

8. STATUS OF CORAL REEFS IN SOUTH ASIA: BANGLADESH, CHAGOS, INDIA, MALDIVES AND SRI LANKA

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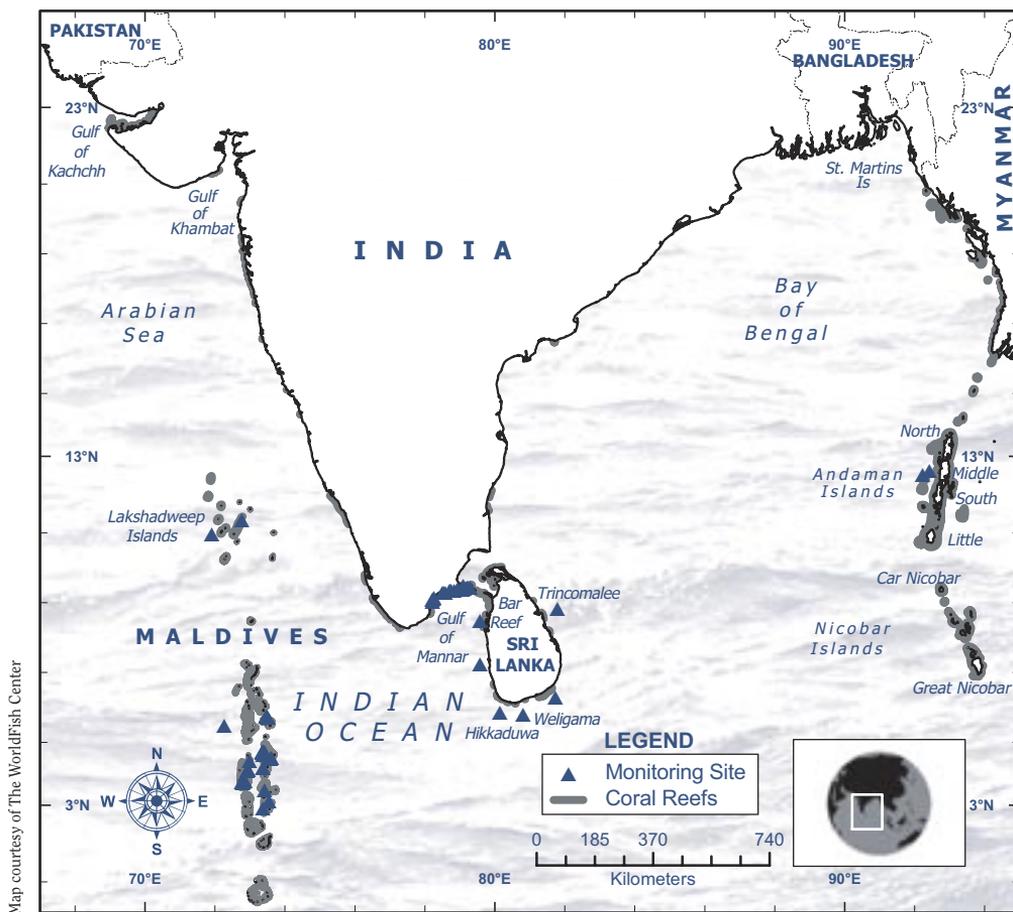
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ABSTRACT

The major coral reefs in South Asia occur in the Maldives, Chagos, Lakshadweep and the Andaman and Nicobar Islands. There are also extensive reefs in the Gulf of Mannar, and fringing and patch reefs elsewhere in India and Sri Lanka. Limited coral communities occur around St. Martin's Island in Bangladesh and on the Balochistan coast of Pakistan. Coral reef recovery following the 1998 bleaching was variable. Some areas show relatively good recovery, such as the severely bleached Lakshadweep Islands, where coral cover has doubled from less than 10% after the bleaching to 20% on some atolls, whereas in other areas there are indications of a phase shift, with algal growth smothering corals. Minor coral bleaching was observed in 2003 and 2004 in the Maldives, Sri Lanka, on the Indian side of the Gulf of Mannar and on St. Martin's Island in Bangladesh, with almost 100% recovery within months. Several reef areas have been declared marine protected areas (MPAs) in India, the Maldives and Sri Lanka. However, with the exception of Chagos, reef management remains poor in the region, particularly in India and Sri Lanka, where the exploitation of reef resources is increasing.

100 Years ago: Most reefs in the region were in pristine condition although the reefs near human populations may have been showing the effects of some resource exploitation. For example, chanks and sea cucumber were heavily exploited in the Gulf of Mannar region in the 1920s.

In 1994: Effects of over-fishing and destructive methods to collect reef resources, e.g. bomb fishing and mining, were clearly evident on reefs close to larger human settlements, resulting in reduced coral cover and ecosystem productivity. New or rapidly growing markets, including tourism and marine aquarium fish collection were affecting the reef resources, e.g. reef fish and lobster populations were depleted. Reefs in the Maldives and Sri Lanka were mostly recovering well from earlier plagues of crown-of-thorns starfish (COTS). There were no obvious signs of large-scale perturbations.



In 2004: Half of the reefs of the region are struggling to recover from the mass bleaching mortality in 1998, partly due to high levels of other stresses. There are indications of phase shifts to algal dominated reefs in many areas, whereas some areas are recovering rapidly. While reefs not affected by the bleaching mortality remain in relatively better health, they are often under threat from human activities. There are clear signs of over harvesting of fish and other reef resources such as sea cucumbers, chanks and spiny lobsters. Minor to serious bleaching was observed in Chagos, Sri Lanka, the Maldives and India in April – May 2004, but most of the affected corals have recovered relatively rapidly with low levels of mortality.

Predictions for 2014: The highly stressed coral reefs will not be managed better and even the more sustainable resource use practices will continue to deplete coral reef resources, with some damaged beyond recovery. This is the probable fate of about a third of the reefs of the region; another third will change from low-moderate threat status to high threat status. Areas under appropriate and effective management or remote from direct human pressures will continue to remain healthy, although all reefs in the region will continue to be vulnerable to large-scale bleaching events.

INTRODUCTION

With the exception of the Andaman and Nicobar Islands and some parts of the Gulf of Mannar, coral reefs in the South Asian region were heavily damaged by the coral bleaching in 1998, with mortality ranging between 50% and 95% of the existing coral cover. Recovery of these reefs remains variable, partly due to high stress from human activities, although some areas are showing signs of a return to pre-bleaching levels of coral cover.

