Coral Reefs of India: Review of Their Extent, Condition, Research and Management Status

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The major reef formations in India are restricted to the Gulf of Mannar, Palk bay, Gulf of Kutch, Andaman and Nicobar Islands and the Lakshadweep islands. While the Lakshadweep reefs are atolls, the others are all fringing reefs. Patchy coral is present in the inter-tidal areas of the central west coast of the country. Coral reefs in India are being damaged and destroyed at an increasing rate. They face serious problems of stress from anthropogenic pressures and interference. However we cannot be precise about how much and where, because of special difficulties of monitoring underwater. The Reef condition is generally poor and declining in near shore waters and areas of high population density. Relatively pristine reefs are located around uninhabited islands or barrier type reefs located away from population centers. Sedimentation, dredging and coral mining are damaging near shore reefs, while the use of explosives and bottom nets in fishing are damaging offshore reefs in specific sites. Although institutions and laws are sufficient in theory to manage and protect the reefs in India, authorities in the field have taken little effective action in implementing these laws.

Introduction

This paper provides a macro view of the status of coral reefs, coral reef research and Government policy towards conservation and management of reefs in India. It draws information from earlier reports prepared by Shepard & Wells (1988), Alan White & Arjan Rajasuriya (1995) and Gopinatha Pillai, (1996). More recent information is cited as available and analyzed to show the most recent trends in resource condition, use and conservation.

Field visits to the Andamans, Lakshadweep and the Gulf of Mannar were made to verify the physical condition of the most frequently visited reefs and to assess the local community attitudes towards reefs and their dependence on reefs. Discussions were held with officers from the Ministry of Environment and Forests, New Delhi, Department of fisheries; Department of environment and forests at the State level, Naval officers, Tourist resort managers and Diving Instructors, to provide a picture on the status of management of coral reefs in India and arrive at the recent trends on Government Policy towards conservation, management and monitoring of reefs. (A visit to the Gulf of Kutch was not possible due to time constraints).

To arrive at the current status and trends in coral reef research, discussions were held with scientists of premier institutions of India associated with coral reef research. Requests were also sent out to research Institutions to provide information on their contributions to coral reef research.

The paper reviews and analyses the existing information found in both published and unpublished reports on the coral reefs in India. It is divided into five sections. The first section deals with an inventory, distribution and extent of coral reefs in India. Section two deals with the status of coral reef research in India and who are the key players. Section three deals with the human impact on coral reefs. Section four discusses Government policy and approaches to coral reef management in India. Section five provides a concluding summary.

Coral reefs are shallow water, tropical marine ecosystems which are characterized by a remarkably high biomass production and a rich faunal and flora! diversity perhaps unequaled by any other habitat. Corals require certain conditions to occur and can flourish only in relatively

shallow waters, exposed to direct sunlight, with optimum temperature of 23-25°c and free from suspended sediments.

The structure of a reef is formed by the calcareous skeleton that houses corals, a type of soft-bodied, radially symmetrical, marine invertebrates of the phylum coelenterate. Individuals of a colony are called polyps or hydroids. Millions of coral skeletons cemented together over a period ranging from a few thousand to millions of years give rise to such reefs (WWF1992). Reefs can vary enormously in structure and complexity and are roughly divided into three major types.

1. *Fringing reefs',* reefs that grow close to the shore and extend out into the sea like a submerged platform.

2. *Barrier reef:* reefs separated from the land by wide expanses of water and follow the coastline.

3. *Atolls: a* roughly circular ring of reefs surrounding a lagoon, a low lying island, common in the Indian and South pacific oceans.

Inventory, distribution and extent coral reefs in India

India with its coastline extending over 7,500 kilometers and subtropical climatic conditions has very few coral reef areas. The absence of reef in the Bay of Bengal is attributed to the immense quantity of freshwater and silt brought by the rivers (Seawell,1932). Other disincentives to reef growth are the heavy monsoonal rains and the high human presence on the coastline (Arthur: 1996)

The mainland coast of India has two widely separated area's containing reefs: The Gulf of Kutch in the north west, which has some of the most northerly reefs in the world (Kelleher et al, 1995) and Palk Bay and the Gulf of Mannar (with numerous fringing reefs around small islands) in the south east.

There are patches of reef in the inter-tidal areas of the central west coast of the country. Coral patches have been recorded in the intertidal regions of Ratnagiri, Malvan and Redi, south of Bombay (Qasim and Wafer, 1979) and at the Gaveshani Bank, 100 Km west of Mangalore (Nair and Qasim, 1978). Hermatypic corals along the shore are reported from Quilon in the Kerala coast to Enayem in Tamilnadu (Pillai, 1996). Corals also occur on the east coast between Parangipettai (Porto Novo), south of Cuddalore (10°50'N, 79°80'E) and Pondicherry but these communities have not been surveyed (Ramaiyan and Adhiyapatham, 1985)

Important off shore island groups of India with extensive reef growth include the Andaman and Nicobar Islands in the Bay of Bengal and the Lakshadweep group of Islands in the Arabian sea. The Andaman and Nicobar islands have fringing reefs and a 320 km long barrier reef on the west coast. The Lakshadweep Islands are made up of atolls.

Figure 1 shows the distribution of coral reefs in India. Table 1 provides an overview of the area estimates of coral reefs in India. These area estimates were calculated from maps developed from IRS LISS II, Landsat TM (bands 2,3 & 4) and SPOT bands 1,2 and 3) FCC (DOD & SAC: 1997). Table 2 provides an overview of the diversity of hermatypic corals in the Indian seas.

Table 1: Area Estimates of Coral Reefs in the Country (Km^2)

Category	**Gujrat**	**Tamilnadu**	**Lakshadweep islands**	**A&N Islands**

Reef flat	148.4	64.9	136.5	795.7
Sand over reef	11.8	12.0	7.3	73.3
Mud over reef	117.1	-	-	8.4
Coraline shelf	-	-	230.9	45.0
Coral heads	-	-	6.8	17.5
Live coral platform	-	-	43.3	-
Algae	53.8	0.4	0.4	-
Seaweeds	-	-	0.7	-
Seagrass	-	-	10.9	-
Reef vegetation	112.1	13.3	-	8.9
Vegetation over sand	17.0	3.6	0.4	10.5
Lagoon	-	0.1	322.8	-
Sandy substrate	-	-	(67.4)	-
Reef patch	-	-	(13.4)	-
Deep	-	-	(98.5)	-
Uncertain	-	-	(143.5)	-
Total	460.2	94.3	816.1	959.3

Ref: DOD & SAC, 1997 "Coral reef maps of India," D O D and S A C, India

Table 2: Diversity of hermatypic corals in the Indian Ocean

Locality	**Genera**	**species**
Gulf of Kutch*	24	37
West Coast Patches*	17	29
Lakshadweep Islands	37	103
Palk bay and Gulf of Mannar	36	96
Tuticorin	19	21
Andaman Islands	31	82
Nicobar Islands	43	103
Total for India*	37	199

Source: Bakus, G.J (1994) and * Pillai, G (1996).

Figure 1. Distribution of coral Reefs in India

South East Coast of India

Palk Bay

Coral reefs on the Tamil Nadu coast are located in Palk Bay near Rameswaram and in the Gulf of Mannar. Palk Bay is separated from the gulf of Manner by Mandapam peninsula and Rameswaram island. The reef is centered on 9 °17'N and 79° 15'. There is only one fringing reef in the Palk bay, which lies in an east-west direction along the mainland from the Pamban channel at the Pamban end of the bridge to Rameshwaram Island. This reef is 25-30km long, and generally less than 200m wide; maximum depth is around 3 m. Visibility is poor around 1 meter

and it is badly affected by the north east monsoon. The reef flat is relatively broad from Pamban channel to the southern end near Ramnad and narrow from Pamban to south of Rameshwaram.

Diversity in the Palk bay reef consists of common sea grasses, sixty five species of coral have been recorded with a large number in the family *Acroporidae.* Turtles and Dugongs are found in the area. Squid breeding grounds occur near Rameshwaram.

Present status

The present day reef growth is poor and it is not in a pristine condition since it was quarried in the sixties (Pillai, 1996). Satellite data shows that the reef flat is barren and is followed by sandy beach on the landward side. A small patch of reef fringes at the Dhanushkodi tip (Bahuguna A. & Nayak, S,1994).

The Gulf of Mannar

The Gulf of Mannar reefs on the other hand are developed around a chain of 21 islands that lie along the 140 km stretch between Tuticorin and Rameswaram (Krishnamurthy, 1987; Kumaraguru, 1997). These islands are located between latitude 8°47' N and 9° 15' N and longitude 78° 12' E and 79° 14'E. A detailed account of each Island is provided by Krishnamurthy (1987) and Deshmukh and Venkatramani (1995). The islands lie at an average of about 8 km from the main land. They are a part of the Mannar Barrier reef which is about 140 km long and 25 km wide between Pamban and Tuticorin (Venketesan, n.d). Different types of reef forms such as shore platform, patch, coral pinnacles and atoll type are also observed in the Gulf of Mannar. The islands have fringing coral reefs and patch reefs around them. Narrow fringing reefs are located mostly at a distance of 50 to 100 m from the islands. On the other hand patch reefs arise from depths of 2 to 9 mt and extend to 1 to 2 km in length with width as much as 50 meters. Reef flat is extensive in almost all the reefs in the gulf of Mannar. Reef vegetation is richly distributed on these reefs. The total area occupied by reef and its associated features is 94.3 sq km. Reef flat and reef vegetation including algae occupies 64.9 and 13.7 sq km, respectively. (DOD & SAC, 1997). Visibility is affected by monsoons, coral mining and high sedimentation load. The reefs are more luxuriant and richer than the reefs of Palk bay.

