KM landward) of Gulf of Mannar Biosphere Reserve.

DISTRICT	**RELIGIOUS**			**HERITAGE/ HISTORICAL**	**WILDLIFE**	**ADVENTURE**	**HEALTH**	**RECREATIONAL**	**MUSEUMS/ AQUARIUMS**
	Temples	**Churches**	**Mosques**						
TTK	Sankara Rameswarar Kovil, Tuticorin **Place Code: TTK/Rel/1**	Panimayamatha Church, Tuticorin **Place Code: TTK/Rel/4**		Veerapandya Kattappomman Memorial Fort, Panchalamkurichi **Place Code: TTK/HH/1**	Blackbuck Sanctuary, Vallanad **Place Code: TTK/WL/1 ***				
	Senthil Nathan Temple, Tiruchendur **Place Code: TTK/Rel/2**	Manappad **Place Code: TTK/Rel/5 *#**		Birth place of V.O.Chidambaram **Place Code: TTK/HH/2**					
	Srivaikuntam **Place Code:**	Kappal Matha							

	TTK/Rel/3	Church, Ovari **Place Code: TTK/Rel/5**							

Suggested Eco-tourism destinations for community involved tourist activities.

Table 5.5. Tourism resource checklist for Tirunelveli district along the coast (50KM landward) of Gulf of Mannar Biosphere Reserve.

DISTRICT	RELIGIOUS			HERITAGE/ HISTORICAL	WILDLIFE	ADVENTURE	HEALTH	RECREATIONAL	MUSEUMS/ AQUARIUMS
	Temples	**Churches**	**Mosques**						
TNL		Kappal Matha Church, Ovari **Place Code: TNL/Rel/1**			Koonthankulam Bird Sanctuary **Place Code: TNL/WL/1**				

Suggested Eco-tourism destinations for community involved tourist activities.

Table 5.6 Tourism resource checklist for Kanyakumari district along the coast (50KM landward) of Gulf of Mannar Biosphere Reserve.

DISTRICT	RELIGIOUS			HERITAGE/ HISTORICAL	WILDLIFE	ADVENTURE	HEALTH	RECREATIONAL	MUSEUMS/ AQUARIUMS	OTHERS
	Temples	**Churches**	**Mosques**							
KK	Kumariamman Temple, KK **Place Code: KK/Rel/1**	St.Xavier's Church, Nagercoil **Place Code: KK/Rel/4**	Peer Mohamed Dargha, Tuckalay **Place Code: KK/Rel/5**	Padmanabhapuram Palace, Tuckalay **Place Code: KK/HH/1**	Bio-diversity Park, Udayagiri Fort, Nagercoil **Place Code: KK/WL/1**	Ulakkai Aruvi Waterfalls, Ulakkai aruvi **Place Code: KK/Adv/1**	Maruthuval Malai, KK **Place Code: KK/Hea/1**	Kanyakumari Beach, KK **Place Code: KK/Rec/1**	Govt., Museum, KK **Place Code: KK/MA/1**	Vivekanandarock memorial **Place Code: KK/Oth/1**
	1500yr old Siva Temple,KK **Place Code: KK/Rel/2**			Vattakottai Circular Fort, Vattakottai **Place Code: KK/HH/2**				Chothavillai Beach **Place Code: KK/Rec/2**	Kamarajar Mani Mandapam, KK **Place Code: KK/MA/2**	Tiruvalluvar Statue, KK **Place Code: KK/Oth/2**
	Suchindrum **Place Code:**							Sanguthurai Beach **Place**		Mathur hangin

	KK/Rel/ 3							**Code: KK/Rec/ 3**		g bridge, KK **Place Code: KK/Oth/3**
								Muttom Beach **Place Code: KK/Rec/ 4**		Pechip arai dam, Pechip arai **Place Code: KK/Oth/4**
								Tiraparap u Waterfalls **Place Code: KK/Rec/ 5**		Mukka dal dam, Mukka dal **Place Code: KK/Oth/5**
								Marthur Hanging Bridge **Place Code: KK/Rec/**		

								6		

Suggested Eco-tourism destinations for community involved tourist activities.

Source: *Government of Tamil Nadu Department of Economics and Statistics Statistical Hand Book 2005.*

Table 5.7: Tourism resource checklist of Kanyakumari District

Place	District	Tourist Attractions	Significance	Accessability	Season	Infrastructure existing
Kanyakumari	Kanyakumari	Gandhimandapam	Historical	Kanyakumari		
	Kanyakumari	Kamarajar Mani Mandapam	Historical	Kanyakumari		
	Kanyakumari	Govt., Museum	Historical	Kanyakumari		
	Kanyakumari	Tiruvalluvar Statue	Historical	Kanyakumari		
	Kanyakumari	Vivekananda Memorial	Historical	Kanyakumari		
	Kanyakumari	1500Year old temple of Lord Siva	Religious/Historical	Kanyakumari		
	Kanyakumari	Kumari Amman Temple	Religious	Kanyakumari		
Suchindrum	Kanyakumari	Vishnu's Temple	Religious	8km from Nagercoil		
Nagercoil	Kanyakumari	St.Xavier's Church	Religious	Nagercoil		
	Kanyakumari	Nageraja Temple	Religious	Nagercoil		
	Kanyakumari	Mathur Hanging Bridge - Longest trough bridge in Asia	Nature based	25 km from Nagercoil		
Pechiparai	Kanyakumari	Pechiparai Dam	Nature based	25km from Nagercoil	Dec-Apr	Water Sports-Pedal boating & Bird watching
Tirparapu	Kanyakumari	Tirparapu water falls	Nature based	30km from Nagercoil		Water Sports-Pedal boating & Bird

						watching
Mukkadal	Kanyakumari	Mukkadal Dam	Nature based	25km from Nagercoil		
Ulakkaiaruvi	Kanyakumari	Ulakkai aruvi water falls-trecking	Nature based	25km from Nagercoil		Trecking trail and a bathing platform
Sanguthurai	Kanyakumari	Beach	Nature based	10km from Kanyakumari		
Muttom	Kanyakumari	Beach	Nature based	16km from Kanyakumari		Rest houses on the beach
Chothavilai	Kanyakumari	Beach	Nature based	10km from Kanyakumari		
Vattakottai	Kanyakumari	Vattakottai circular fort	Historical/Archaelogical	6km from Kanyakumari		
Udayagiri	Kanyakumari	Udayagiri fort- now converted into a biodiversity park with few deers	Historical/Nature Based	16km from Nagercoil		
Tuckalay	Kanyakumari	Tuckalay Palace	Historical/Archaelogical	30km from Nagercoil		

Place	District	Tourist Attractions	Significance	Accessability	Season	Infrastructure
Rameswaram	Ramanathapuram	Ramanathaswamy Temple	Religious Importance	58km from Ramanathapuram	January	
		Kodandaraman Temple	Religious Importance	30km from Rameswaram	January	
		Pamban Rail Scissors Bridge	Openable bridge connecting	40km from Ramanathapuram		
Mandapam	Ramanathapuram	CMFRI Marine Aquarium		40km from Ramanathapuram		
		TNFDC Marine Aquarium		40km from Ramanathapuram		
Ariyaman	Ramanathapuram	Kushi beach	Beach	40km from Ramanathapuram		A water sports
Earwadi	Ramanathapuram	Sultan Ibrahim Syed Aulia's Tomb	800yrs old tomb also attracti	30km from Rameswaram	Feb-Mar	Few private L
		Mental assylum				
Tirupullani	Ramanathapuram	Darbha sayanam,Vishnu's temple	Religious Importance	30km from Rameswaram		
Sethukkarai	Ramanathapuram	A bridge believed to be built by Lord Rama	Religious Importance	30km from Rameswaram		
Uthirakosamangai	Ramanathapuram	Nataraja temple	Religious importance/	35km from Rameswaram		
Devipattinam	Ramanathapuram	Navabhashanam	Religious importance	40km from Ramanathapuram		
Nainar Kovil	Ramanathapuram	Nainar kovil	Religious	40km from Ramanathapuram		
Oriyur	Ramanathapuram	Oriyur Church	Religious	60km from Ramanathapuram		
Ramanathapuram	Ramanathapuram	Sethupathy Raja Palace	Historical/Archaelogical	Ramanathapuram		
Danushkodi	Ramanathapuram	Danushkodi	Religious,Historical,Nature b	90km from Ramanathapuram	January	
Valinokkam	Ramanathapuram	Beach	Nature based	40km from Ramanathapuram		a watch tower
Pudumadam	Ramanathapuram	Beach	Nature based	50km from Ramanathapuram		
Selvanur	Ramanathapuram	Keela Selvanur-Mela Selvanur Bird Sanctuary	Nature based			
Chakkarakottai	Ramanathapuram	Wetland	Nature based	5km from Ramanathapuram		
Tuticorin	Tuticorin	Panimayamatha Church	Religious	Tuticorin		
		Sivankovil	Religious	Tuticorin		
Tiruchendur	Tuticorin	Subramanya temple	Religious/Nature based	Tiruchendur		
Manapad	Tuticorin	Roman Catholic Church- Cross said to be brought from Jer	Religious	18km from Tiruchendur		
Panchalamkurichi	Tuticorin	Remnents of Kattappomman's fort	Historical/Archaelogical	18km from Tuticorin		
Ottapidaram	Tuticorin	Birth place of VO Chidambaram	Historical/Archaelogical	20km from Tuticorin		
Ettayapuram	Tuticorin	Bharatiyar Mani Mandapam	Historical/Archaelogical			
Vallanad	Tuticorin	Vallanad Blackbuck Sanctuary	Nature based	37km from Palayamkottai on NH7,	A watch tower	
Nanguneri	Tirunelveli	Perumal Kovil	Historical	31km from Tirunelveli on NH7		
Ovari	Tirunelveli	Kappal Matha Church	Religious	53km from Kanyakumari		
Koonthankulam	Tirunelveli	Koonthankulam Bird Sanctuary	Nature based			

Information for visitor center

Open and closed seasons of the reserve's tourist areas if any that can be informed to the public through a wide range of public information systems like Media (electronic and print), internet etc., information on this can also be made available to the public through the printed broachers available in the tourist information centers of the reserve.

An annual work plan on monthly calendar basis is very much necessary to organize an ecologically sustainable as well as tourist friendly experience. The annual work plan should be fabricated, keeping in mind, the various ecological processes that are more likely to happen in this area like Turtle nesting, breeding of various migratory species like whales, Dolphins, birds, fishes etc., seed distribution of important floral species like that of mangroves etc., The closed seasons for these areas can be made used for the maintenance of the area such as setting-up or repair of the infrastructure etc., This information should also be made available to the tourists in an understandable manner through printed brochures so that it can be easy for them to plan their tour accordingly.

Daily work plan (visitor hours, routé designation, number of boats/vehicle flow to various sites of interests)

Hours of visitation should be planned based on the activities, a tourist wishes to be involved in like bird watching, turtle walk, whale watching, mangrove site visiting, diving etc., For example, bird watching would be better when done during mornings and late afternoons, turtle walks would be fruitful during nights, diving during the day time etc., for this, a tourist entering the reserve might be required to fill-in the details at the time of his entry into the area itself stating their objective of visit. This plan should also include the limitations on the number of visitors or visitors' boats being operated per day, which has to be decided by the park management based on the sensitivity of the area.

Interpretation Center with audio-visual room

The reserve's interpretation centers may be set-up at three main places like Mandapam, Tuticorin and Kanyakumari. These interpretation centers should be set-up in such a way that their main focus should be on educating people about the significance of the area and bringing awareness among the public through a variety of devices. An audio-visual room should be established at each of these interpretation centers with latest possible equipments with videos about the biodiversity and the need for conservation, the park's expectations from the visitors etc., the videos and information brochures should be in Tamil, Hindi and English languages separately

so as to make different types of visitors easy to understand. Video CDs and other printed material should be made available to the public which could promote the concepts of Biodiversity conservation and sustainable use of resources.

Marine aquarium

Marine aquariums can help managers of any protected area in building-up of curiosity and subsequent awareness about the conservation and sustainable use of resources. Marine aquariums can also be useful to the public as well, by acting as a means of recreation and education. These kind aquariums could also be made useful by managers by exhibiting in such a manner which can depict the negative impacts of human interference into the natural ecosystems' processes.

Two small scale marine aquariums already exist in Mandapam, one belonging to the CMFRI and another, belonging to the TNFDC. However, these aquariums don't have the impact nor imaginative interpretation to educate visitors about the ecology and importance of the marine and flora and fauna vis-à-vis the Gulf of Mannar region. One of the world's best marine aquarium is located in Townsville, the Head Quarters of the Great Barrier Reef Authority in Australia. No visitor to the Brisbane- Townsville – Cairns – Darwin region of Queensland and Northern territory will miss an opportunity to visit this aquarium. This aquarium not only provides a window to the diversity of the marine flora and fauna but also the wonders of reef systems as well as the professionalism in which the Great Barrier Reef Management Authority manages this system.

It is in this context, a **World Class State of Art Aquarium** is suggested to be established in the Rameswaram Island perhaps in Pamban. This way the new aquarium will not pose any competition with the Heritage Museum and aquarium of the CMFRI and the new small scale aquarium of the TN FDC. It is suggested that the Tamil Nadu Government through a Global Tender seek 'Expression of Interest' of interested and experienced corporate sectors and or global consortium to invest and construct a world class aquarium on a 'Build, Operate and Transfer (BOT)' basis. Alternatively, CMFRI may be requested to establish and maintaine this Aquarium with financial supports either from Government or Corporates. With an annual tourist inflow of two million people to Rameshwaram, which is expected to grow even higher, the prospect of such a facility getting back its investment in a short span of time can not be over emphasized. The well known global marine aquarium specialists are the Great Barrier Reef Management Authority of Australia, The Sea World of USA, Ocean Park Foundation of Hong Kong and the Singapore Aquarium. These specialists may also be contacted, if required.

Publicity for visitors orientation (production of maps, brochures, curios, sale centers, T-shirt, caps etc)

Publicity is a very important tool to send the desired message into the public. Publicity makes communication with masses a lot easier. Park managers can make use of a wide range of options available for publicizing the theme of conservation and sustainable use of resources like media (print as well as electronic), information boards along the road sides etc., Internet can also be used to publicize this concept.

For the better management of any protected area, satisfaction of its stakeholders is a very important factor. Fisher folk, being the major stakeholder group of the area, their benefits should be given equal importance along with the conservation so as to gain public support for better management of the reserve. Fisher folk can be involved in maintaining the sale centers which sells various products to the tourists, whose inherent theme would be promotion of the park's biodiversity, its significance, conservation and sustainable use. These products may include printed T-shirts, caps, various handicrafts like baskets and mats made from palm leaves etc., The sale of these products should also aim at promoting or getting people to know about the local traditions and culture. These sale centers can be set-up at major tourist spots, by local communities for whom, the financial aid can be given through subsidized loans. This can also be a good option for alternative livelihood for those who are interested to leave fishing.

Visitors management guidelines

Conducting tourism can be beneficial to the park authorities only when organized in a proper manner. Visitors should be asked to enter their details like their origin, duration of stay, their expectations from their visit to this area, and few other questions which can give an idea of their level of understanding about the need for conservation. This helps the management to categorize visitors and lead them accordingly. This also enables the management on how to educate people about the key concept of the park. On entering the reserve, after their registration, they can be handed information brochures which includes what on the park authorities expect the visitors to do during their stay. A list of Dos and Don'ts should be included in these brochures. All visitors should be made well aware of their responsibility towards the park. Feed back forms are also to be handed over to the visitors so as to enhance the better management of the reserve.

Infrastructure:

Necessary accommodation facilities, roads, road transport, jetty, boats, scuba and snorkel equipment, private rooms, security force

with necessary life saving equipments need to be established in each site.

Human resource and capacity building

Plans should identify and fulfill needs of the staff involved in tourism sub-plan. Capacity building is an important determining factor for success of any protected area management plans. Staff should be given enough training not only to organize sustainable tourism, but also to react to any accidents taking place in the reserve. Issues for such training should include components like visitor safety, search and rescue etc.

Apart from this, staff should also be trained in the fields of biology and conservation which would get them a better understanding of what they are doing and why. Training can be obtained from any localized research institutions in the reserve.

Community involvement

The conservation philosophy that has traditionally been used in the past in the creation of national parks has been a closed protection model. Parks were designed on the assumption that they were free from human influences. Large areas of land were set aside for protection. In non-populated areas, this system has advantages. The challenge in East Asia is that in many potential locations where parks were to be designated, people were already living in some part of the area, and human influences were present. Using a traditional model, park agencies inform local communities of the specific park boundaries and tell them which activities are permitted and which are no longer permitted. Much attention is given to regulations and enforcement. In the traditional model very little consideration is given to the interests of communities in and around protected areas. Often no efforts are made to involve local people in the planning and management of the area, even though many regulations imposed by the park staff have an impact on the livelihoods of the residents. The results include poor relations between government park staff and local communities, confrontations, and lack of support for conservation activities. One example of an alternative to the rigid conservation-focused traditional approach to protected areas is the biosphere reserve. Like national parks and other protected areas, one of their official functions is to protect genetic resources, the environment, the flora and fauna, etc.(conservation function). Biosphere reserves also have two other functions that address the human dimensions of park-human interactions. They are designed to facilitate sustainable development in socio-cultural, ecological and economic terms (development function) and to assist research, monitoring, environmental education and training, and information exchange related to issues on sustainable development at the regional, national and global levels (logistic support function).

Nature based tourism will only be sustainable if the support of the local communities are obtained. This can be attained by making them aware of nature's potential to support the tourism industry, through which the lively hood of these communities could be generated. Multiple-use planning would be more successful when needs of local people are allowed to be expressed and understood. Local people should be made involved in the tourism plans of the reserve by opening sale-centers of locally made handicrafts showing the local tradition and culture. They may include baskets and mats made out of palm leaves, printed T-shirts which illustrate the history and culture of this area, caps, and other curios and souvenirs. They can also be made involved by allowing them to operate boating, dive operations and other recreational activities.

Visitor survey

Periodic survey of visitors will help management to get a clear idea of visitor needs and market trend, which would enable park managers to offer tourists what they expect. Feedback forms should be obtained from the tourists comprising questions like what they have expected before entering the reserve. Their expectations on their next visitation, suggestions to the park management for better management of the area etc., this kind of periodic surveys will help authorities in keeping a track on the market trends and visitor psychology.

Guide and guide training

Tourists should be posted at important spots with place of religious/archaeological / historical importance. These guides, if selected from the local community, this program would be a useful tool for local economic boost. Guides must be properly trained like providing them with basic foreign language skills, a focus on environmental interpretation, conversation techniques etc., Contents and time frame of this guide training course may be modulated in collaboration with local/international tour operators, Tourism Department officials, Environmental conservation groups etc., Scuba divining training to local fishermen youth is also required at regular interval and these certified fishermen divers would be involved in divining tourism. It should be made mandatory for all tour operators to use only the local divers for their diving and snorkeling tourism.

Networking with other tourism organizations.

Networking of the reserve's tourism plans with other tour operators (local and international) enables the park management to not only attract tourists from far away places, but also in organizing plans in a better manner and upgrading themselves to the existing trends.

MoUs can be obtained from the bordering state's Tourism Departments. Stalls should be kept in the tourism festivals of the other districts of the state for a better publicity. Focus should be on the Biological and cultural wealth of the area.

Activities (adventure, beach, bird watch, cetacean watching, diving and coral viewing):

A clear code of conduct should be written on the permissible activities of the visitors of the reserve, which can prevent the conflicts between the visitor and the management. Boards displaying Dos and Don'ts should be kept at places wherever is applicable.

Taking the advantage of the resources available, a wide range of activities can be organized inside and outside the Biosphere Reserve. For example:

- Ulakkaiaruvi, a natural waterfall in the Kanyakumari district, can be promoted as a good trekking site.
- This area has good sandy beaches with calm waters at various places like Danushkodi, Mandapam, Pudumadam, Seeniyappa Dargha, Valinokkam etc., could be promoted as good destinations for recreational tourism where water sports complexes with speed boating, water skiing etc., can be organized by involving local fishermen communities.
- Bird watching is one sector which can attract lot of tourists from all over the world during winter months into this area. There are four bird sanctuaries present in this reserve which can serve good for this purpose. Setting up of basic infrastructure like interpretation centers, watch towers, place for parking vehicles etc., Pedal boating may be permitted where possible.
- Activities like diving and Coral viewing could not be conducted in this area. However, divers can be entertained if taken to the Palkbay side near Mandapam. Glass bottomed boating is already being done at this place. This needs to be publicized more intensively. Snorkeling and diving can also be conducted here provided the tourists are accompanied by trained divers of the reserves tourism related staff. Local people can be involved in these activities (contradicts the table below ,diving depth not very good in these suggested areas proper areas are to be surveyed ,plus these activities are seasonal).

Activities to be prohibited for tourists:

- Entire tourism zone should be plastic free.
- Dumping of any kind of wastes on the beaches, sea and island should be prohibited. Separate dust bins for biodegradable and non-biodegradable wastes should be placed on the beaches.
- A trained diver should accompany the visitors while diving and snorkeling to minimize the destruction to the ecosystem and also to reduce the risks of any accidents.
- Sounding vehicular horns should be prohibited in the areas of bird watching.
- Zero percent oil leakage should be there in all boats operated in the tourism activities.

- No anchoring of boats in the coral reef areas.
- Snorkling site should give feeling of marine biodiversity occur in the region but acropora corals sites should not be choosen for snorkeling site. There is a lot probability that inexperienced tourists may step on these vulnerable corals.
- Tourists should not be allowed to get into sea without a life jacket.

20.9 Prescriptions (Eco-tourism)

A. Suggested Coral reef based eco-tourism
   a) No tourism and its related activities will be allowed inside the Core Zone of the Biosphere Reserve i..e. in the Marine National Park.
   b) Eco-tourism can be allowed in the buffer zone of the Biosphere Reserve
   c) As a part of the value addition to the Eco-tourism in the Gulf of Mannar Biosphere Reserve, around 50 km stretches of land and sea areas around the Biosphere Reserve has been identified as 'Value added tourism zone'. All the tourist centers in this area have been assessed and included in the Management Plan for visitors to benefit more.
   d) Visitors/Tourists need to be guided to all the available tourism resources in the Biosphere Reserve as well as in the 'Value added tourism zone' of the Biosphere Reserve.
   e) Places for coral reef watching have been identified and given in the below table. BR Authority should prepare a detail eco-tourism plan for each site mentioned in the table with the high level participation of local communities.

Place	**Location**	**Activities**		
		Coral watching using glass bottom boat	**Snorkeling**	**Scuba diving**
Kurusadai Island	**Inside NP**	√	√	√
Keelakarai	Inside BR	√	√	√
Sethukarai	Inside BR		√	
Tuticorin	Inside BR	√	√	√
Pamban	Outside BR	√	√	
Mandapam (Palk Bay side)	Outside BR	√	√	√

Rameswaram Island Palk Bay side (other than Pamban)	Outside BR	√	√	√

B. Establishment of State of Art World class Marine Aquarium at Pamban / Mandapam (Rameswaram Island).

a. Global tender for Expression of Interests for this aquarium on BOT basis by the Tamil Nadu Government.

C. Value addition to Eco-destinations

a. A series of nature and wilderness based destinations have been identified. With innovative and imaginative upgradation and value addition by the GOMBR, these sites can evolve into major eco-tourism destinations. It is strongly suggested that these value added eco-destination sites are managed by Community Based Organizations (CBO). A world class model value added eco-destination 'The Fire Fly Sanctuary in Malayasia' is classic example.

D. Beach tourism

a. A number of under utilized but excellent beaches along the Gulf of Mannar Biosphere Reserve coastline have been identified. However, it is strongly urged that these beach developed as ecologically sound leisure recreation destinations with great degree of focus on conservation related activities. For this reason a series of sea turtle hatcheries (a model programme of the SABAH Wildlife Management Authority is appended), beach walk programmes, sand dune based nature trails and backwater, lagoon and swamp tours are suggested to be developed. All these activities are low-tech and through training and capacity building can be very well managed by local educated youths. The prospect of 'Home stay' for eco-tourist may also be examined as this region has a host of tradition, culture, festivals, art, handicrafts and cuisine to be shared with visitors.

E. Experimental guided safaris (tour circuits)

a. With Kanyakumari at the southern end, Rameswaram at the northern end and Tuticorin at the center at least two or three low-volume guided safaris with a mixed range of tourism destinations can be experimented. For this local entrepreneurs are to be promoted with participation of local educated youths. Three pick-up points and terminals suggested are

   i. Day 1: Madurai – Ramanathapuram – Mandapam – Pamban – Rameswaram (halt) – Day2: Temple visit – Danuskodi lands end – coral watch - Madurai

ii. Day 1: Trivandrum – Padnabapuram – Kanyakumari (halt) – Day 2: Circular Port – Wind mills – Koodenkulam Power Plant – Manapadu back water and Church – Uvary - Tiruchendur (halt) –Day 3: Tuticorin – coral watch – swamp and lagoon – Mandapam – Rameswaram (halt) – Day 4- Danuskodi – Pamban – Ramanathapuram – Madurai
iii. Day 1: Tuticorin – coral watch – swamp and lagoon – Mandapam - Rameswaram (halt) – Day 2 - Danuskodi – Pamban – Ramanathapuram – Madurai
iv. Day 1: Tuticorin – coral watch – swamp and lagoon — Tiruchendur (halt) - Manapadu backwater and Church – Kanyakumari - Trivandrum
v. Day 1: Tuticorin – coral watch – swamp and lagoon — Tiruchendur (halt) - Manapadu backwater and Church – Uvary – Koodenkulam – wind mills – Kanyakumari (halt) Day 3: Manakudi estuary – Suchindram – Padnabapuram palace - Trivandrum

F. Capacity building and Guide Training

a. To gradually implement the suggested eco-tourism related activities with community participation it is important to identify and empower CBOs. The success of many of these activities will depend on availability of trained man power in the form of guides. The suggested guide trainings are to be targeted to matriculates (SSLC), intermediates (HSLC) and graduates. The following guide trainings are suggested
    i. Reef watching , skin diving, snorkeling and glass bottom boat viewing training modules to be developed and trained by GOMBRA and PAD
    ii. Reef watching and scuba diving training modules to be developed and trained by GOMBRA and PAD
    iii. Nature and cultural guides training modules to be developed and trained by GOMBRA and other identified professional organizations such as ATREE, WWF, BNHS etc.

Chapter 21

Eco-development Plan for Livelihood Generation

21.1 Introduction

Conservation of Biosphere Reserve and its rich biodiversity such as coral reefs, seagrass beds, oyster beds etc require the resolution of conflicts among its users, which should be interactive in nature to arrive at agreeable regulations in different areas of use by keeping the conservation and livelihood benefits to co-exist especially in the buffer zone and it should be a sustainable mechanism aided by people participation. With this principle, this eco-development plan is being prepared. The term "eco-development" seeks to reflect the interdependency between environmental problems and those connected with economic growth, demography and poverty. This leads to the principle of a trade-off between development and ecology or "eco-swap", according to which the project undertakes to support activities meeting the community's immediate needs in exchange for the latter's commitment to environmental restoration or conservation activities, in the spirit of a "social contract for long term concerted development" (Michel & Lazarev, 1997). The notion of participation brings the human development dimension into the eco-development concept, by introducing the idea of local control over decision-making (Michel & Lazarev, 1997).

With the setting up of Gulf of Mannar Marine National Park in Tamil Nadu, under the provisions of Wildlife (Protection) Act 1972, covering the 21 offshore islands along the Ramanathapuram and Tuticorin Districts, fisherfolks have lost livelihood access to the common property resources from the coral reef-based fisheries operations. However, to seek out a subsitence of livelihood option, they still resort to some level of marine resource harvesting from the protected area. By setting up the Gulf of Mannar Biosphere, a large buffer zone of seascape surrounding the Marine National Park as well as a coastal terrestrial landscape have been earmark as a multiple-user area where a diversity of alternate livelihood options are to be facilitated by the Gulf of Mannar Biosphere Reserve management agencies in an attempt to wean away the dependency of coastal communities from a multitude of marine resources. This major marine protected area management objective has been met with only to some extent by initiating some “eco-development measures” by the GOMBRT in the year 2002 following the India Eco-development Program (IEP) model. In this present plan, it is proposed to enhance the eco-developmental activity in a planned manner within the GOMBR limits following the guidelines setforth by Wildlife Institute of India (WII, 2004). This is proposed to be achieved by a proper assessment of the socio-economic dependency levels of dependent communities on coastal and marine biodiversity, identifying aternate livelihood options, enhancing

community empoverment and setting in place proper intersectoral institutional mechanisms for the sustainability of such eco-developmental initiatives. The plan therefore examines the cultural, socio-economic and the sicio-political situation to suggest an implementatble eco-development plan.

Cultural and social Consideration in the Gulf of Mannar Biosphere Reserve Region

In Thavukadu locals believe the Gulf of Mannarto be a male sea, due to the nature of its rough waves, which hit against the reef belt and subside in force by the time they arrive at the shore. In contrast, Palk Bay is believed to be a female sea, where like a woman the waters are calmer most of the time, but once they awake due to wind or storms the damage is heavy, for there is no reef belt to control the action of the waves. (Rengasamy *et al.*, 2003).

Among the coastal communities of the Gulf of Mannar, India, locals believe that Appa Island is the home of an island God (*Santhanamariamman*) and by pleasing this God they will be protected from evil spirits when they stay on the island. It is also believed that another god (*Muniyasamy*) resides in a coral mound just near the island and close to an area known for dangerous currents and an underwater cave. Fisherfolks are warned that in order to escape from the wrath of deities they should not approach this area (Rengasamy *et al.*, 2003).

In the cultural and historical background of India, the Gulf of Mannar occupies a prominent place. The famous pilgrim centre of Rameswaram is situated in the Gulf, on the island of Pamban. It is connected with the religios hindu epic the Ramayana. It is said that Rama worshipped Shiva here, after his victory over Ravana, on his way to Ayodhya. The places mentioned in connection with Ramayana are situated in the environs of Rameswaram, and draw thousands of pilgrims daily from all over India (some of the other places are Dhanushkodi, Kandamadhana Parvatham, Navabashanam, villundal etc.). In fact the mainland and coastline of Ramnad district (the district is also named after Rama) too is associated with places where the events mentioned in Ramayana are supposed to have taken place (e.g., Tirupulani, Devipattinam, Darbasaynam). Rameswaram is known as Sethu. The adage “from the Himalayas to Sethu” speaks of the oneness of India since prehistoric times.

The Raja of Ramnad from the mediaeval times (with the title “Sethupathi”) ruled over Rameswaram and the islands in the region of the Gulf of Mannar also came to be in his possession. It is said that the later parted away some of the islands either as gifts for use in trade to the businessman. Thus, some of the islands like Muyal tivu

and Nallathanni Tivu were either fully or partly owned by individuals. Some of the islands like Krusadai were parted to the British long ago.

Liverlihood-based scio-economic considerations in the Gulf of Mannar Biospher Reserve region

India is one of the lower ranking Medium Human Development countries. Coastal areas of India are heavily populated. Reef fisheries in India have been estimated to contribute to 5–10% of the total marine landings (Pet-Soede *et al.*, 2000), and contribute significantly to the subsistence and income of coastal fishing communities of Gulf of Mannar regions. Estimates of the numbers of small-scale fishers, amount to 21 000 in the Gulf of Mannar (Rengasamy *et al.*, 2003).

In the Gulf of Mannar, coral reefs fringe a chain of 21 coralline islands, sheltering mangroves, lagoons and a shallow 'trapped sea' with extensive seagrass beds. This mosaic of coastal ecosystems forms the basis for sea-based livelihoods among the coastal communities, including the extraction of seaweed, shells, lobsters, sea cucumbers and reef fish from the reef flats and lagoons; and the harvest of crabs, squid, fish and shells from the seagrass beds and 'trapped sea' between the islands and the mainland coast. For the coastal people of the Gulf of Mannar coral reefs are perceived as part and parcel of the ocean, as expressed below:

• 'It is the reef from where everything sprouts and spreads throughout the entire sea'
• 'The reef is a natural nursery'
• 'It is because reefs are there and its fertility, we get different varieties of fish to catch and we have to keep different nets' (Rengasamy *et al.*, 2003)

Socio-economic activities for livelihood generation in the Gulf of Mannar region

Exploitation of fishery resources in the inshore waters had been the sole occupation of several thousand fishermen families living along the Gulf of Mannar coast for centuries. They have been in such close intimacy with the sea that their life-style, culture, community and social life all centres around the sea.

Fisheries is the predominant industry in the coastal belt of the Gulf of Mannar. In Tamil Nadu marine fisheries account for 82% of all active fishermen, who are responsible for 76% of the total fish production in the state and 8% of the total marine catch for India. Tamil Nadu's fishing fleet numbers about 84000 vessels of which more than 60% are traditional crafts (known locally as *Vallams* and *Vathai*) contributing 47% of the total fish landings. There are an estimated 8,02,912 people earning their livelihoods from marine fishing in the

state, distributed among 573 fishing villages. The maximum number was in Ramanathapuram district with 178 villages.

Table. Details of fishermen communities who depend on marine resources of Biosphere Reserve.

District	Landing centres	Fishing villages	Fisherman Families	Traditional fishermen families	BPL families	Fisherfolk Population
Ramanathapuram	90	178	41,048	37,680	33,429	193,413
Tuticorin	27	32	19,998	18,828	13,212	82,560
Tirunelveli	9	9	6,132	6,125	2,399	24,639
Kanyakumari	46	47	40,266	39,941	7,601	156,595
Total	**172**	**266**	**107,444**	**102,574**	**56,641**	**457,207**

Table. Details of fishermen communities who engaged in aquaculture activities along Biosphere Reserve

District	Type of aquaculture						Acquired training
	Fish	Prawn	Crab	Lobster	Seaweed	Total	
Ramanathapuram	61	0	0	1	149	211	130
Tuticorin	3	2	1	2	0	8	508
Tirunelveli	8	1	0	0	0	9	16
Kanyakumari	2	2	0	0	0	4	61
Total	**74**	**5**	**1**	**3**	**149**	**232**	**715**

Traditional or small-scale fishing is carried out predominantly in the 'trapped sea' between the islands and the mainland coast and in the shallow waters and reef areas surrounding the islands. Fishing takes place throughout the year, but changes in nature according to local availabilities of different species. Wind patterns generally restrict the use of small-scale crafts between the months of August and October, and during this period many fishermen simply switch to labouring on larger mechanized boats.

In addition to fisheries-related occupations along the coast, there are opportunities for employment in salt extraction, particularly in the western side of the Gulf near Tuticorin, and also in Palmyrah (toddy) tapping and agricultural labour. Skilled work is also undertaken, with mat weaving common in Ramanathapuram district. Moving inland from the coast toddy tapping and agriculture are the predominant occupations with small business-related opportunities prevalent near Rameswaram in connection with the tourism in this area.

Fishery based livelihood in Gulf of Mannar Biosphere Reserve region:

Marine Fisheries:

The livelihoods of people in the coastal buffer zone of the Gulf of Mannar Biosphere Reserve region largely depend on coastal and marine resources. However, agriculture and allied activities also plays a significant role in providing livelihoods for the poor. The activities of coastal-based people largely include fishing, salt making and seaweed collection while other marine-based activities are also gaining importance. Ninety percent of the fisherfolk in the GOMBR region are artisanal (using wind or small engine powered craft) and only 10% use mechanized trawlers.

The GOMBR coastal belt has a very large proportion of country crafts, about 87%, against the mechanised boats, about 13%, in the total crafts. Thus a very large segment of traditional fishermen population has to work closer to the shoreline in shallow waters where the resources are poor and thereby their income is also poor. There are increasing number of instances where, due to poor catches and diminishing economic returns, the owners are selling the mechanized boats.

The fishermen employ traditional crafts such as catamarans, vallams, masula boats and dug-out canoes for their fishing operations. The mechanized fishing boats of 30' – 32' size, introduced by the Fisheries Department in the late fifties have proved extremely popular especially with the subsidy and soft loan facilities. Presently, 500 of these boats operate in this area mainly from Pamban, Mandapam and Valinokkam. About 165 traditional crafts in this area are mechanized under the Modernization Programmes introduced by the Department during the last few years. Despite the mechanization programmes initiated four decades ago, about 70% of the fish landings are still brought in by the traditional crafts. Since these islands are in close proximity to the main land, most of the fishing operations are conducted with their bases in the main land.

Table.Types of fishing crafts operating in the Gulf of Mannar Biosphere Reserve region.

Crafts	Length	Mode of Operation	Machinery		Fish Workers
			Cylinder	Horse Power (HP)	
Catamaran	6 to 25 Mulam	Sail/ Out Board Engine	1	8	1 to 4
Fibre Boat	25 Mulam	Out Board Engine	1	8 to 10	1 to 4
Vathai	7 to 15 Mulam	Sail/ Out Board Engine	1 to 2	8 to 14	1 to 4

Vallam	10 to 23 Mulam	In Board Engine	1 to 4	10 to 40	3 to 7
Thoni	> 15 Mulam	Sail/ Out Board Engine	1	8 to 10	20 to 40
Valivalai Boat	> 38 Feet	In Board Engine	6	80 to 120	5
Iruvalai Boat	35 to 52 Feet	In Board Engine	6	80 to 120	4 to 7

Note: 1 Mulam = 1.5 Feet

The various types of fishing gears used by the fishermen for fish capture are trawl nets, gill nets, shore seines, drift nets, olaivalai, karavalai, kalamakatti valai, long-lines, traps and others. Of these, drift nets, long-lines, bottom-set gill nets, olavalai, karavalai and kalakkatti valai are mainly operated in and around these islands. Nylon and polypropylene had replaced the earlier cotton nets which were popularized by the Department by providing subsidy and loans.

Table. Types of fishing gears using in the Gulf of Mannar Biosphere Reserve region.

Name of the Net	**Position Laid**	**Gear Composition**	**Thread Size (Diameter)**	**Mesh Size**	**Net/ Mesh Row's Depth**	**Casting Place**	**Species Caught**
Nandu Valai		Synthetic Nylon	23, 28, 32 mm	90 to 130 mm	13 Mesh	Clay	Crabs
Chanku Valai		Plastic	0.5 mm	90 to 130 mm	13 Mesh	Sandy	Chanku
Singi Valai		Plastic	0.5, 0.75 mm	110 to 130 mm	13 Mesh	Rocky	Singiraal
		Synthetic Nylon	32, 40, 45 mm	110 mm	13 Mesh	Rocky	Singiraal
Disco Valai	Centre Position	Nylon	0.25, 0.5 mm	38 mm	65 Mesh	Clay/ Sandy	Iraal

	Outer Position	Nylon	3 mm	7 Inch	9 Mesh	Clay/ Sandy	Iraal
Thirkai Valai		Plastic/ Nylon	1.5 mm	1 Feet	13 Mesh	Rocky / Clay	Thirukai Meen
Mandal Valai		Synthetic Nylon	45 mm	110 to 120 mm	20 to 35 Mesh	Rocky	Parai Meen
Maya Valai		Synthetic Nylon	23 mm	55 to 60 mm	30 Mesh	Rocky	
Kelunga Valai		Synthetic Nylon	20 mm	34 mm	50 Mesh	Rocky	Kelungaan
Velameen Valai		Synthetic Nylon	23 mm	48 mm	25, 35 Mesh	Rocky	Vela Meen
2 No. Valai		Synthetic Nylon	2 mm	60 mm	170 Mesh	Watery	Kumla, Sheela, Vaalai, Paarai, Vela Meen
Kola Valai (Chala, Chuda Valai)		Synthetic Nylon	0.5 mm	26, 27, 29 mm	350 to 400 Mesh	Watery	Chala, Chuda, Keeri Meen
Meen Valai		Synthetic Nylon	23 mm	55, 60 mm	100 Mesh	Watery	Mixed
Mural Valai		Synthetic Nylon/ Nylon	20/ 0.5 mm	38 mm	50 Mesh	Watery	Mural Meen
Kumla Valai		Synthetic Nylon / Nylon	2 mm	60 mm	100 Mesh	Watery	Kumla, Sheela, Vaalai Meen
Vali Valai (Paru Valai)		Nylon	4, 6, 8, 10 mm	95 to 120 mm	100 to 130 Mesh	Watery	Nei Meen, Keluthi, Ooli, Parai, Katta,

							Kaarai

The mechanisation of fishery has displaced women from their traditional roles in processing, marketing and making of nets; forcing them to take up alternative livelihoods. As women play a major role in supporting the sector, they would be the primary beneficiaries. Existing livelihoods related programmes in the buffer zone area do not provide adequate economic alternatives and in particular do adequately address the needs of women fisher-folk. As a result, people's only alternative livelihood option has been harvesting of wild seaweed or coral, which they have been over harvesting.

As a result of the complexity of the types and efficiency of fishing craft and gear and the fluctuations in the available fishery resources, there are wide variations in the catch and income of fishermen. More than 70% of the active fishermen work as labourers in the boats owned by others on share-basis or for wages. The fishermen working in the country crafts such as catamarans, vathai, thoni and vallam (not motorized) earn a daily income in the range of Rs.100-200, except on a few days during the peak fishing season.

Holothurian Fishing

Fishing for holothurians has gained importance during 1980s although the industry is ancient and reported to have been established about hundred years ago. The two commercial important species that are collected by fishermen are *Holothuria scabra* and *Holothurai spinifer* which are processed and exported to Singapore and Hong Kong. The fishermen collect the holothurians by diving in shallow waters of 2 to 10 metre depth. Fishermen from Chinnapalam, Vadalai, Mandapam, Periapattinam, Kilakarai and Tuticorin are engaged in this kind of fishing. Annually 60 tons of Holothurians valued at Rs. 90 lakhs were collected from Ramanathapuram district of which 50% are estimated from the Gulf of Mannar area. Due to the over exploitation of the holothurians their population have drastsically declined, therefore, the Government of India banned Holothurians fishing, henceforth also in the Gulf of Mannar Biosphere Reserve.

Sea-weed collection

The species that are commercially valuable are *Sargassum* spp. *Turbinaria* spp., *Gelidiella* spp., *Gracillaria* spp., which are in demand for the production of agar, cellulose and algin used for food processing and pharmaceutical industries. 5000-7000 tons (dry weight) are harvested annually of which *Sargassum* spp. form the bulk. More than 1000 fishermen and 450 fisherwomen are engaged in seaweed collection which brings in a daily income on Rs. 100/- to 150/- per fisherman. The fishermen and women collect seaweeds near the islands and at times stay in the islands and collect them. The islands where significant quantities of seaweeds are harvested are Anaiparai,

Pallimunai, Nallathanni, Challi island, Puthur theevu, Pamban island, Appa tivu, Anaipar, Manoli island, Putti island and hare island.

Coral collections

Coral reefs play a complex but a significant role in the marine eco-system. Coral reefs are said to be one of the most productive areas in the sea. Corals which were indiscriminately mined and harvested a few years ago from the Gulf of Mannar have been banned since 1982. Although this may help halt further degradation and facilities the recovery of the depleted areas, improved protection would be necessary to halt some level of illegal coral collection practiced now and suitable restoration and management to maintain a possible sustainable utilization of reef resources.

Chank, Pearl and Oyster fishing

Diving for pearl oysters and chanks had been another important occupation of fishermen for more than 2000 years. Collection of chanks and oyseters by diving is still a major vocation for several hundred fishermen in Gulf of Mannar region. Pearl fishery which was a government monopoly had been conducted sporadically depending on the abundance of spat falls with great fan fare and had attracted pearl merchants from all over the world into this region. The last pearl fishery in Gulf of Mannar was conducted in 1961 and since then due to various reasons, the population of pearl oysters had not been adequate enough to organize such fishery.

Chank fisheries is also a Government controlled activity and continues to be fished on an annual basis, which is of considerable commercial importance to government. The Department of Fisheries registers divers for fishing from November to May; takes over the chanks collected and pay the Divers at a predetermined rate depending on the size and quality of chanks fished. The Tuticorin *jadi* varieties of chanks are in demand in West Bengal for making ornaments and for manufacturing artifacts. Chanks below the size of 60 mm. diameter considered juvenile when caught are released to sea and no payment is paid for such collections. Chank diving supports nearly 770 divers who take to this profession by hereditary. The average collection of chanks during the last five years is 4,80,000, which fetch a revenue of Rs. 48 lakhs.

Other non marine based livelihood activities:

In addition to fishing many are involved in various supplementary activities for their livelihoods viz., charcoal making, salt making, mat weaving, coir making and agriculture and allied activities. Availability of timely and adequate credit from the formal system and lack of support systems for marketing are the two main problems faced by the people.