Virtually all coral reefs in the region outside MPAs are subject to various levels of exploitation. The pressure is exceptionally high in Sri Lanka and the Gulf of Mannar and Gulf of Kachchh areas in India, where poverty, population growth, coastal development and other land-based activities pose a serious threat to the existence of the reefs. Furthermore, management of coral reef areas remains poor in many parts of the region, both inside and outside MPAs, due to a lack of technical, institutional and financial capacity.

Regular ecological monitoring of coral reefs continues in India, the Maldives and Sri Lanka, based on training and financial support from national governments, the GCRMN South Asia Node, the Coral Reef Degradation in the Indian Ocean (CORDIO) program and other research projects funded by the Swedish aid agency Sida and other bilateral donors such as the Global Environment Facility (GEF). Increased emphasis has been put on pro-poor approaches to management, with training in socio-economic monitoring, implementation of socio-economic assessments, and development of alternative livelihoods in the region through initiatives such as CORDIO and GCRMN. These regionally oriented approaches remain a priority in South Asia.

This report provides an update to the 'Status of Coral Reefs in South Asia: Bangladesh, India, Maldives Sri Lanka' in the 'Status of Coral Reefs of the World: 2002'.

Bangladesh

The only coral communities in Bangladesh are found around St. Martin's Island. A fringe of rocky substrate and coral communities extends about 200 m from the island, with a total reef area of less than 50 km². The area is influenced by freshwater influx, monsoons and frequent disturbances such as cyclones and storm surges, resulting in high sedimentation as well as mechanical damage. Pressure from human activities, mainly resource exploitation, tourism and coastal development, is high. A shallow reef area about 15 km west of St. Martin's Island, locally known as Marphati bandth is not currently under any form of management, but is less damaged due to its inaccessibility to coral poachers.

Chagos Archipelago

The British Indian Ocean Territory of Chagos is on the southern end of the Laccadive-Chagos ridge. The archipelago consists of 6 large atolls and many small islands and submerged shoals, with a total reef area of 3,770 km². The largest atoll, Diego Garcia, hosts a US naval base. The coral reefs of Chagos are the best conserved in the South Asian region. There is comparatively little human activity, with the only human pressures arising from the military base, recreational yachts and some poaching.

India

The total coral reef area in India is 5,790 km², distributed between 4 major regions: Lakshadweep; Gulf of Mannar; Gulf of Kachchh; and Andaman and Nicobar Islands. Reef structure and species diversity vary considerably between the areas due to differences in size and environmental conditions.

Lakshadweep is an archipelago of 12 atolls surrounded by deep water, on the northern end of the Laccadive-Chagos ridge. In the Gulf of Kachchh, there are shallow patchy reefs growing on sandstone platforms that surround 34 islands. The reefs experience high salinity, frequent emersion, high temperature fluctuations and heavy sedimentation. In the Gulf of Mannar, coral reefs are found mainly around 21 islands between Rameshwaram and Tuticorin. Two former islands are now submerged, probably due to coral mining and erosion. The Andaman and Nicobar Islands consist of 530 islands with extensive fringing reefs which are mostly in good condition. Corals have also been reported from Gaveshani Bank about 100 km offshore from Mangalore, and several areas along the eastern and western coast of mainland India, e.g. the Malvan Coral Reef Sanctuary near Mumbai.

Large areas of coral reefs of India, with the exception of the Andaman and Nicobar Islands, were severely affected by the 1998 coral bleaching event. Reef resources are heavily exploited, particularly in the Gulf of Mannar and Gulf of Kachchh and to a lesser degree in the Lakshadweep and Andaman and Nicobar Islands.

Maldives

The Maldives are in the centre of the Laccadive-Chagos ridge, and consist of 23 atolls, including 1,190 coral islands and numerous sand cays, within an area of 8,920 km². The archipelago is surrounded by deep oceanic water and reefs are generally less threatened by human activities than in other parts of South Asia, as the human population is low and there are large distances between atolls. Coral reefs form the resource base for the two major economic sectors, tourism and fisheries, including the provision of bait for the offshore pole and line fishery for tuna. The tourism industry has become the largest income earner and the Government expanded the island hotel industry to all atoll groups of the Maldives in 2004, as a diversification strategy. Thus the tourism sector provides most of the reef management by reducing exploitation of fish, coral rock and sand and other reef resources in proximity to the resorts. Government interventions are steadily being reduced.

Pakistan

Little is known about the coral communities of Pakistan. The total reef area is less than 50 km². There are isolated coral patches on hard substrates along the Balochistan coast, but coral reef development is poor due to high sedimentation and turbidity. Coral development similar to that of the southern Arabian reefs may occur along the coast further west. No information on status and trends is available as few surveys have been conducted.

Sri Lanka

There are fringing, patch and platform reefs around Sri Lanka including sandstone/limestone and rocky reef habitats, covering 680 km². The most extensive coral reefs are offshore in the Gulf of Mannar region. The northeast and southwest monsoons govern environmental conditions for reef development. The southwestern coast of Sri Lanka has many rocky headlands and most fringing coral reefs have developed on the leeward side of these headlands due to strong waves generated by the southwest monsoon; there are no barriers to the south of Sri Lanka to reduce the impact of oceanic waves on the coast. There is better fringing coral reef development along the eastern coast, both on the leeward side of headlands and on offshore rocks and islands. Reefs are heavily exploited for resources and management intervention is generally inadequate.

CORAL REEF STATUS AND BIODIVERSITY

Bangladesh

The rocky substrate reefs have a coral cover of 7%, with 66 species of hard corals, dominated by branching (Acroporidae) and massive (Faviidae and Poritidae) species. There are 86 species of reef fish with damselfish, surgeonfish and parrotfish being the most common. The most abundant molluscs e.g. *Monodonta*, *Thais*, *Cypraea*, *Conus* and *Trochus* species are heavily traded.

Chagos

The marine fauna of the Chagos Archipelago has more similarity with Indonesian and East African reefs than with the coral reefs to its north. Chagos has high diversity, with the 220 species of hard corals being among the highest recorded in the Indian Ocean. Fish abundance is expected to be higher than in the Maldives, but there have been no detailed surveys.

Coral reefs were severely depleted during the 1998 coral bleaching event, which destroyed up to 80% of live coral cover to a depth of 40 m. In early 2004, the coral reefs that were recovering from 1998, suffered very extensive repeat bleaching. However, the peak water temperatures were reduced by cyclonic winds bringing heavy cloud cover and rain for a critical 10 days when bleaching was clearly evident. Recent information suggests that the bleached corals in the lagoons of Diego Garcia mostly recovered, with little mortality.

