

# EAST AFRICA: Coral reef programs of eastern Africa and the Western Indian Ocean

Prepared by  
**Nyawira Muthiga, Lionel Bigot and Agneta Nilsson**

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## Introduction

This report gives an updated description of the coral reef and associated ecosystem programs of the Eastern African mainland states, which include the nations of Somalia, Kenya, mainland Tanzania, Zanzibar and Mozambique as well as the Western Indian Ocean island states of Comoros, Madagascar, Mauritius, Reunion and Seychelles.

The Eastern African mainland countries have similar histories and ecological profiles including the following.

- All the nations of this region are classified as developing countries.
- All have rapidly growing coastal populations. It is estimated for example that 75% of Mozambique's population lives within 40 km of the coast.
- The countries have diverse political histories: 1) Somalia is still at war; 2) Kenya recently held its first multiparty elections; 3) Tanzania just emerged from a socialist system into a market economy; and 4) Mozambique is recovering from a long civil war (1976-1992). Often the political system is key to the distribution and utilisation of natural resources in these countries.
- The countries all have similar marine ecosystems including coral reefs, mangroves and seagrass beds, where mainly subsistence level utilisation occurs.

All countries of the region cover a wide range of political and economic development. All states are heavily dependent on their coastal environments as sources of food, income and employment. Rapidly expanding coastal populations, as well as increasing industrial and agricultural activities, are potential sources of pollution that threaten the sustainability of coastal and marine ecosystems and their associated resources (UNEP/IMS/FAO/Sida 1998).

The coastline of the Eastern African and Western Indian Ocean islands region is an area rich in natural marine resources and of breathtaking scenic beauty, with pristine beaches of coral, estuaries, mangroves, lagoons and several beautiful islands rich in biodiversity. The coastal environment is being threatened by pollution, habitat destruction and the pressure from growing coastal populations, tourism and urbanisation.

The climate is generally tropical to sub-humid. The two monsoon seasons have a major influence on wind direction and strength, air temperature and rainfall. They also influence the coastal currents.

The coastal ecosystems of the region are generally rich in natural resources and highly productive. Important habitats include mangroves, coral reefs and seagrass beds, which sustain a great diversity of marine life and are important food sources for most coastal communities. The ecosystems are greatly interdependent, and the integrity of each ecosystem is dependent on the health and influence of adjacent ecosystems. For example, nutrients, sediment and organic matter are interchanged between coral reef and mangrove ecosystems. Mangroves are also nursery grounds for a variety of fish, some of which mature in coral reefs and seagrass meadows.

The economies of all countries in the region benefit from reef fisheries as well as reef related tourism. Artisanal fisheries, mostly in reefs, seagrass and associated platform environments, represent more than 95% of the total marine fish catch, (UNEP/IMS/FAO/Sida 1998). For example, more than 60% of the fish species caught in Tanzania are caught in or around coral reefs (Francis and Muhando 1996). For many coastal communities, mangroves are the primary source of timber, firewood, charcoal and a variety of other forest products. Consequently, mangroves as well as coral reefs are under increasing pressure from expanding coastal populations.

The destruction of coastal habitats by the expanding coastal populations has led to the degradation of interdependent coastal ecosystems and reduced productivity. For example, reductions in mangrove cover has reduced fish spawning, leading to reduced catches with both social and economic implications, especially for artisanal fishers (FAO/IMS/Sida 1999). Both coral reefs and mangroves are among the most biologically diverse ecosystems and greatly at risk. The rapid expansion of coastal populations and consequentially increased loads of domestic sewage, agricultural run-off and industrial effluents to the marine environment represents a significant threat to the coral reefs of the Region.

In general, the mechanisms to manage coastal resources are poor and management programs are often sectoral and implemented within weak institutional frameworks with poor coordination between different sectors (FAO/IMS/Sida 1999).

## Somalia

### Introduction

Somalia has the longest coastline of the Eastern African mainland states stretching 3000 km from the north coast bordering the Gulf of Aden to the east coast that opens to the Indian Ocean. Reef growth is inhibited by seasonal cold upwelling in the northern and Gulf of Aden region. Fringing reefs occur from Adale southward to the Kenya border with a major break at Mogadishu (UNEP/IUCN 1988). The coral reefs and associated ecosystems of Somalia are the least understood in the region with earlier descriptions being limited in scope and scale. A recent resource survey conducted in the Saardin Islands, Gulf of Aden under the IUCN/EU Somali natural resources program for example recorded flourishing and diverse coral reefs comparable to reefs in other parts of the Western Indian Ocean in an area previously believed to harbor poor reef growth.

Mangroves occur in creeks along the coast of southern Somalia and in isolated stands in the north coast of Somalia and south of Kismayo as part of a more extensive mangrove forest that extends into the Boni and Dodori reserves of Kenya. Seagrass beds have been reported along the south coast of Somalia from Adale to Chamboni (UNEP 1987) but in general the distribution of seagrass beds in Somalia is poorly documented. Sea turtles including the green, hawksbill, ridley and leatherback and dugongs have been reported in Somali waters.

### Resource Extraction

Artisanal fishing has been going on for centuries in Somalia. During the drought of 1973–1974 the government resettled many nomads and trained them in fishing and provided them with equipment. The government also encouraged and supported the development of fishing cooperatives. Much of this administrative structure has now broken down due to the ongoing civil war.

Reliable estimates of the fisheries stocks of Somalia are difficult to get although estimates indicate a highly productive system. According to Stromme (1987), the annual level of production may be as high as 150 000 tonnes. Exactly how much of this production comes from coral reefs and associated ecosystems is difficult to tell. Artisanal fishing targets sharks, spiny lobsters, tuna and grouper. Fishing takes place all year round in motorised wooden boats with a crew of up to 10 men. Commercial fishing has also been undertaken for decades in Somalia targeting crustaceans, and demersal fish. Several countries including Italian, Greek, Egyptian and Japanese companies were given concessions by the Somali government for trawling of pelagic and demersal stocks. Currently Russian, South Korean, Taiwanese and Italian vessels are trawling illegally in Somali waters.

Marine turtles were traditionally harvested in Somalia including the green turtle and the hawksbill turtle. Previous records indicate a high number of turtles in Somali waters with artisanal fishermen catching roughly 2–3 turtles a day in the coastal towns of Kismayo, Brava and Merca (UNEP 1987) a very high uptake. There is no published information on harvesting of sea turtles therefore making it difficult to estimate the sustainability of this activity.

Information on the harvesting of mangroves is not available though it is clear that mangroves are utilised for scaffolding and roof support in buildings and boat construction. It is speculated that these mangroves come from Lamu (Kenya). Mangrove poles sold at Kismayo are harvested from south of Kismayo, but apparently much of the trade originates from Lamu where larger poles are available.

## Management

At present there is no functional government in Somalia, hence resource extraction is unregulated. In the past the Department of Fisheries under the Ministry of Marine Transport and Ports regulated fisheries. There are also no marine protected areas in Somalia and with the present political instability there appears to be no initiatives to manage coral reefs and associated ecosystems at present. A community initiative to settle Somali refugees, Somalia Community Service, is interested in conservation activities (Salm et al. 1997). There was no specific agency to manage protected areas and several Ministries had jurisdiction over marine resources including the Ministry of Livestock, Forestry and Range, the Ministry of Marine Transport and Ports, the Ministry of Fisheries and the Ministry of Tourism. This structure is likely to be retained when a functional government is reinstated in Somalia. Unfortunately the overlap in jurisdiction will cause problems in the management of any marine resources.

## Capacity Building and ICRI Coordination

The ongoing civil war in Somalia has made it difficult to develop any programs to manage reefs and associated ecosystems. Somalia at present has no capacity to manage or monitor any marine resource use since. Any legislative or regulatory authority that exists is largely ineffective.

# Kenya

## Introduction

The Kenyan coastline is approximately 500 km long, with a well-developed fringing reef system except where major rivers (Tana and Athi Sabaki) discharge into the Indian Ocean (Hamilton and Brakel 1984). Additionally, patch reefs occur in Malindi and Kiunga in the north and Shimoni in the south on the Kenya Tanzania border. Coral reefs are the predominant marine ecosystem in terms of ecology and economy but seagrass beds and mangrove forests also contribute to the economy of the coastal communities. Seagrass beds are usually associated with reefs growing in the shallow lagoons between the shore and reef lagoons as well as in the shallow bays, Ungwana and in the shallow channels of drowned river beds (creeks). Mangrove forests are well developed in the Lamu archipelago where 70% of the total mangrove cover of Kenya occurs. Coral reefs are poorly developed towards the north due to the influence of the cool waters from the Somali upwelling. In general, the coral communities are similar to other parts of the Western Indian Ocean (Hamilton and Brakel 1984), dominated by *Porites* assemblages in calm waters and *Acropora* assemblages in high energy waters.

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**Table 1:** Studies on coral reefs and other associated communities

COMMUNITY	NO. SPECIES/GENERA	REFERENCE
Scleractinian corals	140 species 55 genera 183 species 55 genera	Hamilton & Brakel 1984 Lemmens 1993
Finfish	350 species	Samoilys 1988
Mangroves	9 species	Issac & Issac 1968
Algae	277 species	Issac 1968
Seagrass	12 species	Moorjani & Simpson 1988
Gastropods	135 species	McClanahan 1989
Sea urchins	12 species	Clark & Rowe 1971
Sea turtles	5 species	Frazier 1975
Marine mammals	1 species	Pertet & Thorsell 1980

The distribution and diversity of scleractinian corals has mainly been studied in the Malindi-Watamu reef complex, where 183 species and 59 genera were identified. Reef edges and deeper reefs as well as soft corals, coralline algae and other reef building species have received less attention. Kenya has a rich and diverse fauna of seagrass and algae (Issac 1968; Moorjani and Simpson 1988) attributed to the heterogeneous benthic habitat and the wide tidal range. The coral reef finfish fauna has received less attention with the few existing studies indicating high species diversity and finfish communities similar to other reefs in the western Indian Ocean (Table 1). Additionally all nine species of mangrove found in east Africa occur in Kenya. There is a general north to south increase in coral reef diversity, with Tanzanian reefs having a higher diversity of gastropods (Yaninek 1978).

## Resource Extraction and Tourism

Currently, fishing, gleaning, mangrove harvesting and tourism are the main direct uses of coral reefs and associated ecosystems in Kenya. Artisanal fishing is the most common resource extraction activity in coral reefs, seagrass beds and mangrove creeks. An estimated 2000–5000 fishers are involved and dugout canoes are the main type of vessel (Fisheries Department, pers. comm.). Gear includes basket (madema) and fence traps (uzio), handlines, pull and gill nets and spear guns (Table 2).