The fisherwomen are more burdened and try to supplement the family income through fishery related trades such as dry fish preparation and marketing, seaweed collection and net-making and mending, and non-fishery activities such as working as labour in salt pans, and beedi making. These activities are seasonal and possible only in certain areas and do not add much to the family income.

Drift wood and dry twigs are collected from the islands mostly by fisherwoman as firewood and sold. Tough this is not a major occupations, this is taken up by fisherwomen for supplementing the family income.

The status of Eco-development Programme practiced in the Gulf of Mannar Biosphere Reserve region

The Gulf of Mannar Biosphere Reserve Trust (GOMBRT) which was set up by Tamil Nadu Government in December 2000 have been responsible for initiating several eco-developmental activities in the Gulf of Mannar Biosphere Reserve area after the GEF-Supported UNDP Project for Strengthening the Management of the Gulf of Mannar Biosphere Reserve was initiated in the year 2002.

The project addresses a major challenge, namely the conservation of coastal biodiversity of the highest ecological value in a large area subject to considerable pressure from poor populations upon the sole resources that appear to be at their disposal. To meet this challenge, the project follows the only framework which can succeed, namely to combine the necessary protection of the threatened ecosystem and ecological processes while facilitating other economic and social benefits which will meet the essential need of local people, through providing appropriate institutional, financial and managerial arrangements.

In order to integrate the concerns of livelihood security of the people in the vicinity of the BR with Conservation, GOMBRT in collaboration with several Non-Governmental Organization has divided the entire Marine National Park coastal area into core zones and in a 10 kilometer terrestrial area from the coast has identified a total of 306 villages which are considered to have been located within the area of influence and impact the coastal and marine resource. Of these, 222 coastal villages have been prioritized to be covered under the UNDP-GEF project based on their marine resource dependency. Of these, 139 villages have organized democratic institutional structures in the form of municipalities and panchayats. Eco-development committiees have been established in 73 villages till the first week of October 2006 out of the 222 prioritised in Ramnad and Thoothukudi Districts. An

institutional mechanism for each of these EDCs have been set in place through a governing body consisting of 8 members representing different castes among villagers with one member being from the Forest Department (Forest Guard) representing the GOMBRT for implementing the eco-development programs in each of these villages. Various eco-developmental programmes (alternate liverlihood options) have been initiated by the Trust in these 73 villages based on detailed micro-plans developed by collaborating NGOs through Participatory Rural Appraisal (PRA). After a review of the existing eco-development programs implemented by the GOMBRT under the supervision of the Eco-Development Officer (EDO), the present eco-development plan proposes the need to continue and enhance the eco-developmental activities with certain modifications as suggested in this management plan in all the identified villages during the 10 year plan period.

This Plan has also identified the villages along the Gulf of Mannar Biosphere Reserve in the two other distrcts such as Tirunelveli and Kanyakumari, where the process of micorplan and VMC development needs to be taken up gradually during this 10 year Plan period.

Table Identified marine resource dependent villages in the Gulf of Mannar Biosphere Reserve 10 km terrestrial buffer zone

SL. NO.	NAME OF THE VILLAGE	TOTAL NUMBER OF HOUSEHOLDS	DISTANCE FROM THE SEA SHORE IN KILOMETERS	FISHING DEPENDENCE			ILLEGAL ACTIVITIES
				COMPLETE DEPENDENCE	PARTIAL DEPENDENCE	NO DEPENDENCE	
MANDAPAM ZONE DANUSKODI SUB - ZONE							
001	Ramakrishnapuram	230	02	✓			
002	Natrajapuram	287	02	✓			
003	Rajagobal Nagar, Nethaji Nagar, Muthuramalingam Nagar	300	03		✓		
004	Verkodu	250	04	✓			
005	Maruthupandiyar Nagar	137	04	✓			
006	Karaiyur	174	04	✓			
007	Serankottai	296	04	✓			
008	Sethupathi Nagar	72	04	✓			
009	Mariyamman Kovil South Karaiyur	223	3.5	✓			
010	Muthuraiyar Nagar	250	04	✓			
011	Manthoppu	100	04	✓			
012	Sallimalai	200	06		✓		

013	Kentharma Parvatham, Irattaipillaiyar Kovil	250	06		✓		
014	Vadakadu	220	06	✓			
015	Sudukattanpatti	300	06		✓		
016	Erakadu	200	06		✓		
017	Theetchadhar Kollai	200	06		✓		
018	Ramar Theertham	300	04		✓		
019	Sambai, Bathirakaliyamman Kovil Street	320	04		✓		
020	Olaikuda	180	07	✓			
021	Gandhi Nagar, Railway Colony	320	05		✓		
022	Santhiya Nahar, M.S.K. Nagar	180	04		✓		
023	Semma Madam	100	04	✓			
024	Kudiruppu	190	04	✓			
025	Narikuli, Keelakadu	92	04	✓			
026	Mangadu	100	04	✓			
THANGACHIMADAM SUB – ZONE							
027	Thangachimadam	360	03	✓			
028	Panaththoppu	300	04	✓			
029	Nalu Panai	80	04	✓			
030	Anthoniyarpuram	100	05	✓			
031	Susaiappar Pattinam	580	05	✓			
032	Victoriya Nagar	350	05	✓			
033	Manthoppu	250	05	✓			
034	Thaneerutru	120	06	✓			
035	Ariyankundu	125	06	✓			

036	Meyyampuli	165	06	✓			
037	Pekkarumpu	110	05	✓			
038	Notchivadi	50	05	✓			
039	Thenkuda Verkadu Pudur	76	04	✓			
040	Raja Nagar	320	03		✓		
041	Ayanthoppu	45	03	✓			
042	MGR Nagar	140	03	✓			
043	Savariyar Nagar	60	03	✓			
044	Valasai Theru	180	03	✓			
045	Pallivasal Theru	240	03		✓		
046	Budaiyal Nagar	85	03		✓		
047	V.O.C. Street, North Street	135	04		✓		
048	Nadu Theru South Street	90	03		✓		
049	Gandhi Nagar, Indira Nagar, Arul Nagar, Balan Nagar, Grace Nagar	94	03	✓			
050	Francis Nagar	230	01	✓			
051	Light House	265	1	✓			
052	Akkal Madam Colony	300	2	✓			
053	Kamarajar Nagar	180a	2		✓		
054	Thravai Thoppu	100	2		✓		
PAMBAN SUB – ZONE							
055	Kundugal	145	1	✓			
056	Chinnapalam	200	1	✓			
057	Thoppukadu	120	1	✓			

058	Therkuvadi (Nadutheru Mundalmunai)	428	1	✓			
059	Pamban	550	1	✓			
060	Thonithurai (Thoppukadu, Kalangiyam Nagar, Fishermen Colony Old and New)	289	1	✓			
061	Koviladi Gandhi Nagar	300	0.5	✓			
062	A.K.S.Thoppu, Munaikadu, Ummaiyalpuram	255	1		✓		
063	Rawoother Appa Tharga 1 to 8 street, Mykundu	261	1		✓		
064	T. Nagar, Kanakku Appusamy Street 1 to 3	300	1		✓		
065	Sethu Nagar St. 1 to 4, Sethu Nagar Main Road	182	1		✓		
066	Sethu Nagar St.5 to 7, Main Road 1st street	180	1		✓		
067	Sethurastha Main Road, East st, West st, North st, Nalla Rawoother street	162	1		✓		
068	Pallukadichan Street, Sethurastha Main Road East, Sammatiyar Street	211	1		✓		
069	Thandal Street, Thandiyar street,	210	1		✓		

	Maniyakarar street						
070	Kadai Theru 1 to 3, Nadutheru, Maraikayar Street, Ambalagarar Street, Tharagam Street	419	1		✓		
071	East street 1, 2, Railway Peetar Street, Valaiyar street, North sea shore	350	1		✓		
072	I.N.P. Colony, Olaithoppu st. 1,2, Koviladi, Railway Colony(100)	188	1		✓		
073	Jamine Sathru Street	215	1		✓		
074	South sea shore, Idaiyar Street, Jamine sathru Street	253	1		✓		
075	Maravar street, East st.1,2, West st.1-3	256	1		✓		
076	Adidravidar Colony, Sigara Thoppu st.1	174	1	✓			
077	Singara Thoppu st.2, Anna Kudierupu, Ayyanar Kovil Kudieruppu, Chikri Kudieruppu, Mandapm Camp	156	1		✓		
078	Maraikayar Pattinam	150	0.5		✓		
079	Samathuvapuram	101	0.5		✓		
080	Valaiyarvadi	254	2	✓			
081	Idaiyar valasai	150	2		✓		

082	Nadumunai Kadu	50	2		✓		
083	Vedalai South Sea shore, Aruppukadu, Muslim St. East, South, North	565	0.5		✓		
084	Kunjar valasai	225	0.5		✓		
085	Seeniyappa Therga	140	0.5		✓		
UCHIPPULI SUB – ZONE							
086	Suntharamudaiyan	134	1		✓		
087	Pillaimadam	136	2		✓		
088	Sathakon Valasai	62	5		✓		
089	Ariyaman	43	5		✓		
090	Thillai Natchiyamman Kovil Kudieruppu	73	5		✓		
091	Palkulam	32	5		✓		
092	Alaikathavalasai	75	4		✓		
093	Irumani	80	5		✓		
094	Manthoppu	100	5		✓		
095	Salavalasai	100	5		✓		
096	Kupanivalasai	60	5		✓		
097	Maravetti valasai	70	5		✓		
098	Pirappan Valasai	100	5		✓		
099	Kadukai Kiramam	150	5		✓		
100	Enmanamkondan	190	5		✓		
101	Therga Valasai	220	5		✓		
102	Pudunagaram	650	5		✓		
103	Utchippuli, Sethunagar	220	5		✓		
104	Kettuvalasai	50	5.5		✓		
105	Thoothivalasai	425	5.5		✓		

106	Poomalai Valasai	92	5		✓		
107	Utchippuli Sathiya Nagar	250	5		✓		
108	Notchiurani	66	2		✓		
109	Managudi	15	2		✓		
110	Kadukai Valasai	100	3		✓		
111	Keela Kadukai valasai	60	3		✓		
112	Melakadukai Valasai	100	3		✓		
113	Surankattu valasai	85	3		✓		
114	Chinnudaiyar Valasai	50	3		✓		
115	Kilakku Naraiyurani	70	3		✓		
116	Ammapatinam	60	3		✓		
117	Agasthiyar Kootam	58	3		✓		
118	Naraiyurani East & West	100	3		✓		
119	Kuduwathi	100	2		✓		
120	Pudhumadam	270	1		✓		
121	Chinna Irattaiyurani	100	2		✓		
122	M.K.Valasai	70	3		✓		
123	Vaniyankulam	60	2		✓		
124	Vairamperumal Valasai	70	2		✓		
125	Iruttuyurani	40	2		✓		
126	Moopan Valasai	80	2		✓		
127	Poovalli	60	2		✓		
128	Thamaraikulam	150	2		✓		
129	Valngapuri	75	1	✓			
130	Keelamangundu, Meelamangundu	65	2		✓		
131	Karan	108	2		✓		
132	Thalai Thoppu	150	0.5	✓			
133	Sembadaiyar Kulam	150	8		✓		

134	Perunkulam	200	8		✓		
135	Kumbaram	100	7		✓		
136	Servaigarayurani	50	7		✓		
137	Vattan Valasai	100	7		✓		
138	Enthal	120	7		✓		
139	Otaichar Valasai	62	7		✓		
140	Valantharavai	100	8		✓		
141	Valudur	100	8		✓		
142	Vani	70	8		✓		
KEELAKARAI ZONE PERIYAPATTINAM SUB – ZONE							
143	Salaithottam	35	8		✓		
144	Kollanthoppu	22	8		✓		
145	Sethu Nagar	60	5		✓		
146	Vadakku Pudukudiyiruppu	65	5.5	✓			
147	Muthuarayar Nagar	59	5.5	✓			
148	Muthupettai	210	4.5	✓			
149	Indra Nagar	65	0.5	✓			
150	Therku pudukudiyiruppu (Muthu Nagar)	45	0.5	✓			
151	Periyapattinam	800	3.5	✓			Sea Cucumber Collection
THINAIKULAM SUB – ZONE							
152	Pannakarai	10	3.0		✓		

153	Karichankundu	50	3.0		✓		
154	Krishnapuram	52	2.5		✓		
155	Thoppuvalasai	80	0.5	✓			
156	Kalkadu	25	1.0	✓			
157	Anjaneyapuram	42	1.0	✓			
158	Velayudhapuram	63	0.5	✓			
159	Kalimankundu	95	0.5	✓			
160	Kattayan Valasai	102	1.5	✓			
161	Kuppa Valasai	35	2.5	✓			
162	Vellayan Valasai	39	3.5		✓		
163	Mottayan Valasai	38	4		✓		
164	Chittan Kadu	48	4		✓		
165	Kuthukal Valasai	65	3.5		✓		
166	Kuppachivalasai	60	3.5	✓			
167	Marivalasai	66	3.5	✓			
168	Shanmugavel Pattinam	60	0.5	✓			
169	Kattaiyan Peran Valaivu	56	3.5	✓			
170	Thinaikulam	52	3.5		✓		
171	Silayappan valasai	44	4.0		✓		
172	Vethakkran Valasai	48	4.5		✓		
KEELAKARAI SUB – ZONE							
173	Sethukarai	55	0.5	✓			
174	Kizhakku Mutharayar Nagar	35	0.5	✓			
175	Pakkiriyappa Pallivasal	98	0.5	✓			
176	Idinthakal Pudur	35	0.5	✓			
177	Sivagamipuram	68	2.5	✓			
178	Keelaku Pudhu Nagar	48	0.5	✓			

179	Meenavar Kuppam	85	0.5	✓			
180	Keelakarai	700	1	✓			Sea Cucumber and Chank Collection
181	Pannattar Theru	75	1	✓			
ERWADI ZONE ERWADI SUB – ZONE							
182	Bharathi Nagar	139	3	✓			
183	Vivaganantha Puram	67	2	✓			
184	Mayakulam	28	5		✓		
185	Mangaleswari Nagar	230	2	✓			
186	Mutharaiyar Nagar	66	0.1	✓			
187	Chinna Erwadi	240	2	✓			
188	Sadamuniyan Valasai	180	1.5		✓		
189	Pitchimupan Valasai	41	1.5		✓		
190	Meyyan Valasai	26	1		✓		
191	Mottikilavan Valasai	31	1		✓		
192	Kalpar	62	2		✓		
193	Adhamcheri	60	2		✓		
MARIYUR SUB – ZONE							
194	Valinokkam	700	0.5	✓			
195	Keelamunthal	700	0.5	✓			
196	Meelamunthal	150	1	✓			
197	T.Mariyur	500	3	✓			
198	S.Mariyu	1000	2		✓		
199	Anna Nagar	5	3		✓		

200	Muthuregunatha Pattinam	50	3		✓		
201	Gandhi Nagar	150	1		✓		
202	Pandiyan Nagar	11	3		✓		
203	M. Krishnapuram	150	3			✓	
204	Oppilan	500	3		✓		
205	Periyakulam	400	5			✓	
206	Matathokulam	150	6			✓	
207	Kaduku santhai Sathiram	500	7			✓	
208	Pasumponnar Nagar	6	7			✓	
209	Poopandiyar Puram	400	5		✓		
210	Sanmugakumarapuram	80	4		✓		
211	Elanthaikulam	45	3		✓		
212	M. Kuthiraimoli	50	0.5		✓		
213	Kanigapuri	100	0.5		✓		
214	Therku Mookaiyur	200	0.5	✓			
215	Vadaku Mookaiyur	100	1.5		✓		
216	Uraikinaru	200	6		✓		
217	Vadaku Naripaiyur	600	1.5		✓		
218	South Naripaiyur	600	0.5	✓			
KAMARAJA PURAM SUB – ZONE							
219	Ponnagaram	100	1		✓		
220	Vettukadu	150	1		✓		
221	Kadal Katti kudiruppu	60	0.5	✓			
222	Amman Kulam	30	1		✓		
223	Theraviya Puram	70	1		✓		
224	Velayutha Puram	80	1		✓		
225	Palammal Kudiruppu	40	0.5		✓		

226	Puthu Kiramam	20	1		✓		
227	Vellapatti	250	0.5		✓		
228	Vepamarathu Panai	250	0.5	✓			
229	Kamaraja Puram	100	0.5		✓		
230	Periyanayagi puram	100	1		✓		
231	Rayappar Puram	30	1.5		✓		
232	Manikam Nagar	120	2		✓		
233	Kanniraja Puram	1000	1.5		✓		
234	Pilaiporuthamman Kudiruppu	100	2		✓		
235	Rochma Nagar	300	0.1	✓			
236	Rayappan Nadar Kudiruppu	25	1		✓		
237	Poosari Theru	20	1		✓		
THOOTHUKUDI ZONE VEMBAR SUB – ZONE							
238	Vembar South	280	0.1	✓			Sea Cucumber and Chanks
239	Vembar North	225	0.1	✓			Sea Cucumber and Chank Collection
240	Vembar Subramaniya Puram	125	0.1	✓			
241	Pachaiyapuram	55	3		✓		
242	Kunchaiyapuram	40	3			✓	
243	Periyasamypuram	180	0.1	✓			
244	Ethanapatti	80	8			✓	

245	Kalaikoodam	135	2			✓	
246	Vaipar	140	3			✓	
247	Keelavaipar	350	0.1	✓			Chank Collection
248	Sippikulam	225	0.1	✓			Chank Collection
249	Kundaperumal Puram	75	5			✓	
250	Panaiyoor	80	6			✓	
251	Vepalodai	85	10			✓	
252	Kulathoor	400	8			✓	
253	Therku Kalmedu	90	10			✓	
254	Pattinamaruthur	105	0.1	✓			
255	Tharuvaikulam	1150	0.1	✓			Coral Collection
256	Ananthamadam Patcheri	225	7		✓		Coral Collection
257	Vellapatty	310	0.1	✓			Coral and Chank Collection
258	Keelaarsadi	120	5			✓	
259	Siluvaipatti	150	0.1	✓			Coral Collection
260	Thalamuthu Nagar	360	2	✓			Coral Collection
261	Rajapalayam	210	2	✓			Coral Collection
262	Arokyapuram	320	3		✓		Coral Collection
263	T.Saveriyar Puram	250	4	✓			Coral Collection
264	Poopandiyar Puram	125	5	✓			Coral

							Collection
265	Lourdhammal Puram	180	1.5	✓			
266	Keelalangarathattu	120	1.5	✓			
267	Melalangarathattu	70	1.5			✓	
268	Mettupatty	280	0.5	✓			
269	Sangukuli Colony	350	0.5	✓			Purse Seine Net Operation
270	Mappilaiyoorani	225	4			✓	
271	Poopalraya Puram	550	0.1			✓	Hunting Sea Turtles
272	Threspuram	2475	0.1	✓			
273	Fathima Nagar	550	1	✓			
RATCHANYAPURAM SUB – ZONE							
274	Inigo Nagar	180	0.1	✓			
275	New Harbour	185	0.1	✓			
276	Muthiyapuram	1225	4			✓	
277	Mullakkadu	325	4			✓	
278	M. Xavieyar Puram	125	4			✓	
279	Pullaveli	120	0.1			✓	
280	Ratchenya Puram	280	1.5	✓			
281	Palaya Kayal	385	1.5		✓		
282	Manjalneer Kayal	120	3			✓	
283	Korkai	110	5			✓	
284	Vallavalaan	110	6			✓	
285	Aathoor	720	6			✓	
286	Punna Kayal	1850	0.1	✓			Hunting Sea Turtles
287	Eral	715	7			✓	

288	Keeranoor	125	3			✓	
289	Arumbuganeri	1100	6			✓	
290	Kayal Pattinam	1700	1.5			✓	
291	Kombuthurai	180	0.1	✓			Hunting Shark and Rays
292	Singithurai	285	0.1	✓			Chank Collection
293	Odaikarai	120	3			✓	
294	Veerapandiyan Pattinam	1150	0.1	✓			Chank Collection
295	Mela Shanmuga Puram	275	2			✓	
296	Thiruchendur	2400	0.1			✓	
297	Jeeva Nagar	65	0.1	✓			Chank Collection
298	Amalin Nagar	420	0.1	✓			
299	Aalanthalai	650	0.1	✓			
300	Paraman Kuruchi	850	6			✓	
301	Thandu Pattu	250	8			✓	
302	Udangudi	1425	7			✓	
303	Kulasekarakal Pattinam	180	0.1	✓			Chank Collection
304	Manappadu	1575	0.1	✓			Hunting Sea Turtles and Operation of Purse Seine Nets
305	Padukkapattu	225	3			✓	
306	Periya Thalai	1450	0.1	✓			Hunting Sea Turtles and Operation of

							Purse Seine Nets
TOTAL		71183					

TableDetails of EDC project villages and their fisheries related dependency activities (few villages could not be covered)

No	PROJECT VILLAGES (DISTANCE FROM SHORE)	TOTAL NO OF HOUSE HOLD (ACTIVE FISHERMEN HOUSE HOLD)	FISHING CRAFT	FISHING GEAR	NEAREST ISLAND	NEAREST LANDING CENTRE	FURTHEST FISHING GROUND	COMPETITION/CONFLICT WITH OTHER AREA FISHERMEN
	MANDAPAM ZONE							
	DANUSKODI SUB – ZONE							
1	Ramakrishnapuram (0.3 k.m)	230 (200)	Vallam (48) Vathai (25)	Shore seine , Drag nets, Lobster nets, Prawn nets, crab nets etc	Single island	Danuskodi (20 K.m)	Near srilanka Areas	Naribayur, Pamban, Muthal, Thankachimadam, Serankottai, Kalimankundu, Thinaikulam, Thoothukudi, Vembar, Kannyakumari, etc
2	Nataraja puram (0.6 km)	400 (350)	Vallam(100), Vathai(30)	Shore seine , Drag nets, Lobster nets, Per seine	Single island	Danuskodi (22k.m)	Near srilanka islands	Naribayur, Pamban, Muthal, Thankachimadam, Serankottai, Kalimankundu, Thinaikulam, Thoothukudi, Vembar, Kannyakumari, etc
3	Netaji nagar & Rajagopal nagar (0.4 k.m)	1700 (400)	(Labors only)	_		Verkodu coast (0.4 m)	_	_
4	Muthuramalinga nagar (0.5 k.m)		(labors only)	_		Verkodu coast (0.5 k.m)	_	_
5	Verkodu (0.2 k.m)	500 (450)	Mechanised boat (160) Vallam(5)	Drag net, per seine Trawl net, pair trawl net, crab net ,lobster trap, prawn net (Bottom lined Trawl nets)		Verkodu (0.2 k.m)	Near Srilanka island (Kacha)	Mudukulathur, Earwadi, mundal, Sethu karayoor,mardhupandia Nagar, Sethupathy Nagar Seran kotati Kamuthi, kadal
6	Maruthupandiyan nagar (0.3 km)	160 (130)	Vallam(5) Vathai(25) Mechanized boat(10)	Drag net, per seine Trawl net, pair trawl net, crab net ,lobster trap, prawn net (Bottom lined Trawl nets)		Karaiyur coast (0.5 k.m)	Near Srilanka islands (Kacha	_
7	Karaiyur	600 (500)	Vallam(20)	Crab nets, Disco			Near Srilanka	Mudukulathur, Erwadi,

	(0.3 k.m)		Vathai(1000) Mec . Boat (4)	nets, Shore nets, Lobster nets, Drag nets, Trawl net, Prawn net (Bottom line trawl ets)		Karaiyur coast (0.3 k.m)	islands (Kacha)	mundal, Sethu karayoor,mardhupandia Nagar, Sethupathy Nagar Seran kotati Kamuthi, kadal
8	Serankottai (0.2 k.m)	250 (230)	Vallam(25) Vathai(50)	Crab nets, Cuttlefish net, Shore seine, Drag nets,		Karaiyur coast (0.6 k.m)	_	_
9	Sethupathinagar (0.3 k.m)	70 (20)	Vallam - 2	_		Karaiyur coast (0.8 k.m)	_	_
10	Mariyamman kovil south Karaiyur (0.2 k.m)	160 (130)	Vallam (52) Mechanized .Boat(25)	Crab nets, Cuttlefish net, Shore seine, Drag nets, Trawl nets, Prawn (Bottom line Trawl nets)		Karaiyur coast (0.4 k.m)	_	_
								-
	PAMBAN SUB – ZONE							
11	Tharuvai thoppu & Kundugal (0.4 km)	350 (250)	Vallam - 27 Vathai - 12	Crab net, Lobster net,	Single islands, Kurusadai islands	Kundukal	Srilanka islands	_
12	Chinnapaalam (0.2 km)	230 (210)	Vallam 32 Vathai 113	Crab net Lobster trap Ray net Prawn net Fish net Mural fish net	Kurusadai islands,	China paalam	Srilanka island	_
13	Thoppukadu (0.5 km)	300 (80)	Vallam – 60 Catamaran – 30	Crab nets, Cuttlefish net, , Drag nets, Trawl nets, Prawn (Bottom line Trawl nets)	Kurusadai islands, Manoli islands.	Pamban coast	Srilanka's island	Munthal, Erwadi, Vembar, Thoothukudi, Kunjarvalasai, Notchiyurani, Kadukaivalasai, Chinnudaiyarvalasai, Surankattu valasai, Keezhakarai, Rameswaram, Kanyakumari, uvari, Puthumadam, Uchipulli, Tharuvaikaulam
14	Therkuvadi (0.5 k.m)	400 (220)	Mechanized boat – 80 Vallam -30 Fiber boat -20	Drag nets, Lobster nets, Trawl nets, Prawn Nets (Bottom line trawling)	Kurusadai , Single, Manoli islands	Pamban coast	Srilanka's island	
15	Thonithurai (0.8 k.m)	540 (230)	Mechanized boat -10 Vallam – 20	Gill nets ,Drag nets, Lobster nets, Trawl nets, Prawn Nets (Bottom line trawling)	Kurusadai, Manoli, Mulli islands.	Thonithurai	Srilanka's island	Madapam, Valyarvadi, Vedalai, Nadumunai kadu, Aruppukadu, Sodavalai kuchi, singivalaikuchi.

16	Valaiyarvadi (0.4 k.m)	260 (200)	Vallam (42) Vathai (60) Catamaran(17)	Gill nets, Drag nets, Shore seine, Long line, Crab trap, Prawn nets (Bottom line), Lobster nets etc	Manoli, Kurusadai .islands	Valayarvadi	_	_
17	Nadumunaikadu , Seeniyapa dharga, Mutharaiyarnagar (0.4 km)	300 (200)	Vallam (15) Vathai (12) Catamaran (6)	Gill nets, Drag nets, Shore seine, Logline, others (crap trap, Prawn nets (Bottom line), Lobster nets etc)	Kurusadai, Manoli Islands	Seeniyapa dharga	_	_
18	Vedalai thenkadarkari - singivalai kuchi , soodavalaikuchi, Arupukadu (0.4 K.m)	350 (260)	Mechanized boat – 9 Vallam – 16	Lobster/crab net, Shore Seine, Gill nets, Trawl nets, Shore seine, Long line, Crab trap, Prawn nets (Bottom line), Lobster nets etc	Kurusadai, Manoli , Musal islands	Vedalai	Srilanka's island	_
19	Kunjarvalasai (0.3km)	200 (100)	Labors	_	Kurusadai, Manoli, Musal islands.	Vedalai and mandapam	_	_
	UCHIPULI SUB – ZONE							
20	Pudhunagaram (5k.m)	350 (50)	Vallam – 20 Vathai -50	Crab net, Lobster net, Pawn net , Shore seine, Gill nets (Bottom set, Drift net)	Musal, Valai, Mulli islands.	Thankachimadam & pudhumadam	_	_
21	Notchiurani (1 k.m)	230 (60)	Labors	_		Pudhumadam	_	_
22	Kunduthi , (2.5 k.m) Maanaankudi (2 k.m)	100 (80)	Catamaran - 6	Crab nets, Prawn net, Disco thoondil, Chunk collection	Musal, valai islands	Maanaankudi	_	Pamban , Erwadi, Keezhkarai
23	Kadukai valasai, East, west (3 k.m)	800 (180)	Labors	_		Maaananku di	_	_
24	Surankatuvalasai (3 k.m)	300 (25)	Labors	_		Maanakudi	_	_
25	Chinnudaiyarvlasai (2.5 k.m)	500 (50)	Labors	_		Pudhumadam	_	_
26	Ammapattinam (2 k.m)	400 (40)	Labors	_		Pudhumadam	_	_
27	Agastiyarkootam (0.5 k.m)	117 (70)	Labors	_		Puthumadam	_	_

28	Naraiyurani East (1.5 k.m)	106 (20)	Labors	_		Puthumadam	_	_
29	Naraiyurani west (1.5 k.m)	164 (30)	Labors	_		Puthumadam	_	-
30	Pudhumadam (0.2 m)	< 2000	Vallam - 10 Vathai – 5 Catamaran -5	Drag nets, Preseine, Disco thondil, Prawn nets, Crab nets, lobster nets, Chanks collection, Maya valai	Musal, Valai, Mulli islands	Puthumadam	_	Kanyakumari, Keelakarai, Thoothukudi, Sayalkudi
31	Chinna irattaiyurani (4 k.m)	107 (40)	Labors	_		Puthumadam	_	-
32	Vaniyankulam (2 k.m)	300 (220)	Labors	_		Puthumadam	_	_
33	M.P.K.Valasai , Irruttoorani, Moopan valasai (2 k.m)	500 (100)	Labors	_		Puthumadam	_	_
34	Irrataiyurani (3 k.m)	325 (75)	Labors	_		Valankapuri	_	_
35	Thamaraikulam (3 k.m)	291 (27)	Labors	_		Valankapuri	_	_
36	Valangapuri (0.5 k.m)	300 (35)	Vallam -4 Catamaran – 3	Crab net, Prawn net, lobster net, Disco thoondil.,Chooda valai,,	Musal, Valai, Mulli islands	Valangapuri	_	Puthumadam, Kanyakumari, Keezhakarai
37	Arul ozhi ngar (0.4 k.m)	65 (20)	Vallam – 17 Catamaran - 2	Shoreseine, Nadu valai, Mural valai,		Valangapuri	_	Kanyakumari, Keelakarai, Thoothukudi
38	Keelamankundu , Melamankundu (1 k.m)	200 (85)	Labors	_		Karan	_	_
39	Karan (0.3m)	275 (60)	Vathai -5	Lobster nets, Paru valai, Crab net	Musal, Valai, Mulli islands	Karan	_	Kanyakumari, Keelakarai, Thoothukudi
40	Thalaithoppu (0.5 k.m)	114 (72)	Vallam 6	Lobster nets, Paru valai, Crab net	Musal, Valai, Mulli islands	Thalaithoppu, karan	_	Kanyakumari, Keelakarai, Thoothukudi, vembar
41	Sembadaiyarkulam (3 km)	112 (23)	Labors	_		Thalai thoppu	_	_
42	Perunkulam (5 k.m)	200 (65)	Labors	_		Thalai thoppu	_	_
43	Kumbaram (3 km)	300 (40)	Labors	_		karan	_	_
44	Servaigarayurani	30 (46)	Labors	_		karan	_	_

	(4 km)							
45	Vattan valasai (3 k.m)	275 (40)	Labors	_		karan	_	-
46	Enthal (5 k.m)	350 (30)	Labors	_		karan	_	_
47	Otaicharvalasai (4 k.m)	160 (20)	Labors	_		karan	_	_
	KEEZHAKKARAI ZONE							
	PERIYAPATTINAM SUB – ZONE							
48	Salaithottam (1 k.m)	30 (10)	(Labors)	_		Indira nagar	_	_
49	Kollanthoppu (0.8 k.m)	210 (75)	(Labors)	_		Pudhukidiruppu	_	_
50	Sethunagar (0.6 km)	75 (40)	(Labors)	_		Indira nagar	_	_
51	Pudhukudirupu North (0.5 km)	170 (120)	(Labors)	_		Indira nagar	_	_
52	Mutharaiyar nagar (1 k.m)	150 (110)	Vallam – 5 Vathai - 16	Crab nets, Prawn nets Lobster net, Gill nets, Shore seine etc.	Thaiyari Appa Islands	Indira nagar	Kanyakumari, Palk bay, Dhoti	Keelakarai, Pannakarai, Erwadi
53	Muthupettai (1k.m)	500 (200)	Vallam – 30	Crab nets, Prawn nets Lobster net, Gill nets, Shore seine etc.	Thaiyari Appa Islands	Indira nagar	Dhanuskodi, Pamban,	_
54	Indranagar (0.5 km)	300 (170)	Vallam – 15, Vathai – 25	Crab nets, Prawn nets Lobster net, Gill nets, Shore seine etc.	Thaiyari Appa Islands	Indira nagar	Dhanuskodi, Pamban , Rameswaram, Kanyakumari	Keelakarai, Pannakarai, Erwadi, Pamban
55	Pudhukudiruppu South (0.6 km)	120 (70)	Vallam – 45 Vathai - 10	Disco thoondil, Gill nets, Lobster nets, Prawn nets, Crab nets	Thaiyari Appa Islands	Pudhukudiruppu South	Rameswaram, Danuskodi, Pamban	Keelakarai, Pannakarai, Erwadi
56	Periyapattinam (1 km)	2000 (500)	Mechanized boat - 50 Vallam -20	Per seine, Drag nets, Drift gillnets, Lobster nets etc	Thaiyari Appa Islands	Indiranagar	_	Danuskodi, Srilankas island, Pamban
	THINAIKULAM SUB – ZONE							
57	Pannakarai (3 k.m)	30 (10)	(labors)	-	Thaiyari Appa Islands	Indiranagar	_	_
58	Maraikayar nagar (3k.m)	70 (30)	(labors)	_	Thaiyari Appa Islands	Indiranagar	_	_

59	Karichankundu (4 k.m)	100 (60)	(Labors)	_	Thaiyari Appa Islands	Thoppu valasai, Indira nagar	_	_
60	Krishnapuram (4 k.m)	120 (30)	(Labors)	_	Thaiyari Appa Islands	Thoppu valasai, Indira nagar	_	_
61	Thoppuvalasai (0.2 k.m,)	150 (125)	Vathai – 32 Vallam - 11	Disco thoondil, Gill nets, Lobster nets, Prawn nets, Crab nets	Thaiyari Appa islands	Thoppu valasai	Erwadi, Pamban, Vembar, Keelakarai	Pannakarai, Maraikayar, Karichanundu, Krishnapuram
62	Kalkadu (0.6)	25 (20)	Labors	_	Appa islands	Kaliman kundu	_	_
63	Anjaneyapuram (o.6 k.m)	120 (100)	Vathai – 18 Vallam – 4 (without engine)	Drag net, sooda valai, Crab net, Disco hoodle, Prawn nets, Ray island	Appa, Mulli islands	Kaliman kundu	_	Pamban, Kanyakumari, Thoothukudi, Danuskodi
64	Velayudhapuram (0.3 k.m)	80 (60)	Vallam – 30	Drag net, sooda valai, Crab net, Disco hoodle, Prawn nets, Ray island	Appa, Mulli islands	Kaliman kundu	_	Danuskodi, Kanyakumari, Thoothukudi
65	Kaliman kundu (0.5 m)	1250 (220)	Vallam – 102 Mec . boat -5	Mural nets, Sooda valai, Disco Thoodlle, Drag nets,	Valai,Appa, Mulli islands	Kaliman kudu	Thoppu valasai, Kalkadu	Danuskodi, Kanyakumari, Thoothukudi
66	Kattaiyan valasai (1 k.m)	120 (80)	Vallam – 4 Vathai - 12	Mural nets, Nandu valai, Singi valai, Sooda valai, Disco Thoodlle, Drag nets,	, Valai Appa, Mulli islands	Kaliman kudu	Thoppu valasai, Kalkadu	Danuskodi, Kanyakumari, Thoothukudi
67	Kuppa valasai (2 k.m)	125 (10)	Labors	_		Kaliman kundu	_	_
68	Vellayan valasai (5 k.m)	75 (25)	Labors	_		Kaliman kundu	_	_
69	Mottaiyan valasai (5k.m)	61 (30)	Labors	_		Kaliman kundu	_	_
70	Chittan kadu (4 k.m)	70 (50)	Vallam – 1 Vathai - 4	Sheela valai, Kumla valai, mural valai, Prawn nets, Crab nets	Appa, Valai islands	Kaliman kundu	_	_
71	Kunthukal valasai (2 k.m)	75 (40)	Labors (only)	_		Kaliman kundu	_	_
72	Kuppachivalasai (1.5 k.m)	80 (30)	Labors	_		Kaliman kundu	_	_
73	Marivalasai (0.8 m)	250 (40)	Labors	_		Kaliman kundu	_	_

74	Shanmugavel pattinam (0.2 m)	80 (75)	Vallam – 10 Vathai – 2	Sooda valai, Nandu valai, Disco Thoodle Kumula valai,	Appa , Valai, Musal	Shanmugavel pattinam	Kaliman kundu, Sethukarai, Keelakarai, Periyapattinam	Rameswaram, Erwadi, Vembar, Thoothukudi
75	Kattiyan peran valaivu (1 k.m)	70 (20)	Labors	_	Appa , Valai, Musal	Shanmugavel pattinam	_	_
77	Thinaikulam (3 km)	450 (40)	Labors	_	Appa , Valai, Musal	Shanmugavel pattinam	_	_
78	Silyappan valasai (5 km)	130 (45)	Labors	_	Appa , Valai, Musal	Shanmugavel pattinam	_	_
79	Vethakkaran valasai (6 km)	66 (10)	(labors only)	_		Shanmugavel pattinam	_	_
	KEEZHAKARAI SUB – ZONE							
80	Sethukarai (0.3 k.m)	280 (75)	Vallam – 25	Soda valai, nandu valai, Disco thoondle, Kumla valai, ean valai	Appa islands	Sethu karai	Shanmugavel pattinam, Keelakarai, kaliman kundu	Keezhkarai, Erwadi
81	Mutharaiyar nagar East (0.5 k.m)	44 (40)	Vallam - 3 Vathai -8	Soda valai, nandu valai, Disco thoondle, Kumla valai, ean valai hoodle,	Appa islands	Pakriyappa palivasal coast	Kalimankundu, Keelakarai, Erwadi, Thoothukudi, Kanyakumari	_
82	Pakkiriyappa pallivasal (0.8 k.m)	30 (20)	Vallam 6 Vallam with engine 1 Vathai 23.	valai, Disco thoondle, Kumla valai, mean valai, Sooa valai, nandu	Appa islands	Pakriyappa palivasal	Kalimankundu, Keelakarai, Erwadi, Thoothukudi, Kanyakumari	Erwadi, Keezhkarai, Vembar, Vaipar.
83	Idinthakalpudur (0.8 km)	200 (150)	Vallam 1 Vathai 4 Vathai with engine 5	Drag nets, Nandu valai, Cumla valai, Singi valai, Velameen valai, Vali valai	Appa islands	Keelakarai	Kaliman kundu, Erwadi, Vembar, Thoothukudi, Kanyakumari	_
84	Sivakamipuram (0.5 km)	120 (40)	Vathai – 10	Nandu valai, Disco valai, Mean valai, Cumla valai.		Keelakarai		
85	Pudhu nagar East (0.8 k.m)	82 (60)	Vathai 12 Engine vathai 9	Velameen valai, Maya valai, Disco valai, Nadu valai, singi valai		Keelakarai	_	_

86	Meenavar kuppam (0. 5)	60 (40)	Vallam 28 Vatahi 4	Disco thoondle, singi valai, Nadu valai, Thirukai valai, mural valai, Siru valai, Paru valai,		Keelakarai	_	_
87	Keelakarai (0.3 k.m)	10000 (350)	Mechanized boat – 30 Vallam – 70 Vathai – 100 Catamaran - 40	Paru valai, siru valai, Disco thoontle, Drag net, Per seine, Trawl net, Lobster net, Prawn net (Bottom-line)	Appa , Poomarichanpatti Pullivinichalli islands,	Keelakarai	Erwadi, Vembar, Thoothukudi, Kaya kumari	Dhanuskodi, Periyapattinam, Kanyakumari
88	Pannatar theru (0.5 K.m)	120 (70)						
	ERWADI ZONE							
	ERWADI SUB - ZONE							
89	Bharathi nagar (0.5 km)	300 (250)	Labors	_	_	China Erwadi, Keelakarai	_	_
90	Vivekananthapuram & Muthurajapuram	110 (80)	Labors	_	_	China Erwadi, Keelakrai	_	_
91	Mayakulam	120 (100)	Labors	_		China Erwadi	_	-
92	Mangaleswarinagar (0.8 km)	300 (180)	Vallam (engine)– 10 - 15 Vathai – 30 -40	Crab trap, mural net, vilai mean valai,		China erwadi	Keezhakarai, Pamban, Danuskodi	Thoothukudi, Kanyakumari, Periyapattinam, Tharuvaikulam, Chinna erwadi
93	Mutharaiyar nagar (0.5 km)	70 (40)	Labor	-		China Erwadi	_	_
94	Chinna Erwadi (0.8 km)	120 (100)	Vallam 50-60 Vathai 4-5 Mechanized boat 2,	shore seine, trawl net , lobster trap, moral net,	Appa , Poomarichanpatti Pullivinichalli islands,	China erwadi	Danuskodi, Rameswaram, Pamban, Munthal, Keezhakarai	Kanyakumari, Thoothukudi, Mannapadu, Periyathalai, Tharuvaikulam
95	Sadaimuniyan valasai (0.5 km)	300 (290)	Vathai – 200 Vallam -5	Lobster net, Crab nets, Chunk collection, Mural nets , Shore seine	Appa , Poomarichanpatti Pullivinichalli islands,	Sadaimuniyan valasai	Keezla karai, Vembar, Danuskodi	Chinna Erwadi, Mangaleswari nagar, Tharuvaikulam, Thoothukudi,
96	Mariyamman nagar (1 k.m)	70 (30)	Labors	_		_	_	_
97	Pitchimoopan valasai (1 km)	200 (75)	Labors	_		_	_	_
98	Meyyan valasai (1 km)	175 (20)	Labors	_		_	_	_
99	Mottaikilavan valasai (1 km)	130 (45)	Labors	_		_	_	_
100	Kalpar (1 km)	57 (20)	small Vathai 4	Crab, disco and fish net	Appa , Poomarichanpatti	Sadaimuniyan valasai	Keezhakarai, Danuskodi,	Thoothukudi, Tharuvaikulam, Manappadu, Vaipar,. Pamban

					Pullivinichalli islands,		Rameswari, Vaipar	
101	Adamcheri (1 km)	98 (60)	Vallam 1 Vathai 14	Crab net fish net, ray net, lobster trap, prawn net, disco net	Appa , Poomarichanpatti Pullivinichalli islands,	Sadaimuniyan valasai		
102	Adenchery (1Km)	40 / -	_	_		_	_	_
	MARIYUR SUB- ZONE							
103	Vaalinokkam (0.5 km)	1200 (700)	Vallam – 40 Vathai – 20 Catamaran – 10 Mechanized boat – 10	Drag net, Per seine, Crab net, Lobster net, Disco net, Mean vaslai	Poomarichanpatti , Pullivini islands	Valinokam	Danuskodi, Rameswaram, Vaipar	China Erwadi, Keezhkarai,Mariyur, etc
104	Mela munthal (0 5 km)	800 (600)	Vallam – 20 Vathai – 45 Catamaran -40	Shoreseine, Crab net, Drag net, Lobster nets, Mean valai, Nandu valai, Sooda valai	Poomarichanpatti , Pullivini islands	Muthal	Danukodi, Rameshwaram, Kanyakumari	China Erwadi, Munthal, Mariyur, Keezhkarai, Tharuvaikulam, Thoothukudi
105	Keelamunthal (0.6 km)							
106	T. Mariyur (0.4 km)	1200 (800)	Vallam – 60 Catamaran – 20	Drag net, Lobster nets, Mean valai, Nan	Poomarichanpatti , Pullivini islands	Mariyur	Danukodi, Rameshwaram	Munthal, Vaipar, Ervadi, Thoothukudi
107	S. Mariyur (0.5 km)							
108	Muthu requnatha pattinam (1 k.m)	150 (70)	Labors	_		Mariyur , Muthal	_	_
109	Ganthinagar, Annanagar, & Pandiyan nagar (1 k.m)	300 / 120)	Labors	_		-	_	_
110	M. Krishnapuram (1 k.m)	75 / 20	Labors	_		_	_	_
111	Oppilian (0.5 k.m)	1000 / 250	Vallam -30 Vathai -20	Shore seine, crab nets, Prawn net, Lobster net , Sooda mean valai, Mural mean valai, chunk valai	Pullivini islands	Oppilan	Munthal, keezhkarai, Dhanuskodi, Dhoti,	Thoothukudi, Kanyakumari, Mannapadu, Vaipar, vempar,
112	Periyakulam\ (2 km)	450 / 50	Vallam -4	Shore seine		Muthal, Mookaiyur		
113	Madathokulam (3 k.m)	96 / 20	Labors	_		_	_	-
114	Kaduku santhai (4 km)	180 / 40	Labors	_		Mookaiyur, Muthal	_	_