India

A total of 262 species of hard corals, 145 species of soft corals and 1,087 species of reef fish have been recorded from Indian coral reefs, but diversity varies significantly between areas. There are 104 hard coral species in the Gulf of Mannar, with dominant families being the Acroporidae, Faviidae and Poritidae, and more than 538 fish species. The 1998 coral bleaching event did not cause major losses in the Tuticorin group, and current live coral cover is 26%, dominated by massive coral species.

In the Andaman and Nicobar Islands, there are 203 hard coral species with *Porites* spp. being dominant in the northern and southern Andaman Islands, while *Acropora* spp. dominate the middle Andaman and the Nicobar Islands. The 1998 bleaching had far less effect on corals in the archipelago compared to other parts of the region. Currently live coral cover averages 65% and about 1,200 fish species have been recorded. The diversity of the Andaman and Nicobar Islands has greater affinity to Southeast Asia than to other reef areas in the South Asian Region due to the currents in the north-eastern Indian Ocean promoting larval exchanges with Southeast Asia.

The Lakshadweep Archipelago experienced severe coral mortality in 1998, and the live coral cover in the reef lagoons was reduced to less than 10%, with some variation between areas. Today the live coral cover is about 20%, with the previously severely damaged Kadmat and Agatti atolls showing good recovery.

The fringing coral reefs in the Gulf of Kachchh generally have low diversity, with around 42 hard coral species and 10 soft coral species. Live coral cover is generally low, currently about 20%.

Maldives

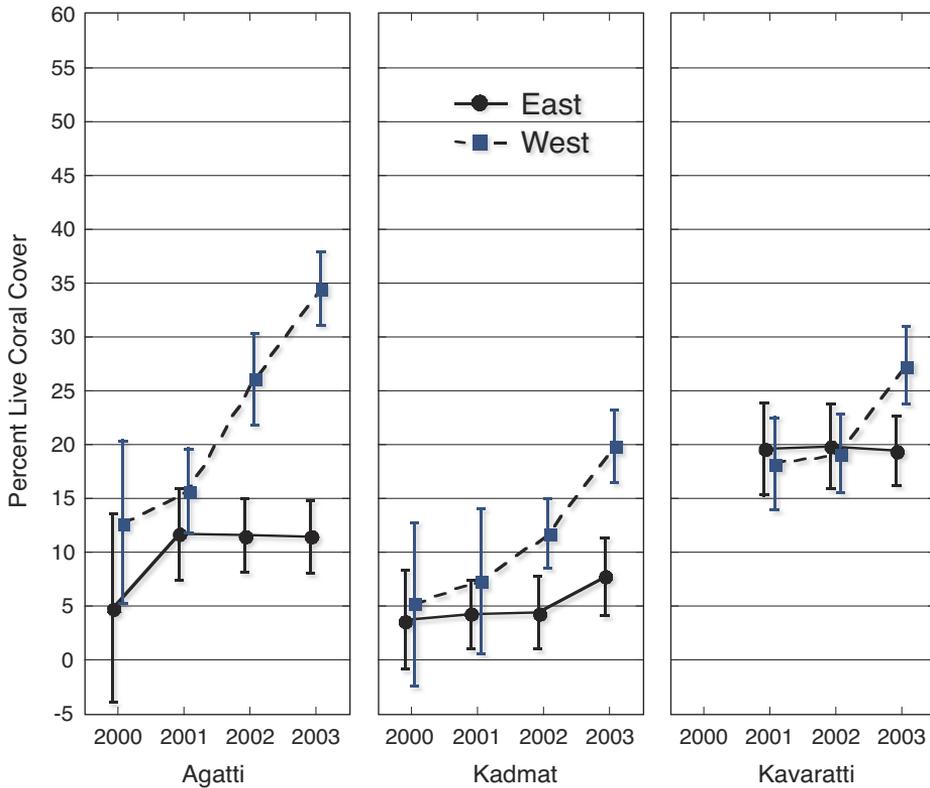
The coral reefs of the Maldives support a high diversity of reef animals, with about 250 species of corals and 1,200 reef and reef associated fish species. The bleaching in 1998 was most severe

in the northern and central parts of the archipelago, and recovery has been variable on reef flats and slopes. Reefs in the southern atolls, which were generally less affected by the 1998 bleaching, appear to be recovering faster and are currently in much better condition. However, in May 2004 a severe storm inflicted damage on Hithadhoo, resulting in a significant reduction in live coral cover on both the reef flat and slopes, particularly in shallow areas. Minor coral bleaching was observed in Ari, Vaavu and Addu atolls during April and May 2003. Monitoring of permanent sites established in 1998 continued in 2003-04, however, monitoring of some sites and fish surveys planned for 2003 were not completed due to a lack of resources. These surveys remain a high priority, including studying the effects of coral bleaching on reef fish populations.

DIFFERENCES IN CORAL RECOVERY IN THE LAKSHADWEEP ISLANDS, INDIA

The 1998 El Niño climate change event caused considerable coral bleaching and mortality on the reefs of the Lakshadweep Islands. The benthic communities on many of these reefs were radically altered, with the potential for wide-ranging consequences for reef diversity and for the populations of reef-dependent organisms. Monitoring on the eastern and western sides of 3 atolls, Agatti, Kavaratti, and Kadmat showed a marked difference in the recovery of coral cover. Corals on the western sides of reefs showed very encouraging recovery between 2000 and 2003, dominated by rapidly growing branching and table *Acropora* species. In contrast, coral recovery on the eastern sides was either slow or virtually absent, although initially the recovery was good. These differences in coral cover were also observed in larger-scale, rapid assessments of more reefs in 2002.

The differences in coral recovery were not due to different recruitment patterns of the coral larvae, but to higher mortality of juveniles settling on the eastern sides. In 1998, the bleaching mortality was followed immediately by the summer monsoons that brought stormy conditions to the western sides in the Lakshadweep Islands. Much of the unstable dead coral on the west was cleared away relatively quickly from the reef, whereas even 4 years after the mortality event, there was much more dead standing coral on most eastern side reefs. Juvenile corals settled on these dead coral skeletons, which soon crumbled or toppled over resulting in considerable mortality of the new corals. Another major threat to new corals on disturbed reefs is overgrowth by fleshy macro-algae. However, on these reefs, the macro-algal cover remained very low between 2000 and 2003; probably because the strong ocean swells prevented accumulation of high nutrient levels and the large populations of herbivorous reef fishes, particularly scarids and acanthurids, kept the algae in check. Moreover the herbivores were the dominant trophic group on the reef after the bleaching, constituting 70% of the total fish abundance at some sites in 2000. Generally the fish communities in the Lakshadweep were remarkably stable after the bleaching, with a gradual increase in coral eating fishes as coral cover increased. These healthy fish populations were probably a major contributing factor to the rapid recovery of the Lakshadweep reefs after the massive coral mortality. From: Rohan Arthur, Nature Conservation Foundation, Mysore, India; rohan.arthur@jcu.edu.au.