Reef diversity and resources

A detailed report on the Gulf of Mannar, their coral fauna, reef associated resources and suggestions for conservation and management was prepared by Krishnamurthy (1987). A comprehensive account of the coral fauna of this region are provided by Pillai (1986). There are about 96 species of corals belonging to 36 genera in the Gulf of Mannar. In a recent survey only 94 species of corals have been identified (Ramaiyan V et al, 1995). The most commonly occurring genera of corals are *Acropora, Montipora* and *Porites.* The hermatypic coral harbour filamentous algae in their "skeletal framework" as well as symbiotic zooxanthellae in their soft parts. The imprisoned algae release enough oxygen to meet the entire respiratory needs of corals. Apart from algae the reefs also harbour boring sponges, molluscs, worms, echinoderms, common shrimps, and fish (Krishnamurthy, 1987). Coral associated ornamental fishes belonging to the family *Chaetodontidae,*(butterfly fish); *Amphiprion spp* (clown fish), *Holocentrus spp* (squirrel fish), *Scarus* spp (parrot fish), *Lutjanus* spp (snapper fish) and *Abudefduf saxatilis* (sergeant Major) are abundant. (Kumaraguru, 1997). Extensive sea grass beds are present; green turtles, olive ridley turtles and dugongs are dependent on the sea grasses.

Current Status

Pillai (1975,1978,1986,1996) presents an overview of the status of coral reefs in Mannar and the species diversity. His publication (1975) cites the example of Manali island in the Gulf of Mannar, and lucidly presents the situation in the gulf before the 1960's coral mining activities and the situation after the mining had taken place. He feels that coral growth in the Gulf of Mannar will be irretrievably stunted since the bottom is sandy and the planulae will not be able to settle (Pillai: 1996). Recent underwater survey's conducted by Kumaraguru (Personal Communication: 1997) are more encouraging. They reveal that there is luxuriant coral growth around the Mannali island and that the overall condition of the reef patches in the Gulf of Mannar is not too alarming.

Andaman and Nicobar Group of Islands.

The Andaman and Nicobar group of Islands are located in the SE of the Bay of Bengal, between 6°-14° N lat and 91 °-94° E longitude. They are the emerged part of a mountain chain and lie on a ridge which extends southward from the Irrawaddy delta area of Burma, continuing the trend of the Arakan Yoma range.

They consist of 350 islands, of which only 38 are inhabited along with a number of exposed islets and rocks. The principal of these are the North Andaman, Middle Andaman with Ritchies archipelago to the east, South Andaman, little Andaman, Baratang and Rutland island. Barren island lies to the east with Narcondum and other extinct volcanoes to the north (Reddiah, 1977). The larger islands are mountainous and several are fully forested. Mangroves form extensive coverage along the shores. Annual rainfall is about 3000 mm and salinity of the waters is around 33 ppt. The coral reefs are of fringing type and except for a few investigation reports the reefs of the area still largely remain unknown. A deep oceanic ridge along 10°N seperates the Andaman Group and the Nicobar group of Islands. The general orientation is north-south.

Reef structure and corals

Almost all the islands of the Andaman and Nicobar groups exhibit narrow, linear and extensively well developed fringing reefs. Nayak et al, 1994 have published lists of the coral reefs for every island and classified them as either fringing reef or coral pinnacles. A detailed report on the corals of Andaman and Nicobar is provided by Dorairaj and Soundararajan, 1987. A total of 135 species divided among 59 genera is know to both Andaman and Nicobar (Pillai 1983). The biodiversity of fauna is yet to be ascertained. These areas have biotic elements from Polynesian, Indo Malayan as well as Burmese provinces.

The reef flats are dominated by massive *porites* and *favids* that form the chief frame builders. The shore-ward side is generally with luxuriant growth of arborescent genera such as *Acropora, Pocillopora, Seriatopora, Stylopora* etc. The reefs are rich in soft corals (Pillai, 1996). The wind ward side slopes down to a depth of 350-540 m and is subjected to the monsoonal winds. Channel reefs are found on the leeward side of the shore line.

The reef-flat occupies an area of 795.7 sq km. Coral heads and coraline shelf occupies 17.5 and 45 sq km respectively. 8.4 sq km is occupied by mud over reef. Mud deposition on the reef flat near navy bay, flat bay, reef island etc. indicates degraded condition of the reef. The deposition of mud on the reef flat is as a result of felling of mangrove trees and clearing of other forests. Conservation measures should be taken up to prevent further degradation of the reefs. (Nayak et al: 1994).

Reef diversity and resources

The islands have important nesting beaches for leatherback, hawksbill, olive ridley and green turtles and marine mammals such as Dugong. Several hundred estuarine crocodiles occur in densities inversely proportional to human populations (Whitaker and Whitaker 1978). Clams *Donex* spp and *Actactodea*, several gastropods and species of crabs are found in the sand and shingle of the upper littoral zone. Seagrass beds *(Cymodocea* and *Thalassia) are* found in the nearshore waters. They harbour three species of sea cucumbers, star fish and two species of brittle stars. Bivalves and pearl oysters are found amongst the subtidal dead shingles. 442 fish species are were reported for the Andaman and Nicobar (Dorairaj, Soundararajan and Singh, 1987).

Current status

Reef watch studies indicate that the reefs have been badly damaged in the recent past (Wood, 1991). This survey was limited to a few locations around the South Andaman islands. My own experience as a lay observer, snorkelling around Jolly Boy and Scuba diving at Pig head reef in Rutland Island in October 1997 was that the reef was fairly rich in life forms. In a qualitative comparison with the reefs in Lakshadweep and the Gulf of Mannar I feel that the reefs were in a better condition than the Gulf of Mannar and a close second to Lakshadweep (Bangaram and Kadmat dive locations). One observed some sedimentation in the near shore reef and the visibility in October was around one to two meters. There is not enough recent information about the reefs around North Andaman and the Nicobar islands to provide a true picture of the current status of the reefs.

The Gulf of Kutch

The Gulf of Kutch located at 22°15'-23°40' N Latitude and 68°20'-70°40' East Longitude, is one of the indentations found on the northern side of the Saurashtra Peninsula. It has and area of approximately 7350 sq km. The Gulf which is aligned approximately E-W is about 170 km long and 75 km wide at the mouth, after narrowing down abruptly at a longitude of 72° 20' it gets divided into three major creek systems at the island of Satsaida bet. The southern shore is fringed by numerous live and some dead coral reefs, islands and extensive mud flats, that dry at low tide. In contrast the northern coast is fringed by tidal flats only.

The coral formations of the Gulf of Kutch represents one of the extreme northern limits of corals in the Indian ocean. The approach to the corals is difficult due to the existence of vast intertidal mud flats which are difficult to negotiate by foot at low tide. The sudden influx of tidal waters also renders it risky to work on the exposed bank (Pillai, Rajagopalan, Varghese, 1975).

These reefs are mostly of fringing type along with offshore platform reefs, patch reefs and coral pinnacles. There are some 40 islands with patchy coral formation of which the largest is Pirotan Island. The coral reefs are in a highly degraded condition. The major source of degradation has been mud deposits on various coral reefs e.g. Bural Chank, Kalubhar, Munde ka bet and Jindra reef. Mud over reef occupies a major portion (117.1 sq km. of the reef). The reef area of the gulf of Kutch is 148 sq km and the total area occupied by the reef is 315 sq km (DOD & SAC, 1997).

Reef diversity and resources

The available data reveals that the area supports 120 spp of algae, 70 spp of sponges, 200' types of fish, 8 types of sharks, 27 spp of prawns, 30 spp of crab along with lobster and barnacles. There are two hundred species of phyllum molluscs with oysters, three species of turtles and three species of marine mammals (dugongs, dolphins and whales) (GEC:1997).

The coral fauna is comparitively less diverse when compared to other parts of India. According to a taxonomic study conducted at 15 reef locations in Kutch viz, Okha, Dholiogugar, Dona, Boria, Magunda, Savaj, Paga, Manmarudi lanmarud, Ajad, Burel reef, Dhani, Kazimbar reef, Narara reef, Goose reef and Piroten islands has reported 40 species of corals (Pillai and Patel I988 in GEC 1997). Ramose corals such as *Acropora*, *Pocillopora*, *Stylopora* and *Seriatopora* are not found at present though semi-fossilised specimens of *Acropora* are found on some beaches in moderate density (Pillai, 1996).

Current status

Living coral area rarely exceed 20-30 % (GEC, 1997). The preventive measures taken in the marine national park has resulted in the restoration of the area under reef significantly.

West Coast of India

The west coast of India between Bombay and Goa is reported to have submerged banks with isolated coral formations (Nair and Qasim, 1978). Coral patches have been recorded in the intertidal regions of Ratnagiri, Malvan and Redi, south of Bombay (Qasim and Wafer, 1979) and at the Gaveshani Bank, 100 Km west of Mangalore (Nair and Qasim, 1978). *Ponies*, *Coscinarares*, *Turbinaria*, some favids and *Pseudosiderastrea* are reported. All the genera recorded are massive or encrusting without any of representation of ramose forms (Pillai, 1996). Siltation is of high rate and salinity may drop to 20 ppt during monsoon in these habitats which may restrict the growth of ecologically sensitive forms of ramose corals (Bakus et al, 1994).

Hermatypic corals along the shore are reported from Quilon in the Kerala coast to Enayem in Tamilnadu. *Pocilipora* spp is the most common genus in this area. *Accropora* is found with representation of three species. *Pseudosiderastrea* and *Ponies* spp are also found. A recent investigation has shown that 29 species in 17 genera of scleractinians occur in this area (Pillai, 1996).

Current status: Unknown for several of the areas.