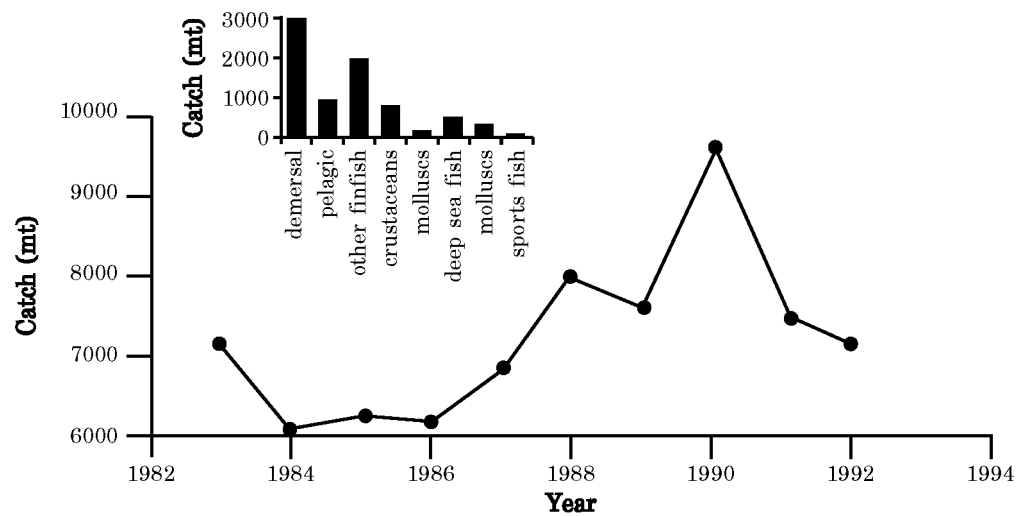
**Table 2:** Artisanal fishing activities on the coast of Kenya

FISHING GEAR	FISHING ACTIVITY
1. Spear guns	A rudimentary gun made from wood with sharpened metal rod, and a mask made of window glass with metal and rubber sides is used. Spear fishing is restricted to shallow reef areas and seagrass beds in marine reserves.
2. Basket traps (madema)	Basket traps are baited with seaweeds, urchins or trash fish, and usually set in seagrass beds or channels in the reef and mangroves.
3. Fence traps (uzio)	Fence traps are constructed from shore to the shallow seagrass areas at headlands in a funnel shape guiding fish into the ends as the tide rises.
4. Hook and line	Fishers use small canoes to get the reef edge or channels in the reef and fish with hook and line baited with shrimp, squid or octopii.
5. Beat seining	A weighted net is set out in a U-shape and the water is beaten to scare fish into the net. Considerable damage to coral is caused and this type of fishing is discouraged in marine reserves.
6. Gill netting	Gill nets with a stretched mesh size of 2.5" (often much less) are used. However, in most reserves these nets are discouraged for inhibiting sustainable fishing.
7. Gleaning	Marine snails, sea cucumbers, oysters and octopii are the main organisms collected, usually during low tide in the intertidal lagoons, reef flats and mangroves.

The fishers of Lamu are traditionally more sophisticated and use sail and engine-powered boats (Mashua and Dhows) with seine, gill and drift nets, troll-lines and long-lines. The catch is mainly composed of Lethrinids, Acanthurids, Scarids, Siganids, Carangids, sharks and rays. Additionally, transient fishers including fishers from Pemba often fish an area on a seasonal basis, sometimes for a specific resource i.e. lobsters or sea cucumbers. Fishers have recently started using SCUBA for sea cucumbers due to sea cucumber scarcity in shallow areas.

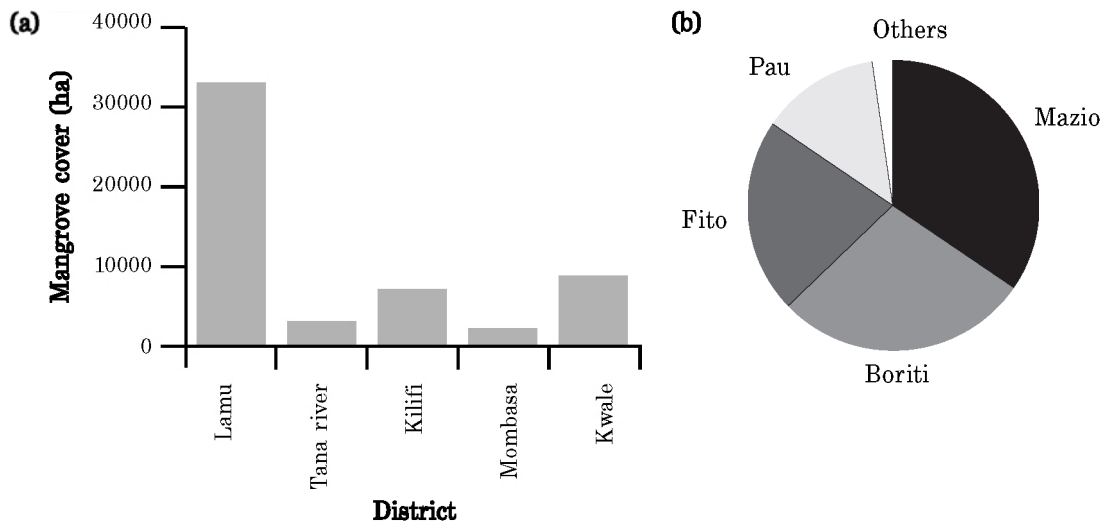
Gleaning for sea cucumbers, crabs, octopii, molluscs and bait fish and aquarium fish is carried out in shallow seagrass beds and reefs at low tide. Men carry out most fishing activities but women are involved during the processing by frying the fish for sale at the village level. Commercial fishing includes fourteen commercial trawlers that have been licensed to fish for prawns and fish in the Ungwana Bay and the Tana delta, as well as sports fishing.

The fisheries resources of the Kenyan coast are poorly documented with annual estimates from the fisheries department ranging between 6000 to 9000 tonnes from 1983 to 1992 (Fig. 3.1). Approximately 80% of the marine fish catch is demersal mainly from shallow coastal waters and reefs, the remainder is caught offshore by sports or commercial fishing vessels. An FAO commissioned study of the marine fisheries sector of Kenya estimated an artisanal catch of approximately 10 000 tonnes at a productivity of 5.5 tons/km<sup>2</sup>/yr. This would indicate that this is an over-exploited fishery using the FAO fisheries rule-of-thumb for a multi-species/multi-gear fishery. Additionally, annual yearly yields reported for Kenya are variable at 2.6 to 13.3 tons/km<sup>2</sup>/yr reported for Kisite in southern Kenya, 12.9 tons/km<sup>2</sup>/yr for reefs at Kilifi and 10.5 to 12 tons/km<sup>2</sup>/yr for Diani. These yields are greater than the maximum sustainable yields of 5 tons/km<sup>2</sup>/yr suggested by FAO.



**Figure 1:** Total catch of fish, molluscs and crustaceans from the Kenya coast. Inset is the distribution of the catch on an annual basis from 1988 to 1992. (Source: Fisheries Department)

Mangrove cover in Kenya is estimated at 52980 ha with Lamu district having 68% of the total cover and the most productive stands (Figure 2a). Mangrove exploitation has been going on for centuries along the East Coast of Africa with most of the harvesting going for export to the Middle East.



**Figure 2:** (a) The distribution of mangroves along the coast of Kenya and (b) the percentage of the total harvest by mangrove size in diameter (Fito are <6 cm, Mazio range between 6.1 and 9.0 cm and Boriti range between 9.1 and 13.0 cm). (Source: Forestry Department)

Mangrove export was banned in 1982 but there has been a lot of pressure by mangrove licensees to lift the ban. Currently mangroves are exploited for building material for domestic and commercial purposes (especially hotels), fencing and firewood. *Rhizophora mucronata* (Mkoko) is the most popular mangrove species due to its straight shape and resistance to termites. *Ceriops tagal* (Mkandaa) and *Bruguiera gymnorrhiza* (Muia) are also popular as they have fast growth rates. Mangrove poles of the Mazio (6.1–9.0 cm) diameter size class dominates the market followed by Boriti (9.1–13.0cm) (Figure 2b).

#### TOURISM

Until recently tourism was the major foreign exchange earner for Kenya with 75% of all tourists (~200 000 visitors) visiting Kenya spending a few days at the coast. There are 412 hotels (~30 800 beds) along the prime beaches of Malindi, Watamu, Bamburi and Diani, all adjacent to fringing reefs. Additionally there are numerous cottages, apartments and private houses that cater for the local market and low-cost visitors. Tourism is poorly developed in Shimoni in the south and the Lamu/Kiunga area in the north. The development of tourism has been very rapid and uncontrolled leading to a great demand for marine resources including fish, shellfish and molluscs and mangroves for building, ultimately causing the over-exploitation of these resources. Most of the recreational activities are also concentrated around reefs. Glass bottom boats, sailing, goggling and SCUBA diving are the major activities (Table 3). Few hotels have installed sewage treatment plants, most depending on cesspits and soakage pits, raising the risk of underground seepage to the adjacent reefs and seagrass beds.

**Table 3:** Tourist-based activities within marine protected area in Kenya

ACTIVITIES	REMARKS
1. Glass bottom boat tours	Tourists and local residents hire these boats to go to the coral garden. Goggling is often involved. A daily fee is charged in MPAs.
2. SCUBA diving	Tourists and locals are taken to the reef edge, wrecks and caves for SCUBA, usually by companies affiliated with hotels. This activity requires a daily park fee in MPAs.
3. Goggling	Visitors to the park who swim from shore to the reef using goggles are charged a daily fee.
4. Sailing	Modern and traditional sailboats, including dhows and ngalawas, ply the waters of MPAs either for tourist or fishing purposes.
5. Windsurfing	Tourists and locals can windsurf in MPAs without paying a fee.
6. Jet skiing	Several hotels have watersports desks that hire out jet skis. MPA managers by legal notice restrict the area and time for this activity.

## Management and Its Effectiveness

The coral reefs and associated ecosystems of Kenya fall under the jurisdiction of several government departments (Table 4). The Fisheries department has jurisdiction over all fishing activities, the forestry department has jurisdiction over all forestry resources including mangrove trees and the Kenya Wildlife Service manages all biodiversity resources within national reserves and national parks and wildlife outside parks and reserves. Other departments with interests in marine resources include the Kenya Marine and Fisheries Research Institute (KMFRI) and the Coast Development Authority (CDA) who monitor resources and developments that affect these resources at the coast.

