THE STATUS OF CORAL REEFS IN THE DAR-ES-SALAAM MARINE RESERVES SYSTEM AND THE STATE OF REEFS IN OTHER MARINE PROTECTED AREAS OF TANZANIA

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Executive summary

Studies dating to the 1960s revealed that the marine environment and its resources are over-exploited and in need of management. The establishment of Dar-es-Salaam marine protected areas (MPA) was adopted by the Government, in 1975, as one of the options to facilitate sustainable utilization of the environment and resources in specified areas. Since coral reefs play a crucial role in the ecology and socio-economy of most MPA in Tanzania, sustainable use of coral reefs has always been an important goal of MPA management.

Due to the narrowness of the continental shelf, the majority of the reefs are close to land, as a result they are strongly subjected to human influences and natural calamities. While coral reef studies in the 1960s and 1970s reported high diversity and luxurious growth of corals and associated resources, surveys in the 1980s and 1990s described a general degradation of coral reef ecosystems, mainly due to destructive fishing (dynamite and dragnets) and over-exploitation of certain species key species. Increase in coastal populations, poor economy (lack of alternative employment), unplanned tourism and coastal construction as well as lack of trained personnel and resources to enforce legislation have contributed towards coral reef degradation.

The coral reef environment in the Dar-es-Salaam Marine Reserve System, which includes: Mbudya Marine Reserve, Bongoyo Marine Reserve, Pangavini Marine Reserve and Fungu Yasini Marine Reserve, was reported to be so degraded that some scientists questioned whether it was worth maintaining them as a MPA. In addition, Coral reef degradation was reported for reefs in Tanga, Mafia, Songosongo, Mnazi Bay and Msimbati Bay in Mtwara.

The 1998 coral bleaching and subsequent mortality event caused further degradation of many reefs in Tanzania. The coral mortality differed between and even within sites and species. To some extent, the differential mortality of corals brought alarming and confusing signals to many coral reef (MPA) managers. This study was undertaken to update MPA managers on the current status of reef benthic cover, macro-invertebrates and reef fish population. Recent information was compared with that obtained prior to the post bleaching data.

The live hard coral cover in the Dar-es-Salam Marine Reserves according to recent studies (1999 and 2000), has increased on most reefs assessed except in Fungu Yasini where bleaching effects were severe. However, the coral species composition changed in favour of *Montipora aequiturberculata,* an opportunistic coral species and largely responsible for the observed increase in coral cover. *Acropora* mortality was high and its dominance was reduced significantly on most

areas while *Montipora, Galaxea, Fungia* and *Porites* survived well the bleaching event. The abundance of coral competitors such as soft coral, corallimorpharians and algae was more significant in Fungu Yasini than on the more sheltered sides of Mbudya, Pangavini and Bongoyo. The density of macro-invertebrates, such as lobsters, sea cucumbers, clams, ornamental shelled molluscs, and starfishes were surprisingly very low. Reef fish density as well as the diversity, seemed to have decreased slightly in the marine reserves. The deposition of mud at the lower end of the reef slope on the west sides of Mbudya and Bongoyo and the continuing use of destructive fishing methods are major threats to the structure and composition of coral reefs in the reserve. Despite existing environmental problems, the coral reefs and its resources in the Dar-es-salaam Marine Reserve System could recover if proper management strategies are implemented now.

In other MPA in the country, the coral reef degradation after the bleaching event was highest in areas previously described as excellent, e.g. Misali in Pemba and Tutia in Mafia. In Tutia for example, the live coral cover decreased from 80% in the 1980s to 15% in 1999. Not all reefs in Mafia Island Marine Park suffered high mortality, the live coral cover in the Chole Bay was high (>30%). In Mnazi Bay Marine Park and Tanga reefs, the live hard coral cover decreased from 45-70% to 16-42% after the bleaching event. Unlike other reefs around Unguja Island, the live coral cover in Chumbe Marine Sanctuary declined from an average of 60% to 30%. Reefs in Songosongo seemed to have been less affected compared to reef in Tanga, Mafia and Misali. Invertebrate counts including sea urchins, sea cucumber, starfish, gastropods, bivalves, octopus, lobsters varied relatively little despite the increase in substrate available for growth of filamentous algae. Fish counts have shown marked increase in herbivores, which may be due to one or a combination of increased food or the cessation of dynamite fishing pressure. The bleaching event seems to have little or no observable effects on artisanal fisheries as well as on tourism. Recent studies have indicated that coral reefs have started to recover but at different rates. Full and fast recovery will depend on management of human disturbances on the ecosystem. Research and monitoring are important and must be included in setting of management strategies. Building capacity for research and monitoring should be the first step.

