4. **Status of Coral Reefs in the Western Indian Ocean and Evolving Coral Reef Programmes**

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**Abstract**

The region has all reef types from atolls to fringing reefs with many endemic species shared within the Western Indian Ocean (WIO), which suggests that the reefs are linked by currents to make this a discrete biogeographic region. This also means there is a need for regional collaboration among the ten WIO states to manage these reefs.

Reef management is not well developed in the WIO, and is focused at the site rather than at national or regional levels. Poorly regulated fisheries and coastal development, together with increasing populations and tourism are major contributors to reef destruction. This is ironic, as both fisheries and coastal tourism are heavily dependent on healthy coral reefs, and make major contributions to the economies of most countries.
Many of the reefs in the region are showing distinct signs of damage from human activities, and bleaching in 1998 has been particularly severe in the Seychelles and Kenya.

The principal reef management activity is the establishment of marine protected areas (MPAs) mainly for tourism, and little is being done to safeguard reefs for biodiversity or fisheries conservation. Although progress is being made in collaborative reef management at the community-government level, there is the need for collaboration among the WIO states to conserve reefs. This will enable sharing of successful approaches for management problems that are common to the region, use of a standard methodology and database for reef assessments to facilitate data sharing and analysis, understanding of processes sustaining the regional linkages, and will facilitate regional collaboration.

INTRODUCTION

The Western Indian Ocean (WIO) countries and states (Kenya, Mozambique, Somalia, South Africa, and Tanzania on the coast; and islands Comoros, Madagascar, Mayotte, Mauritius, Réunion, and Seychelles) extend from 12°N to 29°S, and from the African coast to 65°E. The region has both tropical and subtropical waters with northeast to northwest monsoons from November to April, and southwest to southeast monsoons between June and October. Tropical cyclones occur south of the equator, mainly during the northern monsoon. The major linking current is the South Equatorial Current, which flows west throughout the year at about 12°S, until it hits the African coast where it splits into the southerly Mozambique Current, and the northerly East African Coastal Current. Sea-surface temperatures rarely fall below 20°C, except off northern Somalia during upwelling and off South Africa.

Well-developed fringing and patch reefs occur along the narrow continental shelf of Somalia, Kenya, Tanzania, and northern Mozambique, and around the offshore islands. Reefs off the mainland are broken by the large rivers. The southernmost reefs are at Inhaca Island in Mozambique, just north of South Africa, although coral communities occur off Maputoland in South Africa. Madagascar and the Comoros have well-developed reefs, including barrier reefs off Toliara on the southwest coast of Madagascar, and around Mayotte in the Comoros Archipelago. The Seychelles Bank has reef-fringed granite islands, and patch and fringing reefs around the coral atolls of the Amirantes Bank. The large Saya de Malha Bank, Nazareth Bank and Cargados Carajos Shoals are mostly submerged, and may contain coral communities or reefs. The Mascarene Islands further south have good reefs: Rodrigues and Mauritius have extensive reefs, but not Réunion. Coral diversity decreases in the Indian Ocean from east (Australia) to west, but there are many endemic species.
THREATS TO CORAL REEFS AND ASSOCIATED ECOSYSTEMS

The threats to coral reefs and their associated ecosystems vary widely between countries, but fall into the following four main groupings.

Resource extraction related activities:
- over-exploitation of living resources;
- destructive exploitation of living resources, including blast fishing;
- coral and sand mining for construction.

Poorly controlled development:
- poor land use practices leading to erosion and sedimentation;
- dredging and/or filling operations;
- tourism-related activities.

Pollution-related activities:
- pollution from land-based activities;
- pollution from maritime transport.

Natural disasters:
- tropical storms;
- coral bleaching;
- Acanthaster planci outbreaks (crown-of-thorns starfish).

The underlying causes for these problems are poverty, and the lack of sustainable income-generating opportunities. Inadequate planning, lack of institutional will or capacity to implement policies and regulations, and civil disturbances, which resulted in the displacement of many people to coastal areas, have aggravated the coral reef management problems. The underlying causes must be addressed to achieve sustainable conservation of coral reefs.