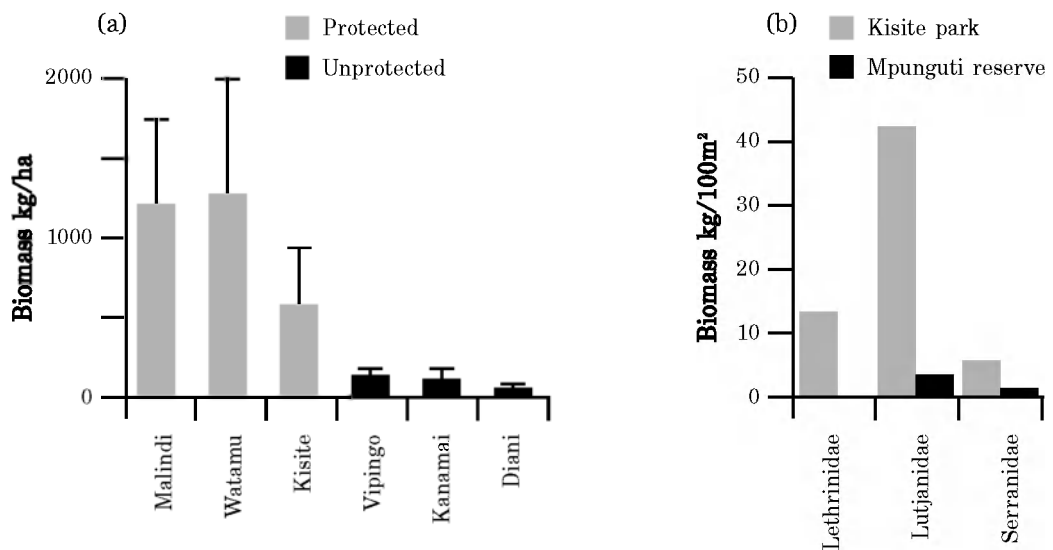
**Table 4:** Government departments, their responsibilities and legislation with jurisdiction over coral reefs and related ecosystems

DEPARTMENT	MINISTRY	RESPONSIBILITY AND CAPACITY
Fisheries Department	Environment and Natural Resources	Licensing, enforcement and monitoring of catches, protection of sea turtles
Kenya Wildlife Service	Office of the President	Conservation of all fauna and flora in parks and reserves and wildlife outside parks
Forestry Department	Environment and Natural Resources	Licensing of forestry products and management of forest reserves
Kenya Marine & Fisheries Research Institute	Research Technical Training & Technology	Research monitoring of marine and freshwater habitats and resources
Coast Development Authority	Rural Development	Development of the welfare of rural communities

The Fisheries Department has landing bases along the entire coastline that are manned by a fisheries officer who monitors the catch and submits reports at the district and provincial levels. Ideally, data are compiled at these levels and sent to the headquarters in Nairobi. Inadequate resources and skills has led to lack of commitment and hence poor monitoring of fisheries activities making it difficult to develop management strategies for any fishery. Although no long-term data are available on any fisheries stocks, there is sufficient information to show that at the very least the marine artisanal fishery is over-exploited in unprotected reefs (McClanahan and Obura 1995; Watson et al. 1996). Artisanal fishing in Kenya has a dramatic effect on reefs including:

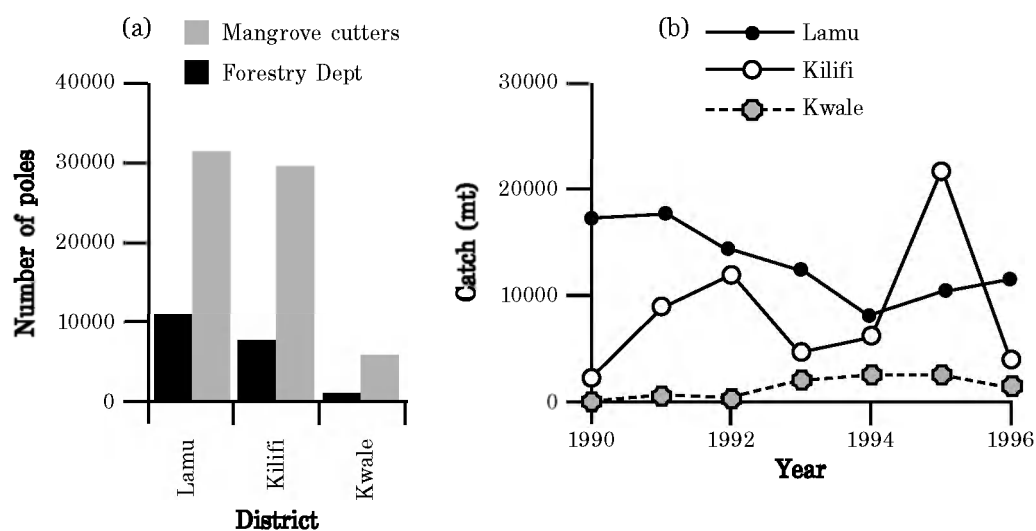


- A reduction in fish biomass and sizes (Fig. 3a): protected reefs averaged 800–2000 kg/ha while unprotected reefs average about 100 kg/ha (McClanahan et al., in press (a)). Comparisons between reserves where restricted fishing is allowed and parks where fishing is prohibited also show large differences in commercially important species (Figure b).
- Changes in reef community structure due to the reduction of the predators and competitors of sea urchins, which has caused an increase in sea urchins, especially *Echinometra mathaei* an aggressive bio-eroder as recorded in Diani.
- The Fisheries Department also has no capacity, including surveillance vessels and training, to monitor commercial trawlers that are restricted by law to 10 km from shore but are frequently seen within 1 km offshore. Trawlers are perceived by the local fishing communities as the major culprits in the reduced fisheries catches and the prime danger to turtles in Kenya.



**Figure 3:** Biomass of finfish in protected versus unprotected areas. (Source: Coral Reef Conservation Project database)

The Forestry Department is equally under-funded and under-skilled. Ideally all products from mangrove forests are supposed to be checked by forest guards posted at landing points along the coast. Traditionally, forest guards also assessed the stock at cutting sites for recommendations to district and provincial forestry officer for future licences. Currently forest guards have no resources to monitor the stock, putting in doubt the basis for issuing licenses.



**Figure 4:** Mangrove harvest (a) estimates in three districts in Kenya as reported by Forestry Department and mangrove cutters and (b) the number of poles traded in the three districts between 1990 and 1996 (Source: Forestry Department)

Several factors indicate that mangrove resources are over exploited:

- Discrepancies between mangrove cover estimates by the Forestry Department of resource survey and remote sensing and the Forestry Department (52 980 versus 64 427 ha).
- Discrepancies between forest department estimates of harvest and estimates from mangrove cutters (Fig. 4a), with mangrove cutters estimating more than double the number of poles recorded by Forestry Department. More than 50% of the trade in mangroves comes from Lamu district and much of the trade using the century old dhow routes to the Middle East is centred in Lamu, which leads to speculation about potential illegal export of mangrove poles from this area.
- There has been a steady decline since 1990 of harvest over the years except for 1995 when ~20 000 poles were harvested from Kwale district (Fig. 4b).
- The low quality of mangrove products from Kenya compared to other east African countries, including Tanzania, probably because the parent stock is of low quality (Luvanda et al. 1997).

There is an urgent need to ascertain the standing stock and quality of mangrove before any ban can be lifted. The ban was originally imposed because inadequate mechanisms to monitor the export trade were in place. To date these mechanism have not been developed.

Kenya has the oldest managed MPAs in the region, which are administered by the Kenya Wildlife Service. The MPAs of Kenya include four Marine National Parks (Malindi, Watamu, Mombasa and Kisite) and six Marine National Reserves (Kiunga, Malindi, Watamu, Mombasa, Diani-Chale and Mpunguti) (Table 5). In all cases, marine national parks are adjacent to (Kisite) or encompassed within marine reserves (Watamu, Malindi, Mombasa). Additionally, Watamu and Kiunga Marine National Reserves are Biosphere Reserves under the UNESCO Man and the Biosphere System. Fishing and all other forms of extraction are prohibited in marine national parks and only fishing using traditional and non-destructive gears and techniques are allowed in marine national reserves. Managers of MPAs may limit the type of gear and the area of fishing through zoning by posting legal notices.

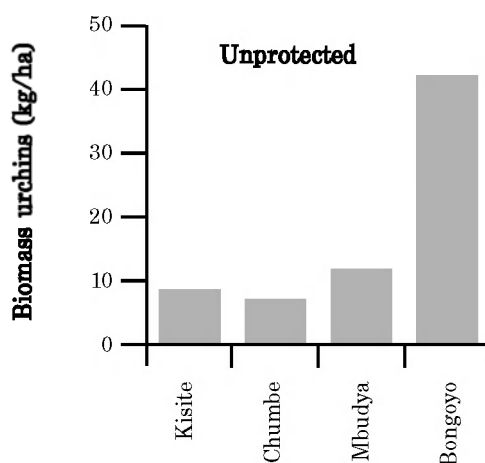
**Table 5:** The Marine Protected Areas of Kenya

MPA	GAZETTED	SIZE	LOCATION
Kiunga Marine National Reserve	1979, Biosphere status 1980	25 sq. km	Lamu district
Malindi Marine National Park and Reserve	1968, Biosphere status 1979	Park: 6.3 sq. km Reserve: 165 sq. km	Kilifi district
Watamu Marine National Park and Reserve	1968, Biosphere status 1979	Park: 10 sq. km Reserve: 10 sq. km	Kilifi district
Mombasa Marine National Park and Reserve	1986	Park: 10 sq. km Reserve: 190 sq. km	Mombasa district
Diani-Chale Marine National Reserve	1995	250 sq. km	Kwale district
Kisite Mpunguti Marine National Park and Reserve	1978	Park: 28 sq. km Reserve: 11sq km	Kwale district

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Wind surfing, jet skiing, sailing, SCUBA and dolphin watching in traditional and modern craft are all common tourist activities. In most parks daily entry fees and annual boat fees are collected by park rangers, except in the Mombasa Marine Park and Reserve where a partnership with adjacent hotels allows daily access to the park and reserve for US\$0.5 per bed per night.

There is sufficient evidence to show that Kenya's marine parks are effective in protecting coral reef communities with higher hard coral cover in marine parks, larger and higher diversities of finfish, fewer sea urchins (Fig. 5) and greater topographic complexity. Parks are managed by wardens with a cadre of trained and armed rangers responsible for maintaining security, collecting revenue and maintaining facilities, especially moorings and monitoring. In the last few years with the reduction in tourism, resources for daily operations have decreased markedly thus increasing the threat of encroachment by artisanal fishers as documented in Watamu and dynamite fishing on the Kenya-Tanzania border as recorded in Kisite.



**Figure 5:** Biomass of sea urchins (kg/ha) in protected (Kisite Kenya and Chumbe Zanzibar) and unprotected areas (Bongoyo and Mbudya, Tanzania). (Source: Coral Reef Conservation Project Database)

## Threats to Kenyan Coral Reefs and Associated Ecosystems

The main threats to Kenya's reefs are similar to those found in the rest of the region and they fall into the following main categories.

- Over-exploitation of marine resources fuelled by the increase in the coastal population. Fisheries products including finfish, octopii, sea cucumbers and lobsters are all showing signs of overexploitation. Illegal exploitation of sea turtles that are valued by the Bajuni people of northern Kenya and overexploitation of mangroves also pose a serious threat to these species.
- Destructive methods of fishing, especially beach seining which causes extensive damage to coral and seagrass beds, octopii gleaning and fishing for aquarium fish which cause breaking up of coral, and on the Kenya-Tanzania border dynamite fishing has been recorded on Mako-Kokwe reef inside the marine reserve.
- Poor land-use practices, especially cultivation along river beds, have caused the increase of sedimentation and is a threat in the Malindi and Watamu areas.
- Tourism-related activities, including collection of marine curios such as shells, seastars and coral, cause depletion of these resources.
- Pollution from land-based activities is also proving to be a threat in Watamu where algal cover has increased in some reefs.

## Integrated Management

In the past, biodiversity conservation and management of natural resources in Kenya has tended to emphasise the international and scientific values and benefits of biodiversity. However, many Kenyans depend to a very large degree on biological resources at the subsistence level, especially coastal communities, making these resources very vulnerable to over-exploitation. Given this overwhelming dependence on biological resources, it has become increasingly clear that new strategies incorporating local and national interests must be developed. At the national level, there is a new awareness that sustainable economic development and biodiversity are intricately linked and, as a signatory to the Convention on Biological Diversity, the government of Kenya has shown its commitment to biodiversity conservation. Within institutions mandated to manage natural resources including KWS, Fisheries Department and Forestry Department, more and more emphasis is being put on integration of communities and other stakeholders in management. These three institutions are in the process of drafting new policies or have already submitted new policies to parliament that address a more integrated way of management. However, the framework within which integrated and collaborative management can work at the national level is lacking.