There was more rapid recovery in live coral cover on the western sides of coral reef atolls of Agatti, Kadmat and Kavaratti in the Lakshadweep Islands than on the eastern sides from 2000 to 2003 (error bars represent 95% confidence intervals).

Sri Lanka

About 190 species of hard coral have been recorded from Sri Lanka. The 1998 bleaching event had a profound effect on the western and southern coral reefs, while the damage was lower on the eastern coast. Monitoring data from shallow reefs in the table below show the initial losses from the bleaching and subsequent recovery at 4 sites in the northwest (Bar Reef Marine Sanctuary), southwest (Hikkaduwa National Park), south (Weligama) and east (Pigeon Island National Park).

Live coral cover at 15 monitoring sites in the Maldives following the 1998 bleaching event shows generally consistent recovery, especially in the southern reefs of Villingili, Hithadhoo and Gan, which were less seriously affected in 1998 (n/m – not monitored).

Reef Sites	1998	1999	2000	2002	2003	2004
Reef flat (1-2 m)	% cover	% cover	% cover	% cover	% over	% cover
Hondaafushi	1.6	0.5	0.9	1.7	3.1	n/m
Finey	0.7	0.1	0.3	1.4	2.5	n/m
Hirimaradhoo	0.7	0.3	0.4	1.1	1.1	n/m
Feydhoofinolhu	1.7	2.3	1.8	1.9	n/m	n/m
Bandos	1.9	7.6	5.0	6.9	n/m	n/m
Udhafushi	1.3	1.5	2.1	2.9	n/m	n/m
Fesdhoo	3.3	3.8	9.9	22.1	n/m	27.2
Maayaafushi	0.6	0.9	1.5	2.7	n/m	4.8
Velidhoo	0.2	0.2	0.7	2.3	n/m	2.3
Ambaraa	1.2	0.9	3.2	2.9	4.8	n/m
Wattaru	2.8	2.4	2.7	3.7	5.0	n/m
Foththeyo	5.0	2.7	4.1	5.0	9.7	n/m
Gan	4.0	4.5	5.0	12.9	n/m	17.0
Villingili	4.3	n/m	9.2	13.2	n/m	n/m
Kooddoo	1.0	2.3	n/m	6.0	n/m	n/m
Reef flat (3 m)						
Hithadhoo				51.6	59.1	32.0
Reef slope (7 m)						
Gan				42.8	n/m	n/m
Reef slope (10 m)						
Villingili				54.3	n/m	61.4
Hithadhoo				40.9	62.6	51.7

There is evidence of recovery of corals on Sri Lankan reefs after 1998 when coral bleaching dramatically reduced coral cover to almost zero on many reefs on the western coast, whereas reefs on the eastern coast (e.g. Pigeon Is.) were not affected; n/m – not monitored

Reef sites	Depth	Pre-bleaching	1999- 2000	2001-2002	2003-2004
Bar Reef Marine Sanctuary	0 - 3 m	78.5%	Near 100% mortality	Some new colonies	17.7%
Hikkaduwa National Park	0 - 3 m	47.2%	7.0%	12.0%	10.1%
Weligama Reef	0 - 3 m	92%	28.0%	54.0%	70.6%
Pigeon Island National Park	0 – 3 m	n/m	51.3%	n/m	54.4%

Recovery of bleached reefs was slower on the northwestern, southwestern and eastern coasts (Bar Reef, Hikkaduwa and Weligama and Trincomalee respectively). Some areas that showed recovery in 2002, have again been overgrown with calcareous algae (*Halimeda* sp). Only the fringing reef at Weligama in the south has shown good recovery, primarily due to an increase in branching *Acropora* spp. Recovery on large coral banks in the Bar Reef Marine Sanctuary is patchy, with strong growth predominantly due to the branching *Pocillopora damicornis* and plate forming *Acropora cytherea* in some areas. The rest of the fringing coral reefs in the southwest and south have not been recolonised by *Acropora* or by *Pocillopora*, although these were common before 1998. The reefs have thus become covered by low-profile foliose *Montipora*. Minor coral bleaching was observed in April and May 2004 just prior to the onset of the southwest monsoon, but no mortality was recorded.

THREATS TO CORAL REEFS AND MANAGEMENT ISSUES

The threats to the coral reefs vary among the countries and reef areas in South Asia. In Bangladesh, mainland India and Sri Lanka there is continual damage to coral reefs from human activities such as the use of destructive fishing methods, over harvesting of resources, development and pollution, while in the Andaman and Nicobar Islands, Lakshadweep, and the Maldives these threats are much lower. There is little direct damage to reefs in Chagos due to low human populations and better protection. However, climate change poses a serious threat to all reefs in the region.

Bangladesh

There is a large market for corals and associated fauna, including e.g. gastropod and bivalve shells and marine turtles, operates in the Cox's Bazaar district. Merchandise is indiscriminately harvested from around St Martin's Island, and other coastal areas of Bangladesh, although it is suspected at least some of the coral skeletons on sale may come from the Mergui area in Myanmar. The Government of Bangladesh declared St. Martin's Island a protected area in 1999, but little action has been taken to manage the area. Land ownership is largely private, and indiscriminate coastal construction and increased tourism pressure pose a potential threat to the reefs. Construction of a large tourist hotel in 1999 led to increased sewage runoff. Construction of jetties and passenger ship operation facilities commenced in 2002.

India

All coral reef areas continue to be under stress, especially in the Gulf of Mannar and Gulf of Kachchh, where coral mining and destructive fishing practices are most prevalent. Sedimentation and pollution pose major threats.

India developed a National Biodiversity Strategy Action Plan in 2004 which includes a conservation strategy for coral reefs. This complements the legislation banning the collection of corals and reef-associated fauna (sea cucumbers, molluscs, gorgonians, sponges, seahorses, pipefishes and sharks) under the Wildlife Act of 1972 and 2002. The plan also aims to regulate coastal resource access and benefit sharing.