115	Sathiram (4 km)	335 / 30	Labors	_		_	_	_
116	Pasumponnar nagar & Poopndiyar nagar (0.5 m)	160 (40)	Labors	_		Mookaiyur coast	_	_
117	Sanmugakumarapuram (0. 6 km)	80 (20)	Labors	_		Mookaiyur, Munthal	_	_
118	Elanthaikulam (1 km)	250 (60)	Labors	_		Mookaiyuir, Munthal	-	_
119	M. Kuthiraimozhi (1 km)							
120	Kanigapuri (0.6 km)	250 (120)	Vallam -4	Shore seine		Mookaiyur coast Mookaiyur coast	Danuskodi, Rameswaram, Keezhakarai, Vembar	Thoothukudi, Kanyakumari, Cheval patti,
121	Mookaiyur North (0.5 km)	200 / 50	Vallam -7	Lobster net, Prawn nets, Shore seine, Per seine, Disco nets, Crab nets, Mean val;ai				
122	Mookaiyur South (0.5 km)	1000 / 500	Vallam – 60					
123	Uraikinaru (0.6 km)	200 / 40	Labors	_		Naripaiyur coast	_	_
124	Naripaiyur North (0.5 km)	1400 / -	-	_		_	_	_
125	Naripaiyur south (0.5 km)	700 / 300	Vallam – 20 Vathai – 30 Catamaran -5	Shoreseine, Disco nets, Lobster nets, crab nets, vila mean valai, Sheela valai etc		Naripaiyur coast	Vembar , Keezhakarai, Rameswaram , Danuskodi,	Thoothukudi, Kanyakumari, Tharuvaikulam, Vaipar, Vembar
	KAMARAJAPURAM SUB – ZONE							
126	Ponnagaram (0.5 k.m)	135 / 60	Labors	_	Upputhanni	_	_	_
127	Vettukadu (0.5km)							
128	Kadal katti kudirupu (0.7 k)	70 / 40	Labors	_		_	_	_

129	Amman puram (0.6 km)	65 / 30	Vathai -6	Shore seine, Crab nets, :Lobster nets		Naripaiyur coast	_	_
130	Theraviya puram (0.4 km)	70 / 20	labors	_		_	_	_
131	Velayuthapuram (0.5 km)	150 / 60	Labors	_	_	_	_	_
132	Palammal kudirupu (0.5 k.m)	120 / 40	Labors	_	_	_	_	_
133	Pudhukiramam (0.5 km)	30 / 15	Labors	_	_	Naripaiyur coast	_	_
134	Vellapatty (0.5km)	80 / 40	Labors	_		Naripaiyur coast	_	_
135	Vepamarathupanai	80 / 60	Vallam – 13 Shore seine Boat – 10	Shore seine, Lobster nets, Disco net etc	Upputhanni, Nalahanni, Karaichalli islands	Naripaoyur coast	Vembar, Keelakarai	Vembar, Erwadi, Keelakarai, Tharuvaikulam, Thoothukudi, Thiruchendur
136	Kamarajapuram (1. k.m)	121 / 20	Labors	_	_	Naripaiyur coast	_	_
137	Periyanayagi puram (1 k.m)	70 / 40	Labors	_	_	Naripaiyur coast	_	_
138	Rayyapar puram	50 / 10	labors	_	_	Naripaiyur coast	-	-
139	Manikam nagar (0.8 k.m)	121 / 20	Labors	_	_	Naripaiyur coast	_	_
140	Kannirajapuram (0.8 km)	350 / 100	Labors	_		Naripaiyur coast	_	_
141	Pilaiporuthamman kudirupu (0.3 km)	35 / 18	Labors	_	_		_	_
142	Rochma nagar (0.6 km)	270 / 40	_ Vallam – 57 Mechanized Boat – 18 (Erwadi	_ Drag net, Trawl nets, ,Lobster net , Prawn net, etc.,	_	Vembar	_	_
143	Ramya nadar kudiruppu (0.6 km)	34 / 12	Labors	_	_	Vembar		
144	Poosari theru (0.6 km)	21 / 17	Labors	_	Nallathani, Upputhani islands	Vembar		
	THOOTHUKUDI ZONE							
	VEMBAR SUB – ZONE		Vallam – 30 Vathai – 6 Mechanized boat – 28 Shore seine Boat – 6	Trawl nets, Shore seine, Drag nets Nandu valai, soda valai, Singi valai, Disco thoondle etc.	Nallathani, Upputhani islands	Vembar	Danuskodi, Rameswaram, Pamban, Keelakarai, Kanyakumari	Naripaiyur, Vaipar, Tharuvaikulam, Thoothukudi, Uvari, Veerapandiyan pattinam, Mannapdu.
145	Vembar south (0.5 k.m)	2000 / 900						
146	Vembar north (0.7 km)	150 / 60						
147	Vembar valasamuthiram	300 / 50						

	(1km)							
148	Pachaiyapuram (0.5 km)	187 / 50	Vallam – 3 Catamaran -5	Drag nets, Lobster net, Prawn net, Disco net, others	Karaichalli, Uppu thani, nalla thani islands	Pachaiyapuram	Vaipar, Erwai	Vembar, vaipar, Periyasamy puram, Pattinamaruthur
149	Kunchaiyapuram (0.4 km)	43 / 20	Vallam – 2 Catamaran -3	Sooda valai, mural valai, Prawn nets, Disco thoondle	Karaichalli, Uppu thani, nalla thani islands	Periyasamy puram	Vaipar, Erwadi	Vembar, Vaipar, Tharuvaikulam, Thoothukudi, Erwdi
150	Periyasamy puram (0.2 km)	260 / 150	Vallam -10 Catamaran -5	Drag nets, Fishing nets	Karaichalli, Uppu thani, nalla thani islands			
151	Kalaikoodam (3 k.m)	70 / -	Labors	_	Karaichalli, kasuwar islands	_	_	_
152	Vaipar- kalloorani (4 k.m)	245 / -	Labors	_	Karaichalli, kasuwar islands	_	_	_
153	Keelavaipar (1 k.m)	648 / 300	Vallam – 110 Vathai – 6 Catamaram -24 Fibre boat -25	Crab net, prawn net Salai valai, parrh valai, tirka valai , Drag nets	Karaichalli, kasuwar islands Kaswar	Keela vaipar Chippikulam	Vembar, Chippikulam, Tharuvaikulam, Thrku kalmedu, Thoothukudi	Vembar, Erwadi, Keelakarai, Dhanuskodi , Rameswaram, Kanyakumari
154	Chippikulam (0.8 km)	500 /350						
155	Veppalodai (3 km)	700 / 30	Labors	-	Kaswar	_	_	_
156	Therku kalmedu (5 k.m)	125 / 10	Labors	_	Kaswar	_	_	_
157	Pattinamaruthur (0.5 km)	250 / 100`	Vallam 15 Vathai 10	Salai, Valai, Sheela, Surai, , Lobster, Disco net, Sudai	Kaswar	Pattinamaruthur	Vembar, Thiruchenthur	Thoothukudi, Vembar, vaipar, tharuvaikulam, vellapatty etc
158	Tharuvaikulam (0.5 km)	1610 / 800	Vallam – 40 Vathai – 10 Mechanized boat -45 (thoothukudi fishing Harbor)	Drag net, Crab trap, Trawl, Prawn, Lobster net, Perseine,	Kaswar, van islands	Tharuvaikulam	Kanyakumari, Vembar, Keezhakarai, Erwadi, Dhanukodi, Rameswaram	Manapadu, Kulasekara pattinam, Periyathalai, Thersapuram, Vembar, Keezhakarai,
159	Ananthamadam patcheri (5 k.m)	290 / 40	Labors	_	Kaswar, van islands	Tharuvaikulam, Vellapatty,	_	_
160	Vellapatty (0.8 km)	800 / 500	Vallam-65 Vathai-4	Shore seine Drag net Crab net	Kaswar, van islands	Vellapatty	Vembar, Keelakarai, Danuskodi, Rames waram, Kanyakumari	Manapadu, Kulasekara pattinam, Periyathalai, Thersapuram, Vembar, Keezhakarai,
161	Keela arasaradi and thupaspatti (3 k.m)	207 / 20	Labors	_	Kaswar, van islands	Vellapatty	_	_
	THOOTHUKUDI SUB –							

	ZONE							
162	Siluvaipatti (1.5km)	201 / 170	Vallam – 25	Drag net, disco net, Soo da valai , Mural Valai , nandu valai, Singi valai	Kaswar, van islands	Siluvaipatti	Om sakthi nagar, Thai nagar, Durarai singh nagar, sahersain nagar, Ganapanthi nagar, Alagu muthu nagar	Vembar, Ratchenyapuram
163	Thalamuthunagar (1 km)	368 / 250	Vallam- 5	Drag nets, Disco net, Singi valai, Nandu vali, Mural valai, Kla valai	Kaswar, van islands	Therasa puram	_	_
164	Rajapalayam (1 km)	325 / 170	Valam- 30	Drag net, Thirukai valai , Disco thoondle, Mural valai, Vali valai Disco net,	Kaswar, van islands	Rajapalayam	Vaipar, Vembar, Tharuvaikulam, Kayakumari	_
165	Samir rose nagar (1 km)	220 / 140	Vallam – 25	Drag net, Disco net	Kaswar, van islands	Therasapuram	Kanyakum,ari, Mannapadu, Vembar, Vaipar, Keelakarai, Erwadi, Rameswaram, Dhanuskodi	_
166	Arokyapuram (1 km)	320 / 100	Vallam - 5		Kaswar, van islands	Thersa puram		_
167	T.Saveriyar puram (2 km)	242 / 155	Vallam – 14 Mechanized Boat -	Shoeshine, Prawn nes, Mural nets	Kaswar, van islands	Therasa puram		_
168	Poopandiyar puram (3 km)	150 / 80	-	Shore seine	Kaswar, van islands	Thersapuram		_
169	Loorthammal puram (0.5 km)	300 / 150	Vallam -20	Shore seine, Dragnet	Kaswar, van islands	Therasa puram		_
170	Keela alankarathattu (0.6 km)	120 / 85	Labors	_	Kaswar, van islands	Therasa puram		_
171	Mela alankarathattu (0.7 km)	300 / 75	Labors	_	Kaswar, van islands	Therasapuram		_
172	Cruzpuram (0.5 km)	800 / 400	Labors	_	Kaswar, van islands	Therasapuram		_
173	Thersapuram North (0.2 km)	1100 / 600	Vallam – 1000 Ply wood Boat- 20 – 25 Catamaran - 20 Mechanized	Drag net, Illuvalai , Pureseine	van islands	Therasapuram		Kanyakumari, Mannapdu, Uvari, Veerapandiyan pattinam, New harbour, Rajapalayam
174	Thersapuram South (0.2 km)							
175	Therasapuram west (0.6 km)							

			boat – 50 (in Thoothukudi Fishing Harbor)					
176	Santherayapar kovil Street (0.3 k.m)	200 / 100	Mechanized boat – 30 Vallam -20	Drag net, disco net, vilai mean valai, venganei, Deep sea fishing	van islands	Fishing harbour, Thersa puram		_
177	Pudhu theru (0.4 km)	450 / 150	Vallam – 10 Catumaram-2 Mechanized Boat- 100	Crab net, Lobster net, Prawn net, Chunk net, Disco net. Trawling net , Pair Trawler, Pure seine net	van islands	Fishing harbors, Thersa puram		_
178	Sangukuli colony (0.5 k.m)	325 / 300	Vallam – 10 Vathai - 7	Sooda valai, Mural vlai, Crab net, Singi valai	van islands	Thersa puram		
179	Mutharayar nagar	170 / 60	Labors	-	van islands	Thersapuram		-
180	Mettupatti (0.5 km)	300 / 50	Labors	_	van islands	Thersapuram		
181	Poopalarayarpuram (2 k.m)	2000 / 600	Vallam – 10, Mechanized boat – 10 (Fishing harbor)	Drag nets, trawl nets, Pureseine, Lobster net, Nandu valai, Mural valai, Mean valai.	van islands	Thersa puram	_	_
182	New harbour (1 k.m)	70 / 60	Vallam – 45 Vathai – 20 Catamaran 60	Drag net, Mural net, nandu valai, Mean Valai.	van islands	New harbour	Palyakayal, Thoothukudi, Vaipar, Vembar, Erwadi	Thoothukudi, Palyakayal, Thersapuram
183	Inigo nagar (0.6 km)	240 / 200	Vallam - 25 Fiber glass boat – 100 Catamaran – 50	Crab net, Fish net, disco net, Lobster net, Drag nets	van islands	Inigo nagar	Kanyakumari, Danuskodi, Rameswaram	Fathima nagar, Limestone, Tharuvaikulam, New harbour, Thersapuram, Vaipar , Veerapandiyan pattinam
184	Fathima nagar south (1 km)	1100 / 600	Vallam – 4 Catamaran - 20	Crab net , Maya valai, Lobster net, Kuthu valai, Sala valai, Mani valai	van islands	Inigo nagar	_	_
185	Fathima nagar North (1 km)							
186	Limestone (0.8 km)	250 / 75	Labors	_	van islands	Inigo nagar, therasa puram , Fishing Harbour	_	_
187	Annai therasa nagar (0.6 km)	120 / 45	(labors)		van islands	Inigo nagar, Thersa puram, New harbor	_	_
188	Sahayapuram	70 / 60	_	_	van islands	Thoothukudi	_	_

	(1 km)					Fishing harbor, Thersa puram		
189	Vivekanatha nagar (0.8 Km)	80 / 45	_	_	van islands	Thoothukudi Fishing harbor	_	_
	RATCHENYAPURAM SUB – ZONE							
190	Ratchenyapuram & Palaya kayal (3 k.m)	900 / 550	Vallam – 45 Vathai -20 Catamaran – 55	Drag nets, Disco net, Singi valai, Nandu vali, Mural valai, Kla valai	-	Ratchenyapuram & Palaya kayal	Kanyakumari, Keelakarai, Vaipar	Thoothukudi, Tharuvaikulam, Uvary, Veerapandiyan pattinam, Mannapdu, Jeeva nagar
191	Korkai (1 km)	130 / 35	Labors	_	-	Palayakayal	_	_
192	Maramangalam (0.5k.m)	300 / 80	Labors	_	_	Ratchenyapuram & Palaya kayal	_	_
193	Mukkani (1 k.m)	400 / 50	Labors	_	-	Ratchenyapuram & Palaya kayal (3 k.m)	_	_
194	Punna kayal North (0.3k.m)	1500 / 900	Vallam – 300 Vathai – 200 Catamaran – 20	Kanyakumari, Thoothukudi, manappadu, Periyathalai, Thoothukudi, Vaipar	-	Punna kayal	Kanyakumari, Danuskodi, Rameswaram	Thoothukudi, Kanyakumari, Palayakal, Mannapadu, Uvari
195	Punnakayal South (0.3km)				-			
196	Senthamangalam (0.5km)	400 / 150	_	_	-	Punnakayal		
197	Singithurai (0.2 km)	350 / 170	Vallam – 40 Catamaran - 10	Drag nets, trawl nets, , Lobster net, Nandu valai, Mural valai, Mean valai	-	Singithurai	Kanyakumari, Thoothukudi, manappadu, Periyathalai, Thoothukudi, Vaipar	Uvari, Kanyakumari, Veerapandiyn pattinam, Thoothukudi
198	Kombuthurai (0.2 km)	250 / 150	Vallam -70 Catamaran -40	Crab net , Maya valai, Lobster net, Kuthu valai, Sala valai, Mani	-	Kombuthurai	Thoothukudi, Kanyakumari, Periya thalai, Mannappadu	
199	Veerapandiyan pattinam North (0.5 km)	1500 / 600	Mechanised boat – 55 Vathai – 18 Vallam -5 Catamaran -40	Trawl net – Prawn , Lobster (Bottom line trawl nets), Drag nets, Salai valai, Mean valai	-	Veerapandiyan pattinam	Kanyakumari, Vembar, Keezhakarai, Erwadi, Thoothukudi, Dhanuskodi	Kombuthurai, Singithurai, Thoothukudi, Alanthalai, Kayakumari, Uvari
200	Veerapandiyan pattinam South (0.5 km)				-			
201	Jeeva nagar (0.2 km)	200 / 150	Vallam – 13 Vallam with engine – 18	Dragnets, Salai valai, Tirukai valai, Crab nets,	-	Thiruchenthur coast	Thoothukudi, vembar	Alanthalai, Periya thalai, Thoothukudi, Kombuthurai, singithurai, Uvari,

202 203	Alanthalai North (0.3 k.m) Alanthalai South (0.3 km)	232 / 200	Vallam -5 Vathai 12 Catamaran - 200	Drag nets, Per seine, Crab nets, lobster nets, Chanku valai	- -	Alanthalai	Thoothukudi, Kanyakumari	Jeeva nagar, Thoothukudi, Kombuthurai, Singithurai, Uvari
204	Amali nagar (0.4 k.m)	600 / 520	Vallam -5 Catamaran – 70	Drag nets, Salaivalai Crab trap Tirkai valai Chunku valai	-	Amalin nagar	Erwadi, Keelakarai, kanyakumari	Uvari,Periyathalai Kulasekara pattinamAlanthalai, Punakayal, Mannapadu
205 206	Manappadu North (0.4 km) Manappadu South (0.2 km)	1155/ 800	Vallam – 7 Vathai 100 Fibre boat – 101 Catamaram - 10	Drag nets, Salaivalai Crab trap Tirkai valai Chunku valai	- -	Manapadu	Danuskodi, Rameswaram, Erwadi, Keelakarai, kanyakumari	Uvari,Periyathalai Kulasekara pattinamAlanthalai, Punakayal
207 208	Periya Thalai North (0.3 km) Periya thalai South (0.3 k.m)	1500 / 200	Vallam – 10 Catamaran - 100	Drag nets, Per seine, Crab nets, lobster nets, Chunk valai	_ -	Periya thalai	Danuskodi, Rameswaram Kanyakumari, Keelakarai,	Uvari, Mannapadu, Kulasekara pattinamAlanthalai, Punakayal
209	Pathovai nagar (0.6 k.m)	155 / 60	Catamaran -10	Mean valai, disco thoondle	-	Kulasekarapattinam	_	_
210	Kulasekara pattinam (0.2 k.m)	2000 / 300	Vallam -10 Vathai – 40 Catamaran -60	Drag nets, Gill nets, Prawn nets, Lobster nets, Crab nets (Bottom line), mural nets etc	_	Kulasekara pattinam	Danuskodi, Rameswaram Kanyakumari, Keelakarai	Uvari, Mannapadu, Periyathalai, Alanthalai, Punakayal

Table List of Eco-Development project villages with existing democratic institutional structures (panchayats, panchayat unions, special panchayats, and municipalities

S/N	Name of the Zone	Name of the Sub-Zone	Name of the Project Village	Name of the Panchayat	Name of the Panchayat Union/ Special Panchayat/ Municipality
001	Mandapam	Dhanushkodi	Serankottai		Rameswaram Municipality
002	Mandapam	Dhanushkodi	Sethupathi Nagar		Rameswaram Municipality
003	Mandapam	Dhanushkodi	Ramakrishna Puram		Rameswaram Municipality
004	Mandapam	Dhanushkodi	Natraja Puram		Rameswaram Municipality
005	Mandapam	Dhanushkodi	Verkodu		Rameswaram Municipality
006	Mandapam	Dhanushkodi	Karayur Mariaman Koil St.		Rameswaram Municipality
007	Mandapam	Dhanushkodi	Maruthupandiyar Nagar		Rameswaram Municipality
008	Mandapam	Dhanushkodi	Karaiyur South		Rameswaram Municipality
009	Mandapam	Dhanushkodi	Dhanushkodi		Rameswaram Municipality
010	Mandapam	Dhanushkodi	Mukundarayar Sathiram		Rameswaram Municipality
011	Mandapam	Dhanushkodi	Naduthurai		Rameswaram

					Municipality
012	Mandapam	Dhanushkodi	Rameswaram		Rameswaram Municipality
013	Mandapam	Dhanushkodi	Orakkadu		Rameswaram Municipality
014	Mandapam	Dhanushkodi	Kudiyiruppu		Rameswaram Municipality
015	Mandapam	Thangachimadam	Ariyangundu	Tangachimadam Panchayat	Mandapam Panchayat Union
016	Mandapam	Thangachimadam	Vallathaadi	Tangachimadam Panchayat	Mandapam Panchayat Union
017	Mandapam	Thangachimadam	Anthoniyar Puram	Tangachimadam Panchayat	Mandapam Panchayat Union
018	Mandapam	Thangachimadam	Susaiyappar Pattinam	Tangachimadam Panchayat	Mandapam Panchayat Union
019	Mandapam	Thangachimadam	Thangachimadam	Tangachimadam Panchayat	Mandapam Panchayat Union
020	Mandapam	Thangachimadam	Villundi	Tangachimadam Panchayat	Mandapam Panchayat Union
021	Mandapam	Thangachimadam	Saveriyar Nagar	Tangachimadam Panchayat	Mandapam Panchayat Union
022	Mandapam	Thangachimadam	Victoria Nagar	Tangachimadam Panchayat	Mandapam Panchayat Union
023	Mandapam	Thangachimadam	Francis Nagar	Pamban Panchayat	Mandapam Panchayat Union
024	Mandapam	Thangachimadam	Akkalmadam	Pamban Panchayat	Mandapam Panchayat Union
025	Mandapam	Pamban	Kunthukal	Pamban Panchayat	Mandapam

					Panchayat Union
026	Mandapam	Pamban	Thoopukkadu	Pamban Panchayat	Mandapam Panchayat Union
027	Mandapam	Pamban	Pamban	Pamban Panchayat	Mandapam Panchayat Union
028	Mandapam	Pamban	Chinnapalam	Pamban Panchayat	Mandapam Panchayat Union
029	Mandapam	Pamban	Therkuvadi	Pamban Panchayat	Mandapam Panchayat Union
030	Mandapam	Pamban	Thonithurai	Pamban Panchayat	Mandapam Panchayat Union
031	Mandapam	Pamban	Mandapam		Mandapam Special Panchayat
032	Mandapam	Pamban	Kalanjiyam Nagar		Mandapam Special Panchayat
033	Mandapam	Pamban	Marakayarpattinam	Marakayarpattinam Panchayat	Mandapam Panchayat Union
034	Mandapam	Pamban	Samathuvapuram	Vedaalai Panchayat	Mandapam Panchayat Union
035	Mandapam	Pamban	Vedaalai	Vedaalai Panchayat	Mandapam Panchayat Union
036	Mandapam	Pamban	Valaiyerwadi	Vedaalai Panchayat	Mandapam Panchayat Union
037	Mandapam	Pamban	Seeniyappa Dhargha	Sathakonvalasai Panchayat	Mandapam Panchayat Union
038	Mandapam	Uchipulli	Thuthivalasai	Enmanamkondan	Mandapam

				Panchayat	Panchayat Union
039	Mandapam	Uchipulli	Manthoppu	Enmanamkondan Panchayat	Mandapam Panchayat Union
040	Mandapam	Uchipulli	Saalaivalasai	Irumani Panchayat	Mandapam Panchayat Union
041	Mandapam	Uchipulli	Soorangaatuvalasai	Manangudi Panchayat	Mandapam Panchayat Union
042	Mandapam	Uchipulli	Agasthiyar Koodam	Pudumadam Panchayat	Mandapam Panchayat Union
043	Mandapam	Uchipulli	Nedumangundu	Pudumadam Panchayat	Mandapam Panchayat Union
044	Mandapam	Uchipulli	Paal Kulam	Sathakonvalasai Panchayat	Mandapam Panchayat Union
045	Mandapam	Uchipulli	Maanangudi	Manangudi Panchayat	Mandapam Panchayat Union
046	Mandapam	Uchipulli	Nochiyoorani	Nochiyoorani Panchayat	Mandapam Panchayat Union
047	Mandapam	Uchipulli	Naaraiyoorani	Pudumadam Panchayat	Mandapam Panchayat Union
048	Mandapam	Uchipulli	Pudumadam	Pudumadam Panchayat	Mandapam Panchayat Union
049	Mandapam	Uchipulli	Karan	Karan Panchayat	Mandapam Panchayat Union
050	Mandapam	Uchipulli	Thalaithopu	Karan Panchayat	Mandapam Panchayat Union
051	Mandapam	Uchipulli	Valangaveri	Thamaraikulam Panchayat	Mandapam Panchayat Union
052	Keelakarai	Periyapattinam	Sethu Nagar	Karan Panchayat	Thiruppulani

					Panchayat Union
053	Keelakarai	Periyapattinam	Muthupettai	Muthupettai Panchayat	Thiruppulani Panchayat Union
054	Keelakarai	Periyapattinam	Periyapattinam	Periyapattinam Panchayat	Thiruppulani Panchayat Union
055	Keelakarai	Periyapattinam	North Kudiyiruppu	Periyapattinam Panchayat	Thiruppulani Panchayat Union
056	Keelakarai	Periyapattinam	Saalaithottam	Karan Panchayat	Thiruppulani Panchayat Union
057	Keelakarai	Periyapattinam	Kollanthopu	Neyanaar Maraikan Panchayat	Thiruppulani Panchayat Union
058	Keelakarai	Periyapattinam	Mutharayar Nagar	Periyapattinam Panchayat	Thiruppulani Panchayat Union
059	Keelakarai	Periyapattinam	Indira Nagar	Periyapattinam Panchayat	Thiruppulani Panchayat Union
060	Keelakarai	Thinai Kulam	Thinai Kulam	Thinaikulam Panchayat	Thiruppulani Panchayat Union
061	Keelakarai	Thinai Kulam	Thopuvalasai	Thinaikulam Panchayat	Thiruppulani Panchayat Union
062	Keelakarai	Thinai Kulam	Kalkaadu	Thinaikulam Panchayat	Thiruppulani Panchayat Union
063	Keelakarai	Thinai Kulam	Kattaiyanperan Valaivu	Thinaikulam Panchayat	Thiruppulani Panchayat Union
064	Keelakarai	Thinai Kulam	Velayudapuram	Kalimangundu Panchayat	Thiruppulani Panchayat Union
065	Keelakarai	Thinai Kulam	Marivalasai	Kalimangundu Panchayat	Thiruppulani Panchayat Union
066	Keelakarai	Thinai Kulam	Kuppachivalasai	Kalimangundu	Thiruppulani

				Panchayat	Panchayat Union
067	Keelakarai	Thinai Kulam	Kuppavalasai	Kalimangundu Panchayat	Thiruppulani Panchayat Union
068	Keelakarai	Thinai Kulam	Kuthukkalvalasai	Kalimangundu Panchayat	Thiruppulani Panchayat Union
069	Keelakarai	Thinai Kulam	Vellaiyanvalasai	Kalimangundu Panchayat	Thiruppulani Panchayat Union
070	Keelakarai	Thinai Kulam	Mottaiyanvalasai	Kalimangundu Panchayat	Thiruppulani Panchayat Union
071	Keelakarai	Thinai Kulam	Kalimangundu	Kalimangundu Panchayat	Thiruppulani Panchayat Union
072	Keelakarai	Thinai Kulam	Krishnapuram	Vannangundu Panchayat	Thiruppulani Panchayat Union
073	Keelakarai	Thinai Kulam	Karisalgundu	Vannangundu Panchayat	Thiruppulani Panchayat Union
074	Keelakarai	Thinai Kulam	Pannakkarai	Vannangundu Panchayat	Thiruppulani Panchayat Union
075	Keelakarai	Keelakarai	Shanmugavelpattinam	Kalimangundu Panchayat	Thiruppulani Panchayat Union
076	Keelakarai	Keelakarai	Anjineyarpuram	Kalimangundu Panchayat	Thiruppulani Panchayat Union
077	Keelakarai	Keelakarai	Sivagamipuram	Kangirangudi Panchayat	Thiruppulani Panchayat Union
078	Keelakarai	Keelakarai	Pakkiriappavalasai	Kangirangudi Panchayat	Thiruppulani Panchayat Union
079	Keelakarai	Keelakarai	Kilaku Pudunagar	Kangirangudi Panchayat	Thiruppulani Panchayat Union
080	Keelakarai	Keelakarai	Meenavar Kuppam	Kangirangudi	Thiruppulani

				Panchayat	Panchayat Union
081	Keelakarai	Keelakarai	Mutharayar Nagar	Kangirangudi Panchayat	Thiruppulani Panchayat Union
082	Keelakarai	Keelakarai	Sethukarai	Sethukarai Panchayat	Thiruppulani Panchayat Union
083	Keelakarai	Keelakarai	Keelakarai		Keelakarai Municipality
084	Keelakarai	Keelakarai	Pannattar street		Keelakarai Municipality
085	Keelakarai	Keelakarai	Mayakulam	Mayakulam Panchayat	Thiruppulani Panchayat Union
086	Erwadi	Erwadi	Mangaleswari Nagar	Mayakulam Panchayat	Kadalady Panchayat Union
087	Erwadi	Erwadi	Bharathi Nagar	Mayakulam Panchayat	Kadalady Panchayat Union
088	Erwadi	Erwadi	Chinna Erwadi	Erwadi Panchayat	Kadalady Panchayat Union
089	Erwadi	Erwadi	Sadaimuniyan Valasai	Erwadi Panchayat	Kadalady Panchayat Union
090	Erwadi	Erwadi	Kalpar	Erwadi Panchayat	Kadalady Panchayat Union
091	Erwadi	Erwadi	Mottaikilavan Valasai	Erwadi Panchayat	Kadalady Panchayat Union
092	Erwadi	Erwadi	Pichchaimoopan Valasai	Erwadi Panchayat	Kadalady Panchayat Union
093	Erwadi	Erwadi	Meiyan Valasai	Erwadi Panchayat	Kadalady Panchayat Union
094	Erwadi	Erwadi	Adamcheri	Erwadi Panchayat	Kadalady

					Panchayat Union
095	Erwadi	Mariyur	Valinokam	Valinokam Panchayat	Kadalady Panchayat Union
096	Erwadi	Mariyur	Keela Mundal	Valinokam Panchayat	Kadalady Panchayat Union
097	Erwadi	Mariyur	Mundalkal	Valinokam Panchayat	Kadalady Panchayat Union
098	Erwadi	Mariyur	Mela Mundal	T.Mariyur Panchayat	Kadalady Panchayat Union
099	Erwadi	Mariyur	Mariyur	T.Mariyur Panchayat	Kadalady Panchayat Union
100	Erwadi	Mariyur	Oppilan	Oppilan Panchayat	Kadalady Panchayat Union
101	Erwadi	Mariyur	Mookaiyur	Mookaiyur Panchayat	Kadalady Panchayat Union
102	Erwadi	Mariyur	Ilanjipanai	Naripaiyur Panchayat	Kadalady Panchayat Union
103	Erwadi	Mariyur	Naripaiyur North	Naripaiyur Panchayat	Kadalady Panchayat Union
104	Erwadi	Mariyur	Naripaiyur South	Naripaiyur Panchayat	Kadalady Panchayat Union
105	Erwadi	Kamarajapuram	Kamarajapuram	Naripaiyur Panchayat	Kadalady Panchayat Union
106	Erwadi	Kamarajapuram	Periyanayagipuram	Naripaiyur Panchayat	Kadalady Panchayat Union
107	Erwadi	Kamarajapuram	Veppamarathupanai	Naripaiyur Panchayat	Kadalady Panchayat Union
108	Erwadi	Kamarajapuram	Vellapatti	Naripaiyur Panchayat	Kadalady

					Panchayat Union
109	Erwadi	Kamarajapuram	Manikanagar	Naripaiyur Panchayat	Kadalady Panchayat Union
110	Erwadi	Kamarajapuram	Pudukudiyiruppu	Naripaiyur Panchayat	Kadalady Panchayat Union
111	Erwadi	Kamarajapuram	Rochmanagar	Kannirajapuram Panchayat	Kadalady Panchayat Union
112	Thoothukudi	Vembar	Vembar South	Vembar South Panchayat	Villathukulam Panchayat Union
113	Thoothukudi	Vembar	Vamber North	Vembar North Panchayat	Villathukulam Panchayat Union
114	Thoothukudi	Vembar	Periyasamypuram	Periyasamypuram Panchayat	Villathukulam Panchayat Union
115	Thoothukudi	Vembar	Keelavaipar	Keelavaipar Panchayat	Villathukulam Panchayat Union
116	Thoothukudi	Vembar	Chippikulam	Keelavaipar Panchayat	Villathukulam Panchayat Union
117	Thoothukudi	Vembar	Pattinamaruthur	Pattinamaruthur Panchayat	Ottapidaram Panchayat Union
118	Thoothukudi	Vembar	Tharuvai Kulam	Tharuvai Kulam Panchayat	Ottapidaram Panchayat Union
119	Thoothukudi	Vembar	Vellapatti	Mela Arasaradi Panchayat	Ottapidaram Panchayat Union
120	Thoothukudi	Vembar	Lourdhammalpuram	Thoothukudi Rural Panchayat	Thoothukudi Municipality
121	Thoothukudi	Vembar	Sangukuli Colony	Thoothukudi Rural Panchayat	Thoothukudi Municipality
122	Thoothukudi	Vembar	T.Saveriyar Puram	Mappilaiyoorani	Thoothukudi

				Panchayat	Municipality
123	Thoothukudi	Vembar	Siluvaipatti	Mappilaiyoorani Panchayat	Thoothukudi Municipality
124	Thoothukudi	Vembar	Thalamuthu Nagar	Mappilaiyoorani Panchayat	Thoothukudi Municipality
125	Thoothukudi	Ratchanyapuram	Threspuram		Thoothukudi Municipality
126	Thoothukudi	Ratchanyapuram	Inigo Nagar & Fathimanagar		Thoothukudi Municipality
127	Thoothukudi	Ratchanyapuram	Pudhiyathuraimugam	Muthaiyapuram Panchayat	Thoothukudi Municipality
128	Thoothukudi	Ratchanyapuram	Ratchanyapuram	Palaya Kayal Panchayat	Meenavakundam Panchayat Union
129	Thoothukudi	Ratchanyapuram	Palaya Kayal	Palaya Kayal Panchayat	Meenavakundam Panchayat Union
130	Thoothukudi	Ratchanyapuram	Punna Kayal	Punna Kayal Panchayat	Alwar Thirunagari Panchayat Union
131	Thoothukudi	Ratchanyapuram	Kombuthurai		Kayalpattinam Municipality
132	Thoothukudi	Ratchanyapuram	Singithurai		Kayalpattinam Municipality
133	Thoothukudi	Ratchanyapuram	Veerapandiyapattinam	Veerapandiyapattinam Panchayat	Thiruchendur Municipality
134	Thoothukudi	Ratchanyapuram	Jeeva Nagar		Thiruchendur Special Panchayat
135	Thoothukudi	Ratchanyapuram	Amalinagar		Thiruchendur

					Special Panchayat
136	Thoothukudi	Ratchanyapuram	Aalandhalai		Thiruchendur Special Panchayat
137	Thoothukudi	Ratchanyapuram	Kulasekarapattinam	Kulasekarapattinam Panchayat	Udangudi Panchayat Union
138	Thoothukudi	Ratchanyapuram	Manappadu	Manappadu Panchayat	Udangudi Panchayat Union
139	Thoothukudi	Ratchanyapuram	Periyathaalai	Periyathaalai Panchayat	Sathaan Kulam Panchayat Union
Total	4 - Zones	12 - Sub-Zones	139 - Project Villages	44 - Panchayats	9 – Panchayat Unions/ 2 – Special Panchayat/ 4 - Municipalities

Total number of Zones - 004 (Four Zones)
Total number of Sub-Zones - 012 (Twelve Sub-Zones)
Total number of Project Villages - 139 (Hundred and thirty nine Project Villages)
Total number of Panchayats - 044 (Forty four Panchayats)
Total number of Panchayat Unions - 009 (Nine Panchayat Unions)
Total number of Special Panchayats - 002 (Two Special Panchayats)
Total number of Municipalities - 004 (Four Municipalities)

Table . List of identified colloborating NGOs with GOMBRT for implementation of Eco-development activities.

SlN	NAME OF THE NGO	ADDRESS (ES)
01	Tamilnadu Rural Reconstruction and Management (TRRM)	2/1911/12 2nd Floor, Om Shakthi Nagar, 4th main road, Ramanathapuram, Tamil Nadu, Pin code – 623 503.
02	SHAWDO	Mohammed Sathak Polytechnic, Kilkarai, Ramnad, Tamil Nadu.
03	DHAN Foundation	DHAN Foundation Madurai - 625 016 Tamilnadu, India +91-9488464575 Tel: (0452) 2302526, Fax: (0452) 2602247 Website: http://www.dhan.org
04	Small Industries Product Promotion Organisation (SIPPO)	Nodal Office, No.52, First floor, T.B.Road, Madurai – 625 016.
05	Arumbugal Trust	C-92, 2nd Cross Street, Maharaja Nagar, Tirunelveli, Pincode – 627 011.
06	People's Action for Development (PAD)	Field Off: 1/104, Thevar Street, Vembar Post, Villathikulam, Thoothukudi District, Pincode – 628 906.
07	De Rose Society (Chavaliar Roche Society)	Nehru Nagar, Old SBJ Colony, Thoothukudi District, Tamil Nadu.
08	Tuticorin Multipurpose Social Service Society (TMSSS)	Bishop's Harge, Thoothukudi District, Tamil Nadu, Pincode – 628 001.
09	M.S.Swaminathan Research Foundation (MSSRF)	3/231, kanakku Appusamy Street, Mandapam, Ramnad, Pincode – 623 518. Village Resource Centre, 3/1943 Main Road, Thankachimadam, Ramnad.

21.2 Objectives

Conservation of Biosphere Reserve and its rich biodiversity such as coral reefs, seagrass beds, oyster beds etc require the resolution of conflicts among its users, which should be interactive in nature to arrive at agreeable regulations in different areas of use by keeping the conservation and livelihood benefits to co-exist especially in the buffer zone and it should be a sustainable mechanism aided by people participation. In this context, several informal consultations carried out with the dependent fisherfolks, and they expressed their willingness for proper guidance and training in additional income generating vocations that will improve their socio-economic condition and decrease their dependency on coastal and marine biodiversity. Without the support and understanding of the lifestyle of these people who are affected by setting up of the National Park and Biosphere Reserve, no strategies for any kind of management is likely to be sustainable in the long run. This plan, thus is proposed with these following objectives.

The objective of the eco-development plan is to *combine guaranteed ecological balance with economic and socio-political dynamism* at local level. More specifically, the Eco-development plan of the Gulf of Mannar Biosphere Reserve aims:

1. To build collaboration of surrounding village communities and other stakeholders in the management of Biosphere Reserve so as to generate their long term support for the reserve
2. To ameliorate the hardships faced by the fishing villagers living in Biosphere Reserve, due to the curtailment of their access to fishing in the National Park, with a view to reducing their dependence on the protected area
3. Planning for resource substitution
4. Socio-economic upliftment of the target population
5. Involving local communities in conservation by adopting a "Community participatory" system of management, so as to elicit public support for conservation
6. Creating organised community institutions at the village level, and assuring benefits and rights to usufruct by developing viable partnerships with the village communities, subject to successful protection and conditions laid by the park management
7. Developing micro-institutional and technical functions in the community management organisations, so as to make them self-sustaining in the long run with minimum dependence on the Park Management
8. Formulation of utilisation rules and their enforcement, so that the contemplated welfare actions are not nipped in their infancy

The planned activities of eco-development program forms an integral part of the Buffer Zone (Biosphere Reserve) Management objectives, for it is this Zone that is expected to absorb the biotic pressures and insulate the Core Zone (Marine National Park) from such pressures. Community involved activities of "Social buffering" is expected to support "Extension buffering" that involves providing a habitat for the spillover population of fish and other marine resources for sustainable use. The eco-development activities area not restricted only to the presently prioritized 222 Buffer villages of the Gulf of Mannar Biosphere Reserve region but are expected to be carried out in other coastal villages in Tirunelveli and Kanyakumari districts during the plan period of 2018-2027.

21.3 Suggested guidelines for establishment and implementation of the Eco-development plan

a. Establish and empower community based institutions and these insituttions need to be facilitated by GoMBRT.

b. All eco-development initiatives in the Gulf of Mannar Biosphere region should be socio-culturally compatible with the target communities, without changing their original ways of life.

c. Enable the legal and policy framework for eco-development programme for the State in general and for the Gulf of Mannar Biosphere Reserve in particular.

d. Care should be taken to identify such policies that might change in future and affect the eco-development initiatives and beneficiaries negatively.

e. More importance should be given for enhancing renewable resource production under eco-development initiatives.

f. Funds have to be made available as per micro plans. There should not any disturbances in the fund flow.

g. Regulated community based aquaculture and mariculture programmes need to be encouraged; however, these programmes should not affect the environment especially to the ground water system.

h. Without the minimum level of literacy, conservation programmes may be difficult to implement. Hence, proper education should be imparted to the target community.

i. Eco-development initiatives should be directed at generating employment opportunity in large numbers in other than fisheries sector.

j. The inflow of fund should be regular and un-fluctuating to achieve the initiatives as per prioritisation.

k. Community development works should always be undertaken for the continuation of dialogues with the target community.

l. Wildlife crime cases should be quickly disposed of to emphasize the government's commitment to wildlife conservation.

m. An eco-development tax should be levied on all types of charges relating to tourism in the Biosphere. This can be used to support eco-development initiatives.

n. Under sectoral integration, efforts should be made to acquire funds from various quarters, giving an effective thrust to eco-development programme.

o. EDCs should be rewarded every year for their excellent performance.

p. Hoteliers and other businessmen, the sole beneficiaries of eco-tourism in the Biosphere Reserve, should contribute for eco-development from their incomes.

q. Training like driving, cycle repairing, TV repairing, scuba diving, nature guides, aquaculture, mariculture, cultivation and poultry etc. should also be imparted and some incentives should be given to help the villagers start their enterprises.

21.4 The suggested framework for the implementation of Eco-development plan in the Gulf of Mannar Biosphere Reserve region

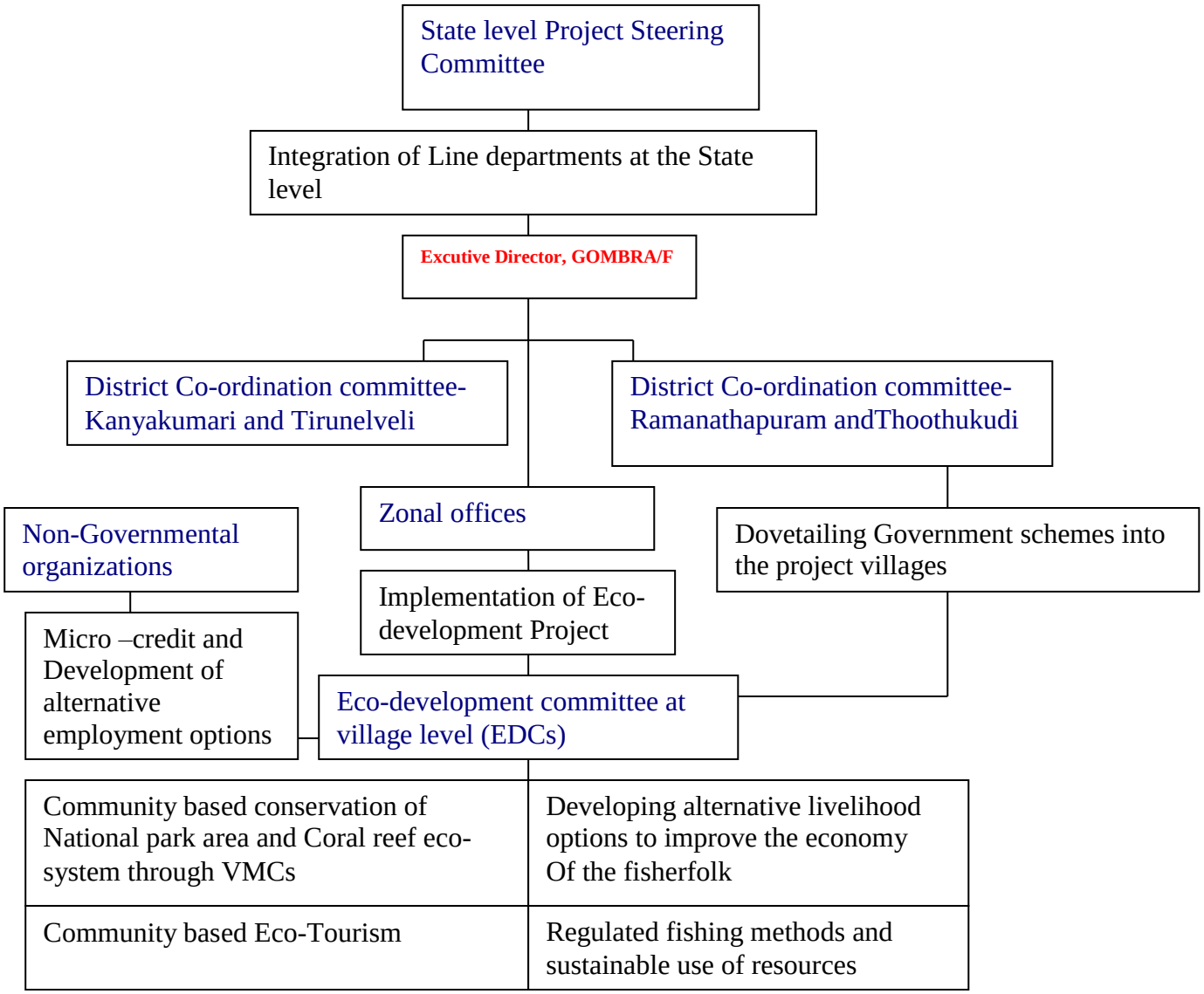


Figure The suggested frame work for implementation of Eco-development plan in the Gulf of Mannar Biosphere Reserve region

While the broad framework for the implementation of the Eco-development plan is already under implementation by the Gulf of Mannar Biosphere Reserve Trust, an appropriate revised framework proposed herewith.