**Table 6:** Projects and activities in coral reefs and associated ecosystems in Kenya

ACTIVITY	INSTITUTION	FUNDING
Integrated Coastal Area Management pilot project	Coast Development Authority Kenya Wildlife Service Kenya Marine & Fisheries Research Institute Fisheries Department Others	UNEP EAF5 USAID
Wetlands training and management	KWS Netherlands Wetlands Program	Netherlands Government
Research and Monitoring	Coral Reef Conservation Project KWS KMFRI	USAID Swedish aid agency Netherlands Government
Management	KWS Fisheries Department Forestry Department Coast Development Authority	German Government through IUCN Netherlands Government WWF
Public Awareness	KWS Wildlife clubs of Kenya	Netherlands Government Japanese Government

There is a great diversity of initiatives and institutions involved in coral reef activities in Kenya (Table 6). These include government departments, international and local NGOs and universities. The activities are varied and targeted often to sites or groups with no national coordination. The National Environmental Secretariat has drafted a National Environmental Plan but the secretariat is relatively weak with little coordination skills and this draft plan has not been endorsed by any institution. Departments are forced to develop other means of cooperation, depending on MOUs and MOAs. KWS for example has MOUs with the Coast Development Authority (1994), Kenya Marine Fisheries Research Institute (1995), Forestry Department (1994), wildlife clubs of Kenya, Fisheries Department (pending) and the National Museums of Kenya (pending). WWF is assisting KWS in a pilot project of community-based management in the Kiunga Marine National Reserve. In Kisite a pilot project to develop stakeholder participation in MPA management is under experimentation with technical assistance from IUCN.

## Capacity Building and Information

Kenya has several institutes of higher learning specialising in marine studies including Nairobi and Moi University. Several donor-funded projects provide training, including the Coral Reef Conservation Project (CRCP) which has a hands-on regional training internship program. The Kenya-Belgium project has conducted two training courses in Kenya on tropical marine ecosystems. The KWS Naivasha training institute has trained all MPA managers and rangers in Kenya in basic marine ecology, swimming and SCUBA, and basic monitoring techniques. This is the first time that MPA managers and their staff have basic knowledge on the ecosystems that they manage. Several important workshops have been held including an ICZM symposium, a workshop on the Coral reefs of the Western Indian Ocean and a regional TED workshop.

Many programs develop awareness materials e.g. KWS Netherlands program is funding a resource and visitor centre in Malindi and has also funded the production of posters and brochures. Additionally, the Wildlife Clubs of Kenya in collaboration with KWS conduct awareness programs on marine resources in primary and secondary schools throughout the coast. The regional centre for information RECOSCIX, based at KMFRI in Mombasa, is the only regional information centre that continues to distribute marine information to the region and plays a crucial role in updating scientists on recent research findings.

Despite the diversity of activities, many of these programs are not based on any assessment of training needs either in the country or the region and there is an urgent need to assess the current regional capacity in coral reef studies and develop programs to address these needs. There is also often no follow-up to assess the effectiveness of the training and the usefulness of the training material usually because many of the programs are short-term and externally funded. In order to develop adequate capacity in the country, the universities and the KWS Naivasha training institute need to work closely together to design appropriate programs that become part of the normal curriculum and that can be upgraded every year. Additionally, marine sciences need to be addressed at the primary and secondary level where this is currently lacking.

## Research and Monitoring

Several institutions and projects carry out research on coral reefs and associated ecosystems in Kenya (Table 6). The Coral Reef Conservation project, working closely with the KMFRI and KWS, has carried out a long-term program of monitoring the finfish, urchins and benthic substrate of protected and unprotected sites for the last 10 years (McClanahan et al., in press (a)). CRCP also carries out studies on different management practices including sea urchin and algal removal (McClanahan et al. 1995). The KWS Netherlands Wetlands program has funded the development of park-based monitoring, including turtle nesting and mortality and basic water quality assessments. Additionally, a national wetlands database is in the process of being implemented which will include shallow coastal areas. Training of marine monitoring rangers in simple transect and quadrat techniques has just been completed prior to instituting a monitoring program for key sites in the MPAs. Information on the communities that utilise marine resources is scanty. CRCP regularly collects fisheries data from landing sites in Mombasa and Diani. Glaesel (1997) studied the fishing community at Diani and Mombasa.

There is a need for managers to start working more closely together with scientists. Additionally, simple park-based monitoring practices need to be developed. Once managers start using data collected by scientists, then the gap between managers and scientists will not be so large.

## ICRI and GCRMN Coordination

Despite Kenyan participation in both the Dumaguete and Seychelles ICRI conferences, an action plan has not been developed at the national level to implement ICRI. The main obstacle has been lack of funds and lack of commitment by the relevant institutions to devote time to ICRI. ICRI activities continue in Kenya but in an uncoordinated manner and with no central lead agency. The relevant institutions to further ICRI are the KWS and the KMFRI in collaboration with the Fisheries Department, the Forestry Department, the Coral Reef Conservation Project (CRCP) and the Coast Development Authority (CDA).

# Mainland Tanzania and Zanzibar

## Introduction

The Tanzania coastline is approximately 800 km long from the Ruvuma River on the Tanzania-Mozambique border, moving north to Tanga at the Kenya-Tanzania border. There are four coastal regions – Tanga, Dar es Salaam, Lindi and Mtwara. The northern part of Tanzania includes the mainland areas of Tanga, Bagamoyo and Dar es Salaam, also the oceanic islands of Pemba and continental islands of Unguja, which make up the state of Zanzibar. In the Tanga area, numerous patch reefs occur in waters 25 m deep (inner patch reefs) and up to the continental shelf (outer patch reefs). Fringing reefs and seagrass beds broken up by bays and river estuaries including the river Pangani, border the mainland coast. Fringing reefs are also well developed along the seaward sides of Bongoyo Island, Fungu Yasin sandbank and Mbudya Island, which make up the Dar es Salaam marine reserve system. Scattered coral developments and a fringing reef surround Unguja Island on the eastern coast and northern and southern extremities.

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South of Dar es Salaam, Mafia Island has an outer reef that extends southward to the Songo Songo archipelago. This reef borders the mainland southward to the Ruvuma delta on the Tanzania-Mozambique border, broken in places by deep-water channels rivers and bays. North of Mafia Island coral reef development is restricted to a few offshore islands due to the turbid waters of the Rufiji River. Seagrass beds occur in the shallow waters around Mafia, Songo Songo archipelago and in the sheltered bays of the southern coastline from Kilwa Kivunje to Mtwara. Mangroves are concentrated in the Ruvuma delta that supports the largest area of estuarine mangrove forest in East Africa.

**Table 7:** Studies on coral reefs and other associated communities

COMMUNITY	NO. SPECIES/GENERA	REFERENCE
Scleractinian corals	88 species, 51 genera	Hamilton 1975; Hamilton & Brakel 1984; Darwall & Guard, in press
Finfish	400 species	Horrill & Ngoile 1991
Mangrove	9 species	Semesi 1998
Algae	154 species	Horrill & Ngoile 1991; Darwall & Guard, in press
Seagrass	12 species	Darwall & Guard, in press
Gastropods	135 species	Kayombo 1989; Brown 1996
Sea turtles	5 species	Frazier 1975

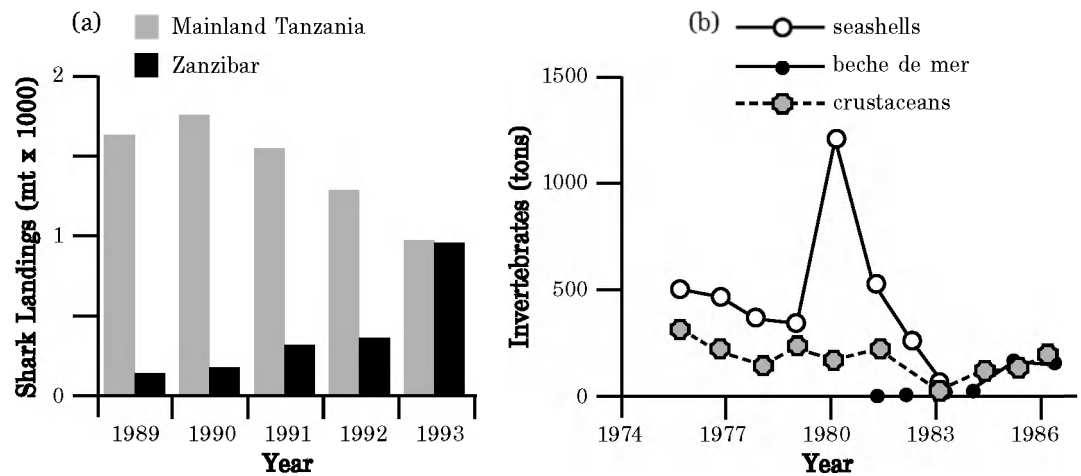
The distribution and diversity of coral reef communities along the Tanzanian coast is similar to reefs found in other parts of the region (Tables 1 and 7). Coral assemblages are dominated by *Acropora*, but *Galaxea* is a characteristic feature of patch reefs (Hamilton 1975), *Pachyseris* is dominant on lower reef slopes and the fungid *Halomitra pileus* forms large aggregations on some reef slopes. Surveys of coral distribution in the Tanga area revealed increased genera from coastal patch reefs to outer reefs (Horrill and Ngoile 1991). Surveys of the distribution and diversity of reef fish are limited but the most comprehensive survey recorded 400 species on Mafia Island. The species of mangrove, seagrasses, algae and gastropods are also similar to records from other parts of the region.

## Resource Use and Tourism

The coral reefs of Tanzania are used in a number of ways by local communities and the private sector. Fishing for finfish is the major activity but fishing for sharks and rays, octopii, sea cucumbers, lobsters, shells (for the curio and export trade) are also important economic activities. Additionally, coral mining for lime production and building, harvesting of mangroves for construction and firewood, and recently mariculture of seaweeds *Euchema spp.* are all undertaken in the shallow inshore waters.

Artisanal fishing in inshore shallow areas dominates the fishing industry in Tanzania. Individuals or pairs of fishermen use small sailboats (Ngalawa) and dugout canoes. Gear types are similar to those used in Kenya (Table 2) including seine and gill nets, handlines, traps and spear guns. Tanzanian fishermen are considered to be more sophisticated than Kenyan fishermen with organised crews manning sail powered, and more recently, outboard engine powered wooden vessels of different sizes (Mashua and Dhows). These crews use troll-lines, long-lines and shark nets, and fish in deeper waters. Pressure on marine resources has unfortunately led to the adoption of more 'efficient' gear techniques including smaller mesh nets, explosives and poisons which are very destructive.

Catch estimates from 1975 to 1993 (McClanahan et. al., in press (b)) ranges between 25 000 to 57 000 mt per year and fishing effort has doubled in the last 20 years. Traditionally, women participated as gleaners of shallow reef lagoons and reef flats while men built boats and fished offshore. In recent times seaweed farming has attracted many women and today 90% of the seaweed farmers are women.