STATUS OF THE REEFS IN COUNTRIES OF THE WESTERN INDIAN OCEAN

Comoros
The Comoros archipelago comprises four isolated volcanic islands. Fringing reefs are found around Grand Comores, Anjouan, and Moheli. Mayotte (France) is the oldest island in the chain, and has a substantial barrier reef. The Banc de Geyser, in international waters, is a large, horseshoe-shaped reef, submerged at high tide that is notoriously dangerous to shipping. Its isolation has preserved it from human damage.
There are no marine protected areas in the Comoros, and there is one fishing reserve in Mayotte lagoon. The European Union is financing a project on the development of artisanal fisheries, which includes introduction of fish aggregating devices and motorisation of fibreglass boats to disperse inshore fishing pressure to the continental shelf.

The Comorian Government, with the help of UNDP, developed the National Environment Action Plan in 1994 as a national biodiversity conservation strategy, including reef management. A management plan will be developed for the Nioumachoua Marine Reserve to conserve marine turtle nesting beaches as well as some good coral reefs.

**Kenya**

Along most of the coastline there are well-developed fringing reefs, which have a high diversity of corals and fish, particularly in the four active marine protected areas. Many of Kenya’s reefs are, however, heavily fished and degraded, and monitoring studies have shown that coral cover is nearly twice as high on protected, compared to unprotected reefs, and that fish diversity is about 30% higher on protected reefs. Recent coral bleaching has reduced coral cover in the parks by 65%, but studies are continuing to determine the rates of recovery. Kenya has the longest continuous monitoring programme in the region, and has monitored corals, algae, molluscs, sea urchins, and fish in eight reefs over the past 10 years. This monitoring programme has shown a variety of surprising human influences on reefs and has been used to develop models of reef degradation.

Kenya has the best marine protected areas in the region, with four marine national parks and six marine national reserves with coral reefs. Extractive activities are prohibited in parks, though some tourist activities are allowed in certain areas. In marine reserves only traditional fishing by approved methods is permitted. All marine parks and reserves are administered by the Kenya Wildlife Service (KWS) under the Coastal Conservation Project of the KWS-Netherlands Wetlands Conservation and Training Programme, which is actively improving site management. Kenya is moving increasingly towards direct community participation in MPA management.

The WWF and KWS are collaborating to enhance management of Kiunga Marine Reserve, a biosphere reserve off the north coast of Kenya. This began in 1996 and focuses on conserving the outstanding biodiversity, natural resources, and ecology of the reserve through consensus-based management with the full participation of local communities. The plan aims to improve the livelihoods of neighbours and users of the reserve.

The Coral Reef Conservation Project is a field programme of the Wildlife Conservation Society (previously the New York Zoological Society), and conducts monitoring and research with
scientists from KWS and Kenya Marine and Fisheries Research Institute on the status of coral reefs, and threats such as fishing, shell collecting, sedimentation, and pollution. This project has been active in determining the rates of recovery of reefs recently protected from heavy fishing, and has worked on a variety of methods to restore degraded reefs.

**Madagascar**

There are numerous reefs around the island, with those on the east coast being the least known, including fringing reefs near Antseranana to the Iles de Leven; fringing coral growth around Nosy Borah (Ile Saint-Marie); and a submerged, fragmented barrier reef off Toamasina, with a reef flat covered by seagrasses. The west coast has more than 1000 km of reefs, located in the northwest and southwest. These reefs have suffered significant damage from sediment runoff as most of the forests have been cleared for timber, and slash and burn agriculture. Fishing pressure is intense on many reefs.