The EDC villages are to be grouped into zones and subzones for administrative convenience. Each zone are to be co-lead by one Range Officer (from GOMBRA) and with one Inspector of Fisheries (from Fisheries Department) to look after the zonal administration. Under

each zone, there will be 2 to 5 subzones headed by either Forester or Sub-Inspector of Fisheries who will liaise with the fisher folk and local NGOs for implementation of the eco-development activities. At each EDC village level, the Eco-development committee will decide the activities to be taken up in the village. Each eco-development committee will consist of one executive council with 6 executive committee members and one president. In the executive council there will be 4 women candidates to ensure gender equity. All the decisions taken by the Eco-development committee will be routed through the executive committee in the form of resolutions.

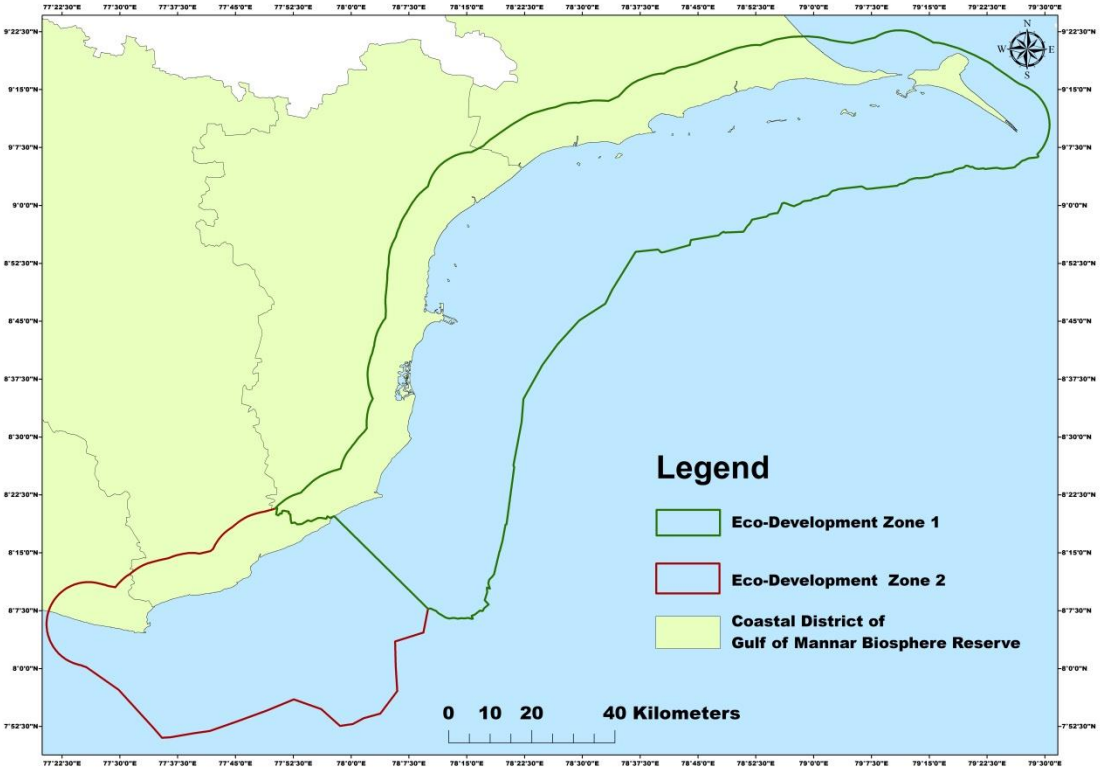
The following activities are to be taken up by the eco-development committee.

- Disbursal of soft loans to the EDC members for undertaking alternative employment options.
- Vocational Training to the fisher folk especially women.
- Capacity building of EDC members.
- Undertaking infrastructure development works in the project village either as entry point activity or through the funds diverted to the project villages by the District co-ordination committee.
- Awareness creation about the importance of conservation of Gulf of Mannar Biosphere Reserve, protected animals under wildlife protection act 1972, harmful netting practices, social issues affecting their quality of life, etc.
- Formation of community based conservation zones to regulate the activities in their respective zones and to promote sustainable harvest of marine resources.
- Coordinated efforts with the local NGOs and local bodies for the overall improvement of the socio-economic conditions of the fisher folk.

Establishment of eco-developmental zones based on area of influence and impact

Coastal resource dependent communities within 10 km from the sea shore between Pamban and Kanyakumari are considered to be the direct dependents on the Gulf of Mannar Biosphere Reserve resources. Presently, however, the coastal communities between Pamban and Tuticorin are considered to have a higher stake on the Biosphere Reserve and the Marine National Park and hence have been prioritised to be covered under the Eco-development Programme in Ramnathapuram and Tuticorin districts (Zone I). Communities from this zone highly influence both buffer and core zones of the Biosphere Reserve. The coastal area between Tuticorin and Kanyakumari comparatively has less influence and impact on the buffer zone of the Biosphere Reserve and hence it is proposed to cover them under the

next phase of Eco-development Programme in Tirunelveli and Kanyakumari districts (Zone II) as early as possible. In the present management plan it is proposed to focus more attention and activities of eco-development in Zone I while initiating the process of creation of identification of villages, formation of EDCs in Zone II as well for which the geographic scope and identification of villages have been carried out.



Improved strategy for formation of eco-developmental committees

Out of the 306 identified villages along the buffer zone of the Gulf of Mannar Biosphere reserve, a total of 222 villages were prioritised as project villages 210 EDCs have been formed as on January 2007. The EDCs, containing a minimum of 8 members each, have atleast 4 female members, which is mandatory. However, the selection of the Presidents for each of the EDCs should be based on the individuals association or involvement with marine resources. The members of the Eco Dovelopment Comitees should atleast be aware of the the Gulf of Mannar Biosphere Reserve's significance and willing to help coserve its biodiversity.

Demarcation and Profiling of marine resources exploitation zone by EDC villages

All depended 125 villages have been covered under the Eco-development programme. More than 210 EDCs have been formed and coordinated by GOMBRT. The functioning of GoMBRT in facilitating these EDCs was significantly reduced in the recent past due to lack of

adequate resources and supports from the Government of Tamil Nadu, which is not good for the long term conservation of Biosphere Reserve that is going to be the important lifeline of future of Tamil Nadu especially for the southern coastal districts. Therefore, it is important for the Government of Tamil Nadu to support the GoMBRT with adequate logistic resources to implement this Management Plan. The villagers from Mandapam zone venture as far as into the Sri Lankan waters. The areas most frequented by this group of fisher men are of Mandapam group of islands, though occasionally they also venture into Anaipar and Appa islands in the Keelakkarai group. The villagers from Keelakkarai group are however confined to the Keelakkarai group of islands, Appa and Thalayari islands are the most frequented ones. Earwadi group of fisherfolks have an added advantage of the three island group, as they are very close to the shore when compared to others. These people also fish in the waters around Poomarichan and Pullivasal islands very often. Tuticorin group of people exploit in waters which are as far as Rameswaram and some times also venture till Danushkodi on north and Kanyakumari in the south. With fishing in the National Park area having been prohibited, all these fishermen not only legally prosecuted by Forest Department but also face resistance from the fishing communities of the villages which are close to those respective islands. This causes much damage to their gears when some people gets hold of the intruders gear and either keep it for themselves or damage their nets. To avoid such infringement and damage of their assets, a strict demarcation of Marine National Park boundaries is required for facilitating the EDC village fisherfolks to be made aware of the exploitation and non-exploitation zones.

Effective and Village Marine Conservation Microplan development through PRA and prioritizing Eco-development activities

Once the dependent villages on the buffer zone have been indentified and EDCs formed, microplans for Eco-development activities needs to be developed through Participatory Rural Appraisal facilitated by Trust building exercises carried out with the involvement of local NGOs. The Strength, Weakness, Opportunities and Threats of implementing identified eco-development activities analysed before they are prioritized for implementation.

Range of livelihood option practices and their impact analysis:

There are a variety of factors that affect or control (externally) the livelihood opportunities of the fisherfolk in the Gulf of Mannar region.

i.) Natural Resources: this happens to be a primary factor affecting the livelihoods of people anywhere in the world. Availability of resources is determined largely by resource status, which in the Gulf of Mannar is observed to be degrading since several decades.

ii.) Cultural Aspects: Attitudes such as responsibility towards sustainable utilization of resources is strongly influenced by cultural aspects of any community. Since the coastal communities have the practice of marine fishing as alivelihood for many generations, it has to be well understood that a great deal of time and commitment should be spent on providing them with proper incentives for altering their livelihood options.

iii.) Market System: with the existing marketing system, a major role being played by the middle-men and few financiers in who lend loans to the fisher folk and in return, the fisherfolks have no other options other than to sell their catch to these financers. In the Gulf of Mannar region, the relationship between market traders and the fishers is known as *Sattambi*, which guarantees trade for the small harvests of the traditional and small scale fishermen (Whittingham,E., J.Campbell and P.Townsley, 2003).

The livelihoods of people in the Gulf of Mannar Biosphere Reserve (buffer zone) are partly on coastal and marine resources. Apart from fishing, the main activities of the coastal fisherfolk include salt making, sea weed collection, fish drying etc., with the mechanization of fishery sector, fisherwomen had been displaced from their traditional roles in processing, marketing, making of nets, fish drying etc. The financial condition of most of the fishing families has led women to deviate into illegal collection of wild seaweed stocks from the Marine National Park area or working as labour in salt pans, beedi making etc. This seldom helps them in supporting their families, triggering their involvement in illegal activities like coral mining, fishing around islands, collection of few protected shells etc.

Agriculture and allied activities, eventhough marginal, still play a major role in providing livelihoods for the people. Major part of the agriculture in the rain deficient Gulf of Mannar Biosphere Reserve region thrives on the existing 71 tanks irrigating 3,750 Ha (MSSRF, 1997). This constitutes 21% of the tank-fed area near the reserve. Tanks irrigate around 80% of the land under cultivation at present as there is no other kind of agriculture existing in this region. As this is mostly seasonal, the farmers, during the non-agricultural season, shift into the fishery sector by working as labourers in trawl boats or even venturing into illegal marine resource harvesting. This trend seems to be increasing in the recent years as seasonal agriculture itself has become eratic.

However, there seems to be an ample demand for the nature based products like palm leaf mats, baskets etc., and artifacts made out of legally permissible exploitation and use of sea shells. Poor marketing options existing in the region coupled with the interference of middle men appears to be the main problem requiring immediate attention to deal with. Apart from this, a survey done by MSSRF during 1999 has

summarized the profitability and marketing options of few of the alternative livelihood options available.

Table: Profitability and marketing options of selected alternate livelihood options (MSSRF, 1999)

Activity	Profitability (CBR)	Employment	Market	Institution
Charcoal production (Prosophis & Cashew)	1:1.15		Urban centers upto Mumbai	
Dairy farming	1:2	300 man days per 6 units	Local	
Pearl culture	1:1.25	5100 mandays per unit	External	CMFRI
Oyster farming	1:1.13	1800 man days per unit	Cochin	CMFRI
Seaweed culture	1:1.12	1200 man days per unit	Local	CMFRI
Agar production	1:1.53	1200 man days per anum	Local	CSMCRI, MPEDA
Fish pickle unit	1:1.18	1800 man days per unit	Local	MPEDA
CBR: Cost Benefit Ratio				

Apart from these, there are a few more alternate livelihood options that could be taken up as the impact they have on the environment is mostly non-detrimental.

- Promotion of charcoal making using invasive *Prosopis juliflora*; already villagers have started this activities in Ramanathapuram and Tuticorin district. Removal of these invasive species also enables native vegetation to florish and improve the local ecology.
- Onshore native seaweed species cultivation can help in reducing the excess nutrients added to the system through eutrophication at some places and also helps in supporting a wide range of fish species as they are good feeding and breeding grounds for many.
- Halophyte plantation in saline infested areas will provide extra income from production of natural vegetation salt (used in ayurvedic medicines) but also helps in delainating the saline infested soil.

There are a few alternate income generation options such as onshore aquaculture practices which may result in eutrophication, salination of soil etc., Nevertheless, these can be avoided if proper precautions are taken.

Alternate livelihood options feasible in the Gulf of Mannar Biosphere region

To wean away a large section of fishermen from illegal marine resource exploitation from protected islands and use of destructive fisheing gears etc. a range of feasible alterative livelihood options have been described. An assessment of 207 EDC villages was carried out to examine their present dependency on livelihood options and their expected and feasible alternate livelihood options (Table 5.5.8) These activities can be taken up not only to generate income for the fisherfolk that also leading to specialized skill development of the local people.

Table Analysis of feasible alternate livelihood options in selected EDC villages.

Zone (No. of Villages)	Fishing			Agriculture			Others			Alternative livelihood options expected	Feasible/ Recommended alternatives
	C	P	N	C	P	N	C	P	N		
MANDAPAM (47)	19	24	0					2		• Small scale hotels, • Grocery shops, • Dried fish, • Horticulture, • Animal husbandry, • Candle making, • Palm based Handicrafts, • STD booths, • Boat mechanics, • Aqua culture, • Phenyl/ Detergent soap manufacturing,	• Fish drying/pickling • Horticulture • Animal husbandry • Palm based handicrafts • Candle making • Aquaculture • Boat mechanics • Phenyl/Detergent soap manufacturing
KEELAKKARAI (40)	19	16			12			2		• Mushroom culture, • Fish drying, • Animal husbandry	• Mushroom culture • Fish drying/pickling • Animal husbandry
VEMBAR/EARWADI (55)	15	35	6					3		• Char coal making, • Animal husbandry, • Fish drying, • Aqua culture, • Palm based handicrafts, • Vermiculture	• Charcoal making • Animal husbandry • Fish drying/pickling • Aquaculture • Handicrafts • Vermiculture

TUTICORIN (65)	38	12	10					16		• Charcoal making, • Palm based handicrafts, • Aqua culture, • Cosmetic making, • Automobile workshops, • Small scale hotels, • Textile business, • Grocery shops, • Cycle workshops, • Sea weed culture, • Auito rickshaws, • Cold storages, • Small scale industries like fish pickling units etc., • Candle making, • Beedi making,	• Charcoal making, • Palm based handicrafts, • Aqua culture, • Cosmetic making, • Automobile workshops, • Textile business, • Cycle workshops, • Sea weed culture, • Auto rickshaws, • Cold storages (community based), • Small scale industries like fish pickling units etc., • Candle making,

Community based seaweed culture using native species

Presently, a large number of marginalized fisherfolk along the Gulf of Mannar Biosphere Reserve region are engaged in the collection of seaweed from the wild either from the Core or the Buffer Zone. Most damaging part of this wild collection is the use of a metal scraper to harvest the weed which leads to the damage of other non-target species. There are no efforts done till date to develop native species seaweed culture in the Gulf of Mannar. This is practiced in the Palk Bay side of Mandapam. This is required to be promoted along the Biosphere Reserve. Culture through rafts has been observed to give good results in this area. However, culture of non-native species should be strongly discouraged. Subsidised loans are reauired to be given to the EDC members seeking to take up this as an alternative income generation source. This should be given to the EDC group as a whole but not to any single person. There should also be a limit on the number of people to be involved in such activity as an increase in number of such onshore seaweed culture may also have negative impact on marine bidoversity. Training on the culture aspects could be sought from specialized research institutes like CMFRI.

Community based fish product industries

To enhance the income generation options of marginal unorganized sector fisherfolks, value addition to the exploited fisheries resource can be done through coverting them as pickle, canned-food etc. The MSSRF and other NGOs have already initiated such model industries. Since such value addition facilities may require significant volume of raw material, this can be taken up by farming cooperatives or through village communities. Such effort however, requires extension and technical training through a slightly educated group and hence requires to be targeted at somewhat educated youth. Such community-based fish product industry also requires safe disposal of waste and a proper marketing network to make them economically viable and sustainable.

Involvement in eco-tourism activities as a guide, scuba driver, boatman etc.

Members of the Eco-development committees could also be made involved in various eco-tourism operations after empowering them through proper training. This would include Dive Guides, Boatmen in tourist boats, nature guides, guides at various tourist places etc. They can also be supported and encouraged to set-up smallscale souvenirs stalls, eateries etc. in main tourist places along the Biosphere Reserve.

Charcoal making

There is a move to eradicate the invasive prosopis from the region due to its negative impact in the landscape. But, prosopis is seems to be one of additional livelihoods of the region. Therefore, charcoal making using *Prosopis juliflora* can be encouraged among the EDC villages. This can be promoted along the Gulf of Mannar Biosphere Reserve terrestrial buffer zone as though the Marine National Park islands are also infested with *Prosopis* such activities may be difficult to take up in a National Park. However, if the National Park as a habitat improvement measure removes the invasive *Prosopis*, the EDC members may be provided with the remove material for charcoal making. Other Government *poramboke* lands along the Reserve may also be leased-out to the EDC members to harvest the *Prosopis* for charcoal making and after complete removal of Prosopis, they can be further contracted to plant the area with suitable local vegetation for restoring terrestrial vegetation.

Handicrafts using palm trees and permitted shells

The Gulf of Mannar Biosphere Reserve coastline has an abundance of Palmyra palm (*Borasus flabellifer)* the State tree of Tamil Nadu. Though almost 100% of this tree is utilized traditionally by people in someway or other, production of value added handcrafts made out of palm leaves can bring in an option of alternate livelihood. Though this is in practice in some coastal villages, efforts needs to be done to bring this into a more organized sector. EDC members who have some know how of making mats and baskets and other artifacts using bamboo or palm leaves need to be provided with additional skill upgradation, marketing opportunities and exposure to similar products being developed in other regions through organized and supported exposure visits. Community owned selling centers in tourist places where the local people could be made to sit and sell their own products may also help. The smallscale industries department and other related agencies may be required to be brought in to develop this sector along the Gulf of Mannar Biosphoere Reserve region. This should be made into an organized cottage industry with links to other places of the country where there is demand.

Halophyte plantation (salt plant) on saline land

In recent years in the west coast of India vegetation based natural salt are being produced from coast-based halophytes like *Salicornia brachiata* and *Salicornia brachiata*. Such natural vegetation origin salt are in high demand in the ayurvedic pharmaceutic industries. Such halophyte

plantations also helps in desalining the hypersaline soils. Such activities can be encouraged by allocating degraded saline patches to village EDCs. Such plantations can also be cultivated along the banks of salt pans or in the salt marshes. In addition natural vegetation salt, pickles can also be prepared from these plants. These products can be sold in the community owned stalls at the main tourist centers or link to other user and marketing agencies. The GOMBRT may organize exposure visit for identified EDC memners to the west coast to enable them understand the prospect of such alternate income generation option.

Community based dairy farming

The Gulf of Mannar Biosphere Reserve region is rain and pasture land deficient area, livestock and animal husbandary related activities have not been a major income generation option. However coastal villagers have been involved in cattle and livestock rearing for emergency supplementary income. With increasing changes in the democgraphic profile and urbanization there is the prospect of additional income out of intensive diary and micro-livestock farming. The GOMBRT may liase with the Animal Husbandry Department of Tamil Nadu for catalysing such activities.

Community based Aqua culture

With the traditional involvement of coastal communities in fisheries sector the EDCs may be at ease to adopt aquaculture involving select marine species. Since export of prawn, lobster, brackish water fishes, and marine ornamental fishes gaining importance day-by-day, prawn/shrimp and other marketable aquaculture may be promoted as alternate livelihood with the EDC members. Suitable villages with brackish water provision located near the coast needs to be identified for this purpose. Training and extension through involvementof professional institutions fromt he Tamil Nadu fisheries Department, CMFRI Mandapam and Tuticorin Fisheries College may be involved in proving training and promoting such activities. Aqua culture practices shall also include culture of edible oyster, pearl oyster etc. Facilities like cold storage and processing plants may also be required at a later stage if a larger number of EDCs become involved in such alternate income generation options.

Capacity building of EDCs

Capacity building is an important aspect when it comes to empowering communities for adopting alternate licelihood options. In Eco-development programmes such as this is very essential to

empower community not only in the choice of livelihood options but also on various aspect of coastal and marine biodiversity conservation and habitat monitoring. It may be essential to identify suitable EDC members based on their educational qualification, aptitude and willingness to receive professional training to become trainers and also to assist the GOMBRT authorities to monitor sensitive ecosystems like seagrass beds, corals, mangrove habitats etc. Periodic training workshops to refresh the knowledge of these selected people by the GOMBRT will create a local human resource base for long-term involvement and input to the Biosphere Reserve management. Such capacity building exercises can be initiated in partnership with local NGOs and/or Research Institutes who have expertise in the respective fields. For example, training on monitoring coral reefs and sea grass beds can be done in association with PAD/SDMRI; restoration of water tanks with the DHAN Foudation; Sea weed culture and other aqua culture aspects with CMFRI/Tuticorin Fisheries College and Research center etc.

Development of Village Marine Conservation Plans:

The concept of conservation, when people have a major stake over the resources, especially in the places like the Gulf of Mannar, would yield better results when people are made to be involved at the time of planning of any conservation efforts. A recent example of this would be that of Fiji, where a group of land owners from the Nacula Tikina in the Yasawa group of islands, in partnership with Partners in Community Development Fiji (PCDF) and local tourist resorts, have created their own marine resource management plans in 2006 (ICSF, 2006). Similar efforts could be made in the Gulf of Mannar region by making the EDCs participate in developing their own Village Marine Conservation plans.

Initially, four villages, one from each group of the Biosphere reserve was proposed in the previous Management Plan , to be selected and Village Marine Conservation (VMC) plans prepared and the alternative livelihood options may be tested in thse 'Model villages' first and upon getting successful results, the similar VMC plans be developed for other villages along the Gulf of Mannar Biosphere Reserve. However, this was not implemented that needs to be intiated in this Management Plan period.

Institutional mechanism for evaluation of eco-development program and activities

While the institutional structure for implementing the Eco Development plans is proposed to be with Gulf of Mannar Biosphere Reserve Trust in a participatory mode with the identified EDCs, collaborating Non-governmental organization, other Government line Depearments and professional institutions, the progress and

effectiveness of the Eco-development plan with respect to the objectives needs to be monitored by a inter-sectoral high powered committee. The Gulf of Mannar Biosphere Reserve authorities chief executive being the member secretary should have identified members of all involved agencies in this committee. The district collectors of all the four districts as well as nominated members from professional NGOs and scientific institutions may also be included in this high power committee to meet atleast once a year to review the implementation of the Eco-development plan and suggest corrective measures.

Evaluation and review

The future of the Nationla Park depends largely on the effectiveness and successful implementation of this plan in the Gulf of Mannar Biosphere Reserve. While the progress of the implementation of the activities of eco-development plan are to be reviewed by the High powered steering committee suggested in the earlier section, the actual effectiveness of eco-development measures on the enhancement of ecology of the Marine National Park needs to be monitored by identifying indicators, since the assumption of eco-development measures is to decrease the dependency of people on marine resources and their degradation. In such an assumption, if a bench mark status of the indicators is maintained the future monitoring of those indicators must show improvement to conform the eco-developmental activities are providing the anticipated improved ecological status of the indicators. Hence, periodic evaluation and necessary review of implemented works and their expected outputs (Table 5.5.9) needs to be carried out both by in-house agencies as well as independent specialized agencies or a group or individuals. This can be done at regular intervals atleast, not less than once a year. This not only helps to know if the plans are successful or not and also to make necessary changes. The evaluation may also include socio-economic monitoring of the dependant communities. A model collaborative monitoring system example is given in Table 5.5.10. giving detail of indicators, means of verification, who can do this and what is to be done.

Purpose: Local communities practice sustainable fishing.	Output 1: Number of non-fishers in fishing activities is controlled	Activity Cluster 1.1 - Develop livelihood strategies for non-fishers	Activities: - Assess and analyse the in-migration patterns to coast - Assess feasibility/viability of livelihood options - Coordinate with other line departments for improved livelihoods - Capacity building on selected livelihood options	Assumptions, Pre-conditions & Risks: • No new project or programme is implemented by any agency promoting immigration of for away communities • Few enterprising families are encouraged to establish alternate livelihood as models • Proper systems of marketing are developed for promoting the products produced by traditional communities

	Output 2: Enhanced internal/ community pressure against destructive fishing practices	Activity Cluster 2.1: Undertaking awareness programmes for local communities about destructive fishing practices	Activities: - Compile information on destructive fishing practices - Implement campaign with NGOs - Media outreach	• Intensive steps for social capital building are taken for communities • Traditional institutions are identified and revived
	Output 3: Improved in clarity of tenure over resources	Activity Cluster 3.1: Strengthen community management systems	Activities: - Trust building within community through EDCs/SHGs - Community institution building	Information about traditional management systems is gathered and community confidence and pride in these systems is regenerated

	Output 4: Increased incomes from sustainable fishing practices	Activity Cluster 4.1: Work with Fisheries Department on developing appropriate measures for reducing operational costs Activity Cluster 4.2: Work with key agencies towards enhancing the value of catch Activity Cluster 4.3: Work with FSD to improve access to infrastructure needed for fishing	Activities: - Assess information on factors determining operational costs - Training on engine and craft maintenance - Establish information system for increasing fishing efficiency - Take steps for strengthening of local groups/ organizations - Take steps for reducing the control of middle men - Take measures to build strong storage, post harvest and marketing systems	• Fisheries department is taken actively involved • Capacity building of fisheries department is in place • Village level institutions are strengthened
	Output 5: Diverse off season livelihoods for local fishermen in place	Activity Cluster 5.1:	Activities: - Assess feasibility/viability of livelihood options - Coordinate with other line departments for improved livelihoods - Capacity building on selected livelihood options	• Livelihood activities help to reduce migration along coast and between inland and coast • Other agencies are part of co ordination mechanism

	Output 6: System of effective enforcement of existing laws in place	Activity Cluster 6.1: Promoting better coordination between enforcement agencies 6.2: Building capacity of enforcement agencies 6.3 Enhancing capacity of communities for internal enforcement	Activities: - Setting up coordination committee	• There are proper GOs fpr the co ordination committee • Proper institutional arrangements and areas for capacity building identified • New capacities are used
	Output 7: Appropriate and participatory policy frame work in place	Activity Cluster Facilitating participatory review of existing policy to generate refined policy		• Modified policies are accepted by the government and required orders are given

Sustainable fishing practices adopted by mechanized fishing boats	Output 1: Generation of optimum catches from trawl efforts	Activity Cluster Enhancing the non fishery (land based) returns of livelihoods to reduce migration of inland farmers	Activities - Assess feasibility/viability of livelihood options - Coordinate with other line departments for improved livelihoods - Capacity building on selected livelihood options	• Number of people employed by trawlers can be limited • New capacities are actually used
	Output 2: Generation of adequate returns from mechanised fishing	Activity Cluster Working with Fisheries Department for promoting diversified and sustainable fishing practices	Activities Explore and demonstrate alternative/non-destructive methods of trawl fishing	• Required models are built and put in place
	Output 3: System of efficient enforcement of exiting laws and policies in place	Activity Cluster Supporting effective enforcement and monitoring through coordination with relevant agencies	Activities Develop an effective monitoring system Building of local organizations and enforcement agencies	Monitoring systems are actually used and proper management action s are taken as a follow up

	Output 4: Regulatory frameworks for managed trawl operations in place	Activity Cluster Undertake studies for generating data base and information to build refined regulatory framework	Activity - Assist FSD with implementation in critical sites	The findings are shared with others and these actually flow in management actions
Purpose: Conservation of the non-fish natural resources in the GoMBR.	Output 1: Regulated mining of rare earth minerals with minimal environmental impacts.	Activity Cluster 1.1: Reducing the influence of the mining industry.	Activities: *Identify all the major organizations and departments involved in mining *Establish a working relationship with all the identified stakeholders *Sensitize the stakeholders about BD values of GoMBR and negative impacts of unregulated mining and environmental laws *Seek their cooperation for conservation.	• Other agencies are part of co ordination mechanism • There is a system of frequent interaction with the stakeholders

		Activity Cluster 1.2: Enhance capacity and motivation of Panchayats/local communities to enable more effective monitoring of the mining activities.	Activities: *Compile existing guidelines and disseminate in appropriate form *Assess the reasons for the low-levels of motivation amongst the panchayats/local communities * Based on the results of the assessment develop and implement a capacity development strategy to build the capacities of the panchayats/local communities to effectively monitor the environmental impacts of the mining	• Other agencies are part of co ordination mechanism
		Activity Cluster 1.3: Promoting an environmentally sensitive policy framework and legislation for coastal mining	Activities: ***Analysis of existing policies and laws** *Suggest amendments and revisions to the policy and legal framework	The amendments suggested in the existing policies and legal framework are formally recognized and approved by the Govt. and concern Department.

		Activity Cluster 1.4: Promoting coordination among departments for effective enforcement of regulations	Activities ***Identify and establish groups of agencies/ departments dealing with the regulation of mining** *Hold regular meetings for info sharing and to sensitize them to environmental concerns and to ensure better coordination and enforcement	

	Output 2: Controlling coral mining.	Activity Cluster 2.1: Promoting coordination and assisting departments for effective enforcement of regulations	Activities *Enhancing the capacity of the WLW (Infrastructure & equipment and manpower) ***Identify and establish a group of agencies/ departments dealing with the control of coral mining** *Hold regular meetings for info sharing and to sensitize them to the importance of coral conservation and to overall environmental concerns and to ensure better coordination and enforcement	Agencies are involved in decision making and programme implementation
		Activity Cluster 2.2: Enhancing the viable livelihood options for the local communities involved in mining	Activities: *Establishment of EDC/VMCs *Development of microplans *Feasibility study of alternative livelihoods and pilots *Implementation of microplans	• New people do not start coral mining • New industrial use for coral does not emerge • Alternative livelihoods are incorporated and implemented in the microplans

		Activity Cluster 2.3: Advocating stopping the use of coral as a raw material by the lime industry.	Activities: *Identify all the lime industries involved in mining *Establish a working relationship with all the identified industries *Sensitize the industries about BD values of GoMBR and negative impacts of coral mining and environmental laws *Seek their cooperation for conservation.	Agencies are involved in decision making and programme implementation

	Output 3: Illegal collection of protected and rare species reduced	Activity Cluster 3.1: Support relevant agencies in enforcing the existing regulatory laws and policies	Activities: *Enhancing the capacity of all the relevant agencies especially the WLW (Infrastructure & equipment and manpower) and the Customs department, the relevant port officials and the Coast Guard ***Establish a group of agencies/departments dealing with the protection of these species and control of the illegal trade** *Hold regular meetings for information sharing and to sensitize them to the importance of the protection and conservation of these species and the larger environmental concerns, and to ensure better coordination and enforcement	Agencies are involved in decision making and programme implementation

		Activity Cluster 3.2: Reducing the market demand for the protected and rare species	Activities: *Work with relevant agencies to curb the market links and reduce the market demand for rare/endangered species	
		Activity Cluster 3.3: Enhancing the viable livelihood options for the local communities dependent on collection of these species	Activities: *Understand dependency patterns of the local communities on these species *Establishment of EDC/VMCs *Development of microplans *Feasibility study of alternative livelihoods and pilots *Implementation of microplans	

Purpose: Effective safeguards and regulations against negative impacts of infrastructure projects in GoMBR on biodiversity and livelihoods	Output 1:. Conservation priorities are mainstreamed into infrastructure and development planning	Activity Cluster 1.1: Ensuring that the ecological and economic values of GoMBR are recognized by decision-makers and politicians	Activities: - Develop and applying a methodology for valuation of biodiversity and ecological services of GoMBR - Effectively communicate these values to decision-makers and politicians	Assumptions, Pre-conditions & Risks:
Output 2: Strong environmental clearance procedures are in place	Activity Cluster 2.1: Promoting the development of an effective framework, systems and capacities for decision-making	Activities: - Analysis of gaps in existing framework in context of GoM	- Adequate political will exists - Process is not influenced by vested interests	The clearing procedures are made transparent to public at large

		Activity Cluster 2.2: Facilitating effective public participation in the process	Activities: -Create village based awareness programmes -System of public hearings (public view should be considered) - Strengthening of local/ peer pressure groups - Creation of institutional mechanism for wider dissemination of information	
		Activity Cluster 2.3: Ensuring that EIAs are conducted by professional/independent agencies	Activities: - Enhance role of trust in EIA process** - Enhance capacity for carrying out EIAs (through core expert group) - Collate social/ ecological baseline data needed for EIAs	The data generated are actually used for generating the modified clearing procedures with due approvals of the Government.

Table . A model collaborative monitoring system

Identified indicator	Means of verification	Who does it	What is to be done	At what interval
Increased and catch of resident fishers increased	Monitor fish catshes for catch per gear per fisher, income earned	Users, Village Management Committee, fisheries officers	Deliver catches/record data Compile and analyse data Feed back information to fishers and District	Daily Monthly Six months
Increased stocks on all reefs within management area	Simple stock assessment of key species from catch statistics which recorded type and number of gears, area fished, species caught, number of fish per size class, weight of catch. Underwater census of key species	Users, VMC, FOs Same as above	Record data Analyse data Feedback information to fishers and District Same as above	Daily Six months Six months Every Six months
Reduced number of incidences of illegal fishing e.g., dynamite, seine nets and sticks, poison, spears and spearguns	Patrol logs which recorded number and type of complains/reports of illegal fishing and action taken	VMC, FOs, Village Militia	Record complaints, incidences, responses and results Evaluate effectiveness and report to District FO and Village Government	Daily Monthly
All vessels and	District Fisheries Licensing	District FO	Compile licensing	Yearly

fishers of incidences of legal but destructive fishing	records		records	
Reduced number of incidences of legal but destructive fishing	Patrol logs recording instances of extractive use and action taken	Users, VMC, FOs	Record data Analyse data Feedback information to fishers and District	Daily Six months
Management controls in place	Bylaws, regulations	VMC, Village Government, District Government	Formulate bylaws/regulations Approve bylaws/regulations	As required
No extractive use of closed reef	Patrol logs recording number of reported instances and what action taken. Legal gazette of reef closure specifying restrictions and penalities	Users, VMC, FOs	Record data Analyse data Feedback information to fishers and District	Daily Six months Six months
Catch information recorded	Catch statistics recording fishing effort and catch from each device	Users, VMC, FOs	Deliver catches/record data Compile and analyse data, feed back information to fishers and District	Daily Six months Six months
Reduced number of visiting vessels	Catch statistics recording fishing effort of residents and visitors	Users, VMC, FOs	Deliver catches/record data Compile and analyse data, feed	Daily Six months Six months

			back information to fishers and District	

(*Adopted from Horrill and van Ingen, 1997*)

Table: Eco – Development Program villages along the Coastline in the Gulf of Mannar Biosphere Reserve in the District Of Ramanathapuramand Thoothukudi

DISTRICT	ZONAL H .Q	SUB –ZONAL H.Q	ECO DEVELOPMENT COMMITEE	VILLAGES IN SUB – ZONES	NAMES OF THE EDC VILLAGES
	Pamban	Danuskodi	10	11	Ramakrishnapuram,Natarajapuram,Netajinagar & Rajagopal nagar,Verkodu, Maruthupandiyannagar,Karaiyur,Serankottai, Sethupathinagar, Mariyamman kovil street Southkaraiyur)
		Pamban	9	15	Tharuvai thoppu, Kunthukal, Chinnapalam, Thoppukadu, Therkuvadi, Thonithurai, valaiyurvadi, Nadumunaikadu,& (Seeniyapadharga, Mutharaiyar naga), Vedalai thenkadarkarai,& (Singivalai kuchi, Soodavalai kuchi, Arupukadu), Kunjarvalasai)
		Uchipulli	28	31	Pudhunagaram, Notchiurani, Kuduthi,& Maanaankudi, Kadukai valasai(East & west), Surankatu valasai, Chinnudaiyar valasai, Amman pattinam, Agastiyarkootam,Naraiyurani East, Naraiyurani West, Pudhumadam, Chinna

RAMANATHAPURAM					irattaiyurani, Vaniyankulam, M.P.K.valasai, &(Irruttoorani, Moopan valasai), Irrataiyurani, Thamaraikulam, Valangapuri, Arulozhi nagar, Keelamankundu, & Melamankundu, Karan, Thalaithoppu, sembadaiyarkulam, Perunkulam, Kram, servaigarayurani, Vattan valasai, Enthal, Oumbattaicharvalasai
	Keezhakarai	Periyapattinam	9	9	Salaithottam, Kollanthoppu, Sethunagar, Pudhukudirupu north, Mutharaiyar nagar, Muthupettai, Indranagar,Pudhukudiruppu south, periyapattinam
		Thinaikulam	22	22	Pannakarai,Maraikayar nagar, Karichankundu, Krishnapuram,Thoppuvalasai, kalkadu, Anjaneyapuram, Vlayuthapuram, Kalimankundu, Kattaiyanvalasai, Kuppavalasai, Vellyan valasai, Mottaiyan valasai, Chittan kadu, Kunthukal valasai, Kuppachi valasai, Marivalasai, Shanmugavel pattinam, Kattiyan peran valaivu, Silyappan valasai, Vethakaran valasai
		Keezhakarai	9	8	Sethukarai, Mutharaiyar nagar (East), Pakkiriyappa pallivasal, Idinthakalpudhur, Sivakamipuram, Pudhu nagar (East), Meenavar kuppam, Keezhakarai, Pannatar street
		Erwadi	14	15	Bharathi nagar, Vivekanathapuram, & Muthurajapuram, Mayakulam,

					Mangaleswari nagar, Mutharaiyar nagar, Chinna Erwadi, Saaimuniyan valasai, Mariyamman nagar, Pitchimoopan valasai, Meyyan valasai, Mottaikilavan valasai, Kalpar, Adamcheri, Adencheri
	Erwadi	Mariyur	23	22	Vaalinokkam,Keelamunthal, Melamunthal, T. Mariyur, S. Mariyur, Muthu requnatha pattinam, Ganthi nagar,& (Anna nagar, Pandiyan naga)r, M.Krishnapuram, Oppilian, Periyakulam, Madathakulam,Kaduku santhai, sathiram, Pasumponnar nagar &, Poopandiyar nagar, sanmugakumarapuram, Elanthaikulam, M.kuthiraimozhi, Kanigapuri, Mookaiyur North, Mookaiyur south, Uraikinaru, Naripaiyur North, Naripaiyur south
		Kamarajapuram	19	19	Ponnagaram,Vettukadu,Kadalkattikudiruppu,Amman pattinam,Theraviyapuram, Velayuthapuram, Palammal kudiruppu, Pudhukiramam, Vellapatty, Vepamarathupanai, Kamarajapuam, Periyanayakipuram, Rayyapar puram, Manikam nagar, Kanniraja puaram Pilaiporuthamman kudirupu, Rochma nagar, Ramyanadar kudiruppu, Poosari theru
		Vembar	17	17	Vembar south, Vembar north, Vembar valasamuthiram, Pachaiyapuram, Kunchayapuram, periyaswamy puram, Kalaikoodam, Vaipar- Kalloorani

THOOTHUKUDI	Thoothukudi				Chippikulam, Veppalodai, Therku kalmaedu, Pattinamaruthur, Ananthamadam patcheri, Vellapatty, keela arasaradi, & Thoopasupatti
		Thoothukudi	28	25	Siluvaipatti, Thalamuthunagar, Rajapalayam, Samir rose nagar, Arokyapuram, T. Saveriyar puram, Poopandiyarpuram, Loorthammal puram, Keela alakarathattu, Mela alankarathattu, Cruzpuram, Thersapuram north, Thersapuram south, Therasapuram west, Santherayapar kovil street, Pudhutheru, sangukuli colony, Mutharayar nagar, Mettupatti, Poopalrayar puram, new harbour, Inigonagar, Fathima nagar south, Fathima nagar North, Lime stone, Annai therasa nagar, Sahayapuram, Vivekanathapuram
		Ratchenyapuram	21	17	Ratchenyapuram & Palaya kayal, Korkai, Maramangalam, Mukkani, Punnakayal North, Punnakayal south, Senthamangalam, Singithurai, Kombuthurai, Veerapandiyan pattinam North,Veerapandiyan pattinam south, Jeeva nagar, Alanthalai North, Alanthalai South, Amalin nagar, Manappadu north, Mannapadu south, Periyathalai North, Periyathalai South, Pathovai nagar, Kulasekarapattinam

No	District	Total no of EDC	Total no of villages
1	Ramanathapuram	143	152
2	Thoothukudi	66	59
	Total	**210**	**211**

Table. Alternative livelihoods option expressed by people and proposed alternative livelihoods to each village

No	Project villages	EDC Formed	Expected alternatives	Suggested alternatives based on skills / require further counseling
	Mandapam zone			
	Danuskodi sub – zone			
1	Ramakrishnapuram	2006	Small scale hotels, Grocery shop, Dried fish, Plantation for flowers , vegetables, Dairy farm	Horticulture, floriculture and small scale fisheries related activities
2	Nataraja puram	2005	Dried fish, Animal Husbandry etc,	Aquaculture and animal husbandry
3	Netaji nagar & Rajagopal nagar	No EDC formed	_	Require severe counseling
4	Muthuramalinga nagar			
5	Verkodu			
6	Maruthupandiyan nagar	2005	*	Aquaculture, and fisheries related activities
7	Karaiyur	2004	Fish sale, dried fish sale, grocery shop, small scale hotels	New job opportunities including mechanized deep water fisheries activities
8	Serankottai	2004	Candle making, Handicraft (Palm trees & Plastic), Hotel (small scale),, STD booth (For handicraft)	Handicraft and small time avocation

9	Sethupathinagar	2005	-	Require counseling
10	Mariyamman kovil south karaiyur	2005	Boat mechanic, Aqua culture Marine based alternatives	Small scale industries related to fisheries
	Pamban sub – zone			
11	Tharuvai thoppu & Kundugal	2005	*	Require counseling
12	Chinnapaalam	2004	Fishing related alternatives	Reef restroation , aquacultu re
13	Thoppukadu	2005	*	Require counseling
14	Therkuvadi	2005	Dried fish, Animal husbandry	Fishery related activities
15	Thonithurai	2006	*	Require counseling
16	Valaiyarvadi	2006	*	Require counseling
17	Nadumunaikadu , Seeniyapa dharga, Mutharaiyarnagar	2006		Require counseling
18	Vedalai thenkadarkari - singivalai kuchi , soodavalaikuchi, Arupukadu	2006	*	Aquaculture related and fishery related industries
19	Kunjarvalasai	2006	*	Require counseling
	Uchipuli sub – zone			
20	Pudhunagaram	June 2006		Require counseling
21	Notchiurani	Oct 2006	Aqua culture, Palm based alternatives or Recommende d alternatives.	Aquaculture and handicraft
22	Kunduthi , Maanaankudi	2006	Any types of alternatives.	Require counseling