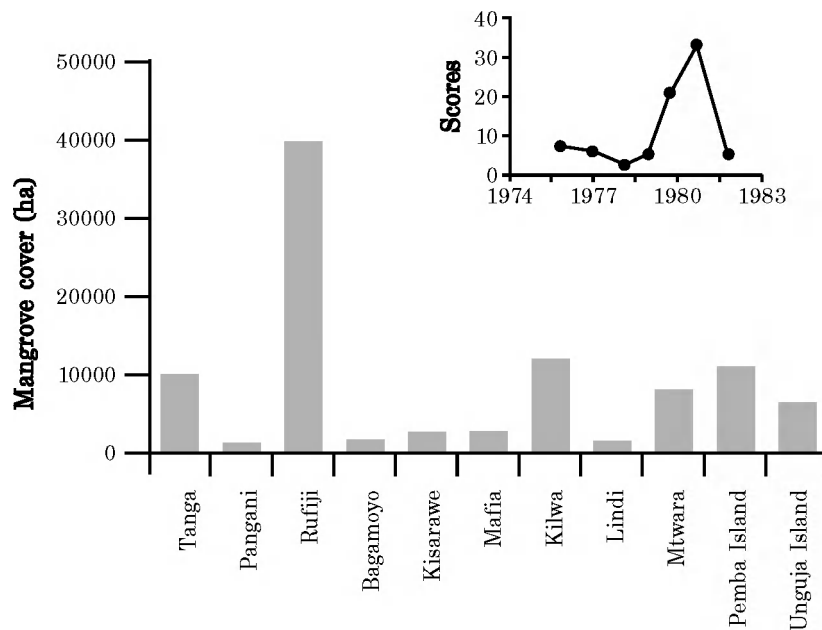


**Figure 6:** (a) Catch of sharks landed in mainland Tanzania and Zanzibar and (b) invertebrate catch in mainland Tanzania (Source: Fisheries Department)

The shark and ray fishery also employs many artisanal fishers working in teams full time. Shark nets are bottom set in 10–25 m of water in seagrass beds, areas of coral rubble and deep channels (Figure 6a). The invertebrate fishery (Figure 6b) includes octopii and sea cucumbers (mainly for export), the lobster fishery which is mainly opportunistic for the local and tourist market, and the prawn fishery for export. Sea cucumbers are currently harvested with SCUBA because the stocks in shallow waters have been over-exploited. The prawn fishery is well organised and controlled by business enterprises in Dar es Salaam who provide boats, engines, cooling facilities and transport to the fishers. Eighty per cent of the prawn catch comes from the Rufiji delta ~7000 ton/year.

Mangrove cover in Tanzania is estimated at 55 000 ha and are all classified as forest reserves. The Rufiji delta has the largest stand of mangroves on the entire East African coast and accounts for 50% of mangrove cover in Tanzania (Banyika 1986). Other important areas include Mwanza, Tanga, and the mouths of the Wami, Ruvu, Matandu and Ruvuma rivers. Islands such as Mbegani, Kunduchi, Latham, Kisiju, Kivinje, Kilwa and Mafia also have important mangrove stands (Semesi 1998; Figure 7). Direct uses of mangroves include building poles, firewood and charcoal and timber for boat and building construction. Other extractive uses include tannins, honey and beeswax. Unfortunately, extensive areas of mangroves have also been cleared for salt production and agriculture, especially in the Rufiji and Ruvuma deltas.





**Figure 7:** The distribution of mangroves in Tanzania and Zanzibar – inset shows mangrove trade from 1976 to 1982

Live coral is harvested in Tanzania from shallow reefs at low tide. *Porites* and other dense corals are preferred and are used directly for building or burnt in kilns to produce white lime which is used as a cement substitute or as a white wash. Unfortunately, live coral is preferred over ancient coral because it produces higher quality lime. An estimated 950 mt has been mined around Mafia Island since 1985 (Anderson and Ngazi 1995).

Coastal tourism is not highly developed along the Tanzanian coastline. However, with the liberalisation of the economy, a rapid increase in the number of visitors is expected. The number of tourists visiting Tanzania decreased markedly after the closure of the Kenya Tanzania border in 1977 because many tourists use Nairobi as the entry point to East Africa. Between 1993 and 1994, the number of visitors to Tanzania has increased the most rapidly in the region. It is estimated that approximately 40% of the total number of visitors to Tanzania visit the coastal zone. The Tanzania Tourist Corporation owns ~15 tourist class hotels (~2500 beds). There are also a few foreign owned hotels. There is a rapid development of recreational use of the reefs of Pemba and Unguja for tourism. SCUBA diving and deep-sea fishing companies are mainly based in Kenya and charter two to three-day excursions to Pemba because infrastructural support is more developed in Kenya.

## Management and its Effectiveness

The resources of coral reefs and associated ecosystems of Tanzania are unfortunately managed by several departments often with overlapping jurisdiction at national, regional and local levels (Table 8). At the national level, the most important ministry is the Ministry for Tourism Natural Resources and Environment with the divisions of Tourism, Fisheries, Environment, and Forestry and Beekeeping.

The Department of Fisheries (*Fisheries Act 1970*) is responsible for management of all marine waters from the mean high-water mark to national territorial waters. The Fisheries Act provides for the protection, conservation development, regulation and control of fish, fish products, aquatic flora and fauna and products thereof (Rumisha 1995). At the district level, district fisheries officers are responsible for checking for implementing fisheries plans and checking hygienic condition of fish for export. These officers however are employed by district authorities from the Ministry of Local Government and Cooperative Development. This multi-employer character of the fisheries administration, despite the highly enabling law and lack of equipment and funds, contributes to the low level of management.

**Table 8:** The government institutions and agencies responsible for marine resources in Tanzania

ADMINISTRATIVE LEVEL	MINISTRY, DIVISION OR OFFICE
National level	Ministry of Tourism, Natural Resources and Environment <ul style="list-style-type: none"> <li>• Division of Tourism</li> <li>• Division of Fisheries</li> <li>• Division of Environment</li> <li>• Division of Forestry and Beekeeping</li> </ul> Ministry of Trade and Industry Ministry of Lands, Housing and Urban Development National Planning Commission Ministry of Energy, Water and Mineral Resources National Environmental Management Council
Regional level	Regional Development office Natural resources office Land office Health office Trade and Industry office Energy, water and mineral resources office District development office
Local level	District development office District natural resources office <ul style="list-style-type: none"> <li>• Fisheries</li> <li>• Forestry</li> </ul> District lands office District council District administrative office Village councils

Jurisdiction for mangroves falls under the Division of Forestry even though mangroves occur above and below the mean high-water mark. All mangrove forests are classified as reserves under the Forest Ordinance of 1957. However, the Ministry of Trade and Industry can issue licenses to develop terrestrial land within coastal areas hence the issuing of licenses for salt pond production in mangrove areas. There are also local level initiatives that further complicate management. Despite the divisions responsible for the coastal resources being in one ministry, there has been little coordination of often conflicting activities and usually no environmental impact assessment is carried out. The lack of coordination has resulted in a lack of accountability, inability to respond to changes and failure to partition responsibilities between institutions especially in the management of the eight marine reserves in Tanzania (Table 9).

**Table 9:** Marine protected areas of mainland Tanzania and Zanzibar

MAINLAND TANZANIA	ZANZIBAR
Dar es Salaam Reserve designated in 1981 <ul style="list-style-type: none"> <li>• Mbudya Marine Reserve</li> <li>• Bongoyo Marine Reserve</li> <li>• Pangavini Marine Reserve</li> <li>• Fungu Yasini Marine Reserve</li> </ul> Mafia Island National Marine Park (designated in 1995) <ul style="list-style-type: none"> <li>• Chole Bay Marine Reserves</li> <li>• Tutia Marine Reserve</li> </ul> Maziwi Island Marine Reserve Tanga Coral Gardens Marine Reserves	Chumbe Island Coral Park (1994)

The few studies that have been carried out on Tanzanian reefs show that there is over-exploitation of the finfish fishery (McClanahan et al., in press (b)) and potential over-exploitation of the shark fishery (Barnett 1997) and the sea cucumber fishery (Darwall and Guard, in press). Recent research in Dar es Salaam (McClanahan et al., in press (b)) showed that the reefs were characterised by low fish abundance (200 kg/ha) with small-bodied damselfish and wrasses being the most abundant fish. There was also a negative relationship between sea urchins and fish biomass, which are replacing the fish herbivores such as parrotfish and surgeonfish. Studies in Tanga (Horrill et al. 1996) showed that there were low abundances of commercially important families such as snappers, grunts and groupers. Comparison between the number of fishers and the catch of selected resident coral reef fish between 1971 and 1992 in Dar es Salaam showed that the optimum level of production (700 mt for 1150 fishers) has been surpassed (McClanahan et al. 1998). This trend was also found in Tanga and Zanzibar where total production is kept constant by a combination of increasing effort and higher catches of sardines and Indian mackerel (Jiddawi et al. 1991).

The Fisheries Department is also responsible for enforcing fisheries regulations but has proved totally inadequate in controlling dynamite fishing. Despite the fact that dynamite fishing is illegal in Tanzania, it is very common. Frontier recorded 441 blasts within a two month period in southern Tanzania (Frontier, unpublished records) and a high percentage of the catch in some landing sites consists of fish caught from blast fishing (~60% in Mnazi Bay). Occasionally fishers are arrested but the fines are minimal. Unfortunately blast fishing has only been brought under control in a few reefs including the Mafia Marine Park and in Tanga, by projects undertaken by international NGOs. The sea cucumber fishery is also showing signs of over-exploitation as evidenced by smaller sizes in the catch and the collapse of the fishery in some areas including Mtwara.

The marine reserves of Tanzania fall under the administration of several of the divisions within the Ministry of Tourism, Natural Resources and Environment which has led to a lack of enforcement of reserve regulations. Marine reserves were established in 1981 under the Wildlife Conservation Act (1974) (Kudoja 1985). Despite Tanzania having eight marine reserves none of these are currently under any form of management. Chole Bay and Tutia marine reserves have recently been incorporated in the Mafia Island Marine Park, the only marine national park in Tanzania. Lack of suitable boats, outboard engines and trained personnel are often cited as the main reason for lack of enforcement of reserve regulations. The lack of enforcement of reserve regulations has caused drastic changes in the community structure of unprotected reefs. A comparative study (McClanahan et al. in press (b)) of the Kisite park (protected since 1978) and Chumbe coral reef park (protected since 1994) and the Dar es Salaam reserves of Mbudya and Bongoyo which have received no protection revealed, on average, a 70% difference in key coral reef fish and increase in urchin biomass. There is also concern that mangrove harvesting is having a detrimental effect on the ecology of the Tanzanian coast. The removal of mangroves along the Rufiji has caused increased sedimentation, putting the reefs of Mafia Park at risk (Andrews, pers. comm.). The management of mangroves suffers similar problems to reefs with mangrove resources falling under several different ministries, each with a conflicting agenda including trade (salt ponds), agriculture (rice farming) and fisheries (aquaculture). This conflict between different management agencies became clear recently when permission for a large-scale prawn aquaculture project in the Rufiji delta was authorised despite resistance from several government agencies and local communities.

## Threats to Tanzanian Reefs and Associated Ecosystems

The main threats to Tanzanian reefs fall into the following main categories organised in order of importance.