The Lakshadweep Islands

The Lakshadweep islands lie scattered in the Arabian sea about 225 to 450 km from the Kerala coast. Geographically, the islands lie between 8°N - 12°3'N lat. And 71 °E- 74°E longitude. The islands consist of coral formations built up on the Laccadive-Chagos submarine ridge rising steeply from a depth of about 1500 m to 4000 m off the "west coast of India. The U.T of Lakshadweep along with the Maldives and the Chagos Archipelagoes form an interrupted chain of coral atolls and reefs on a contiguous submarine bank covering a distance of over 2000 km. This ridge is supposed to be a continuation of the Arravali mountains, and the islands are believed to be remnants of the submerged mountain cliffs (P.S.B.R. James et al: 1986).

There are 36 tiny islands, 12 atolls, 3 reefs and 5 submerged banks, covering an area of 32 km^2 with lagoons occupying about 4200 km^2. Only 11 of the 36 islands are inhabited. They are Andrott, Amini, Agatti, Bangaram, Bitra, Chetlat, Kadmat, Kalpeni, Kiltan, Minicoy and the headquarters at Kavaratti. The Minicoy island is separated from the rest of the islands by a 180 km wide stretch of sea known as the nine degree channel. Kavaratti is the administrative headquarters. Agatti houses the only airport and airstrip. A resort catering to international tourists has been functioning in Bangaram since 1988 and a resort catering to national tourists

with a dive school has been set up at Kadmat in 1995. In addition tourist huts have been erected at Kavaratti, Minicoy and Agatti.

The islands are flat and scarcely rise more than two meters. They are vulnerable to storms and sea erosion. They are made up of coral sand and boulders which have been compacted into sandstone. These islands have a warm humid climate (air temperature 17°-38° C, humidity 70%). The surface water temperature varies between 28-31 °C. While the salinity ranges from 34-37 ‰ Ground water is found a couple of meters below the land surface and is replenished by an annual rainfall of about 150 cm during the south west monsoon from June to September.

Structure of the Reef

Coral reefs of the islands are mainly atoll except one platform reef at Androth. Almost all the atolls have an orientation of NE-SW with the low lying island on the east, a broad well developed reef on the west, with a lagoon in between, connected to the open ocean by one or more channels.

The reef flat occupies 136.5 sq km area. Sea grass occupies 10.9 sq km and lagoon occupies 309.4 sq km (Bahuguna, A and Nayak, S, 1994). The depth of the sea increases outside the coral reef and can reach up to 1500-3000. Androtт is the largest island with an area of 4.84 sq km and the only island that does not have a lagoon. Bitra with an area of 0.10 sq km is the smallest in land area but perhaps has the most magnificent lagoon. All the islands lie north to south, excepting Androth which lies east to west. The distance betweeen them varies from 11 km to 378 km.

On the seaward side the reef slopes into the sea. The first plateau is found around a depth of 5-6 mts. The second plateau with sandy patches is found around 25 mts - 30mts (Andreas: 1997). During high tide water exchange takes place between the lagoon and the open sea over the reef. The lagoons have sandy bottoms with scattered coral boulders and pinnacles followed by extensive sea grass beds at the landward side.

Reef diversity and resources

A detailed report on the islands, their coral fauna, reef associated resources and suggestions of conservation and management are set in a detailed report based on an intensive survey of scientists by CMFRI (bull No 43,1989) and Rodrigues (1996). The coral fauna of Lakshadweep is known to harbour a total of 105 species divided among 37 genera (Pillai 1996). Rodrigues (1996) has recorded 29 new records for species in Lakshadweep. The lagoon and reef flat faunal elements are dominated by *Accropora* spp., *Pocillopora* spp., *Ponies* spp. and massive and encrusting favids. *Psammocora* spp is common in the northern islands. There is a profusion of blue coral *Helipora coerulea. Millepora* spp. forms the dominant element in the lagoon. One finds a latitudinal difference in coral fauna assemblage in the lakshadweep. Minicoy has some elements such as *Lobophyllia* and *Diploastrea* that are common to the Maldives but rarely found in the northern Islands. Similarly the genera *Montipora* and *Echinopora* recorded from the northern group of atolls are not recorded in Minicoy (Pillai, 1996).

86 species of macrophytes, 10 species of Anomuran crabs, 81 spp of Brachyran crabs, 155 spp of Gastropods, 24 spp of bivalves, 13 spp of sea stars, 6 spp of brittle stars, 23 spp of sea cumbers, 15 spp of sea urchins and 120 spp offish are found in the lakshadweep (Rodrigues, 1996). The green turtle and the hawksbill turtle are also found in all the islands. They graze on the sea grass beds and are hunted for their fat.

Current Status

The most recent scientific ecological survey of the islands has been conducted by Rodrigues (1996). This is based on transect studies conducted in the Lagoons in 1993,1994 and 1995. He reports that corals on the reef flats and lagoons of uninhabited islands was diverse and dense however in most inhabited islands their status can be classified as endangered.

Qualitative observations of Andreas who runs a dive school in Bangaram and has been diving off Bangaram, Agatti and Perumal Par for the last nine years, is that the corals are growing and that he had observed some damage due to *Acathanster plancii* attack in a portion of the reef five years ago and that today it is one of his favorite dive locations. The fact that the same diving tourist have made even up to four return visits to Bangaram in the past decade also speaks for itself.

Qualitative observations of two dive instructors at Kadmat is that diving is quite fantastic. They however have also observed *Acathanster plancii* in the dive area and in April 1997 removed two hundred in a matter of twenty minutes of diving time.

There is a unanimous feeling that one had to take proper controls for sewage disposal. The contamination from fecal matter and kitchen waste in the lagoons alone can take its toll of the coral reef.

2. Status of Coral Reef research in India

The major institutions involved in some level of research of Coral reefs and problems related to management and monitoring are: Department of Ocean Development, GOI, The Space Applications Centre, Ahmedabad, The Zoological survey of India, Central Marine Fisheries Research Institute, Madurai-Kamaraj University, CAS, at Parangipettai, Annamalai University, Centre for Earth Studies, Trivandrum, Institute for ocean Management, Madras, National Institute of Oceanography, Goa and the World Wide fund for Nature-India.

The Space Applications Centre at Ahmedabad has used remote sensing data to assess the area under coral reefs and prepare a coral reef atlas of India.

In the fisheries institutes the research focus has been on studying marine fish habitats, fish catch and the economics offish catch. In areas of coral reefs they have focused on studying the ecology of the coral reefs with a focus on fisheries of commercial value; such as ornamental fish, holothurians, live bait availability for tuna fisheries etc. Reliable base-line data does not exist on the extent of live coral cover, species diversity and abundance or status of the reef. This could be mainly due to the paucity of facilities and trained manpower to monitor and collect underwater data. There is also very little hard data on the impact of human activities on coral reefs and the relationship between the human economy and coral reef ecology has not received much emphasis.

The Department of Ocean Development has recently received a grant from the world bank, to prepare a CIS based information system for critical habitats for coastal ecosystems. This will include all the coral ecosystems in India including the patches and submerged banks found along the West coast of India. The institutions involved in carrying out this huge task include: Mangalore university, Gujrat Ecology Commission, Cochin University, NIO, Goa, NIO, Bombay, Anna University, Annamalai University, Andhra University, Zoological Survey of

India, Madras, Madurai-Kamaraj University, CARI, Andaman and Nicobar Islands, CMFRI and Botanical Survey of India (Ramachandran: per.comm. 1997).

Gulf of Mannar and Palk Bay

The Reefs in the Gulf of Mannar are fairly accessible to researchers from Tamilnadu and so have been well studied. The CMFRI has regional offices at Mandapam and Tuticorin and have carried out pioneering work related to surveys of the islands and the reefs. An effect of environment and human interference on the coral reefs of Palk bay and Gulf of Mannar has been carried out by Pillai in 1975. A study of the different species and genera of corals found in the Gulf of Mannar has been carried out by Pillai in 1986.

The Centre for Advanced study in Marine Biology, Annamalai University has also carried out several studies on the ecology and status of the reefs in the Gulf of Mannar.

The Madurai-Kamraj University is involved in an underwater survey using scuba equipment, of the islands of Gulf of Mannar in relation to studying the ecology of ornamental fishes of export value in the Gulf of Mannar. They have established Scuba diving facilities with all the necessary equipment to carry out underwater ecological studies in the Gulf of Mannar. These facilities will be utilized for man-power development in this field of practical significance. (Kumaraguru, 1997).

With the emphasis on people centered development and sustainable management of biodiversity, management research has become a priority. The M.S. Swaminathan Research Foundation has recently received GEF funding to develop a management plan for the Gulf of Mannar. The project report is being prepared jointly with the Tamilnadu Forest Department. The focus of the plan has to be on co-management initiatives involving participation by local people.

Andaman Islands

Several studies in this region have been undertaken by Zoological Survey of India (ZSI), National Institute of Oceanography (NIO), Central Agricultural Research Institute (CARI) and Central Marine Fisheries Research Institute over the last five decades.

The Zoological Survey of India (ZSI) and the Central Agricultural Research Institute (CARI) are the principle Scientific institutions who are located at Port Blair and are currently involved with coral reef research. At CARI while the research focus is on agriculture and culture fisheries, pioneering work on coral and related species taxonomy has also been carried out.

National Institute of Oceanography (NIO) and Central Marine Fisheries Research Institute (CMFRI) regularly sends teams of scientists to the islands to conduct surveys and research. The CMFRI has published a special issue on the Andaman and Nicobar islands (CMFRI Bulletin 34, 1983) based on the detailed studies carried out by their scientists. This includes a detailed report on the islands, their coral fauna, reef associated resources and suggestions for conservation and management.