The Gulf of Mannar Trust was formed in 2003 to undertake a UNDP GEF project on management of coral reefs in Gulf of Mannar, and an implementation office was opened at Ramanathapuram. A UNDP GEF project on land use patterns, biodiversity conservation and management in the Andaman Islands is in the final stages of preparation, awaiting endorsement by local authorities and approval by GEF. In May 2004, the Ministry of Environment and Forests sanctioned grant funds to organisations to undertake coral reef studies in the Andaman Islands

and Gulf of Kachchh. Projects on Integrated Coastal Zone Management with specific reference to development of tourism have been implemented in the Andaman Islands by the Institute of Ocean Management, Anna University, Chennai and in the Lakshadweep Islands by the Centre for Environmental Science Studies, Thiruvananthapuram. A series of projects including coral reef surveys and restoration, socio-economic assessments in reef dependent villages, and awareness raising efforts on the Tuticorin Coast, Gulf of Mannar are being implemented by the Suganthi Devadason Marine Research Institute (SDMRI), with support from the CORDIO Program. Additional options for income diversification for 60 families have been provided through this program that started in early 2002. The Centre of Action Research on Environment, Science and Society (CARESS) is establishing a community based coral reef socio-economic monitoring program in the Lakshadweep Islands in 2003. This project is also supported by CORDIO, and is a continuation and expansion of a GCRMN pilot project in 2001.

Maldives

Several coral reef management activities are being undertaken in the Maldives, including a complete review of existing laws and regulations on fisheries and marine resource management that also encompasses coral reef resources. Faafu atoll has been identified as a High Priority Area for coastal resource management. The Faafu grouper management pilot project has been initiated with technical help from the Asian Development Bank as part of the Coastal and Marine Resources Management and Poverty Reduction in South Asia project. Addu atoll (locally known as Eidhegili Kulhi) and associated reefs were declared a model site for the Australian Aid Maldives Protected Area System Project in 2004. Implementation of the UNDP GEF supported Atoll Ecosystem Management project formulated for Baa Atoll commenced in 2004 and is progressing as planned.

Sri Lanka

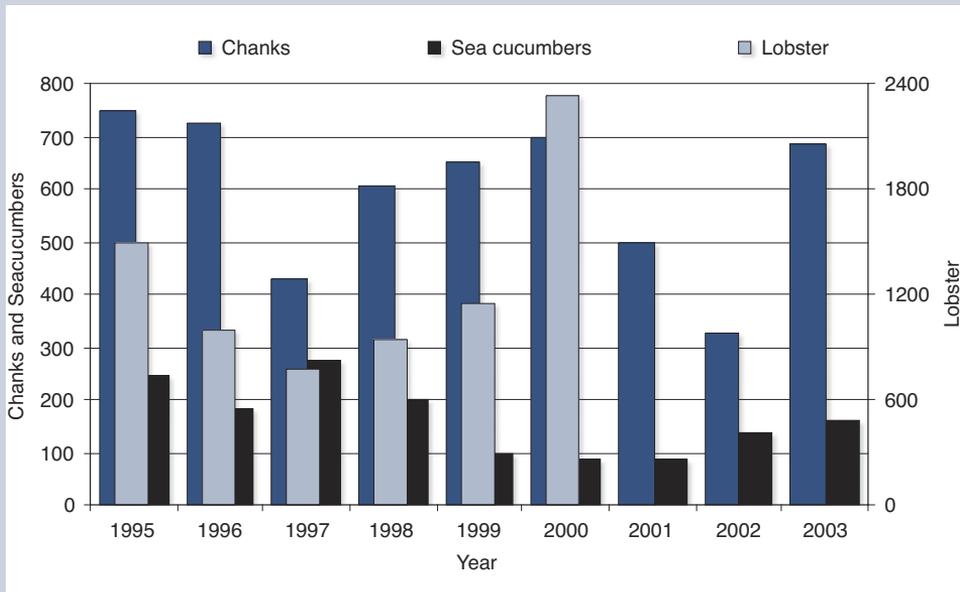
Blast fishing and purse seining continues, even in reef areas designated for protection such as the Pigeon Island National Park in Trincomalee, the Bar Reef Marine Sanctuary and Rumassala Sanctuary. The coast guard is confined to land-based activities and has not taken an active role in prevention of illegal fishing operations and coral mining. Coral mining is rampant in Rekawa, despite a USAID program from 1991-1996 which was established to provide alternative sources of livelihood to coral miners. Miners now use large rafts to drag coral blocks to shore. A socio-economic study of coral mining communities in the south-western coastal areas, identified a lack of alternative employment opportunities as the major reason for continued coral mining. In the same area in 2003 and 2004, the Turtle Conservation Project and CORDIO implemented a pilot demonstration project during which 20 coral mining women were provided opportunities to shift into alternative livelihoods. The Coastal Resources Management Project continues its special area management programs at the Bar Reef Marine Sanctuary, Unawatuna and several other coastal lagoons and estuaries along the western coast. Two new protected areas; the Pigeon Island National Park in the northeast and Rumassala Sanctuary were declared in 2003 to protect coral reefs, however there has been no management due to lack of human, institutional and financial resources.

TRAINING AND CAPACITY BUILDING

In India, an Australia-funded training and capacity building program has trained 25 scientists in scuba diving, taxonomy and GCRMN monitoring methods. The training was carried out during pilot monitoring of coral reefs in the Andaman and Nicobar Islands and the Lakshadweep islands in 2003. In 2004, India held a stakeholder workshop at Port Blair, Andaman Islands, to

UNCONTROLLED SCUBA COLLECTING IS DEPLETING KEY TARGET SPECIES IN SRI LANKA

Divers started using scuba gear to collect for the marine aquarium trade in Sri Lanka in the 1960s, and by the 1970s there were about 50 fishers using scuba for the aquarium trade or to collect spiny lobsters. Today there are about 500 fishers using scuba to harvest aquarium species, sea cucumbers, spiny lobsters and chanks (*Turbinella pyrum*, used for ornamental purposes such as making pearl-like buttons and incorporation into paints in Bangladesh and India). The annual export of sea cucumbers, chanks and other shells decreased between 1995 and 2001, probably because of resource depletion. Field



observations confirm that populations of sea cucumbers are severely depleted to about 30 m in many areas after scuba divers targeted them in the mid-1990s. They are now collected mostly at night as they feed. Scuba is used to collect in MPAs, e.g. to harvest chanks within a fisheries management area in the southeast. Increased export since 2001 is due to the opening of previously inaccessible areas in the north and east following the signing of a cease-fire agreement in 2001. Unlike chanks and sea cucumbers, which are harvested exclusively for export, a large portion of the spiny lobster harvest is eaten in tourist restaurants in Sri Lanka. An increased effort until 2001 resulted in the spiny lobsters being over-fished in the west and south, leading to decreasing sizes of lobsters caught and fewer lobsters seen on the reefs. This is the likely scenario for the northern areas soon. Recent data on lobster harvest are not available.