1. INTRODUCTION

History of the management of the marine environment

The marine environment and its resources support not only the local communities and coastal residents, but also the national economy. Studies as early as in the 1960s (e.g. Ray, 1968;) revealed that the marine environment and the resources are under pressure from unsustainable uses. Overfishing, destructive fishing practices, mangrove deforestation, coral mining, pollution, coastal construction and other misuses were degrading the coastal marine environment and its resources.

In the 1960s there were not enough legislation for the protection of the marine environment and its resources (Ray, 1968). The Fisheries Act of 1970 provided the first comprehensive legislation to safeguard the marine environment and it had a provision that the Minister of Natural Resources and/or the Director of Fisheries may declare a marine protected area if there is enough evidence that by doing so the environment and its resources as well as the national interest is not jeopardised. Lack of capacity and facilities to effectively enforce legislations safeguarding the marine environment and its resources resulted in escalation of marine environmental destruction that was witnessed in the 1980s and 1990s (Bryceson *et al.*, 1990; UNEP, 1989; Ngoile and Horrill, 1993; Johnstone *et al.*, 1998). It was apparent that the government alone could not ensure sustainable utilisation of marine resources and the idea of establishing marine protected areas (MPA), which are under the control of specialised agencies working either under the Central Government (e.g. Mafia Island Marine Park, MIMP) or District authority (e.g. in Tanga) or managed jointly by Government agencies and local communities (e.g. MBCA) was necessary and was adopted accordingly. Further strategy was to allow non-governmental organisations (e.g. Misali) and private individuals (e.g. Chumbe and Mnemba in Zanzibar) to establish marine protected areas.

Definition and objectives of an MPA

Basically, MPA involve retaining some areas in their natural state, thus protecting ecosystems (habitats) and resources for maximum productivity as well as protecting scenic and coastal areas against abuse. The primary reasons for creating MPA according to Kelleher and Kenchington (1991) include:

- to maintain essential ecological processes and life support systems;
- to ensure the sustainable utilisation of species and ecosystem; and
- to preserve biotic diversity

Because of the expected benefits of establishing MPAs, special efforts were directed towards establishment of MPA in the form of reserves, sanctuaries, parks, conservation areas, etc. To date, there are about 11 such systems (Table 1). Although the objectives and management strategies differ slightly between them, they all have the same expectation of maintaining the ecological processes, ensuring sustainable utilisation and preserving biotic diversity. Most of the existing, proposed and potential marine protected areas aim at conservation of coral reefs among other habitats.

The essential components of an MPA which make management easier compared with non-MPA include: defined management boundaries, clear knowledge of the

location and quantities of resources to be protected, agreed strategies for resource harvesting procedures, management structure and technical advisory systems, agreed set of regulations and means of enforcing legislations, strategy for resource marketing and poverty alleviation to local communities around the MPAs (especially for the disadvantaged groups) and education and other forms of environmental awareness. The absence of these elements has complicated management of marine environment and its resources, especially in the current situation of free entry (absence of ownership) to the resource base.

History of management success and failures

In a global survey, it was found that although declared as marine protected areas, in most cases there was no management framework for environment and resource protection in most declared MPA except only in few MPA (Kelleher *et al.*, 1995). The failure was mainly due to lack of trained personnel and financial resources as well as political will among the government authorities and local communities (due to unclear alternative activities and poor focus on consequences).