1. Destructive methods of fishing pose the greatest danger to reefs in Tanzania. Dynamite fishing causes extensive damage to coral apart from killing fish that are not targeted for the market.
2. Over-exploitation of marine resources driven by the increase in the coastal population poses a danger to fisheries products including finfish, octopii, sea cucumbers and lobsters as well as mangroves. Illegal exploitation of sea turtles that are protected under the fisheries also poses a danger.
3. Poor land-use practices especially cultivation along river beds and removal of large areas of mangrove have caused the increase of sedimentation posing a danger to inshore habitats including coral reefs and seagrass beds.
4. Tourism-related activities including collection of marine curios such as shells, seastars and coral pose a danger.
5. Pollution from land-based activities is also proving to be a threat in Watamu where algal cover has increased on some reefs.

## Integrated Management

The concept of integrated management has been introduced in Tanzania and Zanzibar through several donor-funded projects that have varying management strategies. In Tanga a collaborative management program, funded by Irish Aid, includes the district administration and local communities; in Menai bay a WWF funded project includes the central government and local communities; and in Chumbe Coral Park the private sector is involved. The successes and failures of these projects will provide important lessons in the region of the most effective management and conservation strategies.

## Capacity Building and Information

The University of Dar es Salaam and the Institute of Marine Sciences (IMS) provide training in marine sciences. SIDA/SAREC has funded training courses for the region coordinated by IMS since 1988 including resource and pollution assessment. Most of the research and management projects in Tanzania develop awareness materials and training packages but they are usually site or project based. As in Kenya, training is usually project based and no assessment of training needs, either in the country or the Region, has been carried out. There is also the need to assess the effectiveness of the training and the usefulness of the training material in order to improve capacity building in marine sciences.

## Research and Monitoring

The University of Dar es Salaam and IMS are the main institutions in Tanzania and Zanzibar carrying out research on coral reefs and associated ecosystems. Currently programs include mapping of coral reefs around Unguja and Pemba, studies on restoration and resource inventories of Tanzania. The Tanga project carries out regular monitoring of marine resources in the area that includes fishers recording their catches. Frontier Tanzania has carried out resource surveys in southern Tanzania from Songo Songo archipelago to Dar es Salaam and Mafia Island. The main constraint with regards to research and monitoring is the lack of funds and trained personnel in management institutions including the fisheries and forestry departments. Hence no regular monitoring of the national marine resources is carried out. Efforts should be made to design simple and inexpensive methods of collecting resource data that can be used to make informed management decisions.

## ICRI and GCRMN Coordination

Tanzania participated in the Seychelles ICRI Symposium, where a decision was made to share the scientific and monitoring role of the Eastern African mainland states between IMS (Zanzibar) and KMFRI (Kenya). Under the SIDA/Sarec funded project for marine sciences, these two institutions have shared the role of coordinating training courses. Providing funding to develop and implement long-term monitoring programs coordinated by these institutions should enhance this relationship.

## Mozambique

### Introduction

Mozambique has a 2700 km long coastline dominated by estuarine habitats defined by the numerous rivers that empty into the Indian Ocean. The distribution of coastal habitats including mangroves, seagrass beds, coral reefs, sand dunes and numerous island archipelagoes combine to make this shoreline the most complex along the east coast of Africa. The distribution of coral reefs and associated ecosystems is poorly documented (Table 5.1). Reefs have been recorded in the Quirimbas archipelago in northern Mozambique where patch reefs are common on the western sides of islands. Reefs are restricted however by fresh water input from numerous rivers (Whittington et al. 1997). The Mozambique islands at the entrance of the Mozambique Bay have submerged reefs (Fonseca 1996) while the Primeiras and Segundas archipelago have fringing reefs on the eastern sides of the islands but are restricted by cold water upwelling from the Mozambique channel (Tinley 1971; Whittington and Heasman 1997).

In the Bazaruto archipelago, patch reefs occur on the eastern and southeastern shores of the islands (Dutton and Zolho 1989) and back reefs are characterised by high cover of *Porites* and *Acropora* thickets. Offshore islands and fringing reefs also occur on the northeastern shores of Bazaruto Island where high hard coral and soft coral cover has been recorded. Fringing reefs have also been reported along the shores of Inhaca and Portuguese Islands in southern Mozambique and patch reefs have been reported offshore in 15 m of water along the eastern shores (Boshoff 1981; Nestler et al. 1984; Salm 1976). Coral assemblages where soft corals dominate occur from Ponta do Oura to Cabo de Santa Maira in southern Mozambique (Robertson et al. 1996).

**Table 10:** Studies on coral reefs and associated habitats

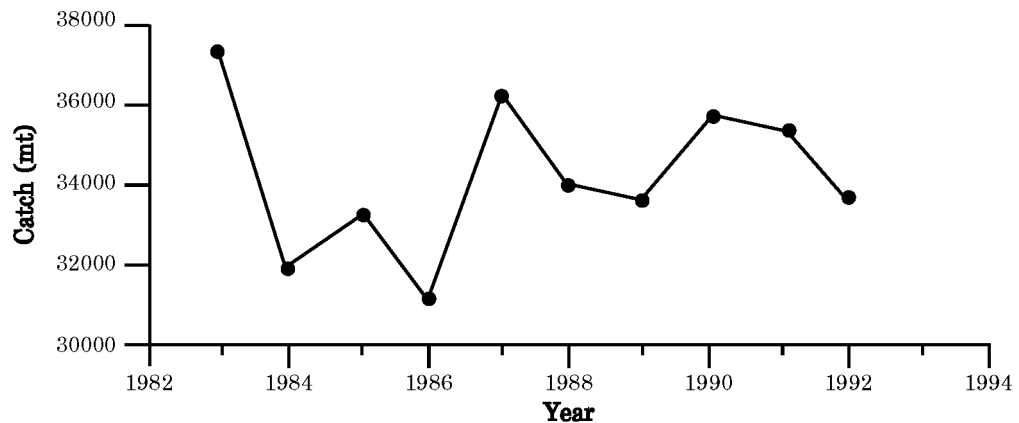
COMMON NAME	NO. SPECIES/GENERA	REFERENCE
Hard corals	160 species, 50 genera	Rodrigues 1996; Whittington et al. 1997
Soft corals	27 species	Benayahu & Schleyer 1996
Finfish	300 species	Fonseca 1996; Whittington et al. 1997
Gastropods	155 species, 39 genera	Dutton & Zolho 1989
Sea turtles	5 species	Fonseca 1996
Dugong	1 species	Magane 1996; UNEP/IUCN 1988

Information on the distribution of seagrass beds and mangrove forests is more limited. Seagrass beds are associated with most of the archipelagos between the islands and the mainland and support turtles and dugongs. Mangroves cover approximately half of the Mozambique coastline (~500 000 ha, Tinley 1971).

## Resource Extraction and Gleaning

The fisheries sector contributes three per cent of the GNP of Mozambique. The marine fisheries resources of Mozambique are estimated at 30 000 mt/yr, including finfish, crustaceans and mollusks (Figure 8). The marine fisheries sector is classified into:

- artisanal fishers who operate on foot, 3–10 m canoes or boats powered by sail or motor. It is estimated that there are 83 000 artisanal fishers composed mainly of communities displaced to coastal areas as a result of the war. Gear includes handlines, beach seines, drift gillnets, and bottom gillnets. Locally made fish traps, spears and gleaning for crabs, sea cucumbers and molluscs is also widely practised in reef lagoons, seagrass beds and mangrove channels;
- semi-industrial fishing operate on 10–20 m motor boats mainly trawling for prawns and demersal fish for domestic use in the bays and areas close to the coast; and
- the industrial sector concentrates on prawn fishing in the Sofala banks and extract shallow and deep water prawns, lobsters, crayfish and fish primarily for export.



**Figure 8:** Total catch of fish, crustaceans and mollusks combined in metric tonnes from Mozambique between 1983 and 1992 (Source: FAO 1994)

Additionally, mangrove cutting for building and firewood, shell collection for food and the curio trade, octopii, sea cucumber and crab collection are also carried out on a subsistence level.

Sports fishing has increased in Mozambique over the last few years. Most of the fishermen are from South Africa and target bonito, tuna, mackerel, bonefish and billfish. With the conclusion of the civil war and the development of tourist facilities, Bazaruto Island has become a popular sport-fishing destination.

## Tourism

The coastal tourism sector is currently poorly developed in Mozambique but is expected to develop rapidly as infrastructure destroyed during the war is rehabilitated. Currently tourism consists of visiting yachts, sports fishermen and backpackers. Snorkeling, SCUBA diving, big game fishing and sight-seeing are the main attractions. There are well-established tourist facilities on the islands of Magaruque, Benguerua and Bazaruto. Bazaruto is also a popular cruise ship destination from South Africa. The Ponta do Ouro and Cabo de Santa Mariam areas have been identified in the National Tourism Policy as a primary focal area for tourism development.

## Management and Its Effectiveness

The coral reefs and associated ecosystems of Mozambique fall under the jurisdiction of several government institutions with mandates that are unclear or overlapping and conflicting making it difficult to effectively manage natural resources (Table 11). The National Directorate of Forestry and Wildlife is responsible for the conservation and management of forestry (including mangroves), wildlife (including fisheries) resources and protected areas. Other departments with interests in marine resources include the Fisheries Research Institute and the Small Scale Fisheries Development Institute who monitor resources and developments that affect these resources. The National Directorate of Tourism is responsible for tourism development and the National Maritime Directorate is responsible for controlling coastal and marine areas and assists in enforcement in areas outside protected areas.

**Table 11:** Government institutions involved in the protection and management coral reefs and associated ecosystems in Mozambique (Source: Modified from Rodrigues et al. 1998)

INSTITUTION	RESEARCH	PLANNING	MANAGEMENT
Ministry of Coordination of Environment Affairs	X	X	X
University of Eduardo Mondlane	X		X
Ministry of Agriculture and Fisheries			
- National Directorate of Forestry & Wildlife	X	X	X
- Fisheries Research Institute	X		
- Small Scale Fisheries Development Institute	X	X	
Ministry of Transport and Communications			X
- National Marine Directorate	X		
- Maritime Administration			
Ministry of Commerce and Tourism			
- National Directorate of Tourism		X	X
- Department of Commerce	X	X	
Ministry of State Administration	X		
Ministry of Industry and Energy	X		

As in the other eastern African countries, Mozambique has enabling laws to protect and manage marine resources but has low capacity in terms of skills and funds to manage these resources. Coral reefs are protected within the Inhaca and Portuguese Island reserves and Bazaruto National Park. Coastal reserves and parks including Pomene and Maputo afford protection to dugongs and turtles. The extension of Bazaruto National Park and Maputo reserve are currently under consideration by the government. There is currently little information to ascertain whether the current protected areas are effectively managed.

## Threats

The rapid increase in the coastal population and the increase in the rate of development of the coastal zone of Mozambique have increased the danger of over-exploitation and destructive exploitation of the coastal resources. The main threats to the coral reefs and associated ecosystems include:

- over-exploitation of marine resources including finfish, octopii, sea cucumbers and crabs. Illegal exploitation of sea turtles and localised intensive cutting of mangroves, especially around population centres, also poses a serious threat to these species;
- destructive methods of fishing, especially beach seining, which cause extensive damage to coral and seagrass beds;
- tourism-related activities, including collection of marine curios such as shells and coral, cause depletion of these resources;
- pollution from land-based activities is a major threat in Mozambique due to the numerous rivers; and
- damage from cyclones and hurricanes also threatens coral reefs in Mozambique.