The Department of Ocean Development also has an office in Port Blair and has funded both Space Application Centre at Ahmedabad and the Anna University of Madras to prepare GIS Maps for the coral reef areas of the Andaman Islands. The Anna University has prepared but not published 1:25,000 scale of maps for the Andaman islands. The Department is also conducting a

programme for the rejuvenation of coral reefs in A& N Islands through Andaman and nicobar Centre for Ocean development Ocean news, 1997)

Two environmental Non Governmental Organisations, Society for Andaman and Nicobar environment (SANE) and A &N Environmental Team (ANET) have also independently carried out a few studies on the status of reef for select areas of the Andaman islands. The research focus has now shifted from carrying out taxonomic studies of corals and related species to extensive surveys and ecological studies of the coral reef and monitoring reef health. A status report of the corals of Andaman and Nicobar has been carried out by CARI, (Dorairaj and Soundarajan, 1987). The most surveyed area are five reef patches of the Mahatma Gandhi Marine national Park at Wandoor (Arthur, R, 1996, Dorairaj, K, 1994, Wood E, 1988). No research on human-reef interactions exists. However impacts of human activity such as logging on reefs has been studied (Sounderajan & Whitkar, 1989). The INTACH - Andaman chapter have collaborated with SANE to produce public awareness pamphlets for corals and other endangered marine animals. Independent studies of the reefs have also been carried out on a reef watch program (Wood C, 1991)

With the emphasis on people centered development and sustainable management of biodiversity, management research has become a priority. ZSI has recently received GEF funding to develop a management plan for the entire Andamans and Nicobar groups of islands. The focus of the plan has to be on co-management initiatives involving participation by local people.

The Lakshadweep Islands

The fauna and flora of Lakshadweep islands have attracted the attention of many naturalists, one of the earliest being Dr. J.S. Gardiner (1903-1906) who explored the Maldives and Minicoy the southern most island of the Lakshadweep group. During the last nine decades, several studies in this region have been undertaken by the National Institute of Oceanography, Zoological Survey of India and the Central Marine Fisheries Research Institute. The ZSI carried out extensive surveys in 1982-87 and published in 1991, a volume on the fauna of Lakshadweep (State fauna series 2). Likewise, the CMFRI carried out a survey from January to March 1987 to study the fishery potential which culminated in the publication of a special issue on Lakshadweep (MFIS No 68,1986) and (CMFRI bulletin 43,1989). Studies conducted in the Lakshadweep so far have recently been compiled by Bakus (1994.) a study of the literature however reveals that most available information is qualitative in nature and there is no published quantitative data, on densities and community characteristics of the fauna and flora of the Lakshadweep. Quantitative data on the distribution and abundance of corals and other associated organisms on a reef flat at Agatti reef flat are now available (Rodrigues, 1996).

In the UT of Lakshadweep CMFRI has located a field station at Minicoy Island, while the focus of their work is related to the commercial fish resources of the Lakshadeep seas, pioneering work in coral and related species taxonomy has also been carried out.

Centre for Earth Studies, Trivandrum has prepared several reports relating to erosion and coastline changes. The Space Application Centre at Ahmedabad has mapped the coral reefs and atolls for the entire Union territory. The A.M.M. Murugappa Chettiar Research Centre, Chennai carried out a study on Energy use in the Islands with an emphasis on time and Energy availability for women's needs. (Hoon V and Seshadri, CVS, 1990). The M.S. Swaminathan Research Foundation, Madras conducted a case study on Gender and Biodiversity in the Lakshadweep islands. (Hoon, V, 1997).

The M.S. Swaminathan Research Foundation is carrying out a project on developing an Agri-biodiversity Conservation Corps of local volunteers. In May 1997, ten volunteers were trained in simple techniques of underwater transect surveys to carry out regular monitoring of the underwater reef biodiversity.

Gulf of Kutch

The Gulf of Kutch has been studied extensively by scientists from the National Institute of Oceanography, Goa. Taxonomic surveys have been carried out with the help of Gopinadha Pillai from the CMFRI. The Space Application Centre, Ahmedabad has prepared maps including coral reef areas with the help of satellite data. The Gujrat Ecology Commission, a Non Governmental Organisation has been active in carrying out field research based on socio-economics in this area and has also been active in developing and carrying out awareness programmes among students, policy makers and the forest department.

3. Human and economic impact on the reef systems

Reefs resources have traditionally been are a major source of food for local inhabitants and of major economic value in terms of commercial exploitation. Reefs in India provide economic security to the communities who live alongside them. In the villages around the Gulf of Mannar the traditional fishermen have been catching reef fish, diving for pearls, sacred chanks, holothuria and sea weed for centuries. In Lakshadweep the reefs are a safety net for food in the monsoon season and also provide the live bait that forms the basis for the commercial Tuna Fishing.

Perceptions of Coral reefs differ according to the priorities of the people in contact with the reef. Traditional fishers and people whose livelihood is dependent on the reef perceive reefs as a safety net in their food production system. For them they are happy hunting grounds where clams, octopus, mollusks and other rich food organisms live and provide them with food and cash income. They also perceive the reef as a defense against the erosive forces of the ocean waves. These people would never willingly destroy the reefs since they realize that they have a long term dependency on them and any destruction of the reef would be destroying the goose that lays golden eggs.

Navigators dread reefs and associate them with ship wrecks. Naval officers only see them as hindrances that come in their way of carrying out their navigational duties. They consider them as hazard zones on their navigation routes. Scientists, scuba divers and snorkeling tourists perceive reefs as places of mystery and wonder. How the corals grow and reefs develop have been questions that have excited their imagination and stimulated their enquiries for several centuries. Mainland communities see reefs as a storehouse of limestone to be extracted for the cement and lime industry. These different perceptions and the fact that reefs are common property resources can often lead to conflicts in resource use on reefs. It also raises special questions on how to effectively manage and monitor coral reef resources.

To have an understanding of the human ecology of the coral reef islands it is important to understand the relationship between local populations and the reef resources. These are the people whose livelihoods become endangered when the reefs are provided protection under protected areas such as biosphere reserves, sanctuaries or marine parks.

One also has to take into account the corporate sector such as cement and lime industries and their exploitative extraction of the reef and the new sector that is coming up in live ornamental

fish and reef fish trade. Coastal populations even if they do not live off the reefs will have a effect on the reef habitat merely by their presence. Sewage disposal is becoming one of the biggest management problems both at the Gulf of Mannar and the inhabited islands of Lakshadweep. All this gives us an idea about interactions between the communities and their ecosystem. It also gives an idea about the political situation and answer questions such as: Who are the main stakeholders of the coral reefs?, are their conflicts arising due to different priorities of users? What are the perceptions of the local population *vis-a-vis* coral reefs etc.

Palk Bay and the Gulf of Mannar

There are about 47 fishing villages along the coast of which 38 are in the Ramanathapuram district and nine in V.O Chidambaranar district bordering the Gulf of Mannar park area. Exploitation of fishery resources in the inshore waters have been the sole occupation of hundreds of fisher families along the coast for centuries. The reefs are used to carry out, reef fishery, chanks and pearl fishery, ornamental shell trade and illegal mining of corals. The villagers around Palk Bay harvest holothurians. Other harvesting activities include chanks and milk fish fry. Turtles are being harvested up to a 1000 individuals annually; Dugongs are also taken.

There are about 50,000 fisher-folk in these villages of whom more than 12,000 are active fishermen. They employ traditional craft such as catamarans, vallans, masula boats, dug out canoes and mechanized boats for their operations. The fishing gear used for fish capture are trawl nets, gill nets, shore seines, drift nets, long lines, traps and others. The average annual fish landings from the Gulf of Mannar in the period 1989-94 are around 46,000 tonnes of demersal fishes and 33,000 tonnes of pelagic fish. These are landed in 33 landing centres along the coast bordering the park area. (Deshmukh S & Venkatramani, 1995). Trawl net fishing and gill nets used for catching lobster causes damage to the reefs around the Tuticorin group of islands.

My own observations at Mandapam in November 1997 are that here are three hundred families from seven villages who are totally dependent on reef fisheries. They place a fish trap *(Kood)* in the patch reef areas in the Gulf of Mannar and every morning go to collect the fish trapped in the trap. Two men go together in a small dug out canoe one dives in to bring the trap and the other in the boat empties the trap and returns it to the diver to place in the reef flat. Shrimp heads are used for bait and trap fishing seems to be restricted to the people who have access to these shrimp heads. These fishermen fish in the Gulf of Mannar during the NE monsoon and for six months in Palk Bay. Personal observations show that this method of fishing causes no harm to the corals.

Studies carried out by various authors indicate severe coral exploitation in the Gulf of Mannar and the Palk bay region. Corals were used in large scale as raw material by the calcium carbonate industry. Extensive areas were leased by the government for coral mining and large scale quarrying was taking place until 1979 when the leases were stopped. However illegal removal still takes place. Cora! mining is centered on the reefs of the Tuticorin group of Islands. Pillai (1973) estimated the annual exploitation of the Gulf reefs to be 90,000 m^3. Venkata-ramanujam et al (1981), show that annually about 15,000 tonnes of coral stones are removed from four islands near Tuticorin alone. Acropora formosa fragments are collected for lime preparation; In tuticorin about 30 boats are involved in this activity and collect over 80,000 m^3 annually. The genera Porites and Favia the principal reef builders and the most abundant massive species on the reef are quarried for use as building blocks, the construction of roads and for the lime industry. It is estimated that the amount of coral removed over 7 years from Mulli, Talaivi and vali in the Kilakarai group is equivalent to a strip of reef 1 m deep x 18.5 m wide x 10 km long (Shepard and wells, 1988). The net result is that the growth rate of their removal and as present

day exploitation is largely confined to water less than 1 m deep, the destruction of live corals is extensive, up to even 100 % in localized sites (Wafer, 1986, Ramaiyan et al, 1995)

Other activities in this area include sea weed collection by local people (mainly women) for supply to institutions and agar-agar manufacturing units. Corals especially the branching type, chanks and shells are collected for selling as curios for the tourist market along the coast. Tourism is not well developed and tourism associated disturbance is minimal.

This being an excellent area for various rare marine specimens, students and scientists tend to be over enthusiastic about collecting zoological specimens. Krusadai and nearby islands are the worst hit.