23	Kadukai valasai, East, west	Sep 2006	*	Require counseling
24	Surankatuvalasai	Sep 2006	*	Require counseling
25	Chinnudaiyarvlasai	Oct 2006	*	Require counseling
26	Ammapattinam	Nov 2006	Palm based , Candle making, Soap, Phenyl preparation	Handicraft and other small scale industries with proper training
27	Agastiyarkootam	2006	*	do
28	Naraiyurani East	Dec 2006	*	do
29	Naraiyurani west	Dec 2006	*	do
30	Pudhumadam	No formed	-	-
31	Chinna irattaiyurani	Dec 2006	*	do
32	Vaniyankulam	No formed	-	-
33	M.P.K.Valasai , Irruttoorani, Moopan valasai	Nov 2006	*	do
34	Irrataiyurani	Dec 2006	*	do
35	Thamaraikulam	No formed	-	-
36	Valangapuri	No formed	-	-
37	Arul ozhi ngar	Dec 2006	*	Require counseling
38	Keelamankundu , Melamankundu	Nov 2006	*	Require counseling
39	Karan	2005	Palm based alternatives, Seaweed culture	Handicraft industries
40	Thalaithoppu	2005	*	Handicraft industries
41	Sembadaiyarkulam	Oct 2006	*	Handicraft industries
42	Perunkulam	Dec 2006	*	Handicraft industries
43	Kumbaram	No formed	-=	- -
44	Servaigarayurani	No formed	-	- -
45	Vattan valasai	No	-	- -

		formed		
46	Enthal	No formed	-	- -
47	Otaicharvalasai	No formed	-	- -
				- -
	Keezhakkarai zone			- -
	Periyapattinam sub – zone			- -
48	Salaithottam	2004	*	Require counselling
49	Kollanthoppu	2004	*	Require counselling
50	Sethunagar	2005	*	Sea weed culture
51	Pudhukudirupu North	2005	*	Any type of small scale industries
52	Mutharaiyar nagar	2005	*	Fishery related industries
53	Muthupettai	2005	Flori culture, Mushroom culture etc	Agriculture based industries
54	Indranagar	2004	*	Require counseling
55	Pudhukudiruppu South	2005	*	Require counseling
56	Periyapattinam	Dec 2006	*	Require counseling
	Thinaikulam sub – zone			
57	Pannakarai	Jan 2007	*	Require counseling
58	Maraikayar nagar	Dec 2006	*	Require counseling
59	Karichankundu	Dec 2006	*	Require counseling
60	Krishnapuram	Dec 2006	*	Require counseling
61	Thoppuvalasai	Dec 2006	*	Require counseling
62	Kalkadu	2006	*	Require counseling
63	Anjaneyapuram	2006	*	Require counseling

64	Vlayudhapuram	2006	*	Require counseling
65	Kalimankundu	2005	*	Require counseling
66	Kattaiyan valasai	2006	*	Require counseling
67	Kuppa valasai	Dec 2006	*	Require counseling
68	Vellayan valasai	Nov 2006	*	Require counseling
69	Mottaiyan valasai	Nov 2006	*	Require counseling
70	Chittan kadu	May 2006	*	Require counseling
71	Kunthukal valasai	Oct – 2006	*	Require counseling
72	Kuppachivalasai	Nov 2006	*	Require counseling
73	Marivalasai	2005	*	Require counseling
74	Shanmugavel pattinam	2004	*	Require counseling
75	Kattiyan peran valaivu	2005	*	Require counseling
76	Thinaikulam	2006	*	Require counseling
77	Silyappan valasai	2006	*	Require counseling
78	Vethakkaran valasai	2006	*	Require counseling
	Keezhakarai sub - zone		*	Require counseling
79	Sethukarai	2004	*	Require counseling
80	Mutharaiyar nagar East	2004	*	Require counseling
81	Pakkiriyappa pallivasal	2004	Boat mechanism, Dried fish	Small scale industries
82	Idinthakalpudur	2005	*	Require counseling
83	Sivakamipuram	2006	*	Require counseling
84	Pudhu nagar East	2005	*	Require counseling
85	Meenavar kuppam	2005	Animal husbandry, Dried fish,	Fishery related and livestock

86	Keelakarai	2006	*	Require counseling
87	Pannatar theru	2005	*	Require counseling
	Erwadi zone			
88	Bharathi nagar	2006	*	Require counseling
89	Vivekananthapuram & Muthurajapuram	2006	*	Require counseling
90	Mayakulam	2006	*	Require counseling
91	Mangaleswarinagar	2006	*	Require counseling
92	Mutharaiyar nagar	2006	*	Require counseling
93	Chinna Erwadi	2005	Aquaculture	Aquaculture
94	Sadaimuniyan valasai	March 2006	Marine related alternatives, Charcoal business	Aquaculture and agriculture related
95	Mariyamman nagar	2006	*	Require counseling
96	Pitchimoopan valasai		*	Require counseling
97	Meyyan valasai	2006	*	Require counseling
98	Mottaikilavan valasai	2005	*	Require counseling
99	Kalpar	2005	* *	Require counseling
100	Adamcheri	2005	*	Require counseling
101	Adenchery	2006	Palm based , Charcoals, Animal husbandry	Handicrafts, agricultural based and animal husbandary
	Mariyur sub- zone			
102	Vaalinokkam	Dec 2006	Aqua culture	aquaculture
103	Keelamunthal	2005	*	Require counseling
104	Melamunthal	2005	*	Require counseling
10	T. Mariyur	2004	*	Require

5				counseling
106	S. Mariyur	2004	*	Require counseling
107	Muthu requnatha pattinam	Nov 2006	*	Require counseling
108	Ganthinagar, Annanagar, & Pandiyan nagar	Dec 2006	*	Require counseling
109	M. Krishnapuram	2006	*	Require counseling
110	Oppilian	2006	*	Require counseling
111	Periyakulam	Decembe r – 2006	Animal husbandry (Goat, Cattle) , Vermi culture, Handicraft (Palm trees & Plastic wire), Charcoal	Animal husbandary, hadicrafts, and small scale industries
112	Madathokulam	Oct 2006	*	Require counseling
113	Kaduku santhai	Oct – 2006	*	Require counseling
114	Sathiram	Nov – 2006	*	Require counseling
115	Pasumponnar nagar & Poopndiyar nagar	Oct 2006	*	Require counseling
116	Sanmugakumarapura m	Dec 2006	*	Require counseling
117	Elanthaikulam	Dec 2006	*	Require counseling
118	M. Kuthiraimozhi		*	Require counseling
119	Kanigapuri	Jan – 2007	*	Require counseling
120	Mookaiyur North	2006	*	Require counseling
121	Mookaiyur South	2004	*	Require counseling
122	Uraikinaru	2006	*	Require counseling
123	Naripaiyur North	2006	*	Require counseling
124	Naripaiyur south	2004	*	Require counseling

	Kamarajapuram sub – zone			
125	Ponnagaram	2006	*	Require counseling
126	Vettukadu	2006	*	Require counseling
127	Kadal katti kudirupu	2006	*	Require counseling
128	Amman puram	2006	*	Require counseling
129	Theraviya puram	2006	*	Require counseling
130	Velayuthapuram	2006	*	Require counseling
131	Palammal kudirupu	2006	*	Require counseling
132	Pudhukiramam	Oct – 2006	*	Require counseling
133	Vellapatty	2005	*	Require counseling
134	Vepamarathupanai	2004	Need a Factories (small scale industries) and support to Marketing	Small scale industries
135	Kamarajapuram	2005	*	Require counseling
136	Periyanayagi puram	2004	*	Require counseling
137	Rayyapar puram	2006	*	Require counseling
138	Manikam nagar	2004	*	Require counseling
139	Kannirajapuram	Oct – 2006	*	Require counseling
140	Pilaiporuthamman kudirupu	Dec 2006	*	Require counseling
141	Rochma nagar	Oct – 2006	We don't have any idea of alternatives.	Require counseling
142	Ramaya nadar kudiruppu	Oct – 2006	We don't have any idea of alternatives.	Require counseling
143	Poosari theru	June – 2006	We expect some	Require counseling

			valuable alternatives	
				- -
	Thoothukudi zone			
	Vembar sub – zone			
144	Vembar south	Dec – 2006	*	Require counseling
145	Vembar north	Dec 2006	*	Require counseling
146	Vembar valasamuthiram	Oct – 2006	*	Require counseling
147	Pachaiyapuram	No formed	*	-
148	Kunchaiyapuram	Nov – 2006	*	Require counseling
149	Periyasamy puram	Nov - 2006	Any Factories and Recommended alternatives	Small scale industries
150	Kalaikoodam	Dec 2006	Charcoal , Palm based	Agricultural based industries
151	Vaipar- kalloorani	sept2006	*	Require counseling
152	Keelavaipar	2004	*	Require counseling
153	Chippikulam	2005	*	Require counseling
154	Veppalodai	Dec 2006	*	Require counseling
155	Therku kalmedu	Nov 2006	*	Require counseling
156	Pattinamaruthur	2005	*	Require counseling
157	Tharuvaikulam	2004	*	Fisheries related industries
158	Ananthamadam patcheri	Dec – 2006	*	Require counseling
159	Vellapatty	2004	*	Require counseling
160	Keela arasaradi and thupaspatti	Dec 2006	*	Require counseling
	Thoothukudi sub – zone			

161	Siluvaipatti	2005	Aquaculture	Aquaculture
162	Thalamuthunagar	2004	Any types of Cosmetics making	Fishery related
163	Rajapalayam	Nov 2006	*	Require counseling
164	Samir rose nagar	November – 2006	*	Require counseling
165	Arokyapuram		Aquaculture	Aquaculture
166	T.Saveriyar puram	2005	*	Require counseling
167	Poopandiyar puram	Oct - 2006	*	Require counseling
168	Loorthammal puram	2004	*	Require counseling
169	Keela alankarathattu	2005	*	Require counseling
170	Mela alankarathattu	2006	*	Require counseling
171	Kruzpuram	No formed	*	-
172	Thersapuram North	April 2006	Lath and auto work shop, Small Hotels, Textiles Business, Cycle work shop, Grocery shop	Industries and mechanical skills related
173	Thersapuram South	Nov 2006	*	Require counseling
174	Therasapuram west	Nov – 2006	Lath and auto work shop, Small Hotels, Textiles Business, Cycle work shop, Grocery shop	Small scale industries
175	Santherayapar kovil theru	Oct 2006	*	Eco-tourism.
176	Pudhu theru	May ,2006	Aquaculture	Fisheries related
17	Sangukuli colony	2006	*	Require

7				counseling
178	Mutharayar nagar	2006	*	Require counseling
179	Mettupatti	2006	*	Require counseling
180	Poopalarayarpuram	Dec - 2006	*	Require counseling
181	New harbour	2006	Seaweeds culture or any other aquacultures	Aquaculture
182	Inigo nagar	2004	Share auto, Cold storage rooms (we need cold storage rooms. Because its reduce the fishing activity.(means if available , fishermen's going to fishing alternative days, or some days in a week) .	Small scale industries
183	Fathima nagar south	2006	(We need Factories or companies (esp. Bouquet shop(Florist companies). Small scale industries (like Fish pickle etc.) , Textiles business) or Should be given Fiber boat to each fishermen's (if given , we survive)	Agriculture, floriculture and small scale industries
184	Fathima nagar North	Oct – 2006		

185	Limestone	2006	*	Require counseling
186	Annai therasa nagar	Nov 2006	*	Require counseling
187	Sahayapuram	2006	*	Require counseling
188	Vivekanatha nagar	Nov 2006	*	Require counseling
	Ratchenyapuram sub – zone			
189	Ratchenyapuram & Palaya kayal	2004	Aqua culture	Aquaculture
190	Korkai	Oct 2006	*	Require counseling
191	Maramangalam	Oct 2006	Beedi making, candle making etc	Small scale industries
192	Mukkani	2006	Beedi making, any other small scale business, Seaweed culture	Small scale industries
193	Punna kayal North	2006	*	Require counseling
194	Punnakayal South	2006	*	Require counseling
195	Senthamangalam	Nov - 2006	*	Require counseling
196	Singithurai	2006	*	Require counseling
197	Kombuthurai	2006	*	Require counseling
198	Veerapandiyan pattinam North	Septembe r – 2006	Government jobs	Require counseling
199	Veerapandiyan pattinam South	No formed	*	- -
200	Jeeva nagar	2004	*	Require counseling
201	Alanthalai North	No formed	*	- -
202	Alanthalai South	Nov 2006	*	Require counseling
203	Amali nagar	2006		Require counseling
204	Manappadu North	No formed	.	-
20	Manappadu South			

5				
206	Periya Thalai North		-	- -
207	Periya thalai South		-	- -
208	Pathovai nagar		-	- -
209	Kulasekara pattinam		Palm based materials (Handicrafts)	- -

Socio-economic profile of coastal villages of Thoothukudi coast to Kanyakumari coast

A total of 99 villages were identified and surveyed along the coasts of Tuticorin (from Tuticorin town, south wards), Tirunelveli and Kanyakumari (east coast) districts to study their socio-economic condition, so that, a better eco-development programme would be initiated in these vilalges. Villages which fall within a distance of 10 KM from the shore line (Biosphere Reserve) were chosen as these areas falls inside the buffer zone of the Biosphere Reserve. Of the 99 villages surveyed, 22 are coastal villages and the remaining 77 are inland village, which fall under the Biosphere Reserve.

In Tuticorin, there are 12 coastal villages and 34 inland villages. In Tirunelveli district, there are 7 coastal and 39 inland villages. In Kanyakumari district, there are 3 coastal and 4 inland villages. From Tuticorin district, people from all the 46 villages in the Biosphere Reserve are dependent on marine resources up to some degree, such as sea weed harvesting or sea shell collection or as laborers in fishing vessels either throughout the year or during a particular season. In contrary, the dependency of people on marine resources is only limited to that of coastal villages, and the people of inland villages are not at all dependent on the marine resources in Tirunelveli and Kanyakumari districts. In Tuticorin district, there are 165 divers who collect molluskan sea shells and 7 families are involved in sea weed culture. In Kanyakumari district, though there are 200 people who were trained to culture sea weeds, there are only 7 people who harvest sea weed from wild. This difference in dependency on the resources may be attributed to a lack of resources such as sea weeds and molluskan sea shells in the off-shore areas of Tirunelveli and Kanyakumari districts and also to the rougher sea condition.

List of fishing villages and their statistics along the coast of Thoothukudi, Tirunelveli and Kanyakumari districts

Table. Population Status

S.No	District	Village	Fishermen Population			
			♂	♀	☺	**Total**
1.	**THOOTHUKUDI**	RATCHANYAPURAM	219	203	208	630
2.		PAZHAYAKAYAL	287	291	265	843
3.		PUNNAKAYAL	2254	2017	2772	7043
4.		KOMBUTHURAI	167	166	270	603
5.		SINGHITHURAI	404	193	444	1041
6.		VEERAPANDIYAN PATTINAM	939	932	790	2661
7.		JEEVANAGAR	64	62	79	205
8.		AMALINAGAR	536	481	652	1669
9.		ALANTHALAI	788	790	981	2559
10		KULASEKHARAPATTINAM	133	154	184	471
11		MANAPADU	1544	1493	1577	4614
12		PERIYATHAZHAI	1535	1397	1681	4613
		TOTAL	**8870**	**8179**	**9903**	**26952**
13	**TIRUNELVELI**	KOODUTHALAI				
14		KOOTAPANAI				
15		OVARI				
16		KOOTHANKULI				
17		IDINTHAKARAI				
18		PERUMANAL				
19		KOOTAPULY				
		TOTAL				
20	**KANYAKUMARI**	AROCKIYAPURAM	768	689	842	2299
21		CHINNAMUTTOM	634	569	741	1944
22		KANNIYAKUMARI	2922	2953	1354	7229
		TOTAL	**4324**	**4211**	**2937**	**11472**
		GRAND TOTAL				

♂ - Male
♀ - Female
☺ - Children (below 17 years of age)

Table. Employment Status (Men)

S.No	District	Village	Fishing	Fresh Fish trade	Dried fish trade	Net making	Diving	Allied activities	Employed in			Total
									Govt.	Private	others	
1.	**THOOTHUKUDI**	RATCHANYAPURAM	181	0	2	0	0	0	4	6	6	199
2.		PAZHAYAKAYAL	180	0	2	0	0	4	6	51	4	247
3.		PUNNAKAYAL	1706	129	0	9	1	32	29	50	206	2162
4.		KOMBUTHURAI	159	0	0	0	0	0	0	0	0	159
5.		SINGHITHURAI	299	0	6	1	0	0	0	2	2	310
6.		VEERAPANDIYAN PATTINAM	341	10	3	0	0	26	46	192	182	800
7.		JEEVANAGAR	63	0	0	0	0	0	0	0	0	63
8.		AMALINAGAR	449	7	3	0	0	0	2	21	21	503
9.		ALANTHALAI	718	30	15	0	0	0	15	10	0	788
10.		KULASEKHARAPATTINAM	132	1	0	0	0	0	0	0	0	133
11.		MANAPADU	1126	34	0	8	0	82	10	100	20	1380
12.		PERIYATHAZHAI	1289	7	0	0	0	76	4	7	23	1406
TOTAL			**6643**	**218**	**31**	**18**	**1**	**220**	**116**	**439**	**464**	**8150**
13.	**TIRUNELVELI**	KOODUTHALAI	172	0	0	0	0	3	0	2	0	177
14.		KOOTAPANAI	212	1	0	0	0	0	1	0	8	222
15.		OVARI	1097	9	0	0	0	0	6	82	103	1297
16.		KOOTHANKULI	843	4	0	0	0	5	10	10	67	939
17.		IDINTHAKARAI	1120	12	0	0	0	0	14	71	100	1317
18.		PERUMANAL	318	8	3	0	0	0	0	0	5	334
19.		KOOTAPULY	818	21	0	1	0	0	30	72	111	1053
TOTAL			**4580**	**55**	**3**	**1**	**0**	**8**	**61**	**237**	**394**	**5339**

20.	**KANYAKUMARI**	AROCKIYAPURAM	650	12	0	0	0	0	0	0	47	709
21.		CHINNAMUTTOM	503	9	0	0	0	0	0	0	48	560
22.		KANNIYAKUMARI	2726	17	0	14	26	0	56	34	12	2885
		TOTAL	**3879**	**38**	**0**	**14**	**26**	**0**	**56**	**34**	**107**	**4154**
		GRAND TOTAL	**15102**	**311**	**34**	**33**	**27**	**228**	**233**	**710**	**965**	**17643**

Table . Employment Status (Women)

S.No	District	Village	Fishing	Fresh Fish trade	Dried fish trade	Net making	Diving	Allied activities	Employed in			Total
									Govt.	Private	others	
1.	**THOOTHUKUDI**	RATCHANYAPURAM	0	0	12	0	0	0	2	8	4	26
2.		PAZHAYAKAYAL	0	0	7	0	0	0	2	36	1	46
3.		PUNNAKAYAL	0	20	30	0	0	0	3	8	40	101
4.		KOMBUTHURAI	0	0	0	0	0	0	0	0	2	2
5.		SINGHITHURAI	0	3	5	0	0	0	0	0	0	8
6.		VEERAPANDIYAN PATTINAM	0	1	3	0	0	3	25	25	6	53
7.		JEEVANAGAR	0	0	0	0	0	0	0	0	0	0
8.		AMALINAGAR	0	3	0	0	0	0	4	3	1	11
9.		ALANTHALAI	0	208	0	0	0	0	0	0	0	208
10.		KULASEKHARAPATTINAM	0	60	0	0	0	0	0	0	0	60
11.		MANAPADU	0	10	0	0	0	0	8	0	0	18
12.		PERIYATHAZHAI	0	0	5	0	0	3	17	7	6	3
		TOTAL	**0**	**305**	**62**	**0**	**0**	**6**	**61**	**87**	**60**	**536**
13.	**TIRUNELVELI**	KOODUTHALAI	0	0	0	0	0	5	0	0	2	7

14.		KOOTAPANAI	7	0	0	0	0	0	0	0	0	7
15.		OVARI	0	0	24	0	0	0	11	28	66	129
16.		KOOTHANKULI	0	10	0	0	0	9	15	13	69	116
17.		IDINTHAKARAI	0	28	0	0	0	0	18	38	239	323
18.		PERUMANAL	0	14	3	1	0	0	1	0	1	20
19.		KOOTAPULY	0	104	0	1	0	0	25	21	62	213
		TOTAL	**7**	**156**	**27**	**2**	**0**	**14**	**70**	**100**	**439**	**815**
20.	**KANYAKUMARI**	AROCKIYAPURAM	0	13	0	0	0	0	0	0	7	20
21.		CHINNAMUTTOM	0	9	0	0	0	0	0	0	9	18
22.		KANNIYAKUMARI	0	72	112	0	0	0	24	97	44	349
		TOTAL	**0**	**94**	**112**	**0**	**0**	**0**	**24**	**97**	**60**	**387**
		GRAND TOTAL	**7**	**555**	**201**	**2**	**0**	**20**	**155**	**284**	**559**	**1783**

Table. Fishing crafts

Village	**Mechanised**						**Non Mechanised**								**IBE**	**OBM**
	Make		**Type**				**Make**			**Type**						
	Wooden	**FRP**	**Trawl**	**Gillnetter**	**Liner**	**Total**	**Wooden**	**FRP**	**Ply-wood**	**Masula**	**Vallam**	**Dugout canoe**	**Catamaran**	**Total**		
RATCHANYAPURAM	0	0	0	0	0	0	31	0	0	0	5	0	26	31	5	0
PAZHAYAKAYAL	0	0	0	0	0	0	25	0	0	0	2	0	23	25	2	0
PUNNAKAYAL	0	0	0	0	0	0	264	20	4	0	259	0	29	288	236	23
KOMBUTHURAI	0	0	0	0	0	0	5	14	26	0	40	0	5	45	0	45
SINGHITHURAI	0	0	0	0	0	0	39	1	0	0	35	0	5	40	35	1
VEERAPANDIYAN PATTINAM	1	32	1	29	3	33	66	0	0	0	0	0	66	66	0	57
JEEVANAGAR	0	0	0	0	0	0	8	0	0	0	8	0	0	8	8	0
AMALINAGAR	0	0	0	0	0	0	162	1	0	0	1	0	162	163	1	155

ALANTHALAI	0	0	0	0	0	0	196	0	0	0	0	0	196	196	0	191
KULASEKHARAPATTINAM	0	0	0	0	0	0	28	0	0	0	24	0	4	28	23	1
MANAPADU	0	0	0	0	0	0	158	22	27	0	26	0	181	207	26	181
PERIYATHAZHAI	0	0	0	0	0	0	479	1	0	0	0	0	480	480	0	389
TOTAL	**1**	**32**	**1**	**29**	**3**	**33**	**1461**	**59**	**23**	**0**	**400**	**0**	**1177**	**1577**	**336**	**1043**
KOODUTHALAI	0	0	0	0	0	0	97	0	0	0	0	0	97	97	0	97
KOOTAPANAI	0	0	0	0	0	0	95	0	0	0	0	0	95	95	0	95
OVARI	0	0	0	0	0	0	420	0	0	0	0	0	420	420	0	420
KOOTHANKULI	0	0	0	0	0	0	301	19	0	0	19	0	301	320	0	216
IDINTHAKARAI	0	0	0	0	0	0	273	0	15	0	15	0	273	288	0	251
PERUMANAL	0	0	0	0	0	0	50	0	0	0	0	0	50	50	0	4
KOOTAPULY	0	0	0	0	0	0	122	0	3	0	3	0	122	125	0	105
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**1358**	**19**	**18**	**0**	**37**	**0**	**1358**	**1395**	**0**	**1188**
AROCKIYAPURAM	4	0	2	2	0	4	284	48	17	0	65	0	284	349	0	72
CHINNAMUTTOM	39	0	32	7	0	39	174	9	6	0	15	0	174	189	0	24
KANNIYAKUMARI	134	0	78	56	0	134	688	17	20	0	37	0	688	725	0	98
TOTAL	**177**	**0**	**112**	**65**	**0**	**177**	**1146**	**74**	**43**	**0**	**117**	**0**	**1146**	**1263**	**0**	**194**
GRAND TOTAL	**178**	**32**	**113**	**94**	**3**	**210**	**3965**	**152**	**84**	**0**	**554**	**0**	**3681**	**4235**	**336**	**2425**

Table. Fishing gears

Village	Gillnet	Trawlnet	Shore seine	Boat seine	Long line	Trap	Others	Total
RATCHANYAPURAM	384	0	0	0	0	0	0	384
PAZHAYAKAYAL	328	0	0	0	0	0	0	328
PUNNAKAYAL	3108	0	0	0	7200	0	0	10308
KOMBUTHURAI	203	0	0	0	1366	0	0	1569
SINGHITHURAI	1398	0	0	0	450	0	0	1848
VEERAPANDIYAN PATTINAM	1745	6	0	0	98	0	307	2156
JEEVANAGAR	0	0	0	0	0	0	89	89
AMALINAGAR	2430	0	0	0	0	0	8	2438
ALANTHALAI	2955	0	0	0	0	0	224	3179
KULASEKHARAPATTINAM	0	0	0	0	0	0	74	74
MANAPADU	2715	0	2	0	0	0	390	3107
PERIYATHAZHAI	3853	0	0	0	0	0	420	4273
TOTAL	**19119**	**6**	**2**	**0**	**9114**	**0**	**1512**	**29753**
KOODUTHALAI	1453	0	0	0	0	0	1191	2644
KOOTAPANAI	1523	0	0	0	0	0	0	1523
OVARI	6398	0	0	276	0	0	197	6871
KOOTHANKULI	4615	0	0	0	17	0	0	4632
IDINTHAKARAI	4193	0	0	0	5910	0	0	10103
PERUMANAL	952	0	0	0	0	0	0	952
KOOTAPULY	1928	0	0	0	0	0	0	1928
TOTAL	**21062**	**0**	**0**	**276**	**5927**	**0**	**1388**	**28653**
AROCKIYAPURAM	320	6	0	0	70	0	0	396
CHINNAMUTTOM	190	45	0	0	65	0	90	390
KANNIYAKUMARI	1150	210	0	0	500	60	170	2090

TOTAL	**1660**	**261**	**0**	**0**	**635**	**60**	**260**	**2876**
GRAND TOTAL	**41841**	**267**	**2**	**276**	**15676**	**60**	**3160**	**61282**

Chapter 22

Research, Monitoring and Training

22.1 Background

Historically, the Gulf of Mannar Biosphere Reserve is known as 'Paradise of Marine Biologist'. Many discoveries and research methodologies on marine biodiversity and aquaculture have been developed from this Biosphere Reserve by Indian marine biologist. Further, Gulf of Mannar Biosphere is most studied Protected Areas of the country with maximum number of research publications. However, most of these studies appreciated the commercial values of the Biosphere Reserve instead of its ecological values that started by mid-1980s.

With the reduction and fragmentation of natural habitats resulting in increased stress on ecosystems and plant and animal populations, there is an urgent need for formulating conservation strategies and Management Plans for the target species and PAs backed by sound scientific research. Climate change and recurring extreme weather events have added new dimensions to the problems in the form of habitat alteration due to sea level rise, emergence of diseases and rapid spread of invasive alien species (IAS) (Corlett 2012, IPCC 2014). This calls for in-depth research on all endangered, keystone, flagship, and umbrella species of wildlife and their habitats so as to develop long-term conservation strategies.

Till now, most of the wildlife research in the Biosphere Reserve centred around natural history and ecology of a few endangered and charismatic species/habitats. But the scope of research needs to be broadened considerably to encompass all marine life, their habitats, interaction with humans and the ecosystem processes at local as well as seascape levels, covering a wide range of themes including animal-habitat interactions to ecosystem functioning, evolutionary processes and molecular biology. The decade of the 1990s and 2000s also saw a steady increase in the number of institutions, both governmental and non-governmental, undertaking research in the Biosphere Reserve.

MoEFCC (2006) has prepared guidelines for conducting research on wildlife in PAs with a view to generate scientific knowledge, both for its own sake and in order to formulate conservation planning for the target species and ecosystems. A few well established Pas including Gulf of Mannar National Park, have identified priority areas of research. However, due to lack of adequate funding to execute research the Biosphere Reserve suffered a lot in the past. There was no information about lesser known fauna of the Biosphere Reserve even today. Efforts at long-term ecological monitoring was also minimal in the Biosphere Reserve.

The opportunities for marine research within the National Park and Biosphere Reserve are abundant, as seen by past research studies that have provided important baseline information about the area. The diversity of habitat types and communities provides a wealth of opportunities for conducting a variety of research programs. For example, the Biosphere Reserve provides a unique opportunity to engage in both shallow and deep- water marine research without extensive voyages offshore. Studies on the natural processes at the land-sea interface are also feasible due to the accessibility of extensive coastline. Finally, the marine research institutions within the area provide an exceptional resource to draw upon in furthering our understanding, and thus the management of, the Biosphere Reserve's marine resources.

Effective management of the GOMBR requires the inauguration of a research program that coordinates the existing research programs and addresses management issues. The proposed Research Advisory Committee of the GONBR provides a forum for discussion of research programs, addresses management issues, and disseminates research information as widely as possible.

Gulf of Mannar is endowed with a rich variety of marine organisms because the biosphere includes ecosystems such as coral reefs, rocky shores, sandy beaches, mud flats, estuaries, mangrove forests, seaweed stretches and seagrass beds. These ecosystems supports a wide variety of fauna and flora including rare cowries, cones, volutes, murices, whelks, strombids, chanks, tonnids, prawns, lobsters, pearl oysters, seahorses, sea cucumbers and dugong. Though the first observation on pearl banks of this region made in 1864, a large number of research programs in the 19th and first half of the 20th century have brought out inventory information on the variety of fauna and flora found in the Gulf of Mannar region. However, researches have carried out in the second half of 20th century have emphasized more on the fish and fisheries of this region. Some research on the environment of this region was carried out in the later part of the 20th century and at present. Regardless of the numerous paperss published on the Gulf of Mannar, emphasis was given to fish and fisheries related research activities and there is no detail information on the status, distribution pattern and ecology of several species and their habitats occur in this region, and also there is no detail study carried out to understand the resource availability and its utilization by the local communities, impact of present fishing activities on biodiversity as well as the future generations of local communities, which are essential for the biodiversity conservation as well as sustainable utilization of resources by the local dependent communities.

22.2 Objectives

The Gulf of Mannar Biosphere Reserve has a lot of opportunities for conduct of integrated research on various aspects of marine science in India. The success of the implementation of the Management Plan of the Marine National Park and the Biosphere Reserve can be studied by conducting a basic applied researches and biodiversity monitoring programs. And the success of the implementation of the Management Plan is also depends upon local participation of Biosphere Reserve Authority and other local populations, who need necessary training and education to carry out basic research and monitoring programs. Hence, this section is included in the Management Plan with following objectives:

a. Prioritization of applied research activities that are relevant for the Management of Biosphere Reserve.
b. Protocol for biodiversity monitoring
c. Human resource development towards basic research and monitoring on marine biodiversity
d. Guidelines to conduct research activities in the region

22.3 Strategies

In 2017, the Ministry of Environment, Forests and Climate Change, Government of India has launched it is 3rd National Wildlife Action Plan. In 2015, MoEFCC has released its 5th National Biodiversity Report and National Biodiversity Action Plan. All these three policy documents have recognized the importance of coastal and marine biodiversity conservation using all available latest scientific knowledge. The 3rd National Wildlife Action Plan of India has recommended the following actions for Marine Biosphere Reserve;

11. Establish a 'Coastal and Marine Ecosystem Cell' to strengthen the conservation and management of coastal and marine biodiversity in all coastal States and UTs.

12. Develop a common action plan for all coastal States and UTs integrating 'Climate Change Adaptation' (CCA) and 'Disaster Risk Reduction' (DRR) with shared responsibility into all sectors of governance and keeping the needs and aspirations of the local communities in focus.

13. Undertake 'Coastal and Marine Habitats Restoration Programme', especially for mangroves, coral reefs, seagrass beds, intertidal zone, sand dunes, lagoons, etc., so that livelihood opportunities of coastal communities are enhanced and they are also protected from impacts of various natural disasters and climate change.

14. Initiate programmes for long term studies and monitoring of threatened coastal and marine species, mitigation of human-marine species conflicts as well as rescue and rehabilitation of marine species.

15. Undertake cumulative and strategic impact assessments to harmonize development with conservation in the context of coastal and marine biodiversity.

16. Prepare guidelines for management of marine invasive species in India.

17. Expand the management intervention and protection to biodiversity rich areas outside the territorial waters but within the EEZ of India.

18. Establish a special centre for strengthening the knowledge management system of coastal and marine biodiversity and their conservation in India in coordination with a network of related organizations.

19. Ensure a 'clean coastal and marine environment in India' by preventing sea pollution including underwater noise.

20. Strengthen the field-based capacity to promote integrated and sustainable management of coastal and marine biodiversity. Training institutes should tailor their training curricula to meet needs of professionals of SFDs and all other Departments /Agencies at all levels of responsibilities to manage coastal and marine ecosystems.

22.4 Monitoring

Creation of research matrix and establishment of 'Marine Research and Monitoring Centre'

Although information on finfish fishery, shellfish fishery, aquaculture technique for certain species present in the region and seaweeds of this region are available in detail, there is a need to carry out various basic researches to understand the ecology of certain endemic and endangered species and habitats, which occur in the Gulf of Mannar. There is also a need to conduct various studies to monitor the socio-economic condition of local people who depend on bio-resources of this region, impact of fishing on the biodiversity, impact of present modern fishing practice on the traditional fisherman, sustainable utilization of marine resources, alternate livelihood options, impact of climate change and developmental projects on the biodiversity of the Gulf of Mannar, etc. Considering all these gap areas in the past research programs analyzed and recommended by various agencies such as;

1. MoEFCC, GoI – 3rd National Wildlife Action Plan
2. MoEFCC, GoI – 1987 documents on Biosphere guidelines,
3. Participatory workshop organized by GOMBRT-UNDP, January 2006,
4. National Workshop on Gaps and Prioritization of Marine Research in India organized by WII in 2010 (Sivakumar, et al., 2010)

A research matrix has been prepared for the better management of the biodiversity of this region without depriving the rights of people who have been dependent on these resources for a longer period.

Research Matrix:

A total of 45 research programs have been identified in seven thrust areas such as landscapes level, habitat level, species level, technology related, multidisciplinary and management related, ecological restoration, socio-economic and policy related studies. Gulf of Mannar Biosphere Reserve Trust can facilitate these programs as per its priority. Probable funding sources have been identified and also some research institutions have been suggested to carry out these studies. However, it is not necessary that these research programs only supported by these funding sources should be sought after, funds from other sources is also be explored. Same applies in the case of research institutions also.

Important thrust areas	**Priority I**	**Priority II**	**Priority III**	**Probable Funding Sources**	**Suggested Institutions**
Landscapes	a. Coral reef status assessment based on ground truthing. b. Status of Intertidal zone and its biodiversity. c. Identification and impact of invasive species in the region.	1. Estuaries and mangroves and its biodiversity including impact 2. Sand dune and sandy beaches and its biodiversity including impact. 3. Anthropogenic and developmental activities driven landuse changes and its impact on important habitats 4. Climate change and its possible	1. Land based fluvial origin and their impact.	MOEF (GOI), DOD(GOI), GCRM NETWORK, DBT, DST, CSIR, UGC, SACEP, IUCN, UNDP, TN GOVT, TERI, NPCB, TNPCB, ISRO, MPEDA, UNESCO MAB Program, UN Foundation, and others	ZSI, CASMB, CMFRI, WII, MKU, SACON, ANNA UNI, ANNAMALAI UNI, TFCRI, MADRAS UNI, SDMRI, ALAGAPPA, MANONMANIAN SUN UNI, BSI, FSI, MSSRF, BNHS, IERSE, MNS, ATREE, IISC, NCF,CSMCRI, Tata Institute of Social Science,

		impact entification and mapping of pollutant sources and its impact on the ecological processes and biodiversity using indicator species			GOMBRT, UNDP, CPREE, NIOT, NIO
Specific habitats	a. Seagrass beds including biomass and productivity, associated fauna assessment. b. Status of terrestrial island biodiversity	1. Mangroves 2. Estuaries and lagoons			
Specific Species	1. Status, distribution and ecology of Dugong. 2. Status, distribution and ecology of other cetacean 3. Status and stock assessme	1. Identification, status and biology of endemic marine fauna 2. Identification and status determination of endemic flora			

	nt of elasmobranches. 4. Status and ecology of breeding and non-breeding coral fishes.	3. Status, distribution pattern and ecology of exploitable mollusks, holothurians and echinoderms			
Technology	1. Documentation of kinds of fisheries practices and their impacts on habitat and species. 2. Development of silvicultural technology for endemic mangroves. 3. Development of propagation technology for endangered species and habitats	1. Impact of bottom trawling on coral reefs and seagrass beds. 2. By-catch assessment in different kinds of fisheries practices. 3. Pollution impact of ballast water release in the seascape.	1. Impact of other fishing technology on biodiversity		
Multidisciplinary & management related research	1. Economic valuation including ecological services of coral reefs. 2. Creation of baseline data on phsio-chemical,	1. Role of coral reefs, mangroves, sea grass beds and intertidal zones as breeding and nursery grounds of various fauna	1. Documentation of changes in the demographic profile in the region and their pressure in the		

	geological and climatological parameters including primary productivity (NIO) 3. Identification of indicator species for evaluation of efficacy of management intervention on ecosystems. 4. Identification and establishment of non-violate vegetation preservation plots and coral reef transects for longterm monitoring	(temporally as well as spatially). 2. Temporal and spatial distribution pattern of migratory fauna in the coastal and marine environment 3. Identification of foraging, breeding grounds of migratory fauna including determination of migratory path through use of advanced technology.	ecological setting		
Restoration ecology	1. Restoration of coral reefs 2. Restoration of mangroves with special reference to endemi	1. Restoration of seagrass beds. 2. Restoration of oyster beds 3. Restoration of turtles nesting beaches			

	cs				
Socio-economic	1. Determination of socio-economic dependency of user communities on coastal and marine resources versus other resources 2. Documentation, promotion and extension of eco-compatible alternate livelihood options. 3. Identification of various stakeholders and assessment of impact of their activities on the ecological resources	1. Gender issues involving resource use and management. 2. Development of empowerment mechanisms and models of community based institutions involvement in resource management			
Policy analysis research	1. The efficacy of International, National and State policy and legal instruments	Mechanism of networking various governmental, non-governmental and communities			

	in the resource management in GOMBR	based institutions in the participatory management.			

Research Framework

Overall, the Biosphere Reserve research program is intended to focus on broadening our scientific understanding of the Marine ecosystems and developing research programs that enhance understanding and provide management with the scientific information necessary to make informed decisions.

Long term research programmes

a. **Inventorization**: It is with a view to continuously carry out inventory of biotic and abiotic components of the Biosphere Reserve. Collection of information will be on meteorology, land use practice, distribution and status of endemic and threatened species using remote sensed satellite information supported by ground truthing. Coral reef status assessment based on ground truthing. Status of Intertidal zone and its biodiversity. Identification and impact of invasive species in the region. Estuaries and mangroves and its biodiversity including impact. Sand dune and sandy beaches and its biodiversity including and its impact. Land based fluvial origin and their impact. Anthropogenic and developmental activities driven land-use changes and its impact on important habitats. Climate change and its possible impact. Identification and mapping of pollutant sources and its impact on the ecological processes and biodiversity using indicator species. Seagrass beds including biomass and productivity, associated fauna assessment. Status of terrestrial island biodiversity, Mangroves, Estuaries and lagoons.

b. **Monitoring**: Effective management requires an understanding of long-term changes in the status of the resources and their environment. Long-term monitoring is a way to detect and document these changes in environmental quality, ecology, and human activity and determine if changes in management strategies are needed. The primary purpose of the monitoring program will be to detect change, determine its causes, whether natural or anthropogenic, and develop and evaluate management strategies. Overall, the monitoring program will assist in our understanding of the general health of the National Park. This program should include pollution monitoring studies and studies monitoring the population dynamics of species in all habitats within the Biosphere boundaries. Identified indicator species and critical habitats needs to be monitored to detect possible changes. Changes in the relative distribution of these species could indicate natural or anthropogenic threats to National Park resources. Monitoring the natural functions of the land and sea interface, as well as human interruptions of those functions, will contribute to increasing understanding of the relationships between ocean and terrestrial ecosystems. Results of the

monitoring program will be applicable to basic scientific research as well as academic, education and applied management goals.

Examples of environmental factors to be monitored include: (1) status and trends of contaminants in Biosphere Reserve; (2) environmental factors, such as wind, sea level, and temperature, collected by coastal stations, offshore data buoys, and satellites; (3) changes in the abundance over various life stages of invertebrates and fish and (4) fluctuations in the abundance of dugong, holothurians, whales, turtles and seabird species in the Biophere; (5) biological input of organics and fecal coliforms from pinnipeds;

Certain activities and their effects, both individually and cumulatively, should be monitored. These include: (l) commercial vessel traffic; (2) recreational activities; (3) commercial fishing and nature observation activity; (4) natural and anthropogenic (e.g., sand mining) erosion and sedimentation; (5) fishery/mammal-turtle interactions, such as the coincidental catch of whales, turtles and other mammals in fishing nets; (6) pesticide usage; (7) sewage discharge; (8) dredge spoil disposal; and (9) reoccurring road repair debris side-casting along the coast. Another important component of the monitoring program is the assessment of the effectiveness of management strategies. Once new management strategies have been put in place, usually in response to a detected change in the environment or use of the Biosphere Reserve, monitoring must continue to determine whether the management strategy is having the desired effect. In fact, in most cases, each new management strategy will require the design and implementation of specific monitoring activities to augment the long-term monitoring program envisioned by this plan.

Monitoring the status of corals, seagrass beds, coral reef fishes, terrestrial vegetation, other fish stock and physio-chemical prosperities of water, holothurians populations and dugong need to be monitored. If required, the Wildlife Institute of India will help the Authority to identify 'monitoring plots' in the Park for long term monitoring of above-mentioned biodiversity except the dugong, which need an aerial survey.

c. Status, distribution and ecology of Dugong. Status, distribution and ecology of other cetacean. Status and stock assessment of elasmobranches. Status and ecology of breeding and non-breeding coral fishes.

d. Identification, status and biology of endemic marine fauna. Identification and status determination of endemic flora. Status, distribution pattern and ecology of exploitable mollusks, holothurians and echinoderms.

e. Documentation of kinds of fisheries practices and their impacts on habitat and species. Development of silvicultural technology for endemic mangroves. Development of propagation technology for endangered species and habitats. Impact of bottom trawling on coral reefs and seagrass beds. By-catch assessment in different kinds of fisheries practices. Pollution

impact of ballast water release in the seascape. Impact of other fishing technology on biodiversity.

f. Economic valuation including ecological services of coral reefs. Creation of baseline data on phsio-chemical, geological and climatological parameters including primary productivity (NIO). Identification of indicator species for evaluation of efficacy of management intervention on ecosystems. Identification and establishment of non-violate vegetation preservation plots and coral reef transects for longterm monitoring.
g. Role of coral reefs, mangroves, sea grass beds and intertidal zones as breeding and nursery grounds of various fauna (temporally as well as spatially). Temporal and spatial distribution pattern of migratory fauna in the coastal and marine environment. Identification of foraging, breeding grounds of migratory fauna including determination of migratory path through use of advanced technology. Documentation of changes in the demographic profile in the region and their pressure in the ecological setting.

h. Restoration ecology: Restoration of coral reefs habitats. Restoration of mangroves with special reference to endemics. Restoration of seagrass beds. Stock enhancement of coral reef fishes. Stock enhancement of sea horses. Stock enhancement of holothurians. Stock enhancement of these animals will help the restoring the Gulf of Mannar marine biodiversity and also to the local communities who can later go for harvesting these resources in a sustainable manner.

i. Determination of socio-economic dependency of user communities on coastal and marine resources versus other resources. Documentation, promotion and extension of eco-compatible alternate livelihood options. Identification of various stakeholders and assessment of impact of their activities on the ecological resources.

j. Gender issues involving resource use and management. Development of empowerment mechanisms and models of community based institutions involvement in resource management.

k. The efficacy of International, National and State policy and legal instruments in the resource management in GOMBR. Mechanism of networking various governmental, non-governmental and communities based institutions in the participatory management.

l. **Modeling**: Three types of modeling activities; numerical simulations, ecosystem models, and statistical models; will be used to interpret data, guide field programs, test hypotheses, and to predict potential outcomes from proposed uses and thereby influence management decisions. Modeling efforts will be based on the information gathered from the baseline, monitoring and experimental studies. As more information is gathered in these endeavors the models will be continuously modified and refined. Modeling efforts can be used to analyze the causes and consequences of

ecosystem changes and predict the effects of new and more intense human activity in the area. Unlike the monitoring program, some of these studies may be predictive, short- term and directly targeted to an immediate management issue. Examples of modeling studies include: (1) determining and predicting the effects on sea turtles and marine mammals from boating activity; (2) predicting the flow of an inadvertent discharge (such as a fuel spill) into the Biosphere Reserve; (3) modeling the transport of sediment in the Biosphere; and (4) estimating the impact of the loss of kelp habitats on higher trophic levels. These types of models are useful for determining effective management strategies. Once strategies are in place, monitoring information will determine their effectiveness and be used to refine the model. .