## Integrated Management

Mozambique has a national master plan, the National Environmental Management Program (NEMP), which includes a national coastal zone management program. The program, which is currently under preparation, will comprise a National Coral Reef Management Program that aims to collect information on the coral reefs of Mozambique for effective resource management. Currently Mozambique has the least expertise and capacity to deal with marine resources in the region. Under the EAF5 project, a coastal profile of Xai Xai has been completed and a rapid assessment training exercise, which included both biophysical and socioeconomic parameters, was also conducted in Xai Xai.

Currently ICZM training courses for local and regional coastal managers are conducted at the Secretariat for coastal area management (SEACAM) based in Maputo and funded primarily by the Swedish government. Additionally, an integrated development plan that takes into consideration the local community for the Inhaca and the Portuguese Islands was completed in 1990 although the Mozambique government has not yet officially approved it. MICOA is coordinating the development of management plans for the Quirimbas with the assistance of Frontier-Mozambique, and the National directorate for forestry and wildlife and WWF are currently implementing a program funded by the EU for Bazaruto that includes the involvement of local communities.

## Capacity Building, Research and Monitoring

The University of Eduardo Mondlane is the only institution of higher learning that has training in marine resources in Mozambique. The University manages the Inhaca and Portuguese Islands reserve where a marine biological station is situated. Most of the studies on coral reefs in Mozambique have been based in this area where studies have been carried out since 1951. Recently, SEACAM has conducted courses on coastal zone management. In general however, the training capacity in Mozambique is weak.

There are several institutions involved in research activities in Mozambique (Table 11). Much of the research however is geared towards collecting baseline information for the development of management plans. No long-term monitoring programs have been developed although records of the Inhaca and Portuguese Island reefs date back to 1935 and descriptions of the coral fauna of these reefs have recently been compiled. There is an urgent need to improve capacity within the educational and management institutions for effective management of coral reefs and associated ecosystems.



## ICRI and GCRMN Coordination

Currently there are no GCRMN activities in Mozambique. There are institutions including MICOA, the Fisheries Research Institute, the Eduardo Mondlane University and DNFFB that could develop the capacity to carry out monitoring and other ICRI activities. Lack of funds and capacity have been the main constraints. However, awareness of coral reef issues, research and training are all increasing in the country.

## Western Indian Ocean Island States

### Introduction

The western Indian Ocean island states comprise the following five states: Comoros, Madagascar, Mauritius, Réunion Island and Seychelles. The islands of Réunion, Comoros and Mauritius are essentially volcanic while those of the Seychelles are granitic. Wider continental shelves feature in Seychelles and western Madagascar.

### The Regional Environment Program of the Indian Ocean Commission

The overall objective of the Regional Environment Program of the Indian Ocean Commission (REP-IOC/EU) is to promote a regional policy for the sustainable management of the natural resources in the five member states: Comoros, Madagascar, Mauritius, Réunion Island and Seychelles.

In particular, the program provides support for national policies on Integrated Coastal Zone Management (ICZM), which encourages the development of a coherent global approach to the management of natural resources in these island states. The main orientations for the REP-IOC/EU for 1998 include interventions at both the political level (framework agreements, conventions, etc.) and the operational and technical levels (training activities, pilot operations, reef monitoring, etc.).

They cover three main themes:

- the definition, validation and application of the framework for the regional policy on sustainable development (RPSD) through the management of the coral ecosystems (reef theme) and the prevention of poisoning by seafoods (ecotoxicology theme);
- the setting up and operating of priority regional networks around the central unifying themes of the reefs and ecotoxicology; and
- the application of the principles underlying ICZM to environmental audits, concrete pilot operations or specific actions having a regional bias (reef monitoring, etc.).

More specifically, the implementation of a Regional Action Plan (RAP) is one of the main themes for the REP-IOC/EU. Defining priority action areas for implementation within the framework during the existence of the REP-IOC/EU (1995–1999) has thus been made possible with the unanimous agreement among all the partners of the COI.

Reef monitoring is one of the priority actions of the RAP through its reef theme, since all five member states have coral reefs and are confronted daily with the problems connected to the integrated management of their coastlines. The data gained through the implementation of a reef monitoring program will provide very important tools to assist in the decision-making process, which can be used in the most sensitive and vulnerable priority areas in ecological terms.

## The Reef Monitoring Program

The coral reefs are subject to increasing pressure, in particular from human activity. As a result, the need to monitor these ecosystems in both time and space has become a major priority for the COI countries. In fact, they represent a unifying theme for the region which in itself justifies the need to develop a reef monitoring program through a regional reef network. The reef can then become, through its associated themes, a clearly defined example of integrated management for the REP-IOC/EU and its various partners, be they institutional, private or community organisations.

At the regional level, the REP-IOC/EU has developed a reef monitoring program based on a methodological handbook entitled *Survey of the Health of the Coral Reefs in the South-west Indian Ocean (Suivi de l'état de santé des récifs coralliens, Conand, Bigot, Chabanet & Quod 1998)* and a specialised database. The methodologies used conform to the overall principles and methods of the GCRMN (Global Coral Reef Monitoring Network). However, they have been adapted to the specific context of the southwest Indian Ocean.

The originality of the regional guide can be attributed to several factors:

- the way several complementary methodologies for follow-up have been meshed together;
- the use of new environmental parameters for follow-up;
- the exploration of new areas in the reefs (e.g. the reef flats); and
- the introduction of scenarios which evolve depending on the available resources (human, material, etc.).

The ARMDES-COI database has been devised to enable the recording and a simplified analysis of the data collected following the protocols described in the COI guide and in the *Survey Manual of Tropical Marine Resources* (English et al. 1994). Using the interfaces in the AIMS database, the ARMDES-COI base has been simplified and adapted to the specific contexts of the countries concerned in accordance with the methodological manual on reef monitoring. This database, which has been translated to French, is designed to be compatible with the GCRMN database. Its evolutionary structure allows for the design and integration of new modules for data processing.

The reef-monitoring program is one of the fundamental projects undertaken in 1998 by the COI countries. Its different elements have been brought together in a regional reef network (a sub-node in the GCRMN) which includes both the on-site operational level of activities (national focal points), and decision-making and policy-making levels (concept of 'servers'). This reef network completes an existing network for the countries on the East African coast (sub-node for Eastern Africa).

## The COI 1998 Report on Coral Reefs

The preparation of a regional reef report on the theme *Survey of the Health of the Coral Reefs* is one of the main outputs from the REP-COI/EU for 1998.

At the regional level, this work is part of the preparations for the effective launching of the IOC regional reef network for which the 'monitoring of the coral reefs' initiative is one of the pivots. At the international level, it is part of the preparations for the Townsville meeting (ITMEMS '98) and contributes to the setting-up of the Global Coral Reef Monitoring Network (GCRMN).

It gives concrete expression to the willingness to present the political, methodological and technical approach (through the preliminary results) used in the Indian Ocean region and the desire to officially register as a recognised partner in the GCRMN.

On the technical side, the 1998 reef report:

1. gives a complete assessment of the evolution and present situation of the COI regional network and its different national components.

The national reef networks have gradually joined together in a regional network which is today completely functional and operational. In this context, the concepts of 'national servers' and 'focal points' have evolved throughout 1998. The follow-up networks for the reefs have been restructured in each country around their focal points. The focal points act as the operational and technical links between the actors on the ground, while the national servers provide the administrative and political links between the networks (control, protocols concerning exchange of data, etc.).

Today, the COI regional network is one of the sub-nodes of the GCRMN in the Indian Ocean region, in accordance with the recommendations of the ICRI Regional Workshop for the Western Indian Ocean and Eastern Africa, held in Seychelles 1996. However, despite the promising results obtained so far, the very recent installation of the new network renders it rather difficult to effectively consider it in the global context of the different world networks (Reef Check, AGRA, CARICOMP, etc.) for the year 1998. The Townsville meeting should make the COI network known and lay the foundations for its recognition at the international level.

2. makes possible the presentation of the first results obtained through the monitoring stations that were set up in each COI country in 1998. More than 24 stations have been set up and followed systematically during the past year:
  - 4 stations in Comoros (Grand Comoros, West Coast);
  - 4 stations in Seychelles (MahÉ, East and West Coasts);
  - 8 stations in Madagascar (North-west, East and South-west Coasts);
  - 4 stations in Mauritius (East and West Coasts); and
  - 4 stations in RÈunion Island (West Coast).

Numerous synthetic results have been obtained using the follow-up parameters described in the COI methodological manual (coral layers, algae, abiotic substrata, abundance in ichthyologic populations, etc.). The number of monitoring stations should gradually increase over the next few years, depending on the resources available in each country. The base data from 1998 are essential for the reef monitoring program, since this initiative is defined in both space and time (setting up of a comparative database).

3. enables the definition of future orientations and concrete proposals to be implemented within the framework of the 1999 Regional Action Plan for Coral Reefs, in order to ensure the continuity of the COI network, its increase in strength and its effective utilisation in ICZM. These proposals, some of which will be implemented with the financial support of the Global Environment Fund (GEF), also include:
  - administrative and political procedures (definition of protocols, conventions);
  - complementary training initiatives (knowledge of terrain, database, diving); and
  - promotion and advertising initiatives (creation of attractive products, such as CD-ROM, handbooks, website).

## Conclusions

The 1998 results for the regional initiative 'Follow-up on the Health of the Coral Reefs in the South-West Indian Ocean' are considered very satisfactory.

The setting-up of the COI regional network and its outputs are the concrete results of numerous initiatives (technical workshops, training programs, political initiatives, etc.) which have been carried out for over two years in the Region (ICRI, Seychelles 1996, Nosy Be 1997, TulÈar 1998, Mauritius 1998). The present results obtained give concrete form to the commitments made by the various partners in these different meetings. Their importance, in terms of the actual functioning of the network and its products (training, technical results), are themselves weighty arguments in favour of pursuing this initiative on its existing base. It

is, however, too early to envisage a direct use of these results within the framework of ICZM. Their use will become more meaningful in the years to come.

'The Coral Reefs Monitoring' constitutes in the short term an important tool for information and assistance in the decision-making process in the COI countries, inasmuch as the restoration of the reef ecosystem must be linked to objectives for the economy, public health and the conservation of biodiversity. The continuity of the COI regional reef network is, therefore, essential for the promotion of a regional environment policy based on the Integrated Coastal Zone Management of the islands in the southwest area of the Indian Ocean.