Population pressure around the Gulf of Mannar and the untreated sewage disposal is causing bacterial infection. Disposal of sewage including the fecal matter and urine due to defecation on the beach is causing problems since it ends up in the Gulf of Mannar. Coliform count even around the islands is high. With the high growth rate of the population in the coastal areas, both due to migration and natural increase these problems are going to be more severe.

AH these activities are no longer sustainable and have a serious impact on the breeding habitats of several species and the reduction of density of the commercially exploited species.

Andaman and Nicobar Islands

According to the 1991 census the population of the islands is 2,79,111 and the estimated population by the year 2000 would be 4,05, 100 of this the total tribal population is only 23, 704 of which the Nicobarese alone are 23, 000 and the other four tribal groups Great Andamanese (38), Jarawas (200), Onges (118), Shompens (250) and Sentehilese (98). Very little documented information exists on the relationship between the original tribal population and the coral reefs. From the artifacts available at the Museum in Port Blair one can gather that their subsistence activities do include reef fisheries. Fishing was carried out by using bows and arrows by the Andamanese and spears by the Nicobarese. (Silas, 1983).

The population mainly consists of settlers from the mainland who came after the establishment of penal settlements in 1857 (Khan I.P & Kala, N 199?). Clearly the greatest impact of human activities on reef resources will be due to the demands of the settler populations, government servants, business opportunists and tourists who visit the islands for pleasure.

It is difficult to provide a good status of the human and economic impact on the reef systems in the Andaman and Nicobar Islands since the entire reef stretch is not regularly monitored or managed. One can only hazard a guess that the maximum impact is in the South Andaman region which is densely populated. Pollution from the Chatham saw mill is asiphixating the reefs around Chatham. Logging derived siltation is smothering the reefs (Soundararajan, R, Whitaker, R, and Acharya, S. 1989). The increasing population densities and rapid industrialization have also resulted in increasing discharge of sewage and effluents into the ecosystem.

Tourism is yet to realize its potential and tourist pressure is limited to two areas regularly visited, Jolly Boys and Red skin. Some tourist induced damage of reefs can be seen on these reefs. Tourism derived damage is caused by trampling of corals by snorkellers and swimmers, and anchoring of boats. Glass bottom viewing is also available within Wandoor national park. There are four dive shops in Port Blair, a rapid assessment shows that in the peak season which last

four months around four to six hundred scuba divers dive every month in Wandoor around, Pig head reef off Rutland island and Havelock island.

Unplanned collection of shells and corals for ornamental trade and commercial exploitation of fishes also contribute to reef damage. It is now very rare to find the Turbo shell which was once abundant.

It is also difficult to give an account of the dependence of local communities on coral reefs and reef resources since there is no published literature from this angle. The anthropological studies on the tribes have mainly been with regard to their material culture. It would therefore be of interest to carry out a socio-economic study based on stakeholder analysis vis-a-vis the coral reefs. As majority of the population of the Andaman and Nicobar Islands have been settlers their knowledge of the coral reef ecology is very minimal. The majority of the settlers came from Bengal and prefer eating fresh water fish to marine fish. The indigenous knowledge component if any lies with the tribal population whose voices are not heard.

Gulf of Kutch

Commercial exploitation of coral sands by the cement industry is considered to be the main cause of the destruction of corals. Felling of mangroves has also attributed to the increase in sediment load arising out of enhanced erosion of exposed mud flats. Pirotan island represents the northern limits of the coral growth with living corals confined to a small area along the northern side of the island. The eastern side exhibits vast areas of dead corals giving a clear indication of mass mortality (GEC. 1077)

Fishing in the park-sanctuary area causes stress on the coral reefs owing to the unsustainable practices that are now popular such as killing fish through chemicals and concentration of fishing activities in the near shore areas owing to the rise in population of fishing communities. Fishermen increasingly use near shore areas, fixing their nets on coral reefs, collecting shells, corals and other marine life for sale. Breeding grounds are over exploited by the use of fine meshed nets that also cause unnecessary killing of commercially non-valuable species that are indiscriminately netted (Nambiar, Oza and Kacher, 1995).

The Lakshadweep Islands

The major economic activity of the Lakshadweep islands is oceanic tuna fishery. Reef fishery have traditionally been exploited to a very low subsistence level. The lagoon and reef patches are however are extremely important to the survival of the islanders since they provide them with a safety blanket for food security during the monsoon season. During this season the fishermen are not able to venture into the open sea and the only food the islanders can bank upon is coconuts and the fish catch available in the lagoons (Hoon V, 1990, 1997).

Table 3: Agencies and Users of the Reef

1. The Department of Fisheries	Fishing research, collection of species for Museum, Aquarium for scientific purposes and awareness creation.
2. *CMFRI*	Collection of specimens for scientific research purposes
3. Harbour works department:	Mainly for surface transport: dredging and deepening of navigational channels.
4. Port Department	Provide anchoring buoys for mooring ships and boats and conduct

	servicing of the vessels.
5. Public Works Department:	Provide tetrapods to stall sea erosion on the island
6. Society for Promotion of Recreation and Tourisms (SPORTS)	Tourism promotion, takes tourists into the lagoon to snorkel, scuba dive and use glass bottom boats to view the corals and associated fish life.
7. Department of Science Technology and Environment,	is the nodal and moderating department. They conduct an environment Impact assessment on the 9th five year plan of the Administration of Lakshadweep. Approve the coastal zone Management Action Plan of Lakshadweep.
8. The islanders	building materials, reef fishing and deep sea fishing
9. Tourist	By there very presence add quantities to the waste disposal and sewage problems

The islanders have developed several traditional tools to capture fish and extract resources from the lagoon. They capture fish by using nets, fish traps, wounding gear and ingenuity. Pole and line fishing for tuna has gained popularity in all the islands. The fishermen use mechanized craft to carry out tuna fishing operations outside the lagoons. However the tuna fisheries are also dependent on live bait. These are one variety of coral associated fish, found only in the lagoon. Hence indirectly the islanders are completely dependent on reef resources for their survival.

The lagoon and reef flats are looked upon as common property resources and therefore equity in resource sharing is an important issue. For example discipline has to be maintained in case more than one person wants to do net fishing. Only one net is placed in the lagoon and the catch is shared by all the parties concerned.

Coral and shingle extraction: The islanders make bricks out of coral shingle and use them for house and building constructions. The islanders know that it is the reef that protects the islands and rarely collect boulder coral for individual use. They rely on shingle collection on the lagoon side. They mix cement with the shingle to make bricks and build their homes.

Developmental and recreational activities', blasting and dredging in lagoon for navigational channels leads to coral mortality. Tourism poses problems of garbage and sewage disposal, anchor damage by tourist boats, collection of souvenirs

Population Pressure: for the isolated island economy of Lakshadweep, pressure of population is the prime concern. At the present rate of growth, the average density which at 1616 per sq kilometers is the third highest in India, will reach socially unacceptable levels in the near future. Even subsistence use will not be sustainable in the long run. Garbage and sewage disposal will cause the main threats to the reef. Right now the Toilets are connected to a septic tank and the waste water ultimately finds its way into the lagoon or open sea and creates both unhygienic conditions for the people and upsets the balance of nutrients in the lagoon, causing algal growth to compete with reef growth.

4. Institutional Jurisdiction and Management Responsibility

The coral reefs of India come under the jurisdiction of the department of forests and wildlife and it is their responsibility to monitor, manage and conserve these fragile eco-system. The Ministry of Environment and Forests is responsible to develop an action plan to manage the reef resources and issue guidelines for the sustainable utilization of coral reefs. These plans have been under

preparation since 1986, they are however yet to be published. The management of coral reef ecosystems has also been affirmed in India's National Conservation Strategy and Environment Action Plan. (UNDP, 1997).

The National Committee constituted for conservation and management of wetlands and mangroves also advises the Government on policy issues related to conservation and management of coral reefs. State level steering committees have been set up for the formulation and implementation of the Management Action Plans for the identified coral reef areas. Management plans for the Gulf of Kutch Marine National Park and Sanctuary has been prepared by the Conservator of Forests in 1994. Recently the Ministry of Environment and Forests has sanctioned preparation of management action plans for the Andaman and Nicobar and Gulf of Mannar coral reefs (MoEF, 1997).

The wildlife protection act 1972 as amended up to 1991 covers various important aspects with regard to protection of wild animals and certain plants. Corals are not as yet covered by this act. It is important to stress here that coral reef areas come under the jurisdiction of the state Wild life department only when the area is deemed a protected area.

The coastal regulation zone notification, 1991 offers the only legal protection to all coral reefs and In this coral reef areas come under the CRZ1 category. A special category CRZ 4 has been prepared for the Islands of Andaman, Nicobar and Lakshadweep. Norms for regulation of activities within the CRZ state that corals and sand from beaches and coastal water shall not be used for construction and other purposes. Dredging and underwater blasting in and around coral formations shall not be permitted. Section 7 (2) also states that construction of beach resorts/hotels shall not be permitted in ecologically sensitive areas such as marine parks and coral reefs (Notification 8.0114 (E) of 19 February, 1991).

Table 4: Protection Status of Coral reef areas

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

While the formation of protected areas and the CRZ notifications and Acts are laudable one finds that there seem to be problems in trying to implement them. These problems are magnified due to the difficulties arising out of monitoring coral reefs and lack of trained departmental staff to carry out these activities. A good example is that coral reefs in protected areas have now come under the control of foresters and Wildlife specialists, who have very little understanding of coral reef ecology and many of them have also never seen a reef first hand. They therefore are only

following a projectionist policy where possible and banning the entry of people into the protected areas.

Palk Bay and the Gulf of Mannar

The Government of Tamilnadu has banned the quarrying of massive corals; dead corals on landward sides can be extracted under a lease. Collection of marine organisms are allowed only for scientific purposes around Krusudai island. Management responsibility of the protected areas and marine biosphere lies with the state department of forests and wildlife. No management or legal protection exists for Palk Bay.