There are also serious health problems associated with using scuba. Exporters usually supply the equipment to the divers, but do not provide training, and many now suffer from the bends. For example, some divers on the eastern coast are working to a depth of 50 m, using

multiple scuba cylinders but without adequate decompression, resulting in some crippling cases of the bends. The naval base at Trincomalee has the only decompression chamber in the area, but it is too far from most dive sites. Thus divers attempt to manage the bends with in-water recompression, further adding to the dangers.

The Sri Lanka Fisheries and Aquatic Resources Act 1996 places restrictions on reef harvesting, but there are no regulations on the use of scuba. The Department of Fisheries and Aquatic Resources formed a committee in 2004 to develop special regulations and management recommendations to stop the over-exploitation of sea cucumber and chanks. However, much remains to be done as there is active scuba harvesting of sea cucumbers, chanks and lobsters, even within MPAs, e.g. in the Bar Reef Marine Sanctuary, which is nominally under special area management of the Coastal Resources Management Program. From Arjan Rajasuriya, National Aquatic Resources Research and Development Agency, Sri Lanka – arjan@nara.ac.lk

identify gaps in coral reef management. The CORDIO program has provided 3 PhD research scholarships in Tuticorin, Gulf of Mannar for coral reef research.

The National Aquatic Resources Research and Development Agency (NARA) and the Sri Lanka Sub-Aqua Club conducted monitoring using Reef Check in Trincomalee in 2003. A team of volunteer divers joined the activities in 2004 with financial support from the Hong Kong and Shanghai Bank. In addition, during 2003-2004, CORDIO and NARA provided training and financial support for the establishment of a coral reef unit at Eastern University, Batticaloa. They also finalised their first surveys of Passikudah Reefs on the East Coast of Sri Lanka.

AWARENESS RAISING

The 'Handbook on Hard Corals of India' (2003), and the 'Bibliography and checklist of corals and coral associated organisms of India' (2004), were published by the Zoological Survey of India to encourage researchers to study the diversity of Indian coral reefs. Twenty-nine posters on marine animals and coral reef associated organisms were also published to create awareness among Indian school children. SDMRI has published a Field Guide on stony corals of Tuticorin, and implemented coral reef education programs for fisher women in the Gulf of Mannar.

In Sri Lanka, several workshops and awareness building programs have been conducted within the Coastal Resources Management Program to educate the public and school children on the value of coastal resources, including coral reefs. IUCN Sri Lanka has completed the CORDIO funded 'Sri Lanka Reef Watch Program Phase 2' with more than 1000 schools along the coast of Sri Lanka receiving educational packages about coral reef issues. Coral reefs are now included in the formal school curriculum of Sri Lanka.

In the Maldives, information dissemination by the popular media has been a high priority. Radio programs highlighting the importance of reefs have been produced, and billboard displays are evident in several island communities. The Ministry of Fisheries, Agriculture and Marine Resources of the Maldives is currently developing a training program in order to establish reef monitoring in island communities, based on Reef Check methods. The program is targeted at

school children with the aim of exposing them to basic monitoring techniques that can gather comparative and consistent data.

RECENT CORAL BLEACHING IN SOUTH ASIA

Minor coral bleaching was observed in South Asia in March - April 2003 and 2004; the same months as massive bleaching occurred in 1998. This time coincides with the warm weather prior to the southwest monsoon. Coral bleaching was observed in India on some islands of the Gulf of Mannar, with 10 - 20% of massive corals bleached, but the majority recovered in the second half of the year. In the Maldives, there was significant coral bleaching in Faafu, Vaavu, Ari and Addu atolls, with an estimated 10-20% of coral colonies totally bleached and a similar percentage showing partial mortality. However, the majority of the corals recovered within months. In Sri Lanka, similar minor bleaching was observed in very shallow areas of Dutch Bay in Trincomalee and at Rummassala, where the water temperature rose to about 31°C. Corals recovered within about 3 weeks. At St. Martin's Island, Bangladesh, some *Goniapora* and *Platygyra colonies* bleached in the south western and north western shallow areas in 2003 and 2004. Some bleaching primarily of *Porites* colonies was also recorded in 1998 (from A. Rajasuriya, K. Venkataraman, H. Zahir, M. Z. Islam).

STATUS AND MANAGEMENT OF MARINE PROTECTED AREAS

India has 36 MPAs, including 3 Man and Biosphere reserves. In the Maldives, 25 protected sites have been established centred on tourist dive locations, and a MPA system is being developed by the Government with support from AusAID. In Sri Lanka 2 MPAs (Rumassala Sanctuary and Pigeon Island National Park) have been declared, bringing the number to 4 MPAs in the country with coral reefs. Bangladesh has one MPA; St Martin's Island.

Management remains inadequate in most MPAs in South Asia, particularly in India, Sri Lanka and Bangladesh. While sufficient legislation, regulatory frameworks and management plans exist in most cases, they are frequently not up to date or fully appropriate. Enforcement and implementation are inadequate. Primary causes for this include a lack of technical and financial capacity, inefficient coordination between various government and non-government bodies, as well as corruption in some institutions. A lack of alternative livelihoods for coastal populations, that use resources in MPAs in breach of regulations, compounds the problems. In the Maldives, reef-based tourism potentially influences reef health in MPAs, although it also offers some protection against other extractive uses.

The current status of marine protected areas in South Asia.

Marine protected areas	Status	Management	Major issues
<p>Bangladesh St Martin's Island is listed in the National Conservation Strategy</p>	Degraded	Little management due to lack of resources & development priorities	Rapid resource depletion, souvenir collection, sedimentation, pollution & physical damage.
<p>India Gulf of Mannar Biosphere Reserve</p>	Damage continues especially in nearshore areas from human activities; bleaching recently observed.	Management is inadequate & habitats continue to degrade.	Coral mining, land-based pollution, unmanaged resource harvesting.
Gulf of Kachchh Marine National Park	Corals are recovering but condition of reefs is poor.	Management is inadequate & habitats continue to degrade	High sedimentation & pollution
Lakshadweep	Corals are recovering slowly.	Has improved	Coral mining & fishing pressure in some islands
Mahatma Gandhi Marine National Park, Andaman and Nicobar	Condition of corals & reef resources is good. Recent bleaching was observed.	Management has improved after 2002, but needs improving	Sedimentation, crown-of-thorns starfish, souvenir collecting, minor bleaching
Rani Jansi Marine National Park in Richie's Archipelago, South Andaman Islands	Condition of corals & reef resources good, with rich diversity of corals & other fauna, Corals recovering & resources	Management plans implemented, but human impacts are generally low.	Little is known, no coral mining, or fishing including destructive practices, little sedimentation & low tourism impacts.
<p>Maldives 25 MPAs (Protected dive sites).</p>	declared protected. Some sites need review	Active management is inadequate. Sites are used by dive operators.	Dive tourism – impact of tourism on MPAs unknown.