Research and monitoring

Research and monitoring of environmental processes and resources is an essential part of the management machinery of MPA. Indeed, all the existing MPAs were preceded by scientific baseline studies, e.g. Talbot (1965), Ray (1968) and Hamilton (1975) for the 1975 declared marine reserves. Mnemba and Chumbe were declared based on scientific surveys carried out by Mike Pearson (UNEP 1989), Ngoile (1990), Jiddawi and Muhando (1990), and other studies by Zanzibar government officials. Recommendation by Ray (1968), UNEP (1989), together with studies by Horrill (while in Tanga) has provided valuable baseline data that lead to the selection of Tanga MPAs (e.g. in Kigombe and Kipumbwi). Baseline studies on Misali area before its declaration as a marine conservation area in 1998 were carried out by several scientist including UNEP (1989), Horrill (1992), Horrill *et al.* (1994) and other student projects. Muhando *et al.* (1997) recommended the location of boundaries of the MPA after assessing and zoning the different habitats in the area (in this MPA there is a small area (reserve) in which no exploitation is allowed). Baseline studies by Horrill *et al.* (1994), Muhando (1995), Muhando and Mohammed (1996) helped in the establishment of the Menai Bay conservation area in 1997. The Mafia coral reef areas have been a subject for several studies including the pioneer works in Kitutia (Tutia) reef by Talbot (1965), Frontier-Tanzania activities 1990-994 (e.g. Gaudian and Richmond, 1990) Most of the latter studies tried to describe and assess the marine environment in the Mafia Island Marine Park. Mnazi Bay Marine Park was officially declared as the second marine park in Tanzania in June 2000. Baseline studies and assessment in the area were carried out by Frontier-Tanzania, e.g. Guard *et al.* (1998), and other scientist such as Muhando *et al.* (1998a, 1998b) and Mwaipopo and Ngazy (1998).

The Dar-es-salaam Marine Reserves (DMR) comprised of Bongoyo Marine Reserve, Fungu Yasini Marine Reserve, Mbudya Marine Reserve and Pangavini Marine Reserve were Gazetted in June 1975 by the Minister of Natural Resources and Tourism following scientific recommendation by Ray (1968) and Hamilton (1975) who showed that the reserves had abundant resources that were in need of protection. Although declared as reserves, it appears till today that there is still no

appropriate management structure in place to protect the environment and its resources (see Kamukuru (1998) for management history of DMR). Surveys in the 1980s (e.g. Bryceson (1981), UNEP (1989) described a general degradation of coral reefs due the use of destructive fishing (dynamite and drag nets) taking place in the DMR area. Kamukuru (1998), McClanahan *et al.* (1999), and Wagner *et al.* (1999) revealed and discussed the effects of fishing on the environment and the possibility that the resources in the area are over-exploited and recommended immediate action to rescue the environment and its resources. Despite the use of destructive fishing methods, coral reefs have persisted and in some areas the coral cover have increased (Kamukuru, 1998).

While coral reef studies in the 1960s and 1970s report high diversity and luxurious growth of corals and reef resources (Talbot, 1965; Ray, 1968; Hamilton, 1975), surveys in the 1980s and 1990s described a general degradation of coral reef environment and its resources mainly due to overexploited and destructive resource harvesting methods, specifically dynamite fishing and dragnets (UNEP, 1989; Johnstone *et al.*, 1998; Ngoile and Horrill, 1993; Muhando, 1995; see Wagner 2000 in Press for more reviews). Increase in coastal population and poor economy as well as unplanned coastal tourism and construction have also been implicated in coral reef degradation.

The unprecedented coral bleaching and mass mortality, which occurred on Tanzania reefs between March and June 1998, resulted in further degradation of coral reefs (Wilkinson *et al.*, 1999; Muhando 1999a 1999b). The mortality of corals along the Tanzania coast brought about uncertainties on the status of coral reefs reported before this event. In order to satisfy coastal managers need for accurate information on the current status of coral reefs it was considered necessary to synthesize recent (after bleaching) information on coral reefs e.g. Mohammed *et al.* (2000), Kuguru and Muhando (2000), Wagner *et al.* (2000) and compare it with the situation before the bleaching event as well as provide updates on prospects for recovery.

In the Dar-es-Salaam Marine Reserves (Mbudya, Bongoyo, Fungu Yasini and Pangavini), despite being declared in 1975, to date no proper description of the boundaries (map) or well-consolidated information on the status of habitats and resource has been prepared. Such information was urgently required before the development of viable management plan in the DMR. This study was undertaken to update the Marine Park and Reserve Unit (MPRU), the Institute of Marie Sciences (IMS) and MPA managers on the current status of coral reefs in the Dar-es-Salaam Marine Reserves and in some of the existing MPAs in Tanzania.

There are two broad objectives of this study:

1. to describe the marine environment (habitats) and resources within the Dar-es-Salaam marine reserves. Specific objectives include:
    - Description of important habitats,
    - mapping of the coral reefs,
    - description of status of the coral reefs and resources (e.g. reef cover, invertebrate counts, fish counts),
    - description of physical processes (threats) influencing life in the DMR.