Gulf of Mannar has been declared a Marine Biosphere Reserve. All 21 islands have been notified as reserve lands under sec.26 of the Tamil Nadu Forest Act. Notification of these islands and the sea around the island up to 3.5-5 fathom deep, as a national park under the provisions of the wildlife Protection Act 1972 has also been published. Dugong hunting has been banned and awareness created among fishermen.

Zoning for tourism development; education and scientific purposes have been recommended for total protection of marine life including dolphins, turtles and sea weeds (Krishnamurthy, 1988).

The M.S. Swaminathan Research Foundation and the Tamilnadu Department of forests are currently in the process of developing a management plan for operationalising the management activities of the Gulf of Mannar Biosphere Reserve.

Andaman and Nicobar Islands

All the coral reefs included under the National Marine park status come under the jurisdiction of the Department of Forests and Wildlife. The unprotected area falls under the purview of the department of fisheries. The department of wildlife and forests lack expertise in managing marine national parks and have yet to develop a strategy for the management and monitoring of coral reef ecosystems. They follow a protectionist policy and restrict entry of people into the parks. Tourists are allowed to visit only the Redskin and Jolly boy islands within the national park.

There is a ban on gathering corals and endangered molluscs however the corals are not included in the wildlife protection act. It is therefore difficult to take action against offenders outside the national park. They cannot be convicted and only the material gathered is confiscated by the department of police. Tourists are not allowed to collect shells, corals etc. for souvenir purposes.

Gulf of Kutch

The Gulf of Kutch including 42 islands along the coast of Jamnagar was declared India's first marine protected area' through a series of notifications between 1980 and 1982. The first notification dated 12-8-80 made a sanctuary of approximately 221 sq. Km and it was later extended by a second notification dated 20-7-82 to include 237 sq. Km more (Nambiar et al, 1995). The national park comes under the jurisdiction of the Department of Forests.

Though there is a ban on gathering corals and endangered marine species, the laws relating to the ban are vague and difficult to implement.

Lakshadweep Islands

The Lakshadweep islands do not boast of a protected area, however this is India's only atoll Union Territory. The administrator therefore declared at the National Development Council meeting in January 1997 that "The corner stone of all policies in the 9th plan is going to be ecology and environment" This declaration is based on the realization that the long term survival of the Union Territory depends upon the protection, preservation and conservation of its unique and extremely fragile eco-system. All development plans in the islands have to be ecologically compatible and must avoid ecological stress.

The Department of science, technology and environment has recently completed an Environment Impact Assessment report of the 9th plan document in which Environment Impact statement in respect of each of the schemes proposed by the plan implementing departments has been prepared and stated from Chapter 1-15. The statement which will have a direct beneficial impact on coral reef management are the following:

1. Cattle rearing is incompatible with the island ecology and so should be halted.

2. All toilets should be biological toilets to eliminate sewage.

3. Stress on Non conventional energy use.

4. Environment audit of all existing factories in all Government and private sectors to be conducted.

5. The shipping vessels should be so designed that the wastes generated should not be dumped into the lagoon but should be stored and disposed in the seas far from the islands.

6. When new vessels meant to enter the lagoons are to be procured it should be ensured that the draft of the vessels should be limited to the existing depth of the channel and further deepening, dredging will not be permitted as prescribed by the CRZMP.

7. Scheme No 8 providing harbour facilities in all the islands by widening channels and extending and widening jetties should be dropped and no dredging work be done in the lagoon as this increases sedimentation which will ultimately effect the health of the corals.

The Department of Science, Technology and Environment also conducts periodic awareness programs and has proposed establishment of a Marine National Park and National and World environmental Heritage status for some of the chosen islands of the UT of Lakshadweep.

Development of an appropriate Sewage systems in association with competent institutions.

They propose to monitor the degradation of corals both inside and outside the reef by regular diving and to employ protective measures to prepare a master plan for the conservation of corals.

With regard to tourism the following statement has been made " the negative impact of tourism, generation of sewage, waste, increased consumption of water and change in landscape etc. An extremely low volume, high value added very specialized tourism therefore would be appropriate to make tourism environmentally sustainable." A regular system to educate tourists of prohibitions under CZMP and environmental laws regarding corals may be introduced. (Srivastava et al, 1997).

Environmental wardens and Wildlife wardens have been appointed in each of the inhabited islands. They have been given scuba diving training. Their duty it is to see that no coral shingle collection takes place and the islanders do not fish endangered marine animals. Recently one chief conservator of forests has been given a post in the Administration of Lakshadweep to develop a management plan for the coral reefs of Lakshadweep.

5. Conclusion

Coral reef research in India is still at a preliminary stage and has not yet gone mainstream. Enormous data exists on corals and related species taxonomy. However very little information exists on population density of corals and reef associated species in relation to abundance.

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

Status of Coral reefs in India

	Bio-physical	**Research**	**Perceived threats**
Palk Bay	Slow recovery from 60's coral mining	Mainly on Bio-physical aspects	Population Pressure and associated effects
Gulf of Mannar	Slow recovery from 60's coral mining	Bio-physical aspects; associated fauna and Human activities damaging the reefs.	Population Pressure and associated effects
Andaman & Nicobar	Fair Excellent, Problems around south island	Bio-physical aspects; associated fauna and Human activities damaging the reefs	Siltation due to logging, Sand mining.
Lakshadweep	Excellent off uninhabited islands and endangered along habited islands.	Bio-physical aspects; associated fauna and Human activities damaging the reefs	Population Pressure and associated effects
Gulf of Kutch	30% of the reefs are living	Bio-physical aspects; associated fauna and Human activities damaging the reefs	Sedimentation and siltation due to cutting of mangrove forests, sand mining for industrial use. Population pressure
West Coast	Unknown	Limited	Unknown

Changing the mandate of research institutions is difficult, hence it is recommended that a special institution to serve the purposes of Coral Reef Research, Conservation and Sustainable Management may be set up under the control of the Department of Ocean Development. This could be an agency like MPEDA or an authority like the Great Barrier Reef Marine Park Authority in Australia. Such a National Centre can help to bring together all agencies/institutions working on coral reefs into a National Network on Coral reefs.

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Key note address: Conservation and Sustainable Use of Coral Reefs by Graeme Kelleher[1]

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Introduction

The seas of South Asia include areas of extremely high biological productivity as well as biological diversity. Coral reefs are the most biologically diverse ecosystems on earth, but they and other marine ecosystems are subject to degradation from a variety of human activities, even though it is widely recognised that their living resources are vital to the survival of many of the region's human communities. The region has a long history of human interaction with the "natural' environment both on land and in the sea. It is necessary to preserve this cultural relationship and to build on it so as to achieve ecologically and culturally sustainable use of the marine environment.

It follows that procedures to evaluate and protect the region's coral reefs must focus on both cultural and ecological attributes. This conclusion is supported by almost universal experience from around the world. Nowhere has marine management been successful where the interests, traditions and involvement of local communities have been neglected.

As a general statement, one can summarise the problems caused by human activities which affect coral reefs (and other marine ecosystems) as;

- pollution,
- overfishing,

- physical alteration of the seabed or coastline,
- introduction of exotic species and
- climate change.

This paper will briefly address the first three.

There are two major deficiencies in our scientific and administrative systems, which place in jeopardy the attainment of ecologically sustainable management and use of coral reefs. The first is the absence of comprehensive, long term monitoring programs. This deficiency prevents us from defining the level of stresses that exist now and the trends in those levels. The second is the lack of integration of planning, management and research in the coastal zone. Without integrated programs, there is little chance that nations win be able to take the actions, on both land and sea that will be necessary to prevent insidious degradation of their marine environments, including coral reefs..

For these reasons, this paper concentrates on Integrated Coastal Management (ICM) and marine protected areas (MPAs). Both these approaches, which merge into each other in the case of large MPA's, incorporate processes for evaluation which have proved essential in the past to achieving community understanding of issues and to generating a sense of community agreement and "ownership" of solutions to problems and conflicts. It is on the basis of such community agreement that coral reefs can in practice be protected so that their great contributions to the biosphere and to human welfare can be sustained.

Addressing the Major Problems

Pollution and its Sources

By far the greatest source, of pollution of the sea is land-based human activity. Not surprisingly, the degree of marine pollution at different parts of a coastline is often closely related to the size of the adjacent human population. There are exceptions to this where, for example, a major river system discharges remotely generated pollutants into the sea.

Forms of human-induced pollution include nutrients (mainly nitrogen and phosphorus), herbicides and pesticides and their derivatives and toxic chemicals and heavy metals.

Nutrients in sewage, combined with contribution of nutrients from other sources, particularly affect coral reef ecosystems adversely, resulting in reductions in strength of calcium carbonate skeletons and smothering of corals by algae. In coral reef environments, tertiary treatment (i.e., the removal of nitrogen and phosphorus) of sewage is essential if long term degradation is to be avoided.

Soil erosion results in suspended sediments being conveyed to the sea. The resulting marine turbidity reduces the ability of corals to gain energy from sunlight and thus their ability to compete with algae.

Fortunately, the interests of farmers coincide with those of people who depend on healthy marine ecosystems. Farmers do not wish to see their lands eroded and are not happy to pay for the application of expensive fertilisers which end up in the sea. An approach which has been started in Queensland, Australia is the establishment of joint research programs, involving farmer organisations, governments, research institutions and management agencies, aimed at defining the marine problems and their causes and formulating solutions which benefit an sectors of the community as well as the natural environment.

Fishing

Virtually every international marine fishery is considered by most experts to be, overfished. The evidence of impending collapse is decreasing catch/effort ratios. Input/output controls by themselves have usually not worked because pressure from the industry prevents imposition of sufficiently stringent controls until after the point of no return in the process of stock collapse has been passed.

Destructive fishing practices such as dynamite and poison fishing not only facilitate overfishing, but also lead to the destruction of the coral reef's ability to replace the fish or to provide the other critical services on which local communities depend.