***Short tem researches*:**

a. The Biosphere Reserve Authority under its research and monitoring programme should take up specific problems posed by the local population for research and should try to find out suitable solutions. These solutions will help attain higher standards of living and may provide avenues for gainful employment to local people. For example, a short term study on the Economic Impact Assessment on the impact of land use pattern changes along the sand dune habitat, etc.

In-house research and outsourced specialized research

Research and Monitoring Centre (RMC) was recommended by the previous Management Plan to take care of all inhouse biodiversity and ecological monitoring but due to lack of fund it was implemented in very shoddy manner. But, many research programs have been outsourced to regional institutions during this period. However, it is important to establish RMC for GoMBR, and RMC should personally involve largely on biodiversity monitoring programs and facilitate the other research institutions to carry out researches other than monitoring, if necessary, other institutions can also be involved in the monitoring programme. RMC should be linked to Tamil Nadu Advanced Institute for Wildlife Conservation at Chennai for data base management and coordination of all research activities. Research Officer who is from the strong research background of marine biology and his team members needs to be continuously sent for the refreshment courses either in India or outside India for updating their knowledge especially in monitoring the marine biodiversity of the Gulf of Mannar and its ecological services to the local communities. The focus of RMC of the Gulf of Mannar Biosphere Authority should not expect to conduct all kinds of marine research programs by its own. Authority can outsource certain research programs which are very important for the conservation of biodiversity and its dependent communities to various concerned research institutions mentioned in the Research Matrix or any other professional institutions.

Coordination, documentation and data base of research information and posting in web page

One of the important activities of the RMC of the Gulf of Mannar Biosphere Reserve Foundation is the coordination with all other research institutions, documentations of all the research findings and maintenance of data base, and sharing data base with outside world by posting its own web page 'www.gombra.com'.

Compiling research recommendation for implementation for management

RMC has to also compile all the research recommendations in a simple manner so that everyone could understand. RMC should take the responsibility of monitoring the success of the implementation of various research recommendations suggested by RMC to the Biosphere Foundation. RMC should also review the progress of the 'implementation program' by the Authority in every six months interval in its Research Advisory Committee meetings.

RMC Research personnel

Research Biologist: One Research Officer, Group A service (equalant to Scientist C) need to be appointed on deputation from the Universities, marine related research institutions for RMC. Deputation period should be three years time period and it may be extended up to two more years. Research Biologist should possess a Doctorate Degree in marine biology with good academic record supported by research publications. He/she should directly report to the Executive Director, Biosphere Foundation. Main role of the Research Officer is to coordinate and facilitate all research and monitoring activities in the Biosphere Reserve. Appointment of the Research Officer will be governed by the CSIR Scientific rules. RO should be provided with a four-wheel vehicle, motorboat and other necessary supporting staff and infrastructure.

Other research staff: As per the requirement of the RMC could hire the research personnel in the project mode, temporarily, preferably research scholars. These research scholars may be encouraged to pursue higher degree while working in the projects of RMC.

Field staff: As per the requirement of each project, field staff could be hired on the temporary basis. RMC should make sure that the majority of the field staff hired in the projects of RMC or others should be from the local communities preferably fishermen.

22.5 Capacity Building

Capacity building for in-house research and monitoring

RMC should regularly conduct the training programs in the field of coral monitoring using scuba diving, monitoring other marine habitats and species of the coastal and marine biodiversity, management of marine

protected area etc. Field staff of RMC should be trained regularly so that they will facilitate various research programs in this region. RMC should seek the help of best resource persons available in India and abroad for its training programs. Expenditure of such training programs may be taken care by the Ministry of Environment and Forests, Government of India, Department of Environment and Forests, Government of Tamil Nadu, and other International and National donor agencies.

Further, officers and frontline staff of the Biosphere Reserve required to be trained regularly on marine biodiversity monitoring and management in India as well as in abroad to get the best scientific skills to manage the Gulf of Mannar Biosphere Reserve more efficiently.

Community involvement in research and monitoring

As mentioned earlier, RMC should make all the efforts to appoint local people as field staff of all the projects, which could send the message to the local communities that they are also part of all the activities of the Biosphere Reserve Foundation. All the research activities of the RMC should be made aware to local communities. Findings of all the research activities, which are related to local communities, need to be shared with them.

Annual research seminar

Biosphere Reserve Foundation will conduct an annual research seminar for presentation and review of research activities undertaken by all organizations and individuals. All the members of Research Advisory Committee are expected to participate in this two day seminar. Only during the ARS the new proposals by any organizations including RMC of the Authority needs to be reviewed and approved. All externally funded research proposals which have already been peer reviewed by the funding agencies are to be ratified with the condition that they must make a presentation on their research progress and must provide annual and final completion report copies to the Biosphere Reserve Foundation research and documentation centre and data base. Tamil Nadu Advanced Institute for Wildlife Conservation and the Gulf of Mannar Biosphere Reserve Foundation jointly can organize this ARS.

Establishing a Learning Centre.

Establishment of a Research and Monitoring Centre (RMC)
Research and Monitoring Centre of the Gulf of Mannar Biosphere Reserve needs to be set up with an aim to:

1. Coordinating all research programs of Biosphere Reserve with the Advanced Institute of Wildlife Conservation, Tamil Nadu.
2. Compile existing data to describe the resources and provide baseline information;

3. Encourage continual information exchange among the organizations and agencies undertaking research and making decisions that affect the Biosphere Reserve;
4. Establish a framework and procedures for administering a research program to ensure that projects are responsive to management concerns and that research results contribute to improved management of the National Park;
5. Encourage multidisciplinary studies that integrate research efforts in the coastal, estuarine, near shore, open ocean, and deep sea ecosystems;
6. Coordinate data collection on the physical, chemical, geological and biological resources and processes of the Biosphere Reserve, to target specific information needs and avoid duplication;
7. Initiate a monitoring program to assess environmental changes due to natural and human processes;
8. Identify the range of effects on the environment that would result from proposed or predicted changes in human activity or natural phenomena;
9. Incorporate research results into an Interpretive Education Program in a format useful for the general public; and
10. Evaluate the effectiveness and efficiency of the research program and its integration with resource protection and education objectives.

RMC in the Gulf of Mannar Biosphere could form a vital component of the Biosphere research activities. RMC should not be an additional institute but it could facilitate all the local and national institutions especially with AWIC of Tamil Nadu, to carry out identified research activities in this region by offering instituitional facilities with scientific environment to researchers. RMC is also expected to have a joint collaboration with the National Institute for Coastal and Marine Biodiversity. This research centre could be established either at **Keelakarai** or at the proposed 'Interpretation Centre (Mandapam)', where the **Research Biologist** of the Gulf of Mannar Biosphere Reserve will be stationed. Keelakarai, being located in centre, would be an ideal location for RMC as several research institutions located in Tuticorin as well as Mandapam. This research centre should have the research and monitoring facilities such as research boat, scuba diving equipment, GIS cell, GPS, marine lab, underwater photography equipment, and other marine research related gear and crafts. All the staff working in this centre needs to be trained to conduct basic marine research and monitoring programs. RMC will also coordinating with all other four island based monitoring stations which need to be established in four island groups such as Tuticorin, Vembar, Keelaikarai and Mandapam. These Islands based monitoring stations need to be established at island with minimum infrastructure facilities so that researchers could stay there for a shorter period and carry out research or monitoring activities. Same research stations can also used for protection purposes.

Research Advisory Committee

- Chief Wildlife Warden, Tamil Nadu - Chairman
- Executive Director, GOMBRF - Member Secretary
- Director, AIWC, Tamil Nadu - Member
- VC/Director or his Representative of Anna University, - Member
    - MKU, CASMS
- IGF (WL) or his representative from MoEFCC, GOI - Member
- Director or his representative, WII - Member
- Director or his representative, SACON - Member
- National NGOs – BNHS & SDMRI - Member
- Director, Core Zone and Buffer Zone, GoMBR - Member
- Wildlife Warden, Marine National Park - Member
- Director, Pollution Control Board, Tamil Nadu - Member
- Director, Fisheries Department, Tamil Nadu - Member
- Director, Department of Environment, Tamil Nadu - Member
- Three more special invitee by the Chairman - Member

Liaison and linkages with funding sources

Based on the various research being carried out in the Gulf of Mannar region by various agencies through external funding sources, the Biosphere Reserve Authority should compile the details of all the funding agencies and share with them the Biosphere Reserve research thrust areas and the research matrix. This will help the Authority to facilitate the research programs with various funding agencies as well as research organizations.

Guidelines for research in the Gulf of Mannar Biosphere Reserve

All the research proposals to be funded by the Gulf of Mannar Biosphere Authority are to be submitted to the RMC of the Biosphere Reserve Authority, in turn, the RAC of the Authority will review the proposals and give its comments to the Investigator(s) or his/her institutions.

Other externally funded project proposals, which have already been reviewed by the funding agencies peer reviewers, are to follow the normal procedures. However, the Gulf of Mannar Biosphere Reserve based on their research matrix priority will facilitate the permission process and maintain the information in their data base, so that repetition of such proposals in the same region will not take place.

Funded project proposals with comments of RAC need to be submitted to the Chief Wildlife Warden, Government of India for permission to work in the Biosphere Reserve. A copy of the letter along with proposal need to be sent to the Director, Gulf of Mannar Biosphere Reserve Authority. The Chief Wildlife Warden is expected to give his/her reply within three months time period from the day of receiving the proposal.

Any project proposals that involves the handling of Schedule I species of the Wildlife Protection Act, 1972 is required to get the permission of the

Additional Director General of Forests (Wildlife), MoEF, Government of India. The Additional Director General of Forests (Wildlife) is expected to give his/her reply within three months time period.

Investigator(s) of the project should work with RMC of the Authority, however, it does not mean that the Authority should directly involve/interfere in the project activities.
Investigator(s) of the project should submit the Annual report every year. Failure to submit the report, will lead to cancellation of permission by the Authority.

Investigator(s) of the project should give presentation of their annual findings in the Annual Research Seminar of the Authority, where the project activities will be reviewed.

Final report of the each project completed in the region needs to be submitted to the Data base of the Authority and the Chief Wildlife Warden within six month period. As per the guidelines issued by the Ministry of Environment and Forests, Government of India, a soft copy of the report needs to be submitted to the Wildlife Institute of India with data, in turn, WII will keep this document available in online so that other users could be benefited.

Summary prescriptions for research, monitoring and training programme of the GoNP

1. Major objectives of this chapter are prioritization of research activities in the region, recommend user friendly protocol for biodiversity monitoring, human resource development towards basic research and monitoring on marine biodiversity and Guidelines to conduct research activities in the region.
2. A total of 45 research programs have been identified in seven thrust areas such as landscapes level, habitat level, species level, technology related, multidisciplinary and management related, ecological restoration, socio-economic and policy related studies. Gulf of Mannar Biosphere Reserve Trust can facilitate these programs as per its priority.
3. Research and Monitoring Center (RMC) of the Gulf of Mannar Biosphere Reserve needs to be set up with aimed to;

    a. Compile existing data to describe the resources and provide baseline information;
    b. Encourage continual information exchange among the organizations and agencies undertaking research and making decisions that affect the Biosphere Reserve;
    c. Establish a framework and procedures for administering a research program to ensure that projects are responsive to management concerns and that research results contribute to improved management of the National Park;
    d. Encourage multidisciplinary studies that integrate research efforts in the coastal, estuarine, near shore, open ocean, and deep sea ecosystems;
    e. Coordinate data collection on the physical, chemical, geological and biological resources and processes of the Biosphere Reserve, to target specific information needs and avoid duplication;
    f. Initiate a monitoring program to assess environmental changes due to natural and human processes;
    g. Identify the range of effects on the environment that would result from proposed or predicted changes in human activity or natural phenomena;
    h. Incorporate research results into an Interpretive Education Program in a format useful for the general public; and
    i. Evaluate the effectiveness and efficiency of the research program and its integration with resource protection and education objectives.

4. RMC needs to be established at Keelakarai. A Research Biologist can head this center. RMC will function as per the guidance of the **Research Advisory Committee** of the Gulf of Mannar Biosphere Reserve Authority.
5. A detail long term and short term research activities have been identified which needs to be carried out as per the priority.

6. In-house research programmes such as monitoring the habitats/species can be taken up by RMC with the help of professional institutions.
7. Basic research programmes need to be outsourced but it should be facilitated by the Authority through RMC.
8. RMC should help to develop the human resources in the field of 'Management of Marine Protected Areas and its biodiversity'.
9. Higher level of community participation is recommended in all the research programmes as per the prescribed above.
10. Guidelines for research activities in the Gulf of Mannar Biosphere Reserve need to be strictly implemented.
11. Annual Seminar for research and other activities of the Authority in the Biosphere Reserve need to be conducted in every year which should be chaired by the Chairman of the RAC. All the ongoing research and management activities should be reviewed critically in this seminar for carrying further, if required.

Chapter 23
Activities and Budget (Rupees in Lakhs)

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
I	**ZONATION**											
	Zonation & boundary demarcation	50	250									300
	Demarcation of 'Tourism Zone inside the National Park i.e. Kurusadai Island' by colour buoys		50									50
	Identification of 'Critical Wildlife Habitat' and protection of the CWH		10	5	5	5	5	5	5	5	5	50
II	NATIONAL PARK											
1	**Administration. Protection& Infrastructure development**											
	Recruitment of proposed staff (with communication and motorboat systems) to enhance the protection measures	30	100	30	33	33	33	36	36	36	39	406
	Establishment of necessary infrastructure facilities (building, vehicle etc)	2	20	20	5	5	2	2	2	2	2	62
	Procurement faster and bigger sea going vessels with communication systems, arms and first aid kits for patrolling as well as for rescue operation	500	20	20	20	20	20	20	20	20	20	680
	Replacement of old boats				10	35	5	5	5.5	5.5	6	72
	Procurement of patrolling vehicles as well as smaller vessels (speed boat) to each Range		50	10	10	11	11	12	12	13	13	142

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	Creation of a Patrolling Hut at each island in first two years and then maintenance cost	50	50	5	5	6	6	7	7	8	8	152
	Field equipments at Patrolling Huts including a small motor boat, walkie talky, binocular,GPS, spot light, life jacket, camping gear etc		10	10	2	2	2.5	2.5	25	3	3.5	60.5
	Creation of a 'Anti-poaching Squad proposed as Pilot Marine Patrolling and Policing Unit' consisting of Ex-Indian Navy and Coast Guard Personnel on outsource basis, including maintenance of data base on offenders	4	5	5.5	6	6.5	7	7.5	8	8.5	9	67
	Restoration of Habitat											
2	**Coral reefs**											
	Vigilance, Protection and Monitoring of coral habitats through Anti-poaching Watchers from nearby villagers		15	15	16	16	17	17	18	18	19	151
	Identification of reefs outside the national park based on satellite data and ground trothing to be designated and multiple use area		5	5	5	5	5	5	5	5	5	45
	Marking permanent monitoring plots for in house monitoring		5									5
	Regular monitoring of permanent plots in all fringing reefs and patch reefs, preferably during Jan - March		5	5	5	5	5	5	5	5	5	45
	A regular out-sourced monitoring		5						5			10

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	project should be taken up for monitoring broad scale threats such as pollutionand for detailed mapping and diversity studies of corals											
	Scaling up of coral rehabilitation activity and regular maintenance and monitoring		200	200	5	5	5	5	5	5	5	435
	Development of artificial reef sites outside the Marine National Park Area for biodiversity enhancement		100	5	5	5	5	100	5	5	5	235
	Monitoring of permanent plots every year,the GOMBRT and GOMMNP management requires to monitor plots in all fringing reefs and patch reefs around the islands through in-house monitoring (preferably during Jan – March).		5	5	6	6	7	7	8	8	9	61
	Co-ordinate and collate information into an open data database at the GOMBR research and monitoring laboratory					50					75	125
	Encourage and facilitate scientific research and monitoring of specific taxon, events and status by professional scientific agencies with their data being documented within the GOMBR database		10			10			10			30
	Restoration of corals using											

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	prescribed methodology in identified seascape											
3	**Sea grasses Habitat**											
	Long term monitoring of sea grass status in the identified sampling points using remote sensing technology		30		30		40		40		50	190
	Awareness programme in the catchment area regarding seawage & solid waste management, excessive use of pesticide and other chemicals and its impact on marine habitat		5	5	8	8	10	10	12	12	14	84
	Marking of permanent sampling plots for long-term monitoring of sea grasses											
	Restoration of degraded sea grass habitat (target 20 sq.km)				20	20	60	50	70	60	40	320
4	**Mangrove Habitat**											
	Long-term research and monitoring studies of mangrove ecosystem with reference to EBSA parameters		10	5	5	5	5	5	5	10	5	55
	Documentation of traditional knowledge and practices		5									5
	Association with national institutions to predict and deal with climate change											
	Mapping of degraded locations across national park and reserve		10									10
	Plantation of intertidal mudflats with suitable mangrove species	1	2	2	1	1	1	1	2	2	1	14
	Natural-cum-assisted restoration of	6	7.5	8.5	9.5	11	2	2	2	2	2	52.5

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	mangrove habitat as prescribed in the Management Plan											
	Monitoring of mangroves in the National Parks											
	Mangrove Restoration Effort Journal, on the lines of forestry plantation journal needs to be maintained	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5
	Maintenance of mangrove plantation		1.5	2.5	3	3.5	4	4.5	5	5.5	6	35.5
5	**Species recovery programme**											
	Recovery of Dugong	1500 (All the recovery programs should be outsourced to professional institutions on the basis of their Species Recovery Plan Proposals after strict review process)										1500
	Recovery of Sea turtle											
	Recovery of Holothurian											
	Recovery of Sea horse and pipefishes											
	Stock enhancement of lobsters											
	Stock enhancement of economically important crabs											
	Monitoring and recovery of sea snakes											
	Monitoring of Coastal Birds											
6	**Research and Monitoring**											
	Formation of Research Advisory Committee of the GONBR		1						1			2
	Establishment of a Research and Monitoring Centre (RMC) at Mandampam or Keelakarai with all logistic facilities including laboratories, mini-aquarium, vehicle, boats, diving equipment etc	200	500	500	50	60	70	80	90	100	110	1780

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	Coordination, documentation and data base of research information, and dissemination of information				10	10	10	10	10	10	10	70
	Establishment of library with books, scientific journals with necessary furniture	5	5	1	1	1	1	1	1	1	1	18
	Recruitment of RMC Research personnel on deputation or temporary basis	20	22	24	26	28	30	33	36	39	41	299
	Participatory capacity building including local community for in-house research and monitoring	10	11	12	13	14	15	16	17	18	19	145
	Annual research seminar	5	5	6	6	7	7	8	8	9	9	70
	Support to research activities	5	5	5	5	5	5	5	5	5	5	50
II	**BIOSPHERE RESERVE**											
1	**Administration, infrastructure and protection**											
	Establishment of proposed GOMBR Foundation											
	Delineation of Biosphere Reserve geographic area on land with hoardings	30		15		15		15		15		90
	Recruitment of newly proposed staff	240										240
	Establishment of infrastructure for all newly appointed Group A service personnel such as Office, residency quarter, vehicle, driver, furniture etc.	100	10	10	12	12	14	14	16	16	18	222
2	**Management of Pollution**											
	A policy level decision to ban untreated industrial pollutants and sewage release into the Gulf of Mannar Biosphere											

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	Reserve											
	Review of Environmental Management Plan (EMP) of all industries in the region by the State Pollution Control Board and the GoMBRA.											
	Identification of highly causative polluting industries in the region and necessary actions required for developing Environmental Management Plan for review and implementation. This needs to be taken up with the State Pollution Control Board – outsource to professional institution	20					20					20
	Preparation of an 'ecological hotspots and fragile heritage' maps along the coast of Gulf of Mannar Biosphere Reserve using the information provided in the Management Plan and to suggest a) no industry zone and b) permitted kind of industry zone – outsource to professional institution	20					20					40
	Hasten the development of regulations for discharge of industrial effluents into the coastal waters with the help of the State Pollution Control Board											
	Plantation around polluted saltpans for desalination: *Salicornia sp.,/Avicenia sp*. may be considered	5	5	5	5	5	5	5	5	5	5	50

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	for this purpose											
	Monitoring of shell craft industries and aquaculture farms with respect to pollution											
	Licensing and permissive system is essential to all fishermen and eliminate subsidies that encourage over fishing											
	A detailed assessment of potential adverse ecological effects and carrying capacity of aquaculture farms and of the ecosystem into which the effluents are discharged are to be assessed.		20									20
	Monitoring of pollution by RMC with TNPCB		5			5			5			15
	An integrated EIA within pollution hotspot areas to control coastal pollution		15									15
	Raising of public awareness of importance of coastal region and threats	1	1	1	1	1	1	1	1	1	1	10
	A review of pollution created by ships		5									5
	Development of Pollution		10									10

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	Abatement Plan for this region											
	Restoration of habitats											
3	**Sea grasses habitat**											
	Mapping of sea grass beds with the information on status of each species in the Biosphere Reserve is needs to be prepared using latest satellite imageries	15										15
	Check on pollution											
	Extension of the present sea grass distributional limit to the historical distributional limit											
	Awareness programme in the catchment area regarding the excessive use of chemicals and its impact											10
	Marking of permanent monitoring plots in different islands											5
	Restoration and monitoring of sea grass habitats in the BR					20	20	5	5	5	5	60
4	**Mangrove Habitats**											
	Natural-cum-assisted restoration of mangrove habitat as prescribed in the Management Plan	300										300
	Monitoring and maintenance of mangrove sites after restoration	4	4	4	5	5	5	6	6	6	7	52
5	**Species Recovery Programme**											
	Recovery of dugongs in the Gulf of Mannar Biosphere Reserve	500 (Outsource to professional institutions and State Fisheries Department										500

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	Recovery of sea turtle in the Gulf of Mannar	whenever required)										
	Stock enhancement of economically important species											
6	**Conservation of protected Sharks**											
	Documentation of current fishing grounds on a spatio-temporal basis with respect to shark resources (may be done by participatory approach)	10						10				20
	Data sharing between fishers and government research/implementation agencies											
	Mandatory reporting of occurrences to monitoring agencies		2				2			2		6
	Shark Eco-tourism											
	Mitigation of habitat degradation impact											
	Awareness campaign to educate fishers and locals about vulnerable shark resources											5
	Continuous monitoring of shark occurrences and landings											10
7	**Management of Molluscan Diversity in Biosphere Reserve**											
	Inventorization of molluscan diversity with reference to pollution and economic importance											10
	Mapping and monitoring of all critical molluscan beds											10
	Patrolling on critical molluscan beds											

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	Enforcement of necessary laws by the wildlife/forest officials, along with educational and awareness programmes and also promoting alternate resource of livelihood											
8	**Invasive species**											
	Eradication of *P. juliflora*	5	5	5	5	5	5	5	5	5	5	50
	Eradication of *Kappaphycus alvarezii*	4	4	4	4	4	4	4	4	4	4	40
	Database on AIS for planning and executing programmes on management of invasives in islands	2			3			4				9
	Preventing the introduction of alien invasive species											
9	**Integrated and Sustainable Management of fisheries**											
	Necessary resource management and conservation initiatives											5
	Minimizing Communication gap between primary stakeholders (fishers) and Biosphere Reserve Authority along with inter-institutional collaborative management programme											5
	Mapping of critical fish breeding distribution area											5
	Awareness programs should be organized for minimizing catch of juveniles and other bycatch											5

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	Development of appropriate gear and craft to minimize bycatch and damage to benthos with the help of CIFT, Kochi											25
	Enforcement of closed season o important breeding grounds											10
	Ranching of suitable candidate fishes needed for stock enhancement											100
	Establishment of alternative livelihood opportunities											100
	Promoting research on the environmental and social impacts of fishing nets and their impacts on biodiversity and Biosphere Reserve fishing communities.											50
10	**Rescue and Rehabilitation of Marine Animals**											
	Establishment of a Marine Animal Rescue and Rehabilitation Facility (MMRRF) at Mandapam in collaboration with CMFRI											400
	Training for Frontline staff and veterinarians on Rescue and Rehabilitation of marine megafauna											50
11	**Climate Change**											
	Monitoring and regulating activities in the national park and											25

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	biosphere reserve to ensure no alteration or dilution is carried out on existing zone of influence											
	Maintenance of mangrove plant nursery and strengthening people participation											
	Promoting drought resistant crops											
	Strategies to build ecosystem resilience											
	Ecosystem based approach to enhance ecosystem resilience and align conservation, development and poverty alleviation interests by involving local communities											
	Ecosystem-based adaptation strategies to minimise anthropogenic stresses											
	Integrating ecosystem based adaptation initiatives											
	Capacity building of managers to help in building ecosystem resilience											5
	Establishing effective communication system to aid in the Adaptation Strategy											5
12	**Interpretation, education, eco-tourism and visitors management**											
	Establishment of State of the Art Marine	400	10	10	20	20	25	25	30	30	35	605

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	Conservation Interpretation cum Education Center(MARCONI) with all necessary facilities mentioned in the Management Plan											
	Establishment of five information centers	100	5	5	5	5	5	7	7	7	7	153
	Establishment of Kurusadai Island as an Eco-tourism zone inside the Marine National Park with all necessary facilities mentioned in the Management Plan											
	Establishment of World Class State of Art Aquarium in the RameswaramIsland perhaps in Pamban	10000 (through BOT mode)										
	Necessary infrastructure development to facilitate and enhance the eco-tourism	310	20	20	30	30	35	35	40	40	45	605
	Human resources and capacity building and guide training	25	25					15				65
13	**Eco-development**											
	Establishment of Eco-development zone in the Tirunelveli and Kanyakumari Districts	25	25	25	25	25	25	25	25	25	25	250
	Preparation of village marine conservation plans through PRA and utilizing local NGOs	30										30
	Improved strategy for formation of EDC villages											
	Promoting community based seaweed culture using native species	90 (through revolving fund credit)										100
	Promoting Alternative livelihoods as suggested in the Management Plan	500 (through revolving fund credit)										500

Chapters/ section No.	Activity	Year I	Year II	Year III	Year IV	Year V	Year VI	Year VII	Year VIII	Year IX	Year X	Budget
	Involvement of community in Eco-tourism activities as a guides, SCUBA divers, boatmen, etc.											10
	Institutional mechanism for evaluation of eco-development program and activities at regular intervals including auditing	2	2	2	2	2	2	2	2	2	2	20
	Capacity building of EDCs											
14	**Disaster Management**											
	Setting up of Disaster Management Cell											
	Establishment of infrastructure, capacity building, training and preparedness as suggested in the Management Plan											10
	Setting up of 'Search and Rescue Teams' in the Biosphere											10
15	**Policy, Administration, evaluation and review**											
	Establishment of Gulf of Mannar Biosphere Reserve Foundation											
	Establishment of Necessary infrastructure facilities at Madurai for the Foundation	100	20	20	20	25	25	25	30	30	30	325
	Implementation of Policy level reforms as suggested in the Management Plan											
	Establishment of Management Plan Implementation and review committee											5
	TOTAL (excluding 5000 lakhs for proposed Aquarium on BOT mode)	Rupees thirteen thousand two hundred and five lakhs										13205

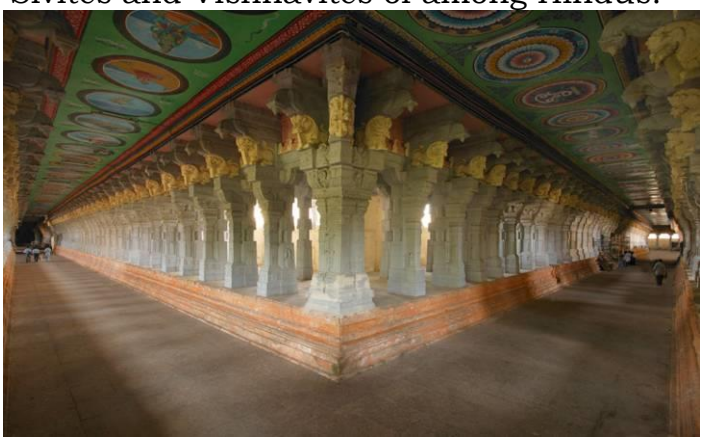
ANNEXURE I

TOURISM RESOURCES IN AND AROUND THE GULF OF MANNAR BIOSPHERE RESERVE

RAMNAD
RELIGIOUS TOURISM

RMD/Rel/1:

RAMANATHASWAMY TEMPLE: Ramanathaswamy temple here attracts both Sivites and Vishnavites of among Hindus.



Season: People visit this place through out the year. The main festival is during Pongal, in January every year. Visitation also peaks during April and May.

Other Attractions:

Gandhamathana Parvatam: Foot prints of Lord Rama can be seen in this temple. It is believed that, it was from this place, where Lord Rama stood and selected a suitable place for construction of Sethu bridge.

***

RMD/Rel/2:

KODANDA RAMAN TEMPLE: Situated on the way to Danushkodi at a distance of 30km from Rameswaram. It is believed that, Vibhishana, the younger brother of Ravanasura was enthroned here by Lakshmana.

Accessibility: Rameswaram is an Island situated on the north eastern side of the Gulf of Mannar. Nearest town is Ramanathapuram (58km).
Airport: Nearest airport is at Madurai (168km). Daily flights by Indian Airlines and Jet Airways comes here from Mumbai and Chennai.
Railhead: Trains come daily from Chennai and Madurai to Ramnad and Rameswaram. Railway is now being upgraded to the broad gauge and hence, trains aren't available now.
Bus Station: Regular bus service from all over the state is available to Ramnad and Rameswaram.

***

RMD/Rel/3:
DARBHASAYANAM: The Vishnu Temple here is dedicated to Lord Adi Jaganathaperumal.
Accessibility: It is 64 KMs from Rameswaram on the way to Sethukkarai.

***

RMD/Rel/4:

SETHUKKARAI: A place of mythical importance, *Sethukkarai* (meaning the Sethu Coast) is an important pilgrim centre having religious significance owing to the belief that Lord Rama is said to have constructed a bridge from here over the sea waters to reach Sri Lanka. It is a hallowed place for Hindus as they conduct their religious rites in this place.

Accessibility: It is situated at a distance of about 68 kilometers from Rameswaram

Airport: Nearest airport is at Madurai (110km from Ramnad). Daily flights by Indian Airlines and Jet Airways comes here from Mumbai and Chennai.

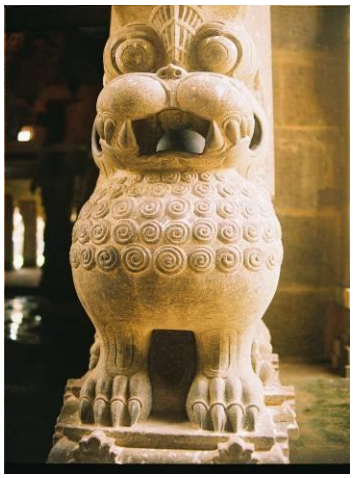
Rail head: Nearest Railway station is Ramanathapuram.

Bus Station: Regular bus service is available from Ramanathapuram.

***

RMD/Rel/5:

UTHIRAKOSAMANGAI: There is an ancient Siva temple, where the presiding deity, Lord Nataraja is carved in Emerald. This emerald idol is kept encapsulated in a paste of sandal wood to protect it from cosmic radiation, which is revealed only during special worships.



The temple s architecture is really breath taking. A chain to hang bell and its main slab was carved out of a single stone. Surrounding the chain, the supporting slab was carved with 12 sun signs. Uniqueness to this temple is a lion s statue, having a stone sphere in its mouth, which is also carved out of a single stone.

Season: Annual 'Arudhra' festival in December attracts a large number of devotees.

Accessibility: this village is situated at a distance of 20km from Ramnad.

Airport: Nearest airport is at Madurai (110km from Ramnad). Daily flights by Indian Airlines and Jet Airways comes here from Mumbai and Chennai.

Rail head: Nearest Railway station is Ramanathapuram.

Bus Station: Regular bus service is available from Ramanathapuram.

***

RMD/Rel/6:

NAVABHASHANAM: A coastal village is also known as Navashabashanam.It is believed that Lord Rama worshipped Navagraha here. The temple near by here is dedicated to Devi, who is said to have killed the demon Mahishasura at this spot. Hindus perform religious rites for their forefathers here.

Season: Most of the pilgrims coming to Rameswaram will be visiting this place also. So, the visitation to this place follows the trend occurring in Rameswaram

Other attractions:

A temple of Sri Adi Jegannatha Perumal situated near the Navabhashanam where, it is believed that Lord Rama has worshipped the Perumal is also famous at this place.

Possibilities of Ecotourism:

The Mangrove swamp present beside the temple can be allowed to be viewed. Being an important area for birds to nest and breed during the season, it has a potential to attract a good number of bird watchers.

Board-walk method can be adopted in the swamp and a watch tower can be built at this swamp for nature lovers.

Accessibility: This is a coastal village situated northeastern side of Ramanathapuram at a distance of 30km.
Airport: Nearest airport is at Madurai (110km from Ramnad). Daily flights by Indian Airlines and Jet Airways comes here from Mumbai and Chennai.
Rail head: Nearest Railway station is Ramanathapuram.
Bus Station: Regular bus service is available from Ramanathapuram, Madurai and Trichy.

***

RMD/Rel/7:
NAINAR KOVIL: This village named after the temple Nainar Kovil, is situated at a distance of 30KM from Ramnad on the Ramnad-Sivaganga State high way. Lord Siva is the main deity here. There's an interesting story behind this temple s name. Once, a dumb girl was gifted with speech by Lord Siva who was pleased by her worship. The first word to come out of her mouth was *Nainar*. One more thing which keeps this temple so unique is its architecture. A chain to hang bell along with the main slab was carved out of a single stone. Sivaratri is the main festival for this temple. This temple is one among the five holy lingams, *Pancha Lingam* .

Accessibility: This village is situated on the northwestern side of Ramanathapuram at a distance of 30km.

Airport: Nearest airport is at Madurai (110km from Ramnad). Daily flights by Indian Airlines and Jet Airways comes here from Mumbai and Chennai.
Rail head: Nearest Railway station is Ramanathapuram.
Bus Station: Regular bus service is available from Ramanathapuram.

***

RMD/Rel/8:
ORIYUR: Oriyur is one of the most revered pilgrim centers for Christians the world over as it is home to the martyrdom of St. John De Britto, a Portugese Jesuit better known as Arul Anandar . It was in this place that the saint was beheaded in 1693 and the sand dune is said to have turned red, believed to be stained by the blood of the saint. Here, one can see a magnificent shrine with its Portugese façade that contains a captivating statue of Arul Anandar offering his neck in humble submission to the executioner.

Season: Devotees from other dioceses and districts visit the shrine on specific dates. In February they come from Dindigul, while in June, they hail from Karunguli and Nagapattinam. During September more than 25,000 pilgrims visit this shrine and offer prayers and offerings. In October another 25,000 pilgrims arrive from the neighboring Sivagangai district and in December pilgrims from Madurai and Melur visit the shrine. Throughout the year, thousands of pilgrims from Sakthikulangara the only parish in Kerala dedicated to the St. John De Britto come to seek blessings. This is also a favorite place for foreign tourists. Thus, the tourist potential is tremendous and perennial that can be exploited to the maximum extent possible.

Accessibility:
Airport: Nearest airport is at Madurai (110km from Ramnad). Daily flights by Indian Airlines and Jet Airways comes here from Mumbai and Chennai.
Rail head: Nearest Railway station is Ramanathapuram.
Bus Station: Regular bus service is available from Ramanathapuram.

***

RMD/Rel/9:
EARWADI DARGHA: The tomb of Sultan Ibrahim Syed Aulia, who came from Arabia *via* Cannanore, is about 800 years old. Pilgrims from far off countries like Srilanka, Malaysia and Singapore visit this tomb.

Season: Santhanakoodu Festival is celebrated in February—March attracts thousands of pilgrims.
Possibilities of Ecotourism:
The landing centre and boat building yard at Earwadi landing centre can be converted into a place of experience tourism for visitors.

Accessability: this coastal village is situated at a distance of 30km from Ramnad on the Ramnad – Tuticorin road.
Airport: Nearest airport is at Madurai (110km from Ramnad). Daily flights by Indian Airlines and Jet Airways comes here from Mumbai and Chennai.
Rail head: nearest railway station is Ramnad.
Bus Station: This place is well connected by road with Tuticorin, Ramnad, Madurai and even Chennai.

HERITAGE/HISTORICAL TOURISM

RMD/HH/1:

DANUSHKODI: This is a fishing village situated on the northeastern tip of the Rameswaram Island, 40km from Rameswaram. Ruins of Church and other government buildings constructed during the British rule present here can be of archaeological value. The marsh here also harbors different migratory birds coming from Europe and Australia during October to January every year.

Possibilities of Ecotourism:

- A bird watching centre, with some basic infra structure like a watchtower and an interpretation centre can be established in Danushkodi.
- The ruins of old buildings can be declared as heritage site, which can attract a good number of tourists.
- A water sports complex like water skiing, speed boating etc., can be established in Danushkodi.
- Eco-friendly resorts along the Danushkodi beach can also be built with the involvement of local communities.

***

RMD/HH/2:

SETHUPATHY RAJA PALACE: In the early 15th Century the present territories of Ramanathapuram district comprising of taluks Tiruvadanai, Paramakudi, Kamuthi, Mudukulathur,

Ramanathapuram and Rameswaram were included in Pandiyan Kingdom. For a short period, this area was under the Chola Kings when Rajendra Chola brought it under his territory in 1063 AD. In 1520 AD., the Nayaks of Vijayangar took over this area under their control from the Pandiyan dynasty for about two centuries, Marava chieftains-Sethupathis who were Lords under Pandiyan Kings and reigned over this part (17th century). At the beginning of the 18th century, family disputes over succession resulted in the division of Ramanathapuram. With the help of the King of Thanjavur in 1730 A.D. one of the chieftains deposed Sethupathy and became the Raja of Sivaganga. Acting upon the weakness of the Nayak rules, the local chieftains (Palayakarars) became independent. Raja of Sivagangai, Sethupathy of Ramanathapuram was prominent among them. In 173(date wrong), Chand, a Sahib of Carnatic, captured Ramanathapuram. In 1741, the area came under the control of the Marattas and then under the Nizam in 1744 AD, Nawab's rule made displeasure in the mind of those chieftains. That made them declare the last Nayak as ruler of Pandiya Mandalam against the Nawab in 1752 AD. By that time, throne of Carnatic had two rivals, Shanda Sahib and Mohamed Ali, and this district was part of Carnatic. The British and French supported Chanda Sahib and Mohamed Ali respectively. It paved the way for series of conflicts in the southern part of the continent.

In 1795, the British deposed Muthuramalinga Sethupathy and took control of the administration of Ramanathapuram. In 1803 Mangaleswari Nachiyar was made the Zamindar of Sivagangai After passing of Queen, the Marudhu Brothers took the charge by paying regular revenue to the East India company. In 1801 the Marudhu Brothers of Sivaganga revolted against the British in collaboration with Kattabomman of Panchalamkurichi. Colonel Agnew captured Marudhu Brothers and hanged them and made Gowri Vallbah Periya Udaya Thevar as Zamindar of Sivaganga. After the fall of Tippu Sultan, British took the control and imprisoned the Nawab. In 1792 the Zamindari system was abolished and a British Collector was appointed for administration.

In 1910, Ramanathapuram was formed by clubbing portions from Madurai and Tirunelveli district. This district was named as Ramanathapuram. During the British period this district was called "Ramnad". The name continued after independence. Later the district was renamed as Ramanathapuram to be in conformity with the Tamil Name for this region.

The palace of Sethupathy Rajas, situated in Ramanathapuram town is now under the control of the Archaeological Department of Tamil Nadu Government.

***

WILDLIFE TOURISM

RMD/WL/1:

MELASELVANUR BIRD SANCTUARY: This is an important area of breeding for many of the migratory birds coming from Europe and Australia during the winter months every year. Grey pelican and painted stork are among the birds visiting this place.

Season: November-March/April.

Possibilities of Eco-tourism:

Given a proper publicity and necessary infrastructure, this has potential to attract many tourists from all over the country during the season. A watch tower and an interpretation center should be built. Poaching can be prevented by putting-up a fence around this area. If this is not feasible, a canal should be dug to prevent poachers and grazing animals to enter this area.

Accessibility: This is situated at a distance of about 35KM from Ramanathapuram.

***

RMD/WL/2:

KANJIRANGULAM-CHITRANGUDI BIRD SANCTUARY: This is situated at a distance of about 5KM from Mudukulathur (24KM from Ramanathapuram) in Ramanathapuram district. It covers an area of around 150Ha. Cormorants, Egrets, Herons, Teals, Pelicans etc., visit this area.

***

RMD/WL/3:

VETTANGUDI BIRD SANCTUARY: This 38 Ha bird nesting area is situated at a distance of about 11KM from Thiruothathur in Sivagangai District.

***

HEALTH TOURISM

RMD/Hea/1:

EARWADI MENTAL ASSYLUM: Mentally challenged people from all over the country come here to get treatment. It is believed that some super natural power residing here is responsible for treatment of these people.

***

RECREATIONAL TOURISM

RMD/Rec/1:

GLASS BOTTOMED BOATING, MANDAPAM: The Glass bottomed boating facility available at Mandapam is now being maintained by village Panchayat administration, Mandapam. People can avail this facility to view corals present on the Palk Bay side of Mandapam. This is the only one existing in the reserve of this kind which can give recreation as well as education to the public.

***

RMD/Rec/2:

DANUSHKODI: Refer to RMD/HH/1.

***

RMD/Rec/3:

KUSHI BEACH: This vast sandy shore fringed with Cassuarina plantations is situated on the Palk Bay side, on the Ramnad-Mandapam road in Ariyaman. A private entrepreneur is maintaining an amusement park for the tourists offering swimming, pedal boating, and other water sports inside the complex. This is an ideal place for picnics, also offering short boat rides now. Water sports can be started here.

***

RMD/Rec/4:

PUDUMDAM: Pudumadam is a coastal fishing village with a vast sandy shore fringed with Casuarina plantation. The calm waters of this shore can offer good recreation for tourist like swimming, snorkeling, light water sports like fast boating, water skiing etc.,

***

RMD/Rec/5:

VALINOKKAM: This is a coastal village with a vast sandy shore and a patch of rocky shore with basic tourism infrastructure like a watch tower and few resting cottages are present.

Season: January to August is ideal to visit this place.

Possibilities of Ecotourism:

- A water sports complex and an eco friendly resort can be established here involving local fishermen communities.

Accessibility: This village is situated at a distance of about 40km from Ramnad on the Ramnad – Tuticorin road.

Airport: Nearest airport is at Madurai (110km from Ramnad). Daily flights by Indian Airlines and Jet Airways comes here from Mumbai and Chennai.

Rail head: The nearest railway station is Ramnad.

Bus Station: it is well connected by road with regular bus service from Ramnad and Tuticorin.

***

Other places of the district which can offer recreational tourism are beaches of *SeeniyappaDargha* (40km from Ramnad), *Pudumadam* (45km from Ramnad) and *Kanjirangudi* (6km from Tirupullani). All these beaches are vast and the calm waters here can offer recreation to the tourists in the form of swimming and snorkeling and other light water sports with the involvement of local communities.

***

MUSEUMS/AQUARIUMS

RMD/MA/1:

MARINE AQUARIUM, CMFRI: A marine aquarium is being maintained by CMFRI, Mandapam, which had a good number of visitors during past but now, due to lack of proper maintenance, visitation has dropped significantly. However, this still has a potential to attract tourists if maintained properly.