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Regional Reports:  
East Africa

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## References

- Anderson, J. E. C. & Ngazi, Z. 1995, 'Marine Resource Use and the Establishment of a Marine Park; Mafia Island, Tanzania', *Ambio*, 24, pp. 475-481.
- Barnett, R. 1997, 'The Shark Trade in Mainland Tanzania and Zanzibar', in *Shark Fisheries and Trade in the Western Indian and Southeast Atlantic Oceans*, TRAFFIC Report, 1997.
- Benayahu, Y. & Schleyer, M. H. 1996, *Corals of the South West Indian Ocean. III. Alcyonacea (Octocorallia) of Bazaruto Island, Mozambique with a Redescription of Cladiella australis spec. nov.*, Investigational Report, Oceanographic Research Institute, 69, pp. 1-22.
- Boshoff, P. H. 1981, *An Annotated Checklist of Southern African Scleractinia*. Investigational Report, Oceanographic Research Institute, 49, pp. 1-45.
- Brown, A. 1996, The Prosobranch Mollusks of Songo Songo, Tanzania: A Species List and an Investigation into the Commercial Shell Trade and the Methods Used by the Environmental Organisation Frontier to Access it, undergraduate dissertation, Royal Holloway College, University of London.
- Clark, A. M. & Rowe, F. W. E. 1971, *Monograph of the Shallow-water Indo-West Pacific Echinoderms*, British Museum of Natural History, Pitman Press, Bath.
- Conand, C., Bigot, L., Chabanet, P. & Quod, J. P. 1997, *Manuel méthodologique pour le suivi de l'État de santé des récifs coralliens du Sud Ouest de l'Océan Indien*, Manuel technique PRE-COI/UE.
- Darwall, W. R. T. & Guard, M. (in press), 'Southern Tanzania', in *Coral Reefs of the Indian Ocean: Their Ecology and Conservation*, eds T. R. McClanahan, C. S. Sheppard & D. Obura, Oxford University Press, New York.
- Dutton, P. & Zolho, R. 1989, *Plano Director de Conservacao para o Desenvolvimento do arquipelago de Bazarut.*, Relatório submetido ao Ministro da Agricultura, Maputo, Mocambique.
- English, S., Wilkinson, C. & Baker, V. 1997, *Survey Manual for Tropical Marine Resources*, 2nd edn, Australian Institute of Marine Science.
- ESCWA/FAO/UNESCO/IMO/IAEA/IUCN/UNEP, 1987, *Coastal and Marine Environmental Problems of Somalia*, UNEP Regional Seas Reports and Studies No. 84, pp 1-215.
- FAO 1994, *FAO Yearbook of fisheries statistics: Catches and landings*, vol. 74.

- FAO/IMS/Sida 1999, *Strategic Action Plan for Land Based Sources and Activities Affecting the Marine, Coastal and Associated Freshwater Environments in the Eastern African Region*, Draft Report.
- Fonseca, R. 1996, Perfil ambiental da liha da Mocambique-Contribuicao para um Plano de Desenvolvimento da zona costeira, paper presented at the Integrated Coastal Zone Management Workshop, Inhaca Maputo.
- Francis, J. & Muhando, C. 1996, 'Coastal Biodiversity and Conservation Strategy for the Fisheries Sector', *CEEST*.
- Frazier, J. 1975, *The Status of Knowledge of Marine Turtles in the Western Indian Ocean*, East African Wildlife Society Report.
- Glaesel, M. 1997, Fishers, Parks and Power: The Socio-Environmental Dimensions of Marine Resource Decline and Protection on the Kenya Coast, PhD dissertation, University of Wisconsin.
- Guard, M., Muller, C. & Evans, D. 1997, *Marine Biological and Marine Resource Use Surveys in the Mtwara District, Tanzania*, Surveys of Fringing and Patch Reefs Within and Adjacent to Mnazi Bay Report No. 1.
- Hamilton, H. G. H. 1975, *A Description of the Coral Fauna of the East African Coast*, vol. 1, (Plates), University of Dar es Salaam.
- Hamilton, H. G. H. & Brakel, W. H. 1984, 'Structure and Coral Fauna of East African Reefs', *Bull. Mar. Sci.* 34, pp. 248-266.
- Horill, J. C. & Ngoile, M. K. 1991, *Mafia Island Report No. 2. Results of the Physical Biological and Resource Use Surveys: Rationale for the Development of a Management Strategy*, The Society for Environmental Exploration, London.
- Horrill, J. C., Darwall, W. R. T. & Ngoile, M. K. 1996, 'Development of a Marine Protected Area: Mafia Island, Tanzania', *Ambio*, 25, pp 50-57.
- Issac, F. M. 1968, 'Marine Botany of the Kenya Coast: Angiosperms', *Journal of the East African Natural History Society*, 116, pp. 29-47.
- Issac, I. W. F. & Issac, F. M. 1968, 'Marine Botany of the Kenya Coast. 3. General Account of Environment, Flora and Fauna', *Journal of the East African Natural History Society*, 27(1), pp. 7-27.
- Jiddawi, N. S., Issa, S. & Shariff, M. 1991, 'Review of the Marine Fisheries Sub-sector for Zanzibar', in *Proceedings of the Workshop on the Priorities for Fisheries Management and Development in the South West Indian Ocean*, eds J. P. Ardil & M. J. Sanders, FAO Fisheries Report No. 457.
- Kayombo, N. A. 1989, *Progress Report: Preliminary Study of the Ecology of the Intertidal Molluscs of Mafia Island, Tanzania*, National Museum of Tanzania.
- Kudoja, W. M. 1985. The Tanzanian Coral Reefs at Risk, in *Proc. 5th Int. Coral Reef Congress, Tahiti*, 2, pp. 209.
- Lemmens, J. W. T. J. 1993, 'Reef-building Corals (Cnidaria: Scleractinia) from the Watamu Marine National Reserve, Kenya: an Annotated Species List', *Zool. Med. Leiden*, 67, pp. 453-465.
- Luvanda, A. M., Mbuvi, M. E. T. & Wandabwa, A. 1997, *The Status of Mangrove Exploitation and Trade along the Kenyan Coastline*, Kenya Forestry Research Institute Report.
- Magane, S. 1996, *Perfil ambiental do Archipelago de Bazaruto, Relatoria apresentado no Workshop Nacional sobre Gestao Costeira em Mocambique, 5-10 de Maio 1996*, Inhaca, Maputo.
- McClanahan, T. R. 1989, 'Kenyan Coral Reef-associated Gastropod Fauna: a Comparison Between Protected and Unprotected Reefs', *Mar. Ecol. Prog. Ser.*, 53, pp. 11-20.
- McClanahan, T. R., Kamakuru, A. T., Muthiga, N. A., Gilagabher, Y & Obura, D. 1995, 'Effects of Sea Urchin Reductions on Algae, Coral and Fish Populations', *Conserv. Biol.*, 10, pp. 136-154.
- McClanahan, T. R. & D. Obura. 1995, 'Status of Kenyan Coral Reefs', *Coast. Manag.*, 23, pp. 57-76.
- McClanahan, T. R., Muthiga, N. A. & Mangi, N. (in press (a)), *The Status of Kenyan Coral Reefs: Results of a Long-term Monitoring Program*, Report of the Coral Reef Conservation Project and the Kenya Wildlife Service.
- McClanahan, T. R., Muthiga, N. A., Kamukuru, A. T., Machano, H. & Kiambo, R. W. (in press (b)), 'The Effects of Marine Parks and Fishing on Coral Reefs of Northern Tanzania', *Biol. Cons.*

- Moorjani, S. & Simpson, B. 1988, *Seaweeds of the Kenya Coast*, Oxford University Press, Nairobi.
- Nestler, A., Paech, J. H. & Schmidt, W. 1984, 'Inhaca Island, Mozambique und die Entwicklung des Riffs vor Barreira Vermelha', *Petermanns Geographische Mitteilungen DDR*, 1, pp. 31-37.
- Pertet, F. & Thorsell, J. W. 1980, *The Dugong in Kenya*, Kenya Wildlife Planning Unit, December.
- Robertson, W. D., Scyleyer, M. H., Fielding, P. J., Tomalin, B. J., Beckley, L. E., Fennessy, S. T., van der Elst, R. P., Bandeira, S., Macia, A. & Gove, D. 1996, *Inshore Marine Resources and Associated Opportunities for Development of the Coast of Southern Mozambique: Ponta do Ouro to de Santa Maria*, vol. pp.
- Rodrigues, M. J. 1996, *Estudo da Estrutura da Comunidade de Corais da Zona do Farol da Ilha do Ibo*, Tese de Licenciatura, Universidade Eduardo Mondlane, Maputo.
- Rodrigues, M. J., Motta, H., Whittington, M. W. & Schleyer, M. (in press), in *Coral Reefs of the Indian Ocean: Their Ecology and Conservation*, eds T. R. McClanahan, C. S. Sheppard & D. Obura, Oxford University Press, New York.
- Rumisha, C. H. 1995, *Fisheries Policy and Legislation*, Technical Workshop on Legislation and Policy Review of Integrated Coastal Zone Management for Tanzania. Dar es Salaam Department of Fisheries.
- Salm, R. 1976, 'The Dynamic Management of the Ponta Torres Coral Reef', *Memorias do Instituto de Investigacao Cientifica de Mocambique*, 12 A, pp. 1-23.
- Salm, R. V., Muthiga, N. A. & Muhando, C. 1997, 'The Evolving Western Indian Ocean Coral Reef Program', in *Proc 8th Int. Coral Reef Sym.*, 1, pp. 323-328.
- Samoilys, M. A. 1988, Abundance and Species Richness of Coral Reef Fish on the Kenyan Coast: The Effects of Protective Management and Fishing, in *Proc. 6th Int. Coral Reef Symp*, 2, pp. 261-266.
- Semesi, A. K. 1998, 'Mangrove Management and Utilisation in Eastern Africa', *Ambio*, 27(8), pp. 620-626.
- Stromme, T. 1987, Annex IV - Sectoral Report on Marine Resources, in *Coastal and Marine Environmental Problems of Somalia*, UNEP Regional Seas Reports and Studies, no. 84, annexes, UNEP, Nairobi, pp. 87-110.
- Tinley, 1971, Determinants of Coastal Conservation Dynamics and Diversity of the Environment as Exemplified by the Mozambican Coast, in *Proceedings of the Symposium on Nature Conservation as a Form of Land Use*, Gorongosa National Park, Sarcus, Pretoria, 125:153.
- UNEP, 1987, *Coastal Marine Environmental Problems of Somalia*, UNEP Regional Seas Reports and Studies, no. 84, United Nations Environment Program, Nairobi.
- UNEP/IUCN, 1988, *Coral Reefs of the World, Volume 2, Indian Ocean, Red Sea and Gulf*, UNEP Regional Seas Directories and Bibliographies, IUCN, Gland and Cambridge, & UNEP, Nairobi.
- UNEP/IMS/FAO/Sida, 1998, *Overview of Land-based Sources and Activities Affecting the Marine Coastal and Associated Freshwater Environments in the Eastern African Region*, UNEP Regional Seas Reports and Studies, no. 167, UNEP, Nairobi.
- Watson, M. R., Righton, D., Austin, T. J. & Ormond R. F. G. 1996, 'The Effects of Fishing on Coral Reef Fish Abundance and Diversity', *J. Mar. Biol. Ass. U.K.*, 76, pp. 229-233.
- Whittington, M. W., Carvalho, M., Corrie, A & Gell, F. 1997, *Technical Report 3: Central Islands group-Ibo, Quirimbas, Sencar, Quilaluia Islands. Marine Biological and Resource Use Surveys of the Quirimbas Archipelago, Mozambique*, Society for Environmental Exploration, London & the Ministry for the Coordination of Environmental Affairs, Maputo.
- Whittington, M. W. & Heasman, M. S. 1997, *A Rapid Assessment of the Subtidal Habitats and Associated Commercial Fish Populations of the Segundas Islands: Santo Antonia and Mafamede Islands. A Technical Report for the Institute for the Development of Small-scale Fisheries (IDPPE)Mozambique*, Society for Environmental Exploration, London & the Ministry for the Coordination of Environmental Affairs, Maputo.
- Yaninek, J. S. 1978, 'A Comparative Survey of Reef-associated Gastropods at Maziwa Island, Tanzania', *Journal of the East African Natural History Society*, 31, pp. 1-16.