There is one marine park (Nosy Atafana Marine Park) and one special reserve (Nosy Mangabe Special Reserve) that includes reefs, but neither are effectively managed. Most marine conservation effort is currently going into the Grand Recif at Toliara. Considerable reef research was undertaken by French scientists from the 1960s to mid-1970s. In 1992, local scientists and the WWF, surveyed the Grand Récif at Toliara and recommended conservation. The Universite de Toliara is active in marine research and multidisciplinary reef surveys. A marine and coastal conservation programme for Madagascar was identified as a priority by the WWF in 1996. The programme includes coastal surveys, and assistance for Malagasy authorities to develop a comprehensive system of coastal and marine reserves to conserve coastal resources, including reefs. The WWF programme complements a UNESCO project to manage the extensive Grand Récif at Toliara, off the southwest coast, as a protected area and biosphere reserve.

**Mauritius**

The central island is in the Mascarene group, and almost entirely surrounded by fringing reefs. More fringing reefs border the channels and protected bays, with patch reefs in the lagoon. The other island, Rodrigues, is older with well-developed coral reefs (200 km$^2$). The Cargados Carajos Shoals are about 190 km$^2$ of reefs and a massive algal ridge — possibly the largest in the Indian Ocean.

The reefs have been badly damaged by overfishing, tourism and development activities, and inactive reef management. Runoff from sugar cane farming is a major problem for reefs in the lagoon. The Mauritian authorities are working with the University College of North Wales to classify and map the coral reefs, and plan for two reef reserves that were originally proposed in 1974.
A series of reefs were prepared for management, with replanting of mangroves and establishment of nurseries, and studies of physical, chemical and biological parameters of lagoon waters influenced by sewage and industrial discharges. A Marine Environment Management Plan was prepared by the Ministry of Fisheries and Marine Resources. The Ministry is also monitoring the reefs and establishing two marine parks to conserve reefs, including:

- banning the removal and sale of shells and corals, whether live or dead;
- banning spearfishing;
- tight control on the use of explosives;
- closed seasons for seine net fishing; and
- establishment of fishing reserves.

Between 1991 and 1994, there has been baseline data collection of reef and water quality at several sites around the island, and lagoon water circulation patterns were studied at Albion as an example of coastal and lagoon water flows. Other lagoon and reef studies are being implemented with technical assistance from Japan through the fully equipped Marine Conservation Centre at Albion.

**Mozambique**

Reef development on the Mozambique coast is limited by freshwater and sediment flows from the large rivers. Reefs are found at Inhaca Island, near the South African border; the Bazaruto Archipelago; and the Primeira and Segundo Islands. Fringing reefs are found close to shore from Macambo Bay to the Tanzanian border.

Ilhas da Inhaca e dos Portuguesas and the Bazaruto National Park are two protected areas with significant coral reefs. WWF has been supporting the community-based management of Bazaruto National Park with European Union funds since 1989. The management plan expands the emphasis on community-based resource management to conserve the fragile Bazaruto Archipelago ecosystem and improve the socioeconomic conditions of island communities.

The Oceanographic Research Institute in Durban, South Africa, in association with the World Bank and the IUCN, has surveyed the reefs around Bazaruto Island for a Park management plan, and a handbook on the island.

**La Réunion**

This active volcano is the youngest and highest of the Mascarene islands, and has relatively little reef development. The other island dependencies of Réunion are spread over a wide area of the Indian Ocean and Mozambique channel: Tromelin (north of Réunion), the atolls Europa and
Bassas de India in the Mozambique Channel, Juan de Nova off the west coast of Madagascar, and the Iles Glorieuses to the north of Madagascar. They are coralline islands with some reef development, and all are declared protected areas with Juan de Nova replaced by Bassas de India under later legislation Réunion has ratified the Nairobi Convention.

The Laboratoire d’Ecologie Marine of the Universite de la Réunion has done considerable research since the 1970s on coral reef populations and processes, and management and exploitation of reef resources. Much research is on anthropogenic impacts on coral reefs, especially the effects of reduced water quality on coral calcification rates. An active programme to involve school students is under way to ensure that the next generation has a reef conservation ethic.

**Seychelles**

There are 115 islands scattered over 1,374,000 km² of ocean. Fringing reefs are dominant on the central granite islands, and numerous patch reefs and coral islands on the outer banks. There are raised and sea level coral atolls with well-developed coral reefs. The best known is Aldabra Atoll, a World Heritage Site. Human impacts on the reefs are generally slight, but fishing pressures are increasing. Tourism is a major industry based around the reefs. The 1998 coral bleaching event has caused large-scale mortality of many shallow corals.