***

RMD/MA/2:

MARINE AQUARIUM, TNFDC: On the Mandapam-Rameswaram highway, a marine aquarium has been set-up by the Tamil Nadu Fisheries Development Corporation in the compound of Office of the AD (Marine), Mandapam. This is gaining popularity very quickly. On expanding it slightly, this can support even more tourist visitations here. However, interpretation is the only thing lacking here. This could be overcome by employing someone who has knowledge to explain tourists about the fishes here. Information to tourists can also be given through printed brochures and sale of CDs.

***

OTHERS

RMD/Oth/1:

PAMBAN RAIL SCISSORS BRIDGE: This 2.06km long bridge connects the island of Rameswaram with the mainland. The specialty of this bridge is that it can be opened like a pair of scissors when large vessels needs to pass through the Pamban strait.

***

TOOTHUKKUDI
RELIGIOUS TOURISM

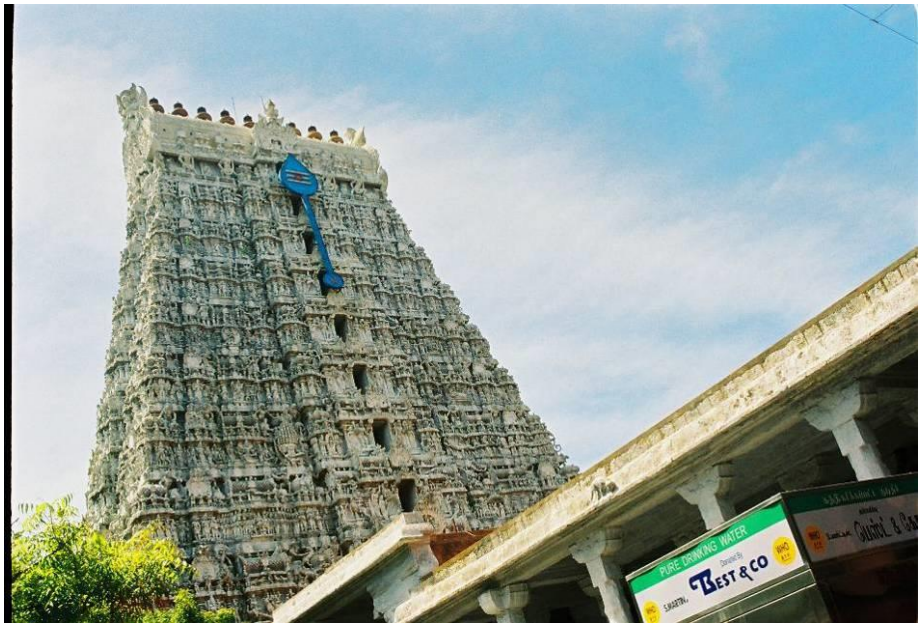
TTK/Rel/1:

SANKARA RAMESWARAR KOVIL: This temple is commonly called as *'Sivan kovil'*. This is believed to be very powerful and hence, tourists from far away [places of India come to visit this place very year in the month of January.

***

TTK/Rel/2:

SENTHILNATHAN TEMPLE: Tiruchendur is very popular for the seashore temple of Lord Subramanian. The temple tower and the sculptures of the temple are worth seeing. It is also ideal for sea bathing.



The temple is one among the six abodes. Lord Subramanya, after defeating Soorapadma came to this place and offered his prayers to Lord Siva. That victory is still celebrated by the pilgrims here during the Tamil Month 'Aippasi' as a festival.

Possibilities of Ecotourism: The vast sandy shore beside this temple can be made use as a site of recreation.

Accessibility: Tiruchendur is situated on the east coast of Mannar, southern to Tuticorin. . It is 40 KMs from Thoothukudi.
Airport: Nearest airport is in Madurai or Thiruvananthapuram.
Rail head:
Bus Station: It can be reached from Chennai, Madurai, Tirunelveli, Courtallam and
Kanyakumari by bus.

***

TTK/Rel/3:
SRIVAIKUNTAM: Temple of Lord Venkateswara is present here, at a distance of 80KM from Tuticorin. The deity is commonly called as *'Kallar Piran'*. Being one among the *Nava Tirupathys,* this temple attracts a huge number of tourists every year in the month of May.

***

TTK/Rel/4:

PANIMAYA MATHA CHURCH: A famous Church named as “PANIMAYA MATHA" (Lady of Snow) is here. It was built by Portugese in 1714

Season: Feb – Mar.

Accessibility:

Airport: Tuticorin is the nearest airport.

Rail head: Daily trains from Chennai and Bangalore used to come here but, were stopped now due to the up gradation of the track.

Bus Station: This town is well connected by road with busses coming from all over the state.

***

TTK/Rel/5:

MANAPPAD: It is also located on the sea-shore of Bay of Bengal about 18 Km, from Tiruchendur. An ancient Roman Catholic Church is here where the Cross is said to have been brought from Jerusalem. This Church is also associated with St. Xavier, the famous missionary from West. Since there are other small temples here this place is called as "Chinna Jerusalem" (Small Jerusalem).

Possibilities of Ecotourism: The vast sandy shore beside this temple can be made use as a site of recreation.

***

HERITAGE/HISTORICAL TOURISM

TTK/HH/1:

PANCHALAMKURICHI: This is a small but historic village from where, the great warrior Katta Bomman Known as "*VeerapandiyaKattabomman*" raised his voice against the British regime in the 17th Century A.D. The existing memorial fort was constructed by the Government of Tamil Nadu in 1974. Sri Devi Jakkammal Temple, the hereditary Goddess of Kattabomman, is located near the fort. The cemetery of British soldiers are seen near the fort. Within the memorial Hall, there are beautiful paintings on the walls depicting the heroic deeds of the saga. The tourists can easily get a good idea about the history of the momentous period from that. The remnants of the old fort is protected by the Archaeological Survey of India. At Kayatar, very near to Tirunelveli , there is another memorial for Kattabomman. It is the place where he was hanged. This was built in 1974. The visitors can see this during the hours of 8-00 to 1-00 PM and 2-00PM to 6-00 PM. The temple for their family goddess Jackammal is nearby to it. His name is *"Vee. Veemaraja alias Jegaveera Pandya Subbramania Kattabomma Durai"* Bommu means the God Sastha Ayyanam Swamy. The British gave the sentence of death by hanging to Kattabomman and others on charges of treason, for their role as freedom fighters.

Accessibility: This village is 3km from Ottapidaram and 18km from Tuticorin.

***

TTK/HH/2:

OTTAPIDARAM: Ottapidaram continues to be a Tourism centre for Freedom fighters, since it is the birth place of the great patriot V.O.Chidambaranar. His house has been converted into a memorial and is preserved by the government of TamilNadu.

WILDLIFE TOURISM

TTK/WL/1:

VALLANAD BLACKBUCK SNCTUARY: A sanctuary, the Vallanad Blackbuck Sanctuary (declared under Indian Wildlife (Protection) Act 1972, Sec.18 (1)) is present on the Tuticorin – Kanyakumari road in

the Tuticorin district, covering an area of 1641Ha. Apart from Blackbuck, other animals of significance here are, Spotted deer, Macaques, Jungle cats, Mongoose, Hares etc.,

***

TIRUNELVELI
RELIGIOUS TOURISM

TNL/Rel/1:

KAPPAL MATHA CHURCH:A small church for St. Mary which was under the control of pastors of Goa mission existed here. In course of time, in 1903, this church was converted into a school. On important occasions as per the wishes of the people, festivals were conducted and prayers were offered to her. There was a custom among the young maidens to go to the nunnery in the night and sleep there. On one such occasion they saw a bright light surrounding this Selvamatha statue even though nobody lit a candle. Many people of Uvari witnessed this light which was there for over an hour. This incident occurred on 18th September which is celebrated as a festival. People used to keep the statue in a chariot and come around this town to bestow the blessing of Mary to the people of Uvari. Due to sea erosion the old church got damaged. Therefore the people decided to construct a new church for which the foundation stone was laid down by Fr.Thomas in 1970, 25th January and the work was finished on 1974. This church designed as a ship, is called Kappal Matha church after its design. It is beautiful church facing the blue sea. The waves rolling near this church gives us an impression that this ship shaped church is sailing on the sea which is a feast to eyes.

***

WILDLIFE TOURISM

TNL/WL/1:

KOONTHANKKULAM: A tiny village in the far south, Koonthankulam in Nanguneri Taluk of Tirunelveli District is emerging as a new favorite for migratory birds. It may soon be catapulted into the list of popular water bird sanctuaries in the country. This village is sparsely populated. Migratory birds start coming by December end and fly away to their northern homes by June or July after they lay eggs, hatch them and the young ones grow old enough to fly with the older ones. About 35 species of birds visit this calm but congenial village for breeding. Birds such as Painted Starks migrate here from North India and East European Countries . Similarly the Flamingoes also fly-in mainly from the Rann of Kutch also lay ,hatch and rear their young ones in the village.

Season: December – June/July.
Accessibility: It is just 38kms. away from Tirunelveli and is in the nearby Nanguneri Taluk.
Airport: Madurai/Trivendrum.
Rail head: Tirunelveli
Bus Station: Tirunelveli.

***

KANYAKUMARI
RELIGIOUS TOURISM
KK/Rel/1:

KANYAKUMARI BHAGAVATHI AMMAN TEMPLE: Kanyakumari derives its name from Goddess Kanyakumari Amman, the presiding deity of the area. The most prominent temple, the Kumari Amman, is dedicated to the goddess Parvathi as a virgin. The temple situated at the edge of the ocean for Goddess Kanyakumari has the legendary account that once Banusura, the demon king got supremacy over Devas and meted out cruel punishment to them. The Devas performed a Yagna pleading to annihilate the evils. Goddess Parasakthi came to Kumari in the form of a virgin girl and began her penance. Meanwhile Lord Shiva fell in love with her and arrangements for the marriage were made in the midnight a particular day. Now the Devine sage Narada realised that their marriage would destroy the chances of annihilating Banusura because he could be killed only by a virgin. When Lord Shiva was on his way to Kanyakumari from Suchindrum at Valukkamparai 5 kms south of Schindram, Sage Narada assumed the form of a cock and crowed falsely heralding the beak of dawn. Thinking that the auspicious time for the marriage was past, Lord Shiva returned disappointed. The Goddess too decided to remain virgin after that. Then, when Banusura attempted to win the Goddess by force, she killed him with her Chakragudha, and relieved the suffering s of Devas. Then she resumed her penance and remained virgin.

***

KK/Rel/2:

1500 year old SIVA'S TEMPLE: This temple dates back to the 5th century, is believed to be the first temple of South India.

***

KK/Rel/3:

SUCHINDRUM: This holy place is located on the bank of the river Pazhayar, adjoining fertile fields and coconut groves and the temple is dedicated to Sri Sthanumalayan. The word denotes Siva, Vishnu and Brahmma. As Sthanu represents Siva, Mal represents Vishnu while Ayan represents Brhamma i.e. Siva, Vishnu and Brhamma in one form Lord Indra had been cursed and had to seek immediate redemption. He came to Gnana Aranya as this place was then called and offered worship to Lord Shiva. Relieving Indra of his curse, Lord Shiva granted him of his wish that the place where he attained purification should henceforth be called Suchindrum. Another story goes to say that the Trimurthys i.e. Brhamma, Vishunu and Shiva, cajoled by their divine consorts came down to the earth to test the chastity of Anusuya, wife of sage Athri at Gnana Aranya. The Gods for this misadventure had to suffer a curse form the Rishipatni and to undergo the purification process, before they could be restored to their former glory. Suchindrum means the place where Indra attained *Suchi* i.e., purification. The Sthalapurana has it that Indra suffered a curse from sage Gowthama, when he stealthily cast amorous glances at Ahalya the wife of Gowthama.

It is said that Thanumalaya Swamy temple is the only shrine dedicated to the Trinity in India. The present structure of the temple is the work of a number of persons spread over a number of centuries. It is a complex of many beautiful structures constructed at various times and is one of the best specimens and a store house of the Dravidian style of art and architecture.

Season: Pilgrims coming to Kanyakumari will visit this place and hence, this follows the same trend of visitorship as Kanyakumari.

Accessibility: Suchindrum is a small village about 12 km. from Kanyakumari and about 7km from Nagercoil.

Airport: Trivendrum, at a distance of 85km is the nearest airport.

Rail head: Nagercoil is the nearest railway station, at a distance of 7km from here.

BusStation: Nagercoil is well connected with frequent bus services from Chennai, Trivendrum, Bangalore and the rest of Tamil Nadu.

***

KK/Rel/4:
ST.XAVIER'S CHURCH:

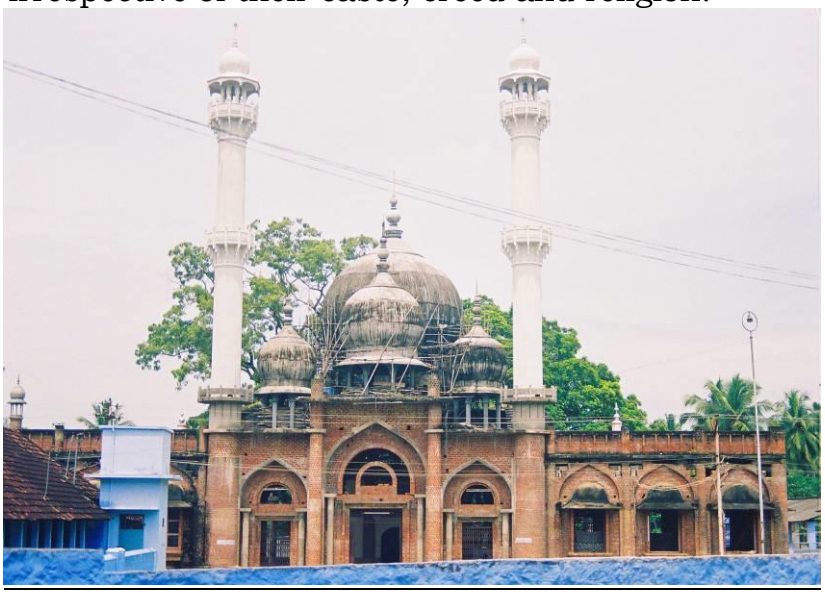
St.Xavier, an outstanding and dedicated priest visited the coastal areas of Tamil Nadu from Goa, he never missed the opportunity of visiting Kottar in Kanniyakumari district which was a celebrated commercial centre at that time. During his stay at Kottar, he used to worship St. Mary in the small temple. He was popularly known as Valiya Pandaram among the people of Kottar. While he was at Kottar, he averted the invasion of Padagas on the people of Venad which was appreciated by the king, who became closer to the Priest. In recognition of Xavier's services, the king allotted a land to him for the purpose of constructing a catholic church at Kottar. There was already a church in 1544 in the same place, where the St. Xavier s church stands now. The church records show that the church was built in the year 1600 A.D. In the year 1865, the Church was enlarged and the shrine of our lady was also renovated and vaulted over. In 1930, the church was raised to the status of a Cathedral. In 1942, in commemoration of the fourth centenary of the arrival of St.Xavier in India, a beautiful tower to the saint, a grotto to Out Blessed Mother and a small shrine to St.Ignatius who sent him to India were constructed in the Cathedral premises. In 1955, the church was further extended and the chapel of Our Lady was incorporated into the enlarged church. The Church of St. Xavier enjoys a great fame as a place of miracles from early times.

Season: The annual festival is celebrated during the month of November—December lasting for 10 days.
Accessibility: Nagercoil is the district head quarters, which is well connected by road and by rail.
Airport: Trivendrum is the nearest airport, at a distance of 65km.
Rail head: Nagercoil is connected with various places by frequent trains.
Bus Station: Busses from all over TamilNadu and from Trivandrum and Bangalore comes to Nagercoil frequently.

***

KK/Rel/5:
PEER MOHAMED DARGHA: There is a durha named Peer Mohamed Oliyullah Durha at Thuckalay named after the great philosopher Mohamed Appa, who was born in Tenkasi of Tirunelveli District. After spending sometime in spiritual pursuits in Peermedu of Kerala State he came and stayed at Thuckalay. Being a Tamil poet of great

eminence, he wrote many books on philosophy. He had intimate relationship with the Kings of Chera dynasty. It is said that he laid foundation stone for the Padmanabhapuram Granite Fort. The Anniversary of the great philosopher poet is celebrated every year on a grand scale on the full moon day in the month of Rajap. Both the people of Kerala and Tamil Nadu attend the celebrations on large numbers irrespective of their caste, creed and religion.



Accessibility: The ancient historical town Padmanabhapuram is one of the four municipalities in the district is 55 Km. south of Trivandrum, about two km. east of Thuckalay and 35 km. from Kanyakumari on the Trivandrum-Cape Comerin road.

Airport: Trivandrum is the nearest Airport.

Rail head: Nearest rail heads are Nagercoil and Trivandrum.

Bus Station: This place is well connected by busses coming from Trivandrum, Kanyakumari and Nagercoil.

HERITAGE/HISTORICAL

KK/HH/1:

PADMANABHAPURAM: This town is surrounded by a fort with an area of 187 acres. The ancient capital of Travancore is thought to be constructed before AD 1601. The palace with an area of seven acres is situated in the very centre on the Padmanabhapuram Fort, amidst hills, dales and rivers. The palace which is situated in Kanyakumari District is under the control of a Curator of the Archaeological Department, Government of Kerala. The fort which was built with mud originally was dismantled and reconstructed with granite by Maharaja Marthanda Varma. The height of the walls varies from 15 to 24 according to the inclination of the ground.

Entrance Hall: - The entrance to the main edifice is controlled by another ornamental gateway with retainers for watch and ward. The gabled entrance has wooden ceiling profusely ornamented with lotus medallions. The most striking feature of the entrance is the clock-tower which is one of the oldest in India erected in 1832 A.D. and still

continues to be in working order. The first floor the Poomuham has a council chamber or Mantrasala which is meant for holding discussions with ministers and prominent citizens. The floor off this hall, which is polished with the admixture of coconut shell ashes, eggs fermented in molasses and lime reflects the figure like a mirror. Next to the Mantrasala is the Dancing Hall which was used exclusively for the members of the royal family. Adjacent to the Council Chamber and to the south of dancing hall is the dinning hall called Uttupura , with two floors (the ground and the first) each measuring roughly 78 by 6 metres and it would accommodate about 2000 people at a time. Feeding of about 2000 poor persons, it is said, was done here every day and so the king was called Dharmaraja.

*UPPIRIKAMALIKA***:** The most attractive building in the whole palace is the Uppirika
Malika which consists of three storied. Uppirika is the abbreviated term of Muppirika which means the residence of the eldest member of the family. A wooden cot is erected on the top most floor in the belief that Lord Vishnu the chief deity. The first floor contains a wooden cot made of 64 medicinal plants, on which Maharaja used to sleep. The medicinal cot was presented to Maharaja Marthanda Varma by the Dutch East India Company in 1750, as a mark of friendship.

THENAVARATHRIMANDAPA:To the west of the Zuppirika Mandapa is the Navarathri Mandapa which is a spacious hall of exquisitely beautiful granite pillars with drooping pendants reminiscent of the Nayakar style of architecture. In the Navarathri Mandapa, performances of Bharatha Natya and musical recitals took place in the royal presence.

***

KK/HH/2:

VATTAKOTTAI: Vattakottai, a granite fort six kilometres northeast of Kanyakumari cape, forms the terminal of a line of ramparts known as the South Tranvancore lines built by Marthanda Varma to serve as defence for Nanjil Nadu. It is rectangular in shape and covers an area of about three and a half acres. The fort is enclosed by walls 25 to 26 feet high, including the parapet, 29 feet thick at the front, 18 feet at the corners and 6 feet at the rear. The portion running into the area is the most strongly built under the orders of De Lannoy during the reign of Mathandavarma (1729-58). About 1810 A.D. the British forces under the command of St. Leger marched into Nanjilnad through the

Aramboly pass and demolished the defence lines. The small river by the side of the fort, and the green vegetation all around add to the scenery of the fort and has now become a holiday resort and picnic centre.

It is said that there is a subway or tunnel about four feet width, supposed to connect the padmanabhapuram palace. Now the tunnel has been closed. On the northern side of the fort is found a slop to being the canon from the lower to the upper part of the parapet of the fort. There is well of about 6m diameter.The whole wall around the fort is repaired and fresh mortar is being applied. Literary or epigraphical evidences are not in store to know much about Vattakotai. However, from the evidence left by the fort itself, it may be presumed that his fort was the military base to protect the Kumari port which was a rich pearl harbour. Since the emblem of the Pandya Kings was Fish and we find this emblem in some of the places of the fort, it can be safely concluded that the Pandya Kings had control over this fort for sometime. Next to Vattakottai, we can see the traces of a light house in Leepuram being called so after Colonel Lee who has destroyed most of the Kadukkarai Kanyakumari Fort in 1806. This is a picnic spot, the sea is calm and suitable for bathing.

Season: This is one lace which doesn't seem to follow any seasonality in visitorship of tourists. Tourists come here all round the year. During the month of January, pilgrims who've visited the Sabarimalai, come here to take a holy dip in the '*Tri-Sea Confluence*' at Kanyakumari. An increase in the numbers is also seen in the summer months of April and May.

Possibilities of Ecotourism:

- The Sanguthurai beach, Chothavilai beach and the Muttom beach are the popular beaches around Kanyakumari at a distance of around 10-15km from Kanyakumari. These are suitable just for a day's recreation and hence, ecofriendly restaurants involving some localites can be started here.

Accessibility: Kanyakumari, the southern most tip of the Indian Peninsula is well connected by rail, road and by air from various locations in India.

Airport: Trivandrum, at a distance of 85km is the nearest airport.

Rail head: Trains come from various important stations like Chennai, Howra, Delhi, Bangalore etc., frequently. Nagercoil is one town which is also well connected by trains. This is at a distance of 19km from Kanyakumari.

Bus Station: Kanyakumari is well connected with frequent bus services from Chennai, Trivandrum, Bangalore and the rest of TamilNadu.

***

WILDLIFE TOURISM

KK/WL/1:

UDAYAGIRI: The fort was rebuilt in the reign of Marthandavarma, the Venad King, during 1741-44. Under the supervision of De Lannoy, the Belgian General, who served as the Chief of the Travancore army; East India Company's troops were stationed there till the middle of the 19th century. Foundry for the manufacture of guns, mortars and cannon balls were also established within the fort under the supervision of the General. In the early days, the fort was of strategic importance. Prisoners captured in the campaign against Tippu were confined in this fort for sometime. It is further said that a brass gun 16 ft. long bored as a 22 ponder, found in the fort could not be removed even for a few yards by a large number of people, even with the help of 16 elephants. A village has come up in front of the fort. The people, who live here, are mostly agriculturists. A few of them are engaged in trade. Pottery making is the chief Industry among a section of the people. Now, the District Administration, with the help of Forest Department has set up a Biodiversity Park over here. Tourists can see deer, ducks, fountains, birds and over 100 varieties of trees inside the fort.

ADVENTURE TOURISM

KK/Adv/1:

ULAKKAI ARUVI: This is a natural waterfall situated in Azhagiapandipuram village of Thovalai Taluk. Water is available in this water fall in the summer season. Many tourists come here for bathing and to enjoy the nature. The pathway to this waterfall lies in the Reserve Forest.

***

HEALTH TOURISM

KK/He/1:

MARUTHUVA MALAI: This is also known as the Marunthu Vazhum Malai the abode of medicinal herbs, forms from part of the Western Ghats. According to tradition, the Maruthuva Malai is a fragment of the Sanjeevi Mountain, a piece of which fell down here, and it was carried by Hanuman from Mahendragiri to Srilanka for healing the fatal wounds of Lakshmana, the brother of Rama, the epic hero. It stretches for more than a km, reaching a height of 800 feet at the highest point. It is about 11km. from Nagercoil and 7 km from Kanyakumari.

RECREATIONAL TOURISM

KK/Rec/1:

KANYAKUMARI BEACH: This is is of the most highly visited beaches of India. Being the southern most tip of Indian peninsula, people from all over the world come here to look the tri-sea confluence at this point. Pilgrims also visit this place after finishing their pilgrimage to Sabarimalai.

***

KK/Rec/2:

CHOTHAVILAI BEACH: This beach is about 10 Kms from Kanyakumari, is one of the best natural beaches of the district. The beach has shallow water and High sand dunes on the back ground. The District Administration has through its own funds and through the funds of MPLAD scheme, put up rest shelters, kudils and a view tower over here for the benefit of tourists. The tourists can reach the beach through the newly laid coastal road which is a very beautiful drive along the sea-coast.

***

KK/Rec/3:

SANGUTHURAI BEACH: Sanguthurai is a beautiful beach resort and is very convenient for the local Population of Nagercoil. It is only about 10 kms from the city.

Unfortunately no infrastructure facilities were available in this beach. The district administration has now sanctioned a project for putting up of a children's park, seating facility, open huts (Kudils) with Terracotta roofs and lighting facility at the beach at a cost of Rs.6.00 lakhs. The entire work has been completed. It is also proposed to put up a few shops for Women Self Help Groups at the site, which can provide eatables to the on coming tourists at the beach side.

***

KK/Rec/4:

MUTTOM BEACH: The famous beach at Muttom is located about 16 kms from Nagercoil and 32 kms from Kanyakumari. Muttom is famous for its beautiful landscaping and high rocks dipping into the

sea at the beach-side. The sun set view point at Muttom is one of the most Panoramic view points in the district. Another attraction of Muttom is the century old light-house built by the British. However so far this beautiful beach has always been unsafe for the tourists since the rocks on which tourists go to see the sea view are slippery and a number of fatal accidents have occurred over the past few years. The district administration, decided to put protective stainless steel fencing across the entire dangerous areas and also to put up small open huts at the rock tops for the tourists to sit and watch the massive sea waves leisurely with protection from sun and rain. The fencing work and the small huts have already been completed to the delight of the tourists who mob the beach in hundreds during week ends. Sitting benches have also been constructed in a circle for the elders to chit-chat, relax and enjoy the sun set. Seeing the response of the tourists, the district administration has sanctioned for the construction of a toilet complex, a small shopping complex and a children's park at a cost of Rs.11.60 Lakhs and there are plans to undertake sculpture - works across the rocks to add to the ambience of the area.

***

KK/Rec/5:

TIRPARAPU: The Kodayar makes its descent at Tirparappu and the water fall at this place is about 13km. from Pechiparai dam. The river bed is rocky and about 300 ft in length. The water falls from a height of nearly 50 feet and the water flows for about seven months in a year. The whole bed above the falls is one rocky mass which extends up to a distance of about quarter of a kilometer upstream where the famous Thirparappu weir has been constructed for supplying water to the paddy fields. On either side of the river, on the left bank of the river in between the water falls and the weir, there is a temple dedicated to Siva enclosed by strong fortification. The District Administration has recently constructed a swimming pool for children over here which is very popular among the children. There are also few boats available for the recreation of tourists.

***

MUSEUMS/AQUARIUMS

KK/MA/1:

GOVERNMENT MUSEUM,KANYAKUMARI: This museum depicts the history of Kanyakumari and peoples' life style. For some reasons, this attracts Keralites mainly.

***

KK/MA/2:

KAMARAJAR MANIMANDAPAM: Another monument **Kamarajar Manimandapam** was raised and dedicated to Late. Sri Kamarajar, The freedom fighter, Former Chief minister of Tamil Nadu, President of Indian National Congress. He was popularly known as Black Gandhi among the masses and king maker during congress regime. This monument was constructed where his ashes were kept here for public to pay homage before immersion into the sea.

***

OTHERS

KK/Oth/1:

VIVEKANANDA ROCK MEMORIAL: This is another place in Kanyakumari which attracts large number of tourists. As its name implies, it is essentially a sacred monument, built by the Vivekananda Rock Memorial Committee to commemorate the visit of Swamy Vivekananda to Shripada Parai during 24th, 25th and 26th December 1892 for deep meditation and enlightenment. From very ancient times, the rock has been regarded as sacred place. In Puranic tradition, it has been known as Sripada Parai: meaning the rock, that has been blessed by the touch of Shripada feet of the Goddess.On the rock, is a projection similar in form to a human fort and a little brownish in complexion, which has traditionally, been revered as a symbol of Shripadam. According to legend, it was on this rock that Goddess Kanyakumari did Tapas. The memorial consists of two main structures, viz (i) Vivekananda Mandapam and (ii) Shripada Mandapam.

VIVEKANANDA MANDAPAM:This 180 -11 ½ X 56 Mandapam consists of

(1) Dhyan Mandapam, i.e., Meditation Hall with six adjacent rooms

(2) Sabha Mandapam or the Assembly Hall including Pralima Mandapam (statue section) two rooms, a corridor and an open Prakaram round the Sabha Mandapam

(3) Mukha Mandapam (Portion) and

(4) the Front Entrance steps with two rooms and a corridor below the steps.

SHRIPADA MANDAPAM: This square hall consists of

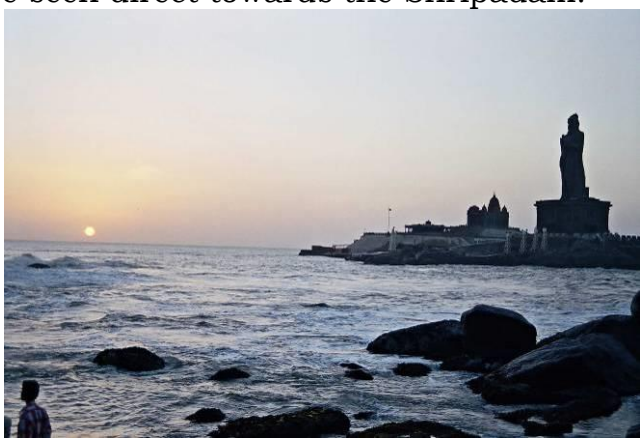
(1) Garbha Graham i.e., (Sanctum Sanctorum)

(2) the Inner Prakaram

(3) the Outer Prakaram and

(4) the Outer Platform all around.

Both the Mandapams are so designed that the vision of Swamiji in the statue would be seen direct towards the Shripadam.



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KK/Oth/2:

TIRUVALLUVAR STATUE:Thiruvalluvar is the immortal poet of Tamil Nadu and has given to the world Thirukkural. The memorial statue of Thiruvalluvar is in Kanyakumari.The pedestal of the statue is of 38 feet height and the statue over it is 95 feet tall with a grand total of 133 feet for the entire sculpture. The 3 tier pedestal known as Atharapeedam is surrounded by an artistic Mandapa known as Alankara Mandapam with 38 feet height. Surrounding the Alankara Mandapa stand 10 elephant statues signifying 8 directions with earth and space down. The father of Sri. Rama, the hero of Ramayana was called Dasaratha as he was able to charioteer in ten directions. To help the tourists to worship the holy feet of Thiruvalluvar 140 steps are constructed inside the Mandapa. The pedestal with a height of 38 feet represents the 38 chapters in the Book of
Aram in Thirukural and the statue of 95 feet on the pedestal represents the total chapters in Porul (70 chapters) and Inbam (25 Chapters). Thus the statue symbolically, and artistically signifies that the theme of Porul and Inbam are based on Aram.

***

KK/Oth/3:

MATHUR HANGING TROUGH BRIDGE: This is the tallest as well as the longest trough bridge in Asia, having a height of 115 feet and a length of one kilometre. Constructed in 1966, this bridge has become a place of tourist importance and hundreds of tourists visit this place. This is situated in Mathur, hamlet of Aruvikkarai revenue village in Thiruvattar Panchayat Union. The bridge has been constructed at Mathur across the river Parazhiyar at a cost of Rs. 12.90/- lakhs and the trough canal (Pattanamkal canal) on the bridge carries water for irrigation from one side of a hill to the other side of a hill. The trough has a height of seven feet with a width of seven feet six inches. The canal is being shouldered by 28 huge pillars. By the unrelented efforts of late Thiru. K. Kamaraj, the former Chief Minister of Tamil Nadu, this canal was constructed as a drought relief measure and for the

development of agriculture in Vilavancode and Kalkulam Taluks. The District Administration has recently put up a staircase from top to the bottom of the bridge and also built a children's park and bathing platforms over here.

***

KK/Oth/4:

PECHIPARAI: About 43 km. from Nagercoil this dam has been constructed. This dam in Kalkulam Taluk, was built during the days of the Maharaja Sri Moolam Thirunal across the river Kodayar. The construction of the dam was designed on the pattern of the Periyar dam in the Madurai district. The length of the dam is 425.1 mts. It has a catchment area of 204.8 sq.km. There is a camp shed provided at the dam side for the visitors. The weather is very pleasant and hence attracts a large number of tourists. The reservoir is surrounded by dense forests which are famous for their valuable trees and rich wildlife such as tiger, elephants, deer etc. A hill tribe, small in number known as Kanikars dwell in the dense forests around the lake.

Season: Winter months are best suited for bird watching since a good number of migratory birds come for breeding in this place.

Possibilities of Ecotourism:

- This place is already having a little tourist infra structure with few pedal boats and rest houses along the dam. This could be made used by involving the local communities in operating this.

***

KK/Oth/5:

MUKKADAL: This is a natural dam constructed by T.Chitirai Maharaja. It supplies water to Nagercoil Municipality and it is also proposed to get water from here for Suchindrum and Kanyakumari. It is very picturesque spot and ideal for picnics by groups.

Accessibility: Pechiparai is situated at a distance of 43km from Nagercoil.

Airport: Trivandrums is the nearest airport.

Rail head: Nearest railway station is Nagercoil.

Bus Station: Busses come from Nagercoil and Trivandrum very frequently.

Annexure II

Biosphere Reserve Notification

No 1/6/80- Mannar
Government of India
Ministry of Environment & Forests

"PARYAVARAN BHAVAN"
CGO Complex, Phase - II
Lodi Road , New Delhi,
New Delhi – 110 003.

Date: 4th April, 1989

To,
The Chief Secrtary,
Government of Tamilnadu,
S. Fort George,
Madras.

SUB : ESTABLISHMENT OF GULF OF MANNAR BIOSOPHERE RESERVE

Sir ,

The Government of India has identified potential sites fro preserving biological diversiy with the following broad objectives :

- *Conservation of representative samples of ecosystem.*
- *Provision of log – term conservation of genetic diversity in-situ*
- *Promotion of basic and applied research work and its monitoring ; and*
- *Dissemination of experience for education and training.*

The Gulf of Mannar represents he unique marine ecosystem in the Indian part of the Gulf situated between India and Sri lanka . In accordance with the guidelines n the subject, a project document for setting up of Biosphere Reserve in the Gulf of Mannar use prepared by Prof. K.Krishnamurthy, the then Director, Centre for Advanced study in Marine Biology, Annamalai University. This has bn considered in detail by the Government of Tamilnadu and he Government of India.

In their telex message NO.75612 / FRV / 88 –3, dated the 24th January 1989, the Government of Tamilnadu have conveyed their acceptance of the proposal for setting up of Biosphere Reserve in Gulf of Mannar area. It has, therefore, been decided that the Gulf of Mannar Biosphere Reserve should formally be deemed to have come into being with effect from 18th February, 1989.

The Indian part of the Gulf covers approximately an area of 10,500 sq.kms, running southwards and parallel to the main land coastline to a distance of about 170 nautical miles and lies between 78^0 11' and 79^0 15' E longitudes and 8^0 49' and 9^0 15' latitude. It has an are of 21 islands starting from the north most Pamban island to Thoothukudi. The boundary and zonation in core and buffer zones of the Biosphere Resrve are given at Annexure – I . The details of the area to be earmarked for manipulation activities such as aquaculture, etc., will be worked on by the project authorities.

The following will be the important aspects of the Gulf of Mannar Biosphere Reserve

a. *The core and the buffer areas and manipulation activities which may be permitted in the buffer zones will be submitted by the Government of Tamilnadu.*

b. *The core zone of the Biosphere Reserve will be kept absolutely undisturbed.*

c. *The constitution of the Biosphere Reserve by itself will not, in any way, change the status of legal ownership of the land*

d. *There will be a Biosphere Reserve Management council with the composition as shown in Annexure – II*

e. *The Government of India will provide financial assistance for approved items for expenditure included in the section and Management plan to be prepared by the Government of Tamilnadu. This may broadly be classified under the following heads:*

- *Survey*
- *Conservation*
- *Protection*
- *Ecorestoration*
- *Education and awareness.*

f. *T here will be a Research Committee as per the composition shown in Annexure – III*

g. *The subject of research and institution identified for the purpos are shown I Annexure – IV*

h. *The Government of Tamilnadu will set up a local committee for coordination of he activities of varies departments in the area covered by the Biosphere Reserve.*

(K. P. Geethakrishnan)
Secretary to the Government of India

ANNEXURE I & II

MANAGEMENT COUNCIL – GULF OF MANNAR BIOSPHERE RESERVE
****

1. Secretary, Ministry of Environment and Forests.	*- Chairman*
2. Joint Secretary(WL), \Ministry of Environment and Forests	*- Member*
3. Joint Secretary/ FA, Ministry of Environment and Forests	*- Member*
4. Representative of State Government of Tamil Nadu	*- Member*
5. Director of Gulf of Mannar Biosphere Reserve	*- Member*
6. Representative of Botanical Survey of India	*- Member*
7. Director-in-charge of Biosphere Reserve Programme in the Ministry of Environment and Forests	*- Member*

Region 2 *– This region comprises six islands between Keelakkarai and Mukkaiyur viz. Upputhanni Tivu, Pullivunnichalli Tivu, Nallathanni Tivu, Anaipar Tivu. Valimunai Tivu and Poovarasanpatti Tivu.*

The Core Zone *– The Core Zone of this region comprises three islands Nallathanni Island, Pullivunnichalli Island and Anaipar Island.*

The Buffer Zone *– The immediate sea and the following two islands will constitute the Buffer zone:*

a) Vallimunai Island
b) Poovarasanpatti Island

Region 3 *– The main land coastline from Mukkaiyur to Tuticorin extends to about 120Km. This Region lies between Mukkaiyur and Tuticorin comprising four islands, viz., Van Tivu, Kasuvar Tivu, Vilanguchalli Tivu and Karaichalli Tivu.*

The Core Zone *– The pearl banks near and away from Tuticorin.*

The Buffer Zone *– the buffer zone will comprise the following four islands:*

a) Van Tivu
b) Kasuwar Tivu
c) Karaichalli Tivu
d) Vilanguchalli Tivu

Region 4 *– This region lies between the Tuticorin and Kanyakumari and Extends to about 110Kms.*

The Core Zone *– The area having pockets of pearl banks and chank beds will constitute "Natural Core Zone".*

The Buffer Zone *– The remaining will be buffer zone.*

Annexure – III

COMPOSITION OF RESEARCH ON GULF OF MANNAR BIOSPHERE RESERVE

*****

1. *Prof.K.Krishnamurthy, Centre for Advanced Studies in Marine Biology, Annamalai University.* - *Chairman*
2. *Representative of Tamil Nadu Government* - *Member*
3. *Representative of Pondicherry University* - *Member*
4. *Representative of Madras University* - *Member*
5. *Representative of Madurai Kamaraj University* - *Member*
6. *Representative of the Regional Centre of the Central Marine Fisheries Research Institute, Mandapam Camp.* - *Member*
7. *Representative of Botanical Survey of India* - *Member*
8. *Representative of Zoological Survey of India* - *Member*
9. *Representative of the Ministry of Environment and Forests, New Delhi.* - *Member*

ANNEXURE – IV

LIST OF RESEARCH INSTITUTIONS AND PRIORITY AREAS IDENTIFIED FOR UNDERTAKING RESEARCH IN GULF OF MANNAR BIOSPHERE RESERVE.