These comments and the solution to the problems apply equally at local and regional levels. A possible answer to the problems of over-fishing and destruction of habitat is to combine multiple use MPA's with traditional fishery management practices. Such an integrated process would allow the various interest groups to agree on what areas and levels of protection should be provided to preserve habitats that are critical or that are representative of major habitat types which occur within each large marine ecosystem. Such protected areas fulfil the multiple roles of providing baselines against which to measure ecological changes caused by human activity, protecting critical life stages in commercially or recreationally fished species (such as nursery or refuge areas), providing sites in which to carry out ecological research and allowing tourists and the public to appreciate and enjoy relatively undisturbed marine environments.

Integrated Coastal Management provides the framework for the community as a whole to make decisions which both provide maximum benefits to the people who depend on coral reef resources as well as ensuring that the reef systems am not progressively degraded i.e. ICM is the key to conservation and sustainable use of coral reefs.

Physical Alteration of the Seabed or Coastline

Destruction of coastal coral reefs and their associated ecosystems for coastal development continues to occur in most parts of the world largely because these developments occur in an unplanned, uncoordinated and disintegrated fashion. Decisions are made without taking into account adverse ecological and economic consequences of destruction of natural coastal environments. Activities such as dredging, harbour construction etc. change water patterns and sediment regimes, often with ecologically undesirable results.

The ecological and economic costs of these piecemeal decisions are rarely taken into account in government approval processes. There is a great need for co-ordinated, integrated planning of the coastal environment in order to achieve both ecologically sustainable development and economically rationally use of coastal resources. This planning must be based on information provided by integrated, multi-disciplinary, ecological research, which defines the interdependencies of the various parts of the marine ecosystem and the coastal zone. This is unlikely to be carried out and the results applied in practice without the involvement of key stakeholders, particularly the local community, in all aspects of planning and research in accordance with the principles of Integrated Coastal Management, which are outlined below.

Integrated Coastal Management

Marine environments are particularly vulnerable to over-exploitation because they include large areas traditionally considered to be "commons". That is, they are not owned by

anyone and everyone is entitled to use Them.. Before and since Garrett Hardin's essay *The Tragedy of the Commons* (1968), there has been ample evidence that the long term effect of uncontrolled human activity on the commons is usually to destroy them. Furthermore, coasts often include areas where a diversity of incompatible activities compete for limited space and resources. In the case of some activities, the profits and benefits are confined to minorities, while costs am imposed on the community and the environment.

Although a clear understanding of the factors involved is often Lacking, widespread concern over the condition of coastal environments has led to demands by the Public for the right to participate in decisions affecting the coast and for better protection of coastal resources. As a result, there has been parallel Development of ICM and MPA programs in various parts of the world that actively involve the public in improving the management of coastal areas, In economic terms, these methods aim to ensure that the costs generated by one sector of society are not imposed on another sector or on the community generally.

Integrated Coastal Management is a process that unites government and the community, science and management, sectoral and public interests in preparing and implementing an integrated plan for the protection and development of coastal ecosystems and resources. The overall goal of ICM is to improve the quality of life of human communities who depend on coastal resources while maintaining the biological diversity and productivity of coastal ecosystems (GESAMP, 1996).

Expressed in this way, the goal of ICM is clearly consistent with national and international commitments to sustainable development for all environments (terrestrial and marine), from the headwaters of catchments (watersheds) to the outer Limits of exclusive economic zones (EEZ), whether or not they are subject to multiple jurisdiction.

A subordinate goal of ICM is to provide an equitable, transparent and dynamic management process that is acceptable to the community.

Introduction to a region of a country of a comprehensive ICM project is very difficult. It is often advisable to focus on a few, relatively small-scale, areas where management policies and techniques can be implemented and to postpone attempts to manage an entire coastal ecosystem until community and governments have developed the capacity to manage as well as commitment. Trial and demonstration of the effectiveness of methodology in MPAs can be an effective starting point. This is often the most responsible approach to dealing with a crisis, such as coral reef blasting, where some early action may be needed pending development of overall commitment and capacity.

Many references exist in the world's literature to the methods necessary to achieve community support for management. The criteria for selection of Marine Protected Areas which appear in IUCN's*Guide lines for Establishing Marine Protected Areas* (Kelleher and Kenchington, 1992) place strong emphasis on social (cultural) criteria. These have been the subject of careful evaluation over the past seven years in various countries and fora. They are, in summary;

naturalness;
biogeographic importance;
ecological importance;
economic importance
social importance
scientific importance

international or national significance; and
practicality/feasibility.

The criteria in full can also be found in A *Global Representative System of marine Protected Areas* (Kelleher et al, 1995).

The ICM Process

The traditional ICM process can be conceived of as repetition of a cycle of five successive stages. (Fig 1). At the end of each cycle, the stages are repeated in sequence in the next cycle. In other words, ICM is a continuing process, not a single event. It is this continuity that allows ICM to adapt to changing natural conditions and to changing human requirements, knowledge and technology.(GESAMP, 1996). The five stages are:

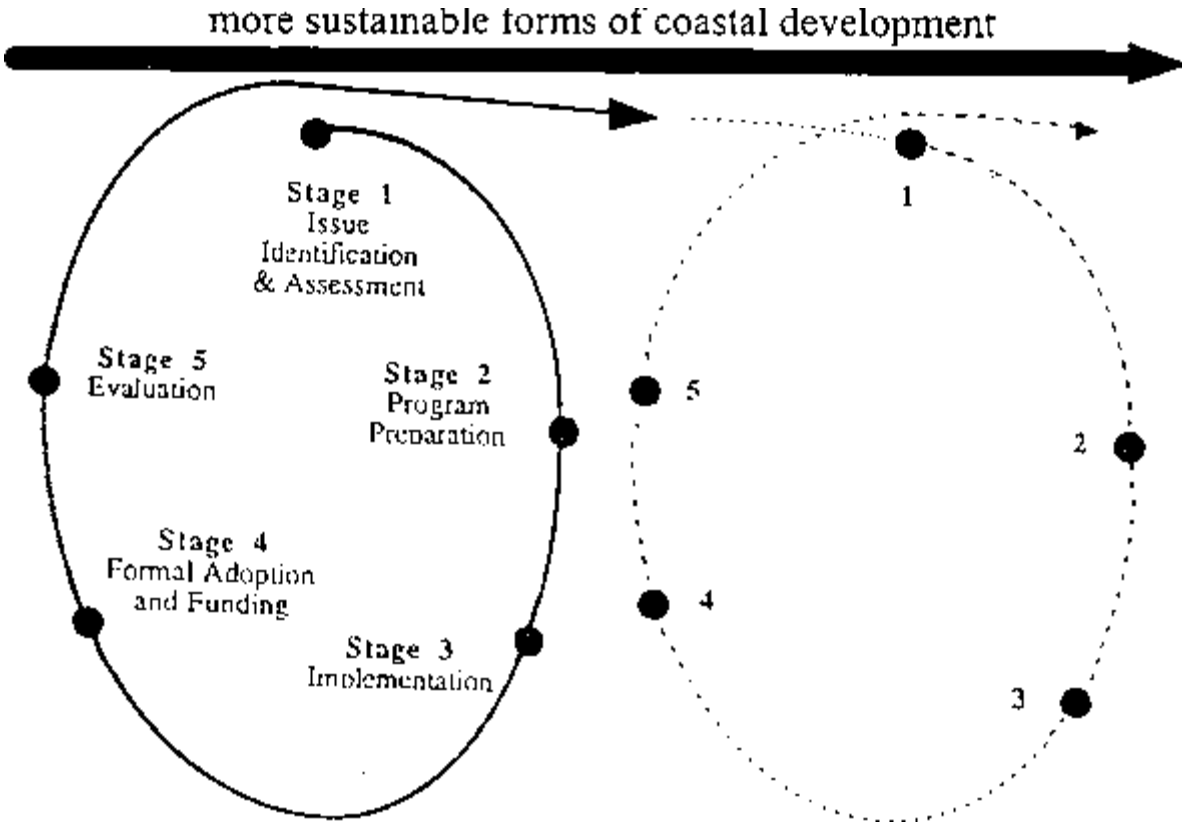
STAGE 1. Issue Identification and Assessment.

This stage consists of compiling, integrating and prioritising information that defines the environmental, cultural and institutional context within which the ICM program will proceed. It is the first, formal stage in the evaluation process.

STAGE 2. Program Preparation.

In contrast to the relatively rapid assessments of Stage 1, this Stage involves a more protracted planning process that may take several years.. The main purpose is to develop a management plan that constitutes 'a vision for the future' and that expresses, in realistic and tangible arms, the qualities of the environment to be achieved and maintained, the way in which resources should be allocated and any necessary changes in patterns of resource use and human behaviour more sustainable forms of coastal development

Figure 1. The stages of the ICM cycle to which sciences contribute.



The dynamic nature of ICM requires feedback's among the stages and may alter the sequence, or require repetition of some stages.

STAGE 3. Formal adoption and funding of the program.

Formal adoption of a program will generally require a 'high-level' administrative decision, for example by the head of a government agency, a minister or the cabinet, or perhaps by presidential endorsement. It will include consideration and agreement of a budget (i.e. levels and sources of funding) for each phase of the program.

STAGE 4: Program Implementation

At this stage in the ICM process the management plan becomes operational and the emphasis shifts to the introduction of new forms of resource development and use, new institutional arrangements and monitoring systems and the application of new controls, regulations and incentives.

Enforcement is an essential element of program implementation and one which clearly demands a constant supply of reliable and readily interpretable monitoring data.

Successful implementation of an ICM program invariably presents new, sometimes unforeseen, challenges and the ICM team must be able to respond to these while maintaining momentum within the core program. Some of the additional tasks to perform might include.