Sri Lanka

Bar Reef Marine Sanctuary	Coral are recovering well but fishing pressure increased	Coastal Resources Management project developing strategies & planning MPA management.	Extractive use has increased, including fishing & especially sea cucumber & chanks collection
Hikkaduwa National Park	Corals in poor condition due to sedimentation & high visitor pressure	No management	Sedimentation, Visitor pressure & physical damage by boats & trampling of corals
Rumassala Sanctuary	Corals in poor condition; recent bleaching observed	No management	Blast fishing, ornamental fish collecting & visitor pressure
Pigeon Island National Park	Corals in good condition	No management	Visitor pressure & destructive fishing in vicinity.

CONCLUSIONS

Coral Reef Status – Past, Present and Future

100 Years ago: Reefs in South Asia were mostly in ‘pristine’ condition. Some fisheries, e.g. chank and sea cucumber collection in the Gulf of Mannar in the 1920s, as well as coral mining had damaged the reefs closer to large human settlements. However, the lower human populations meant that over-extraction of reefs, and destructive fishing methods such as seine nets with rollers and bombs were not used. Consequently the reefs recovered relatively quickly from large-scale or localised damage caused by storms. Mass-disturbances such as the bleaching event in 1998 were not reported.

In 1994: Many reefs in remote areas that had low human populations were still relatively healthy. However, some areas, such as the Andaman Islands, showed some damage from increased sediment levels caused by logging and deforestation. The effects of mining, over-fishing and destructive fishing were apparent in many reef areas, especially in India and Sri Lanka, largely due to population growth in poor reef-dependent communities. The tourism boom, especially in the Maldives and Sri Lanka, was gaining momentum and posing threats to the reefs. In addition to tourism, new and growing markets such as the trade in aquarium species, sea cucumbers, and lobsters for tourist restaurants, reduced populations of these reef resources and altered fish communities. Reefs that were plagued by COTS in the early 1990s were recovering relatively well by 1994, but there was little effective management. In the Maldives, the initial coral reef management was being undertaken by tourist resorts to protect their reef resources. Sri Lanka had already developed an impressive set of legislation and established MPAs but the efforts were largely ineffective, because few attempts were made to control damaging activities. Large areas of northern Sri Lanka were inaccessible due to major ethnic disturbances. In India, there was minimal recognition of coral reefs by the Government, the major reef studies were taxonomic, and there were no MPAs or conservation measures in place.

In 2004: The effects of the mass bleaching in 1998 are still visible in virtually all parts of the region that were affected. The combination of high mortality and continued high stress, such as over-fishing, destructive fishing, mining and land-based activities, has further degraded reefs particularly in India and Sri Lanka, where there are large reef areas with dead coral colonies covered in algae. Many unconsolidated rubble beds remain in the Maldives and there are reports of reefs where the dominant organisms are soft coral-like animals (corallimorpharians). A third to half of coral reefs in the region are now effectively dead, and a further 30% are threatened. Some more remote reef areas are still in relatively good health, with some showing encouraging signs of recovery. There has been considerable growth in human populations, resulting in continuous increases in pressure on the reefs for provision of food and livelihoods. Many reef associated biota such as sea cucumbers and lobster, show clear signs of over-harvesting or population crashes. Minor bleaching was reported from Sri Lanka, the Maldives, Chagos, and India in 2004. However, most of the affected corals recovered relatively well within a short period. The region established a strong coral reef monitoring network in 1996 and all countries have active monitoring programs in most of their coral reef regions, although monitoring in the Maldives has been intermittent. India established the Indian Coral Reef Initiative and a parallel monitoring network, and is making major efforts to conserve and manage their coral reefs. They produced an outstanding handbook on the corals of India in 2004. Coral reef management in Sri Lanka continues to be inadequate and the reefs continue to degrade, even in declared MPAs where there is virtually no enforcement of regulations. In the Maldives, where the Government does not have sufficient financial, human and logistic resources for coral reef management and monitoring, the majority of these tasks are conducted by the tourism industry.

Predictions for 2014: Unless the current rates of over-exploitation and destructive harvesting are controlled, particularly in India and Sri Lanka, the coral reefs in the region will continue to deteriorate and many will degenerate completely. The major pressures on reefs are the rising levels of poverty among increasing coastal populations, and local economic conditions that often drive reef destruction. For example, as long as reef mining is more profitable in the short term than other reef uses by coastal people, and authorities fail to enforce regulations, reefs will continue to be mined. Pressure is also increasing from external market demand, which is driving the harvesting of ornamental fish, sea cucumbers and other resources. Without improved controls, it will be difficult to divert the livelihood strategies of communities away from dependence on reef exploitation.

Improved management could increase the resilience and resistance of the coral reefs by helping to facilitate recovery from the 1998 event, and improve the chances of withstanding another similar event; which appears inevitable based on current predictions. In the Maldives and Chagos, direct pressures on the reefs are lower than elsewhere in the region, but these archipelagos are probably more vulnerable to damage from climate change. Another severe heating event like 1998 would be even more damaging to the reefs and may result in localised extinctions of coral species, from recovering reefs. However, there are also early indications of increased resilience to bleaching in some areas and some species. Thus, the prediction for reefs in areas currently under high levels of stress is not good, while reefs in more remote areas have a better chance of recovering from the 1998 bleaching and withstanding other perturbations. However, there is a risk that over-harvesting of reef resources will shift to these remote areas, if the resource stocks collapse in heavily exploited areas. Greater focus on developing alternative livelihoods that are sustainable and realistic options for coastal people is essential.

The national coral reef coordinators and local experts provided these estimates of coral reef status and predictions for the future. The estimates cover the amount of reef area that: is now effectively dead; was reduced to less than 5% coral cover in 1998; is recovering following damage in 1998; is under critical threat of destruction in 10 to 20 years (if urgent action is not taken); and threatened with destruction in 20 to 40 years. The last two are the high to very high risk and the medium risk categories of the Reefs at Risk process; reef area taken from the World Atlas of Coral Reefs (2001).