*****

1. *Southern Circle Botanical Survey of India, Coimbatore.* - *Floral Inventory.*
2. *Southern Regional Station Zoological Survey of India. Madras* - *Faunal Inventory*
3. *Pondicherry University (Salim Ali Centre of Ecology)* - *Ecological Studies*
4. *Madras University/ Madurai Kamaraj University/ Annamalai University* - *Marine Biology*
5. *National Institute of Oceanography, Goa* - *Mangroves and Coral*
6. *Regional Center of the Central Marine Fisheries Research Institute, Mandapam* - *Fisheries and Corals*
7. *Bharathidasan University* - *Sea grass*
8. *Center for Brackish Water Aquaculture, Madras* - *Fisheries*

ANNEXURE- V

Marine Flora and Fauna of the Gulf of Mannar Biosphere Reserve

SEAWEED

Acanthopora spicifera
Caulerpa laetevirens
Caulerpa taxifolia
Centroceros sp.
Ceramium sp.
Champis sp.
Chondrus sp.
Clatratus sp.
Codium tomentosum
Cystoseira trinodis
Enteromorpha compressa
Euchemia sp.
Gelidiella acerosa
Gelidium sp.
Gigartina sp.
Gracilaria crassa
Gracilaria edulis
Gracilaria folifera
Herphosiphonia spp.
Hormophyra triqueta
Hormophysa triquetra
Hydroclathrus clathratus
Hypnea musciformis
Hypnea valentiae
Kappaphycus alvarezii
Laminaris sp.
Laurencia papillosa
Monostroma sp.
Padina sp.
Polysiphonia sp.
Porphyra sp.
Pterocladia sp.
Sarconema furcellatom
Sargassum tenerrimum
Spyridia sp.
Stichospermum sp.
Tolypocladia sp.
Turbinaria conoides
Ulva latuca
Ulva reticulata
Undaria pinnatifida

SEA GRASSES

Hydrocharitaceae
Enhalus acroides
Thalassia hemprichii
Halophila ovata
Halopila ovalis ovalis
Halophila stipulacea
Halophila decipiens
Halophila beccarii

Potomogetonaceae
Halodule univervis
Halodule pinifolia
Halodule wrightii?
Cymodocea serrulata
Cymodocea rotudata
Syringodium isoetifolium

MANGROVES

Avicenniaceae
Avicennia albaAvicennia officinalis
Avicennia marina
Combretaceae
Lumnitzera racemosa
Euphorbiaceae
Excoecaria agallocha
Lytheraceae
Pemphis acidula
Myrsinaceae
Aegiceras corniculatum
Rhizophoracae
Bruguiera cylindrical
Bruguiera conjugata
Ceriops tagal
Ceriops decandra
Rhizophora conjugata
Rhizophora apiculata
Rhizophora mucronata
Bruguiera conjugata
Ceriops tagal
Ceriops decandra
Rhizophora conjugata

Rhizophora apiculata
Rhizophora mucronata

PORIFERA

1. Order: Agelasida
Agelasidae
Acanthostylotella cornuta
Agelas ceylonica
Agelas mauritiana
2. Order: Amphidiscosida
Hyalonematidae
Hyalonema lamella
3. Order: Astrophorida
Ancorinidae
Ancorina simplex
Asteropus simplex
Ecionemia acervus
Ecionemia laviniensis
Myriastra clavosa
Myriastra purpurea
Penares intermedia
Rhabdastrella globostellata
Rhabdastrella providentiae
Stelletta tethyopsis
Stelletta vestigium
Coppatiidae
Cryptotethya agglutinans
Jaspis bouilloni
Jaspis investigatrix
Jaspis penetrans
Jaspis reptans
Geodiidae
Erylus carteri Sollas
Geodia areolata
Geodia globostellifera
Geodia inconspicua
Geodia perermata
Geodia picteti
Geodia ramodigitata
Pachastrellidae
Halina extensa
Halina plicata
Pachamphilla dendyi
Pachastrella nana
Pachastrella parasitica
Poecillastra schulzei
Sphinctrella annulata
4. Order: Dendroceratida
Aplysinae
Aplysina lacunosa
Darwinellidae
Darwinella mulleri
Dendrilla cactus
Dendrilla membranosa
Dendrilla nigra
Hexadella purpurea
Druinellidae
Druinella purpurea
Dysideidae
Dysidia fragilies
Dysidia herbacea
Spongionella nigra
Spongionella tuburlosa
Grantiidae
Ute syconoides
5. Order: Dictyoceratida
Irchiniidae
Ircinia aruensis
Ircinia cactiformis
Ircinia fusca
Ircinia ramodigitata
Ircinia ramosa
Ircinia tuberculata
Spongiidae
Hyatella cribriformis
Hyatella intestinalis
Phyllospongia papyracea
Phyllospongia papyracea
Spongia hispida
Spongia officinalis var. *ceylonensis*
Spongia officinalis var. *fenestrata*
Theorectidae
Cacopongia salaris
Cacospongia mollior
Fasciospongia anomala
Fasciospongia cavernosa
Hyrtios erecta
6. Order: Hadromerida
Chondrillidae
Chondrilla australiensis
Chondrilla kilakaria
Chondrilla sacciformis
Chondrosia reniformis
Clionidae
Cliona anulifera
Cliona carpentari
Cliona celata
Cliona ensifera

Cliona lobata
Cliona mucronata
Cliona orientalis
Cliona quadrata
Cliona vastifica
Cliona viridis
Delectona higgini
Dotona pulchella
Thooce socialis
Thoosa (*Cliothosa*) *investigatoris*
Latrunculiidae
Latrunculia tenuinstella
Spirastrellidae
Spirastrella aurivilli
Spirastrella coccinaea
Spirastrella cuspidifera
Spirastrella inconstans
Spirastrella pachyspira
Spirastrella puncutulata
Suberitidae
Aaptos aaptos
Aaptos unispiculus
Laxosuberites conulosus
Laxosuberites cruciatus
Laxosuberites lacustris
Laxosuberites proteus
Pseudosuberites andrewi
Subrites carnosus
Subrites tylobtusa
Terpios fugax
Tethyidae
Tethya diploderma
Tethya japonica
Tethya repens
Tethya robusta
Xenospongia patelliformis
Timeidae
Kotimea moorei
Timea capitatostellifera
Timea curvistellifera
Timea spinatostellifera
Timea stellata
Timea stelligera
Timea stellivarians
Placospongiidae
Placospongia corinata
Placospongia melobesioides
7. Order: Haplosclerida
Callyspongiidae
Callyspongia barodensis
Callyspongia ceylonica
Callyspongia clathrata
Callyspongia diffusa
Callyspongia fibrosa
Callyspongia fistularis
Callyspongia pambanensis
Callyspongia spinosissima
Chalinidae
Adocia carnosa
Adocia semifibrosa
Haliclona camerata
Haliclona implexa
Haliclona madrepora
Haliclona obstusispiculifera
Haliclona occulata
Haliclona pigmentifera
Haliclona tenuiramosa
Haliclona viridis
Reniera delicatula
Reniera tuberosa
Sigmadocia carnosa
Sigmadocia fibulata
Sigmadocia petrosiodes
Sigmadocia pumila
Taxodocia dendyi
Taxodocia ridleyi
Taxodocia toxius
Niphatidae
Aka diagonoxea
Aka minuta
Amphimedon multiformis
Gelliodes cellaria
Gelliodes firbrosa
Gelliodes incrustans
Petrosiidae
Petrosia nilgricens
Petrosia similis
Strongylophora durissima
Xerospongia exigua
Xerospongia testudinaria
Phoeodictyidae
Oceanapia arenosa
Oceanapia fistulosa
Oceanapia media
Oceanapia sagittaria
Oceanapia zoologica
8. Order: Hexactinosida
Aprocallystidae
Aphrocallistes bocagei
Farreidae

Farrea occa

9. Order: Homosclerophorida

Tetillidae

Cinachyra arabica
Cinachyra cavernosa
Cinachyra hirsuta
Paratetilla bacca
Samus anonyma

Plakinidae

Corticium acanthastrum
Corticium candelabrum
Plakina acantholopha
Plakina monolopha
Plakina trilopha
Plakinastrella ceylonica
Plakinastrella minor

10. Order: Lithistida

Corallistidae

Corallistes aculeate
Corallistes elegantissima

Desmanthidae

Lophocanthus rhabdophorus

Theonellidae

Discodermia enigmatica
Discodermia interspersa
Discodermia laevidiscus
Discodermia papillata
Discodermia sceptrellifera
Discodermia sinuosa
Discodermia spinispirulifera
Theonella swinhoei

11. Order: Lyssacinosida

Euplectellidae

Dictyaulus elegans
Regadrella decora

12. Order: Poecilosclerida

Anchinoidae

Phorbas dubia

Axinellidae

Acanthella cavernosa
Auletta elongata
Auletta lyrata
Axinella agariciformis
Axinella burbarinoides
Axinella carteri
Axinella ceylonensis
Axinella conulosa
Axinella crassistylifera
Axinella donnani
Axinella durissima
Axinella halichondroides
Axinella labyrinthica
Axinella lamellata
Axinella manus
Axinella symmetrica
Axinella tenuidigitata
Bubaris vermiculata
Higginsia higgini
Higginsia mixta
Monocrepidium eruca
Myrmekioderma granulata
Phakettia ridleyi
Rhabdoploca cruvispiculifera

Coelosphaeridae

Coelosphaera encrustata
Coelosphaera navicelligera
Ectyodoryx lissostyla
Lissodendoryx balanophilus
Lissodendoryx similis
Lissodendoryx sinensis
Lissodendoryx ternatensis
Waldoschmittia schmidti

Crambidae

Psammochela fibrosa

Desmacellidae

Biemna fistulosa
Biemna fortis
Biemna tubulata

Dictyonellidae

Liosina paradoxa

Halichondriidae

Amorphinopsis excavans
Amorphinopsis foetida
Amorphinopsis oculata
Axinyssa flabelliformis
Ciocalypta penicillus
Collocalypta digitata
Epipolasis lapidiformis
Epipolasis topsenti
Halicondria glabrata
Halicondria panacea
Hymeniacidon petrosiodes
Petromica massalis
Spongosorites cavernosa
Spongosorites halichondrioides
Spongosorites solida
Topsentia nigrocutis

Hymedesmiidae

Hymedesmia dendyi
Hymedesmia mannarensis

Hymedesmia mertoni
Hymedesmia stylophora
Hymedesmia tenuissima
Lophomnidae
Acarnus souriei
Acarnus ternatus
Acarnus thielei
Cornulum vesiculatum
Damiria fistulatus
Damiria simplex
Zyzzya papillata
Microcionidae
Antho annarensis
Artemisina indica
Clathria (Clathria) aeandrina
Clathria (Clathria) decumbens
Clathria (Clathria) indica
Clathria (Dendrocia) antyaja
Clathria (Microciona) aceratoobtusa
Clathria (Microciona) affinis
Clathria (Microciona) atrasanguinea
Clathria (Microciona) fascispiculifera
Clathria (Microciona) rhopalophora
Clathria (Thalysias) amiranteiensis
Clathria (Thalysias) longitoxa
Clathria (Thalysias) micropunctata
Clathria (Thalysias) vulpina
Clathria(Thalysias) lendenfeldi
Clathria(Thalysias) procera
Clathria(Thalysias) procera var.*tessellata*
Echinoclathria rimosa
Holopsamma crassa
Mycalidae
Mycale (Aegagropila) contarenii
Mycale (Aegagropila) militaris
Mycale (Arenochalina) spongiosa
Mycale (Carmia) madraspatana
Mycale (Carmia) monanchorata
Mycale (Carmia) sulevoidae
Mycale (Mycale) crassissima
Mycale (Mycale) grandis
Mycale (Mycale) gravelyi
Mycale (Mycale) indica
Mycale (Mycale) mannarensis
Mycale (Mycale) mytilorum
Mycale (Mycale) tenuispiculata
Mycale (Mycale) trincomaliensis
Mycale (Paresperella) bidentata
Mycale (Paresperella) serratohamata
Mycale (Zygomycale) parishii

Myxillidae
Desmapsamma anchorata
Lotrochota baculifera
Myxilla (Myxilla) arenaria
Tedaniidae
Tedania (Tedania) anhelans
Raspailiidae
Aulospongus sessilis
Aulospongus tubulatus
Cyamon quadriradiata
Cyamon quinqueradiata
Echinadictyum clathratum
Echinadictyum gogonoides
Echinadictyum longistylum
Endectyon fruticosa
Endectyon lamellose
Endectyon thurstoni
Raspailia anastomosa
Raspailia fruticosa
Raspailia hornelli
Rhabderemiidae
Rhabderemia acanthostyla
Rhabderemia indica
Rhabderemia prolifera
Phoriospongiidae
Strongylacidon stelliderma
13. Order: Spirophorida
Scleritodermidae
Amphibleptula herdmani
Aciculites orientalis

CNIDARIA

1. Order: Scleractina

Acroporidae
Acropora cytherea
Acropora digitifera
Acropora echinata
Acropora humilis
Acropora hyacinthus
Acropora intermedia
Acropora microphthalma
Acropora millepora
Acropora muricata
Acropora rudis
Acropora secale
Acropora valenciennesi
Acropora valida
Astreopora myriophthalma
Montipora aequituberculata
Montipora digitata
Montipora edwardsi
Montipora explanata
Montipora exserta
Montipora foliosa
Montipora hispida
Montipora informis
Montipora jonesi
Montipora manauliensis
Montipora millepora
Montipora monasteriata
Montipora spumosa
Montipora tuberculosa
Montipora turgescens
Montipora venosa
Montipora verrucosa

Agaricidae
Pachyseris rugosa
Pavona cactus
Pavona clavus
Pavona decussata
Pavona varians

Asterocoeniidae
Madracis kirbyi

Dendrophylliidae
Turbinaria mesenterina
Turbinaria peltata

Faviidae
Cyphastrea microphthalma
Cyphastrea serialia
Echinopora lamellose
Favia favus
Favia pallida
Favia speciosa
Favia stelligera
Favites abdita
Favites bestae
Favites complanata
Favites halicora
Favites pentagona
Goniastrea pectinata
Goniastrea retiformis
Leptastrea purpurea
Leptastrea transversa
Leptoria phrygia
Montastrea valenciennesi
Platygyra daedalea
Platygyra sinensis

Fungiidae
Cycloseris cyclolites

Merulinidae
Hydnophora exesa
Hydnophora microconos

Mussidae
Symphyllia radians

Siderastreidae
Coscinaraea monile
Psammocora contigua
Pseudosiderastrea tayami

Oculinidae
Galaxea astreata
Galaxea fascicularis

Pectiniidae
Mycedium elephantotus

Pocilloporidae
Pocillopora damicornis
Pocillopora eydouxi
Pocillopora verrucosa

Poritidae
Goniopora planulata

Goniopora stokesi
Goniopora stutchburyi
Porites compressa
Porites exserta
Porites lichen
Porites lutea
Porites mannarensis
Porites minicoensis
Porites solida
Order: Alcyonacea
Alcyoniidae
Dendronephthya lanxifera var. *palkensis*
Dompia poecilliformes
Lobophytum compactum
Lobophytum crassum
Lobophytum latilobatum
Lobophytum pauciflorum
Lobophytum ransoni
Lobophytum sarcophytoides
Lobophytum variatum
Sarcophyton cherbonneri
Sarcophyton crassocaule
Sarcophyton elegans
Sarcophyton glaucum
Sarcophyton stellatum
Sarcophyton trocheliphorum
Sinularia brassica
Sinularia dissecta
Sinularia erecta
Sinularia grandilobata
Sinularia granosa
Sinularia hirta
Sinularia intacta
Sinularia leptoclados
Sinularia mannarensis
Sinularia ovispiculata
Sinularia polydactyla
Xeniidae
Xenia nana
Xenia ternate
Xenia umbellate
Nidaliidae
Siphonogorgia asperula
Siphonogorgia duriuscula

MOLLUSCA

1. Order:Mesogastropoda
Cassididae
Cassis cornuta
Cypraeidae
Cypraea talpa
Cypraea mappa
Cypraea lamacina
2. Order:Neogastropoda
Volutidae
Harpulina arausiaca
Conidae
Conus millne edwardsii
Faciolariidae
Pleuroploca trapezium
Order:Vetigastropoda
Trochidae
Trochus (Tectus) nilticus
Strombidae
Lambis (Harpago) chiragra chiragra
*Lambis truncata**sebae***
Lambis chiragra arthritica
Anadara granosa
Anadara sp.
Crassostrea madrasensis
Donax sp.
Dosinia excise
Katelysia opima
Meretrix casta
Meretrix meretrix
Modiolus metcalfi
Ostrea forskali
Perna viridis
Bulla ampulla
Cerithedia cingulata
Cerithedia fluviatilis
Dosinia excisa
Dostia crepidularia
Litoria scabra
Littorina littorea
Melampus ceylonicus
Nassa sp.
Nassarius pullus
Nassarius sp.
Natica lineate
Lambis (Millepes) scorpius indomaris
Lambis crocea
*Lambus scorpius**scorpius***
Lambus millipeda
Strombus plicatus sibbaldi
Turbo marmoratus
Placuna placenta
Charonia tritonis
Tudicla spirilus
Ovulidae
Cyprecassis rufa
Order: Veneroida
Tridacnidae
Tridacna maxima
Tridacna squamosa
Hippopus hippopus
Order: Nautilida
Nautilidae
Nautilus pompilius

BENTHIC FAUNA

Saccostrea cucullata
Solen lamarckii
Tellina nobilis
Tellina sp
Gastropods
Tellina sp.
Turitella attenuata
Turitella sp.
Umbonium vestiarium
Pythia plicata
Telescopium telescopium

ECHINODERMATA

1. Order: Apodida

Synaptidae

Protankyra innominata
Protankyra pseudodigitata
Protankyra tuticorenensis
Syaptula recta
Synaptula striata
Synaptula varians

2. Order: Aspidochirotida

Holothuridae

Actinopyga echinites
Actinopyga miliaris
Bohadschia marmorata
Bohadschia tenuisimma
Holothuria (Halodeima) atra
Holothuria (Halodeima) edulis
Holothuria (Lessonothuria) pardalis
Holothuria (Mertensiothuria) leuospilota
Holothuria (Metriatyla) scabra
Holothuria (Microthele) fuscogilva
Holothuria (Selenkothuria) moebii
Holothuria (Semperothria) cinerascens
Holothuria (Theelothuria) kurti
Holothuria (Theelothuria) spinifera
Holothuria (Thymiosycia) hilla
Holothuria (Thymiosycia) impatiens
Holothuria(Thymosyicia) arenicola

Stichopodidae

Stichopus chloronotus
Stichopus hermanni
Stichopus naso
Stichopus variegatus
Stichopus vastus

Order: Dendrochirotida

Cucumariidae

Actinocucumis typicus
Colochirus quadrangularis
Cucumaria frauenfeldi
Cucumaria turbinata
Havelockia versicolor
Hemithyone semperi
Pseudocolochirus tricolor
Pseudocolochirus violaceus
Stolus buccalis
Stolus conjugens
Stolus rapax
Thyone papuensis
Trachythyone imbricata

Phyllophoridae

Actinocucumis typicus
Phyllophorus (Phyllophorella) spiculata
Phyllophorus (Urodemella) brocki

Psolidae

Psolus complanatus
Psolus mannrensis

CRUSTACEANS

Benthic fauna

Acartia sp.
Alpheus malabaricus
Ampithoe ramondi
Apseudes chilkensis
Apseudes gymnophobia
Apseudes sp.
Atylus minikoi
Balanus amphitrite
Calanus sp.
Calappa sp.
Cheiriphotis megacheles
Clibanarius sp.
Cymadusa pathyi
Diogenes sp.
Erictiwnius brasiliensis
Eriopisa abhilashi
Eriopisa chilkensis
Eriopisa sp.
Eriopisella sp.
Eurydice sp.
Gammaropsis esturinus
Gammaropsis sp.
Graniderrella gilesi
Hyale honoluluensis
Idunella chilkensis
Isopod
Oithona rigida
Paracalliope indica
Parorchestia morini
Quadrivisio bengalensis
Talorchestia martensii
Tanaeus sp.
Urothoe sp.
Veliger larvae

Penaeid prawns

Solenocera crassicornis
S. hextii
S. indica
Metapenaeopsis stridulans
Metapenaeus affinis
M. brevicornis
M. dobsoni
Parapenaeopsis acclivirostris
P. hardwickii
P. maxillipedo
P.stylifera
P. Uncta
Penaeus canaliculatus
P.indicus
P. japonicus
P. latisulcatus
P. merguiensis
P. monodon
P. semisulcatus

Non-penaeid prawn

Acetes indicus

Lobsters

Panulirus homarus
P. ornatus
P. versicolor
or Rama eral
P. longipes
Puerulus sewelli
Thenus orientalis

Crabs

Calappa lophos
Scylla serrata
Portunus pelagicus
P. sanguinolentus
Chrybdis cruciata
C. edwardsi

Stomatopod

Oratosquilla nepa

POLYCHAETES

Ancistrosyllis constricta
Brado villosa
Ceratonereis sp.
Cirratulus cirratus
Cirratulus sp.
Cossura delta
Diopatra neapolitana
Disoma orissae
Euchlymene annandalei
Eunice sp.
Glycera alba
Heteromastus similis
Hydroides heteroceros
Hydroides norvegica
Laonome indica
Lumbriconereis latreilli
Lumbriconereis polydesma
Lumbriconereis simplex
Malacoceros indicus
Marphysa sp.
Mellinna sp.
Nephtys kauderin
Nephtys polybranchia
Nephtys sp.
Nereis costae
Nereis sp.
Onuphis eremite
Pectinaria crassa
Perenereis cavifrons
Perenereis cultrifera
Phyllodoce malmgrani
Polydora armata
Pomatoceros sp.
Potamila leptochaeta
Prionospia polybranchiata
Prionospio pinnata
Pulliella armata
Sabella sp.
Sabellaria sp.
Serpula sp.
Spirorbis sp.
Sternaspis scutata
Sternaspis sp.
Terebellides stroemi
Thalehasapia tenuis
Tharyx sp.
Tylonereis fauveli

Other Benthic fauna

Brittle stars
Cladocerans
Cyprids
Foraminiferans
Lucifer
Mysids
Nematode
Polyclad

FISHES

ELASMOBRANCHS

Sharks:

Chiloscyllium indicum
C. griseum
Rhiniodon typus
Stegostoma fasciatum
Carcharhinus brevipinna
C. dussumieri
C. limbatus
C. macloti
C. melanopterus
C. sorrah
Galeocerdo cuvieri
Laxodon macrorhinus
Rhizoprinodon acutus
Scoliodon laticaudus
Sphyrna blochii
S. zygaena
Centrophorus moluccensis

Skates:

Rhina ancylostoma
Rhinobatus granulatus
Rhynchobatus dijiddensis
Pristis microdon
P. pectinata
P. zijsron

Rays:

Dasyatis microps
D. zygei
D. kuhli
Gymnura micrura
G. poecilura
Himantura bleekeri
H. imbricata
H. uarnak
Hypolophus sephen
Urogynus africanus
Aetobatus flagellum
A. narinari
Aetomylaeus maculatus
A. nichrofii Nieuhof's
Rhinoptera adspersa
R. javanica
Manta briostis
Mobula diabolus
Narcine brunnea
N. timlei

TELEOSTS

Ten pounders:

Elops machnata

Tarpons:

Megalops cyprinoides

Bone fish:

Albula vulpes

Shads, Sprats & Sardines:

Anadontostoma chacunda
Dussumeieria acuta
Escualosa thoracata
Hilsa ilisha
H. keele
H. toli
Ilisha elongata
I. megaloptera
I. melanostoma
Nematolosa nasus
Opisthopterus tardoore
Pellona ditchela
Raconda russeliana
Sardinella albella
S. dayi
S. fimbriata
S. gibbosa
S. longiceps
S. sirm
S. clupeoides

Anchovies:

Coila dussemieri
Setipinna taty
Stolephorus bataviensis
S. commersonii
S. devisi
S. indicus
S. macrops
S. waitei
Thryssa dussumieri
T. malabarica
T. mystax
T. setirostris

OTHER CLUPEOIDS:
Wolf herrings:
Chirocentrus dorab
C. nudus
Milk Fish:
Chanos chanos
Lizard fishes:
Saurida tumbil
Synodus indicus
Cat fishes:
Arius caelatus
A. dussumieri
A. maculatus
A. thalassinus
Cat fish eel:
Plotosus anguillaris
Eels, Morays & Congers:
Gymnothoras undulatus
Uroconger lepturus
Full beaks (Gar fishes):
Albennes hians
Strongylura crocodilus
S. leiura
Half beaks:
Hemirhamphus far
H. marginatus
Rhynchorhampus georgii
Flying fishes:
Cypselurus spilopterus
Exocoetus volitans
Unicorn cod:
Bregmaceros macclellandi
Flute mouths:
Fistularia villosa
Sea horse:
Hippocampus kuda Sea horse
Razor fish:
Centriscus scuttatus
Squirrel fishes:
Holocentrus rubrum
Myripristis murdjan
Barrcudas
Sphyraena barracuda
S. forsteri
S. jello
S. obtusata

Mullets
Liza macrolepis
L. vaigiensis
Mugil cephalus
Thread fins
Eleutheronema tertradactylum
Polynemus heptadactylus
P. indicus
P. plebetus
P. Sexfilis
P. sextarius
Sea perches
Ambasis commersoni
A. gymnocephalus
Lates calcarifer
Psammoperca waigiensis
Sea basses & Reef cods
Cephalopholis boenack
Epinephelus quoyanus
E. areolatus
E. bleekeri
E. diacanthus
E. malabaricus
E. merra
E.morrhua
E. tauvina
E. undulosus
Tiger perches
Therapon jarbua
T. theraps
T. puta
Bull's eye
Priacanthus cruentatus
P. hamrur
Cardinal fish
Apogan leptacanthus
Whiting
Sillago sihama
White fish
Lactarius lactarius
Cobia
Rachycentron canadus
Carangids
Alectis ciliaris
A.indicus
Alepes djeddaba

A. mate
Atropus atropus
Carangoides armatus
C. chrysophyrs
C.ferdau
C.malabaricus
Caranx carangus
C.ignobilis
C.melampygus
C. sexfaciatus
C. stellatus
Decapterus dayi
D. russelli
Elagatis bipinnulatus
Gnanthanodon speciosus
Megalapsis cordyla
Scomberoides lysan
S. tala
Seriola nigrofasciata
Trachinotus bailloni
T. blochii
T. botla
Black pomfrets
Formio niger
Moon fish
Mene maculate
Dolphin fish
Coryphaena hippurus
Red baits
Dipterygnonotus leucogrammicus
Jobfishes, Fusiliers & Snappers
Aprion pristipoma
Caesio caerulaureus
Lutjanus rivulatus
L. bohar
L. fulviflamma
L.lineolatus
L.malabaricus
L. russelli
L. sebae
L. vaigiensis
Threadfin breams
Nemipterus delagoae
N. japonicus
N. tolu
N. mesoprion
Scolopsis bimaculatus
S. vosmeni
Triple tails
Labotes surinamensis
Silverbellis (Pony fishes)
Gazza minuta
Leiognathus berbis
L.bindus
L.brevirostris
L. daura
L. dussumieri
L. equulus
L. jonesi
L. lineolatus
L. splendens
Mojarras
Gerres abbreviatus
G. filamentosus
G. oyena
G. setifer
Pentaprion logimanus
Sweetlips & Grunters
Gaterin diagrammus
G. lineatus
Pomadasys hasta
P. maculates
Johnieops aneus
J. sina Sin croaker
Johnius dussumieri
Kathala axillaries
Nibea maculata
Otolithus cuvieri
O. rubber
Pennahia macrophthalmus
Protonibea diacanthus
Emperor breams
Lethrinus miniatus
L. nebulosus
L. ornatus
L. ramak
Large-eyed breams
Monotaxis grandoculis
Gnathodentex aurolineatus
Gymnocranius griseus
Silver breams
Argyrops spinifer

Mylio latus
Goat fishes
Parupeneus indicus
Upeneus sulphureus
U. vittatus
Silver bat-fish
Monodactylus argenteus
Sweeper
Pempheris moluca
Sea chubb
Kyphosus cinerascens
Spade fishes
Tripterodon orbits
Platax orbicularis
P. teira
Sickle Fish
Drepane punctata
Butter fish
Scatophagus argus
Coral fishes & Angel fishes
Chaetodon auriga
C. collare
C. trifasciatus
C. vagabundus
C. zanthocephalus
Pomacanthodes annularis
P. semicirculatus
Etroplus suratensis
Demoiselles & Pullers
Abudefduf biocellatus
A. septemfasciatus
A. uniocellatus
Amphiprion sebae
Chromis caeruleus
Dascyllus aruanus
D. trimaculatus
Pomacentrus nigricans
P. tripunctatus
Parrot fishes
Callyodon bataviensis
C. ghobban
C. janthochir
C. dussumiere
C. fasciatus
Wrasses
Cheilinus chlorurus
C. diagramma
C. undulatus
Cheilio inermis
Coris gaimardi
Gomphosus coeruleus
Hemigymnus faciatus
Stethojulis axillaries
Thalassoma hardwicki
T. lunare
T. purpurea
Blenny
Entomacrodus striatus
Dragonet
Callionymus japonicus
C.sagita
Spine foots
Siganus oramin
S.javus
S. vermiculatus
Moorish idol
Zanclus cornutus
Surgeon fishes & Unicorn fishes
Acanthurus bleekeri
A. leucosternon
A. lineatus
A. matoides
Naso brevirostris
N. tuberosus
N.unicornis
Snake mackerels
Epinulla orientalis
Ribbon fishes (Hair tails)
Lepturacanthus savala
Trchiurus lepturus
Tunas, Mackerels & Seer fishes
Auxis rochei
A. thazard
Euthynnus affinis
Katsuwonus pelamis
Sarda orientails
Thunnus albacares
T. tonggol
Rastrelliger kanagurta
Acanthocybium solandri
Scomberomorus commerson
S. guttatus

S. lineolatus
Sail fishes (Marlins)
Istiophorus platypterus
Makaira indica
M. nigricans
Sword fish
Xiphias gladius
Scorpaenopsis cirrhosa
Sebastapistes strongi
Sea robins
Peristedion adeni
Flat heads
Platycephalus indicus
P. scaber
P.triocellatus
Zebrias quagga
Cynoglossus lingua
Sucker fishes
Echeneis naucrates
Tripod fishes
Pseudotriacanthus strigilifer
Triacanthoides athiops
Triacanthus brevirostris
File fishes & Leather jackets
Abalistes stellatus
Canthidermis rotundatus
Balistapus undulatus
Rhinecanthus aculeatus
Paramonacanthus choirocephalus
Amanses sandwichiensis
Puffer fishes (Blow fishes)
Pomfrets
Pampus argenteus
P. chinensis
Hump heads
Kurtis indicus
Scorpion fishes (Sting fishes & Fire fishes)
P.tuberculatus
Flat fishes
Psettodes erumei
Bothus ovalis
Engyprosopon grandisquamis
Pseudorhombus arsius

Lagocephalus inermis
Tetradon hispidus
T. immaculatus
T. leopardus
T. nigropunctatus
T. stellatus
T. oblongus
Porcupine fishes
Diodon hystrix
D. maculifer
Frog fishes
Anternnarius leprosus
A. hispidus
Bat fishes
Halicutea stellata
Dragon fish
Pegasus draconis

REPTILES

Order: Testudines
Chelonidae
Caretta caretta
Chelonia mydas
Dermochelys coriacea
Eretmochelys imbricata
Lepidochelys olivacea

Sea Snakes
Sub family
Hydrophiinae
Hydrophis spiralis
H. cyanocinctus
H. ornatus
H. gracilis
H. caerulescens
H. fasciatus
H. lapemoides
Thalassophina viperina
Lapemis curtus
Pelamis platurus
Acrochordus granulatus
Cerberus rynchops

MAMMALS

Order: Cetacea
Delphinidae
Orcaella brevirostris
Physeteridae
Physeter macrocephalus
Ziphiidae
Mesoplodon ginkgodens
Order: Sirenia
Dugongidae
Dugong dugon

Other cetaceans occur in this region:
Steno bredanensis
Sousa chinensis
Grampus griseus
Tursiops truncates
Stenella longirostris
Stenella coeruloalba
Delphius delphis
Lagenodelphis hoesi
Peponocephala electra
Fersa attenuate
Peudorca Crassidens
Orcinus orca
Globicephala macrorhyncha
Ziphius caviorstris
Mesopldon densirostris
Mesoplodon ginkgodems
Physeter macrocephalus
Kogia breviceps
Kogia simus
Megaptera novangliae
Balanoptera musculus
Balanoptera physalus
Balanoptera edni
Balanoptera borealis
Balanoptera acutorostrata

Annexure - VI

FRAMEWORK FOR MONITORING OF HEALTH GULF OF MANNAR BIOSPHERE RESERVE

TABLE . GOMBR HEALTH INDICATORS AND METHODS OF ASSESSMENT

	Criteria and indicators	Explanation	Methods of assessment	Thresholds			Current status
				Poor (Score: 1)	Fair (Score: 2)	Good (Score: 3)	
1.	**ECOSYSTEM INTACTNESS**						
1.1	Upland land use change	The land use practices in the adjacent land have a strong influence on the health of BR. High human activities and encroachments in the surrounding lands indicate low connectivity and disturbed ecosystem. Encroachment causes loss of riparian vegetation, floodplain, and catchment and negatively	Assessment of land use through village survey, participatory mapping, secondary information from local governance bodies such as revenue department, *Panchayat*. Assessment of land use through high resolution remote sensing images and observations in field.	Urban or rural land use/encroachment within 100 m of the high tide line of BR boundary and intensive human activities.	Rural/urban land use outside 200 m of high tide line of BR with moderate human activity	Rural/urban land use with buffer of around 500 m of the boundary of high tide line of BR with negligible human activities	2 BR 0 NP

	Criteria and indicators	Explanation	Methods of assessment	Thresholds			Current status
				Poor (Score: 1)	Fair (Score: 2)	Good (Score: 3)	
		affects ecosystem value.					
1.2	Extent of catchment and watershed remaining under natural vegetation cover (Thamirabarani River)	The natural capital in terms of biodiversity and its intactness would ensure sustainability and higher resilience against anthropogenic and natural functional degradation.	Assessment of secondary data from Forest departments. Examination of survey of India maps, higher resolution remote sensing images and onsite field observations.	< 50% area remaining under natural vegetation cover	50-70% area remaining under natural vegetation cover	70-100% area remaining under natural vegetation cover	1 BR
1.3	Habitat connectivity	Connectivity among surrounding aquatic, riparian and forest habitats in the floodplains and catchment and well as inter and intra-basin connectivity. Connectivity enhances habitat variability, biodiversity value and buffers habitat alteration.	Assessment of land use through village survey, participatory mapping. Examination of survey of India maps, higher resolution remote sensing images and onsite field observations.	Connectivity with other wetland/river, forest and grassland disrupted wholly. Or Linear connectivity between upstream and downstream of a river or stream disturbed by barriers without Environmental Flow and Fish passes	Connectivity exists only in rainy season otherwise no connectivity with other wetland/river/forest. or Linear connectivity between upstream and downstream of a river or stream disturbed by barriers but with MEF and Fish passes	Connectivity with other wetland/river, forest and grassland exist. or Linear connectivity between upstream and downstream of a river or stream undisturbed by barriers	1BR

	Criteria and indicators	Explanation	Methods of assessment	Thresholds			Current status
				Poor (Score: 1)	Fair (Score: 2)	Good (Score: 3)	
1.5	Siltation rate	Siltation is common when surrounding land or catchment has been cleared/disturbed, especially in areas with a steep gradient. It significantly reduces the depth of the water column.	Bathymetry.	Major silt deposit in the wetland causing a general reduction (>5%) of wetland area or average depth or hydroperiod.	Minor silt deposits but there is no significant reduction (<5%) in wetland area or average depth or hydroperiod in last 20 years.	No reduction in wetland area or average depth or hydroperiod due to siltation in last 20 years.	2 BR
1.6	Width of the drawdown zone	Greater width of the area between shoreline and upland provides buffer from shock.	Examination of survey of India maps and higher resolution remote sensing images and field surveys.	Drawdown zone perceived or actual declination of more than 25% or disturbed due to other land use in last 10 years.	Drawdown zone perceived or actual declination of about and less than 25%-, or disturbed due to other land use in last 10 years.	Negligible/ No change in the drawdown zone in last 10 years.	2 BR
1.7	% Littoral zone (shallow water zone <2 m)	A measure of intactness of the BR as this zone is most productive.	Examination of survey of India maps and higher resolution remote sensing maps and field surveys. Bathymetry.	Littoral zone (shallow water zone <2 m), perceived or actual reduced by more than 25% or got disturbed due to other land use in last 10 years.	Littoral zone (shallow water zone <2 m) perceived or actual, reduced by about or less than 25% or got disturbed due to other land use in last 10 years.	Negligible/ No reduction in the original littoral zone in last 10 years.	3 BR
2.	**HYDROLOGICAL INTEGRITY**						
2.1	Hydrological connectivity with floodplain,	Undisturbed connectivity	Monitoring inlet and outlet of	Substantial change in inflow and outflow	Moderate change in inflow and	No change in inflow and outflow of water between	1 BR

	Criteria and indicators	Explanation	Methods of assessment	Thresholds			Current status
				Poor (Score: 1)	Fair (Score: 2)	Good (Score: 3)	
	catchment and other wetlands/ rivers/tributaries	between wetland and catchment is critical for survival of wetland.	wetland and its connectivity with catchment using Survey of India map and remote sensing data and site survey.	of water between catchment and wetland and vice versa.	outflow of water between catchment and wetland and vice versa.	catchment and wetland and vice versa.	
2.2	Water depth	Natural seasonal depth variations provide habitat variability and support biodiversity. Any deviation would cause change in hydro-period, habitat loss and biodiversity loss.	Depth gauge, sonar. Consultation with local communities.	Substantial change (>25% deviation from the average flow/depth of last 10 years) in flow regime or water depth.	Moderate change (<25% deviation from the average flow/depth of last 10 years) in flow regime or water depth.	Negligible change in flow regime or water depth.	2 Thamirabarani River
3.	**WATER QUALITY**						
3.1	Visible water pollution	Lowering of water transparency, greenish/greyish colour, obnoxious odour are indicators of pollution. Presence of floating waste debris also indicates lowly	Site level inspection based on observer's perception. Sechhi Depth for water transparency assessment	Pungent odour in water, brownish colour, floating solid non-biodegradable waste, sewage/industrial effluent discharge	No odour, greenish/greyish colour, floating macrophytes	No odour, no colour, very few floating macrophytes	3 BR 3 NP

	Criteria and indicators	Explanation	Methods of assessment	Thresholds			Current status
				Poor (Score: 1)	Fair (Score: 2)	Good (Score: 3)	
		aesthetics and poor health of wetland.					
3.2	Algal bloom	Affects dissolved oxygen (DO) level available for ecological processes and affects aesthetic value.	Fluorometer and site level inspection based on Phytoplankton abundance survey.	Accumulation of microalgae layer>1 cm thick is evident.	Accumulation of microalgae layer 0.1 to 1 cm thick is evident.	Accumulation of microalgae layer<0.1 cm thick is evident.	3 BR
3.3	Extent of pesticide, herbicide, inorganic manure used in the surrounding urban/ agricultural area	Increased pesticide residue and heavy metals in the water and sediment may lead to bioaccumulation and environmental toxicity. Major pesticides and major Heavy Metals to be analyzed as prescribed in IS: 10500: 2012	Survey of agricultural land surrounding wetlands and rivers, Pesticide analysis by Gas chromatography-Mass spectrophotometry (GC-MS) Heavy metal analysis by Atomic absorption Spectrophotometry (AAS).	Pesticide use in more than 25% of the catchment area. Presence of pesticides and Heavy Metals more than the permissible limits as described in IS: 10500: 2012	Pesticide use in <25% of catchment area. Presence of pesticides and Heavy Metals JUST within the permissible limits as described in IS: 10500: 2012	Negligible (<10%) pesticide used in the catchment. Presence of pesticides and Heavy Metals very less than the permissible limits/Not Detected (ND) as described in IS: 10500: 2012	3 NP 3 BR
4.	**BIOTIC COMMUNITY – FLORA**						
4.1	Free floating invasive species (% wetland area)	Affects native biotic communities	Ocular estimation	>50% of the wetland is colonized by weeds/ invasive species	Some weed incursion into the wetland resulting from edge colonization,	No weeds/ invasive present in the wetland.	2 BR 2 NP

	Criteria and indicators	Explanation	Methods of assessment	Thresholds			Current status
				Poor (Score: 1)	Fair (Score: 2)	Good (Score: 3)	
					however >50% of the wetland remains FREE of weeds/ invasive species.		
4.2	Rooted invasive species (% wetland area)	Affects native biotic communities	Plot method (1 m x 1 m)	More than 50% wetland area covered with weeds or invasive plants.	Some weed incursion into the wetland resulting from edge colonization and/or incursion from roads and tracks, however >50% of the wetland remains free of weeds.	Less than 5% of the wetland and its boundary is affected by weeds.	3
4.3	% shorerline area covered with vegetation	Indicates wetland integrity	Ocular estimation	No vegetation or 50% of shore vegetation degraded.	Less than 25% shore vegetation degraded.	Intact and no degradation of shore vegetation.	1
4.4.	Mangrove cover (ha)	Indicates habitat integrity	Satellite and ground trothing, mapping	Decreased (in last 10 years)	Stable (in last 10 years)	Increased (in 10 years)	2
4.4.	Seagrass cover (ha)	Indicates habitat integrity	Satellite and ground trothing, mapping	Decreased (in last 10 years)	Stable (in last 10 years)	Increased (in 10 years)	1
5.	**5. BIOTIC COMMUNITY – FAUNA**						
5.1	Vertebrate – Richness and abundance of native fish species	Indicates intactness of site specific native biotic community	Netting, fish traps where possible. Secondary data from fishermen on % fish catch and survey of local fish market.	Decreasing trend in native species	Stable	Increasing trend in native species	1

	Criteria and indicators	Explanation	Methods of assessment	Thresholds			Current status
				Poor (Score: 1)	Fair (Score: 2)	Good (Score: 3)	
5.2	Vertebrate – Richness and abundance of all water bird species	Indicates intactness of site specific native biotic community	Standard water bird survey	Decreasing trend	Stable	Increasing trend	1
5.3	Vertebrate – Dugong populations	Dugong populations indicates health of BR	survey/ Monitoring colonial breeding bird and nest	Decreasing trend	Stable	Increasing trend	1
	Vertebrate – sea turtle populations	Sea turtles populations indicates health of BR	survey/ Monitoring colonial breeding bird and nest	Decreasing trend	Stable	Increasing trend	2
5.4	Abundance of aquatic invasive fauna	Affect native biotic community	Standard survey for benthic communities and fish catch	Increasing trend of invasive faunal species in the wetland.	Decreasing trend of invasive fauna in the wetland.	No invasive species in the wetland.	Not fauna
4.5	Coral cover (ha)	Indicates habitat integrity	Satellite and ground trothing, mapping	Decreased (in last 10 years)	Stable (in last 10 years)	Increased (in 10 years)	1 BR 2 NP
5.5	Habitat potential	Overall habitat quality for the species of conservation significance	Standard habitat assessment for wildlife value of species of conservation significance.	Important habitat parameters required for species of conservation concern have degraded.	A few habitat parameters required for species of conservation concern have degraded.	Most of the key habitat parameters required for species of conservation concerns are met.	2 NP 1 BR
6.	**ANTHROPOGENIC DISTURBANCE**						
6.1	Presence of solid biodegradable and non-biodegradable waste of anthropogenic origin in water and on shoreline	Directly impact BR health in terms water quality and aesthetic value.	Field survey based on observer's perception.	Major portion of the wetland have scattered biodegradable and non-biodegradable litter.	Negligible litter in the wetland	Wetland free of scattered biodegradable or non-biodegradable litter.	1 NP 2 BR
6.2	Numbers of untreated sewage and industrial	Sewage and industrial	Field surveys along the	Substantial number of active treated and	Not more than 2 active treated	No wastewater treated or untreated discharge intothe	1 NP 2 NP

	Criteria and indicators	Explanation	Methods of assessment	Thresholds			Current status
				Poor (Score: 1)	Fair (Score: 2)	Good (Score: 3)	
	water active outlets/overflows/drains/storm water canal	effulents directly affects water quality and degrades wetland and river health.	waterways. Secondary data from CPCB/SPCB/PCCs.	untreated wastewater outlets/overflows/drains/ storm water canal draining into wetland.	outlets/storm water canal at the wetlands.	wetland.	
6.3	Quality and quantity of sewage inflow	Sewage directly affect water quality and degrade wetland and river health.	Sampling and analysis as proposed in IS: 3025- Part I (1987). The standard limit is depicted in The Environment (Protection) Rules, 1986, Rule 3A and Schedule VI, General standards for discharge of environmental Pollutants Part A : Effluents, discharge limit for Inland surface water	Higher than the specified standards.	JUST fulfilling the specified standards.	No sewage coming into the wetland Or All effluents well below the specified limits	3 NP 1 BR
6.4	Quality and quantity of industrial discharge	Industrial discharge directly affect water quality and degrade wetland and river health	Field survey and sample analysis using IS: 3025- Part I (1987). The effluent standards will be industry specific and “Standards for Emission or Discharge of	Higher than the specified standards.	JUST fulfilling the specified standards.	No industrial waste coming into the wetland Or All effluents well below the specified limits	1 BR 3 NP

	Criteria and indicators	Explanation	Methods of assessment	Thresholds			Current status
				Poor (Score: 1)	Fair (Score: 2)	Good (Score: 3)	
			Environmental Pollutants from various Industries" by CPCB should be strictly followed.				
6.5	Extent of fishing in the BR	Overfishing may affect biodiversity and resource availability.	Perception of local fishermen. Fishing landing and market surveys.	Indiscriminate fishing using large numbers of modern gear and crafts	Fishing with mechanized crafts with large number of people	Traditional fishing with moderate number of fishermen	1
6.6	Extent of other biomass extraction (BR)	Affects provisioning service value, causes disturbance	Field surveys. Household interviews. Perception of the observer.	Substantial biomass extraction from the wetland for sale as well as consumption. Removal of rare, endangered or threatened plant species.	Occasional biomass extraction from the wetland for consumption only. No removal of rare, endangered or threatened plant species.	Minimal/Negligible/sustainable (?) biomass extraction from wetland.	1 BR 2 NP
6.7	Extent of grazing in the BR	Grazing causes high disturbance and changes plant species composition	Field survey to check number of livestock grazing in the wetland area. Availability of alternative grazing grounds and fodder sources.	Grazing animals have access throughout the wetland, established tracks throughout the wetland, dung widespread, major damage to vegetation	Grazing animals have access to around or less than 50% the wetland, some established tracks, dung uncommon , moderate damage to vegetation.	Grazing animals have partial access (less than 25%) to the wetland and little damage to the vegetation or no current signs of grazing.	2 BR 0 NP
6.8	Sand mining, Stone query	Affect natural shoreline feature, enhance	Field surveys. Perception of the observer.	Substantial sand or boulder mining on the bank and in water for commercial	Sand and boulder mining on the bank and in water using	No sand or boulder mining on the bank and in water.	2 BR 3 NP

	Criteria and indicators	Explanation	Methods of assessment	Thresholds			Current status
				Poor (Score: 1)	Fair (Score: 2)	Good (Score: 3)	
		siltation and alter habitat for nesting reptilians like turtles and crocodiles.		purpose by both manual and mechanized tools. Intensity of mining.	traditional methods, primarily for local subsistence.		
6.9	Boat wave or wake	Boat wave or wake caused by the movement of the boat through the water, the faster the speed, the larger and more damaging the effect of the wash on river banks and shorelines. Boat wave has potential to erode and undercut banks, causing severe damage to the riparian zone	Field observations.	Powered vessels frequent the waterway, and are found travelling above 'no wash' speeds. Erosion and undercutting of banks is severe in places within the study site.	Few small powered vessels are found on the waterway, travelling only at 'no wash' speeds of below 4 knots. Some erosion of the bank may be evident within the study site.	No powered vessels are permitted or found on the waterway. No erosion or undercutting of the bank is evident at any location in the study site.	1 BR 2 NP
6.12	Oil and grease from motorized boats for ferry and tourism	Leakage of oil and grease from motorized boats could lead to mortality of	Sampling and analysis as proposed in IS: 3025- Part I (1987). The standard limit is depicted in The	> 10 mg/L	Maximum 10 mg/L	Well below 10 mg/L	-

	Criteria and indicators	Explanation	Methods of assessment	Thresholds			Current status
				Poor (Score: 1)	Fair (Score: 2)	Good (Score: 3)	
		planktonic biota and suffocate fish and other aquatic life.	Environment (Protection) Rules, 1986, Rule 3A and Schedule VI, General standards for discharge of environmental Pollutants Part A : Effluents, discharge limit for Inland surface water				

BOX 1: ASSESSMENT SCORING SYSTEM

From Table 1, the scores for all assessed individual indicators should be summed up and the sum of indicator scores needs to be expressed as a percentage of the maximum achievable score. The actual percentage shows the degree of the deviation of a wetland from its natural condition.

Maximum Percentage for a Very Good wetland is 100% =
(Sum of Scores of the wetland / (Number of Indicators Assessed X 3)) X 100

Class A (Very Good) Percentage of Maximum is >90%
Class B (Good) Percentage of Maximum is 76 – 90%
Class C (Fair) Percentage of Maximum is 51-75 %
Class D (Poor) Percentage of Maximum is < 50 %

Conditions: Minimum number of Indicators need to be assessed for a wetland is 24 that should include minimum four indicators from each criterion.

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