The Seychelles have a comprehensive system of marine parks and reserves. The Division of Environment, with technical assistance provided by IUCN, is implementing two protected area projects with a focus on coral reef conservation: Rehabilitation of Curieuse Marine National Park (with funding from France), and a country-wide biodiversity conservation and national parks programme (funded by the European Union). The Fisheries Act and Regulations 1986/87 prohibit blast and spearfishing, and are enforced by the Seychelles Fishing Authority.

A reef monitoring programme has been set up with training funded by Sweden (SAREC), and assistance from the Great Barrier Reef Marine Park Authority. Through the Indian Ocean Commission, the Seychelles are implementing a project to:

- prepare a bibliography of all information on Seychelles coral reefs;
- identify sensitive coral reef areas being degraded around Mahé, and establish monitoring using IUCN rapid assessment methods;
- identify other coral reefs around the inner granite islands for protection; and
- identify reef sites for restoration.
Somalia
Reef growth is inhibited by cold upwellings off the northern coasts of Somalia, but there are fringing reefs between 0.5 km and 1.5 km off Adale to the Kenyan border, coming close to shore near Kismayo. There are coral islands and reef flats in the Bajuni Archipelago near the Kenyan border. The only major break in the barrier reef is off Mogadishu, where there are a few patch reefs with seagrass beds. The coral reefs are poorly known with no marine protected areas, nor any activity to conserve the reefs. IUCN is working with the Somaliland administration to develop management options for the coral reefs along the western part of the Gulf of Aden coast, particularly near the Saad ed Din Islands near Djibouti. These northern reefs are in excellent condition, and rich in biodiversity because of their proximity to the Indian Ocean, the Red Sea, and the Arabian Gulf.

South Africa
There are no true coral reefs, but there is a 65 km stretch of coral-covered rocky reefs off Maputoland (KwaZulu/Natal), between Ponto do Ouro on the Mozambique border and Cape Vidal. These reefs are remote from the large industrial areas and the influence of runoff from rivers, therefore they are largely unspoiled, and are protected as the St Lucia Marine Reserve. The area is used intensively by recreational divers, but is well managed by the Natal Parks Board and is being monitored by scientists from the Oceanographic Research Institute (ORI) in Durban, in collaboration with the University of Tel Aviv. The scientists are examining reef damage caused by human use and other disturbances (including a small crown-of-thorns outbreak) and have recommended a zoning plan for long-term reef use that emphasises ecotourism and reduces diver damage. Artisanal fishing is permitted in much of the reserve and local communities are gaining increased benefits from ecotourism through direct employment, and the development of secondary industries. A management plan is being developed for Aliwal Shoal. This is an island community of corals and associated fauna off the south coast of KwaZulu/Natal that is used by anglers, spearfishermen, and is a popular dive site.

Tanzania
There are fringing and patch reefs along two thirds (600 km) of the narrow continental shelf. The many patch reefs are often extensions of fringing reefs and develop away from river mouths. The continental islands of Mafia, Zanzibar, and Pemba, along with many other small uninhabited islands are surrounded by fringing reefs. The Department of Fisheries regulates all fishery activities, but has not been successful at controlling blast fishing and destructive forms of seine netting. The reefs are also being damaged by sediment runoff from increasing agriculture and coastal development.
In 1981, Tanzania gazetted a number of MPAs, but these exist only on paper. However, the Institute of Marine Science in Zanzibar, the WWF, and Frontier are assisting Mafia Island communities in the design and development of Mafia Island Marine Park, the first in Tanzania under the Marine Parks and Reserves Act, 1994. Mafia Island has some of the best coral reefs on the African coast, and the Fisheries Division and the WWF are developing a management plan with strong community participation, which will provide them with direct benefits. The Department of Environment, the Institute of Marine Science, and Sub-committee of Fisheries are actively promoting reef management in communities on Zanzibar, and transferring the successes to other sites. The Chumbe Island Reef Sanctuary in Zanzibar is an experiment in reef management by a private company. Collaboration between the WWF, government, and local communities has developed a multiple-use, community-managed marine conservation area in Menai Bay, southwest Zanzibar. The Kunduchi Marine Biological Station has a programme of reef fisheries research.