South Asia	Coral Reef Area km ²	% Reef Now Dead	% Reef Destroyed in 1998	% Reef Recovered After 1998	% Critical Stage Reefs	% Reefs Threatened Stage
Bangladesh	50	25	10	50	50	25
Chagos	3770	50	75	50	0	20
India	5790	25	30	15	20	25
Maldives	8920	55	80	25	5	25
Sri Lanka	680	35	40	15	10	45
Region Total	19210	44	62	31	9	25

RECOMMENDATIONS

- Initiatives on conservation, development and poverty reduction in coastal areas need to be more effectively integrated, reflecting their inter-connectedness and ensuring problems that are linked are not addressed in isolation;
- Increased focus is needed on development of sustainable alternative livelihoods to reduce the pressure on reef resources. These must be viable options for coastal populations, and could include:
 - developing suitable approaches and tools for livelihood diversification that are poverty focused and integrated with wider coastal development and poverty reduction strategies;
 - building capacity in the region to address sustainable livelihoods development for reef users;
 - monitoring the effectiveness and sustainability of alternative livelihood initiatives, including development of methodology; and
 - identifying and undertaking research needed to support the above activities.
- Management of coral reef areas should be improved by:
 - Increasing the efficiency in use of funding;
 - increasing cooperation between agencies, including government institutions and ministries, with complementary or overlapping mandates;
 - developing partnerships with all major stakeholders and ensuring that governments and NGOs function cooperatively;
 - increasing technical capacity among key institutions;
 - increasing funding to key institutions, while ensuring that they operate transparently and efficiently;
 - increasing enforcement of existing laws such as those relating to coral mining in Sri Lanka, while ensuring that populations are not deprived of livelihood options;

- enforcing regulations developed for MPAs;
 - establishing a representative network of MPAs in the region, through an analysis of ecological coherence and connectivity in present MPAs, identification of gaps and declaration of new MPAs as needed (this includes all forms of protected areas, i.e. including fish refugia, fisheries management areas etc.).
- Research into current conservation status of food fishes, lobsters, chanks, sea cucumbers, ornamental fishes and other reef-associated biota is needed.
 - Appropriate regulation mechanisms should be developed to ensure that fisheries are sustainable, possibly through introduction of licences and certification schemes;
 - Increase ecological and socio-economic monitoring and research, to provide reliable data and information to meet national and regional requirements;
 - Develop mechanisms for managing coral reef information, including monitoring data, and ensure that these are available to coral reef managers and decision makers.

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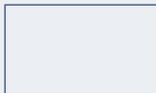
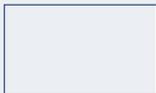
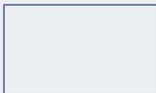
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GULF OF MANNAR, INDIA - MAN AND THE BIOSPHERE RESERVE

The Gulf of Mannar Biosphere Reserve stretches for 180 km along the coast of India across from Sri Lanka and covers an area of 1,050,000 hectares. It is one of the world's richest regions from a marine biodiversity perspective and comprises 21 islands, including estuaries, algal communities, sea grasses, coral reefs, salt marshes and mangroves. Among the Gulf's 3,600 plant and animal species are the globally endangered sea cow (*Dugong dugon*) and 6 mangrove species endemic to peninsular India. Significant elements of the Gulf of Mannar include the largest remaining feeding grounds for the dugong and 5 species of marine turtles: Green, Loggerhead, Olive Ridley, Hawksbill and Leatherback. The Gulf's seagrass communities are valuable habitats for commercial species such as prawns, sea cucumbers, and several species of seaweeds. The Gulf of Mannar also has 17 species of coral from 7 genera.

The inhabitants are mainly Marakeyars, local people directly dependent on fishing, seaweed collecting, or other coastal activities for their livelihoods. There are about 47 villages along the coastal part of the biosphere reserve which support 100,000 people (200,000 seasonally as of 2001). The Global Environmental Facility (GEF) financed an initiative in the Gulf of Mannar Biosphere Reserve aimed at strengthening the capacity of local communities, particularly women, for managing the coastal ecosystem and wildlife resources. The project will demonstrate new approaches to the integration of conservation, sustainable coastal zone management and livelihood creation through an innovative institutional and financial mechanism.

Ecological Monitoring: Many Indian research and development institutions, including the Central Marine Fisheries Research Institute, National Institute of Oceanography, and Madras University, have on going research and monitoring programs in the Gulf. Research focuses on climate change, coral mining, pollution, bio-prospecting, and threatened species. Long-term monitoring of fisheries and of marine flora and fauna has helped to develop an integrated ecosystem management model for sustainable resource harvest.

Socio-economic Monitoring: No information was provided.

Contact: Ministry of Environment and Forests, Paryvaran Bhavan - C.C.O. CompJex Lodhi Road, New Delhi, India | 10 003 Email: pccfwl@vsnl.com)

Coral reefs are 50% of the natural resources.

Ecological Monitoring is effective.

Socio-economic Monitoring is unknown.


RAMSAR

DIEGO GARCIA, UNITED KINGDOM (BRITISH INDIAN OCEAN TERRITORY) - RAMSAR SITE

Diego Garcia is a particularly good example of a relatively unpolluted coral reef system providing a valuable link to the marine ecology of the Indian Ocean. Covering a total area of 35,424 hectares, this wetlands site provides habitat for marine flora and fauna including endemic coral species and endangered sea turtles. It supports 220 coral species of 58 genera, and is otherwise rich in marine life. Within the seagrass beds a number of fish species have been recorded which have not been seen anywhere else in the Archipelago. The site is also important for breeding seabirds and serves as a valuable nursery ground for fish stocks.

Diego Garcia is the southernmost atoll of the Chagos Archipelago. It is a mid-ocean coral reef system and the only known area of seagrasses at Diego Garcia is found on the eastern side of the lagoon. The island consists of subtidal rock (including rocky reefs) and subtidal sediments (including sandbank/mudbank) and is owned by the Crown Estate. Part of Diego Garcia atoll is excluded from protection under a 1976 UK/US Agreement and is set aside for military uses as a US naval support facility. The site and adjoining areas are used for research, recreational fishing, and military activities.

A fully comprehensive Natural Resources Management Plan for Diego Garcia was issued in 1997 and is currently being revised. Nature and Strict Nature Reserves have also been established. The site's international importance is legally recognised in the BIOT Conservation Policy Statement (1997). The enforcement of conservation measures is the responsibility of the Commissioner's Representative, assisted by the BIOT police and fisheries officers.

Ecological Monitoring: No information was provided.

Socio-economic Monitoring: No information was provided.

Contact: Commissioner's Representative, NP 1002 BFPO 485, Diego Garcia, British Indian Ocean Territory.

Coral Reefs are an **unknown** percentage of the natural resources.
Ecological monitoring is **unknown**.