* conflict resolution;
* public education;
* inter-agency co-ordination;
* training of management or enforcement problems;

* infra structural changes;
* planning and research on new areas or problems.

STAGE 5. Evaluation

This stage, where the greatest learning should occur, has been omitted or performed in a superficial manner in a great majority of coastal management initiatives. Yet, if ICM programs are to proceed through a series of cycles or generations to more sustainable forms of coastal development, this stage should be the critical juncture between one cycle and the next. The evaluation stage must address two broad questions:

- What has the preceding cycle of the program accomplished and learned and
- how should this experience affect the design and focus of the next cycle?

In other words, how has the context (e.g. environment, governance) changed since the program was initiated? This, in essence, sets the stage for repeating the assessments in Stage 1.

A meaningful evaluation can be conducted only if the program objectives have been stated in unambiguous terms and if indicators for assessing progress were identified in Stages 2 and 3, and monitored during the preceding generation. Baseline data are essential. Many evaluations yield ambiguous results because these preconditions for assessing performance do not exist.

***Integrating Science and* Culture.**

Public perceptions about the past, current and future status of the coastal environment and its resources, and how and why they should be managed are invaluable in developing strategies for a coastal management program. While not expressed in formal instruments such as laws and institutions, perceptions, aspirations and world views directly influence how a society manages its natural resources.

Experience has shown that, for ICM programs to work, managers and scientists must work together to achieve community support, minimising the creation of conflict and enmity and maximising opportunities to identify common interests. The generation of a commitment to a team approach is necessary for real co-operation.

Community groups must be involved in the design, conduct and interpretation of research that has the potential to lead to management decisions that seriously affect them. Otherwise they are likely to deny the validity of the research results and oppose strongly the decisions based on them.

Scientists and managers must work together continuously if science is to be relevant and applied to management decisions, lie two professions speak different languages, have different perspectives and imperatives and approach the solution of problems in different ways. They have to learn to work together effectively, for instance in posing management relevant questions in ways that allow them to be addressed by science.

Attachment 1 identifies the simple rules, in addition to those just mentioned, that have been demonstrated in practice to determine whether or not scientists and managers can effectively apply their disparate talents, methods and perceptions to the solution of marine and coastal problems in ways which protect the ecological and cultural heritage of a country, while contributing to the welfare of the human community.

Marine Protected Areas.

Marine protected areas can either form vital components of ICM or, if like the Great Barrier Reef Marine Park they encompass a complete marine ecosystem, they can be synonymous with ICM.

IUCN has had a major program to create MPAs for a number of years.- The first major phase of IUCN's program to establish a global representative system of marine protected areas was completed with the publication by IUCN in 1992 of *Guidelines for Establishing Marine Protected Areas* (Kelleher and Kenchington, 1992) and, in 1995, in association with the World Bank and the Great Barrier Reef Marine Park Authority (GBRMPA), of the four volume report A *Global Representative System of Marine Protected Areas* (Kelleher, Bleakley and Wells (Eds), 1995).

This latter Report lists existing marine protected areas in each of the 18 major biogeographic regions into which the world's coastal seas have been divided and identifies priorities, on both regional and national bases, for establishing new MPAs or for improving management in those which exist but are poorly managed or not managed at all. As well, general recommendations are made relating to the protection and sustainable use of marine biological diversity and productivity, with particular emphasis on the need for management regimes which provide for integrated management of ecosystems, either by incorporating complete ecosystems in MPAs or by using MPAs as a component of a wider integrated system of planning and management.

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It is worth noting that there is a general recognition that MPAs which consist of one or more highly protected core areas, surrounded by areas (buffer zones) with lower levels of protection, offer significant advantages over the "classical" model of a small, highly protected MPA surrounded by areas that are subject to very little management. Those advantages include:

- the ability to protect the core area from effects generated outside that core area; and

- the opportunity to provide explicitly for commercial or productive activities in the buffer zones which are compatible with the protection of the core area, thus contributing to the sustainable welfare of the community and generating community support.

This model is consistent with and was developed in parallel with the Biosphere Reserve concept.

Because properly managed MPAs protect habitat, as opposed to individual species, they contribute strongly to the conservation of biodiversity, as well as sustainable use, whether or not there is significant knowledge regarding the species that occupy or use the habitat or habitats that are included in the MPA. In the face of continued acceleration in the over-exploitation of marine ecosystems in many parts of the world, MPAs represent an essential part of any strategy for maintaining marine biodiversity. However, they will not by themselves be able to constitute such a strategy, except in the rare cases where an MPA includes a complete ecosystem, because many species and habitats will not be adequately represented in any system of protected areas and because protected areas are vulnerable to the effects of human activities outside their borders. Protected areas must operate within a system of integrated ecosystem management if they are to be effective.

***Local* community *involvement in MPAs and ICM*.**

In most countries, there is a long history of public or sectoral use of marine areas close to the coast, often for subsistence purposes. It is thus generally the case that consideration of continuing human use within and adjacent to MPAs must play a major role in their selection, design and management. Humanitarian, economic and pragmatic considerations often mean that where there is a choice of ecologically suitable areas, the dominant criteria for selection of MPA locations, boundaries and management systems will be socio-economic. Clearly, where there are few, if any alternative sites, ecological criteria should be critical and decisive.

Attempts to exclude traditional human uses from protected areas may jeopardise the physical or economic survival of the people. Community opposition will, in such cases, be very strong and will jeopardise successful management of these areas. It is often better to establish and successfully manage a MPA which may not be ideal in ecological terms but which nevertheless achieves the purposes for which it is established than it is to labour futilely to create the theoretically "ideal" MPA. The problems affecting choice of area and boundaries are reduced if political, legal and social conditions allow the creation of large MPAs covering complete marine ecosystems. Education is usually the means by which such community conditions are established. This allows integrated management regimes to be established which provide for continued human use while achieving conservation objectives.

Therefore, every effort should be made to ensure that local communities stand to gain economically and socially from the operation of a MPA. Developing locally owned, managed and staffed tourist enterprises is one approach that has been successful. Another has been the creation or conformation of exclusive fishing rights to local communities, thus providing an incentive to protect areas critical to fish production, such as nursery areas or coral reefs.

Capacity building and training.

In most parts of the world there is an urgent need for improvement in the capacities of local communities and of officials to manage human activities so that use of the marine environment is ecologically sustainable. In most places the greatest deficiency is in the application of the social sciences- how to inform, motivate and empower communities and officials so that they will work co-operatively and effectively to develop and apply practices that do not degrade the ecosystems on which they depend.

Under the aegis of UNEP's Regional Co-ordinating Unit of the East Asian Seas Action 91 Plan, a compendium of staff training materials for management of MPAs has been developed and applied in South East Asia (Kenchington and Ch'ng, 1994). These materials were designed specifically for application in the Region, but they form an excellent base for review for application in other parts of the world.

Conclusion

Sustainable development has been defined as "development that meets the needs of the present without compromising the ability of future generations to meet their needs". The historical approach by developed economies to the use of natural resources in the sea have failed to be sustainable largely because of the factors encapsulated in the phrase " the tragedy of the commons" (Hardin, 1968). The reliance on sectoral management, which fails to take account of effects of sectoral activities on other sectors, has shown that integrated

coastal management is a necessity. Equally, the almost universal failure of traditional fishery management, based on control of fishing effort and/or catch, to prevent stock collapse and ecological damage, shows that new approaches are needed.

Marine protected areas are vital components of integrated ecosystem management regimes. They can provide almost complete protection of important elements of marine ecosystems and, if large enough, can protect entire ecosystems. The Great Barrier Reef Marine Park is the best example of the latter type of MPA, protecting an area more than twice as large as the island of Java while allowing economic activity worth more than $ 1000 million per year and supporting a fishing industry worth about $300 million per year.

Marine protected areas, if they either by themselves or as part of integrated management programs encompass complete ecosystems, can provide for the needs of the present while ensuring that the ecological processes on which all life depends are protected for future generations, lie involvement of local communities in the establishment and operation of MPAs and the provision of definable economic and social benefits to those communities from the MPAs is vital in all societies.

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Attachment 1

Rules for Scientists and Manager to Work Together Successfully in ICM.

The following summary identifies the simple rules that have been demonstrated in practice to determine whether or not scientists and managers can effectively apply their disparate talents, methods and perceptions to the solution of marine and coastal problems in ways which protect the ecological and cultural heritage of a country, while contributing to the welfare of the human community.(GESAMP, 1996)

- Scientists and managers must work together continuously throughout the ICM program. It is not enough for the relationship between the two groups of people to be sporadic or occasional;

- managers must make decisions, whether or not unequivocal scientific information is available. We have learned that managers should base their decisions on;

- trends rather than states,

- the precautionary principle so that where there is doubt about the outcome of the matter, the decision should err on the side of preventing environmental damage,

- priorities i.e. management effort and scientific effort should be related to the importance of the issues. At present we are far from this,

- scientists are unlikely to address management issues unless there am incentives provided within the system for them to do so. Experience has shown that the transmission of a proportion of the funds for research through the management agencies will provide such incentive:

- managers and scientists, working together, must monitor the results of management decisions and adapt management to the results of that monitoring;

- managers will never be successful without community support. In a democratic society, governments follow community opinion. Therefore managers and scientists must work so as to achieve community support for decisions which protect the ecology of the area being managed,

- critical stakeholders must be involved in the design, conduct and interpretation of research that has the potential to lead to management decisions that seriously affect them. Otherwise they are likely to deny the validity of the research results and oppose strongly the decisions based on them.

- there are likely to be many opponents to ICM, both potential and real, in the community. Our mutual efforts will only be successful if we minimise the creation of enemies and maximise the opportunities to identify common interests. A particular example of this is the issue of run-off from the mainland of nutrients and suspended sediments. Farmers are just as interested as are those who care for the marine environment in preventing the removal of these materials from their farmlands. Our presentations and attitudes should reflect the fact that we recognise the commonality of our interests.