The Swedish government (SAREC and Sida) is supporting national coral reef surveys and research through the Institute of Marine Science. Integrated coastal management is being developed for the Kunduchi area of Dar es Salaam on the mainland to address the critical problems of reef pollution and blast fishing. In Tanga, northeast Tanzania, the Regional and District Government Authorities are implementing integrated coastal management focused on coral reef restoration and community-based management with assistance from IUCN and Irish Aid. This is a test case in community-based management and restoration by controlling blast fishing and the use of weighted seine sets.

**CORAL REEF MANAGEMENT IN THE WESTERN INDIAN OCEAN**

Reefs in the region are probably all linked closely by ocean currents that carry larvae, migratory species, nutrients, and pollutants across national boundaries. Destruction of the source of larvae on one reef may impoverish others down current, therefore an understanding of source-sink relationships is essential for long-term reef management. MPAs are more likely to be located for the tourism industry, than to conserve reef larval resources. Little knowledge is available on the sources, circulation patterns, fates of pollutants, and effects at national and regional levels. Little is known on the links between coral reefs, mangroves, lagoons, and seagrass beds in the region. Successful management also requires information on reef status, and human uses and threats. Above all, there is a fundamental need for community involvement in reef management and the incorporation of traditional management systems, user rights, and socially acceptable alternatives to reef fisheries.
Capacity for research and training

Until recently, there was little capacity for marine research and management in the region. Most interest was from outsiders who had little interaction with local researchers. Now there are many more competent nationals, but there is a great lack of funds, equipment, and infrastructure for national research institutions, and national funds are unlikely to be diverted away from poverty alleviation and development. Institutional budgets barely cover salaries, therefore donors are urged to provide relevant equipment, encourage regional collaboration to maximise the effects of the limited resources, and encourage partnerships between international scientists. Offers of training should be pertinent to national problems. Training in integrated coastal management is essential, with emphasis on multi-disciplinary approaches involving ecology, economics, law, and other social sciences.

Approaches to conservation of coral reefs and their associated ecosystems

The traditional approach for reef conservation of village-imposed closed seasons or areas, such as for octopus and some fish around Zanzibar and Tanzania, have been eroded and replaced by MPAs. Protected areas can be valuable management tools to balance the effects of exploitation elsewhere and improve fishing yields nearby, but these require good planning and adequate resources for maintenance. But MPAs alone are not adequate for long-term management of reefs because they seldom address threats from land-based activities. Without full community involvement, MPAs cannot resolve user conflicts, nor address the resource needs of coastal communities. Reef conservation will require an integrated management approach that includes land use planning, pollution reduction, fisheries management, user conflict resolution, environmental education, protected area management, and the capacity to respond to environmental disasters. Regional coordination is needed to safeguard circulation of larvae, nutrients and migratory species, and to maintain water quality. Community management of coastal resources is the focus of increased attention in Kenya, Zanzibar, and Tanzania by IUCN and the WWF, but conflicts between different government sectors can only be resolved when higher levels of government are aware of the problems, possible solutions, and the need for immediate action.

INTERNATIONAL AND REGIONAL CORAL REEF PROGRAMMES

The International Coral Reef Initiative brought all of the states together in March 1996 to develop a coherent program for reef management. Countries observed that they shared common problems and investigated common solutions. Currently, coral reef regional activities are being undertaken through: UNEP Eastern Africa Regional Seas Programme; Indian Ocean Commission (for the island states); WWF and IUCN; IOC/UNESCO; Coastal Resources Center, University of Rhode Island; with aid from Ireland, the Netherlands,
Sweden, and USA, with participation from the Western Indian Ocean Marine Science Association (a regional NGO supporting reef research).

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