2. to describe the current status of coral reefs and associated resources in other MPA in other parts of Tanzania

2. MATERIALS AND METHODS

The status of coral reefs after the bleaching event was evaluated from results obtained during surveys conducted in MPA by scientists from the Institute of Marine Sciences (e.g. Muhando, 1999a; Muhando 1999b; Ohman *et al.*, 1999; Mohammed *et al.*, 2000, Kuguru and Muhando, 2000; Mbije *In prep*; Moh'd, *In prep*) and that of Wagner *et al.* (1999), Wagner *et al.* (2000), Semesi (2000) and interviews with Chris Horrill. In order to quantify the changes, recent data was compared with that obtained in previous studies in the areas under consideration. Comparisons and determination of the change over time were possible because some of the studies provided accurate description of their study sites (e.g. Ngoile, 1990; Horrill *et al.* 1994) and some of the sites were revisited after the bleaching event. Several studies have attempted to describe coral reef community changes in this way (e.g. Kamukuru, 1998; McClanahan *et al.*, 1999; Mohammed *et al.* 2000; Kuguru and Muhando, 2000).

The baseline map on to which Dar-es-Salaam Marine Reserves physical features were added was digitised from Admiral Chart No. 674 of 1983. Coral reef distribution data collected using a combination of GPS, manta tow, drift dives, reef viewer from boat in 1997 (Muhando and Johnstone unpublished). More information on coral reef distribution was obtained during this study. The Silversand Hotel dive centre operator, Mr. Jens F. Kruuse described the location of coral reefs on Mbudya shores (probably the best dive sites around in Dar-es-Salaam). Maps of other MPAs were obtained from the IMS maps database.

The habitat types adjacent to coral reefs in the DMS were determined by examining the nature of the bottom and the type of vegetation on them during drift dives and manta tows. Habitats were then characterised as sand, seagrass, rocky intertidal (with or without seaweed), mud or silt, and beach.

The reef benthic cover was assessed using a combination of Line-intercept transect method as in English *et al.*, (1994), Line-point intercept as in (Mohammed *et al.* 2000) and by rapid assessment technique described in Horrill, 1996. Study areas on to which this report refers include: Pangavini SW (first surveyed by Kamukuru (1998) in 1997 and later by Wagner *et al.*, (2000) in 1999 and also during this study), Pangavini NE (Wagner *et al.* 2000 and this study), Bongoyo NW and NW (McClanahan *et al.*, 1999; Kamukuru, 1998; Mohammed *et al.*, 2000; Kuguru and Muhando, 2000), Mbudya SW and NW ((McClanahan *et al.*, 1999; Kamukuru, 1998; Mohammed *et al.*, 2000; Kuguru and Muhando, 2000) and Fungu Yasini SE1, SE2 and SE3 (see Fig. 1).

Macro-invertebrates were counted along a belt transect 50 m long and 2 m wide in all the study sites above. Invertebrates groups considered include clams, shelled molluscs, lobsters, sea cucumbers, sea urchins, crown-of-thorn starfish and other starfishes.

Recent information on fish counts data was obtained from Mohammed *et al.* (2000) and was compared with that obtained in previous years by McClanahan *et al.* (1999) and Kamukuru (1998).

3. THE BIO-PHYSICAL RESOURCES IN THE DAR-ES-SALAAM MARINE RESERVES (DMR)

3.1 The *Islands and sand beaches on the DMR*

The islands of Mbudya, Pangavini and Bongoyo are Pleistocene coral islands, with an area of about 529629 m^2, 874 m^2 and 805179 m^2 respectively. These islands support various kinds of plants and animals. While Mbudya and Bongoyo islands have sand beaches for recreational purposes (Mbudya east beach is 270 m, Mbudya northwest beach is 170 m, Bongoyo east is 500 m and Bongoyo northwest is 300 m long) Pangavini is a coral rag Island surrounded by steep cliffs making the island inaccessible (unavailable) by humans. The absence of human disturbances has attracted animals, especially birds and reptiles (snakes and lizards) making this island an important roosting and nesting site for resident as well as migrating sea birds. On the other hand, the sand beaches on Mbudya and Bongoyo have attracted tourists from hotels and other parts of Dar-es-Salaam and else where. In Fungu Yasini there is a sand bank, which is exposed only during low tides and has no land vegetation. During spring tides the total sand bank area is about 53364 m^2 and rocky exposed intertidal area of about 1653390 m^2. The cleanliness of the sand beach during spring low tides attracts tourists though for few hours.

The coastline along the mainland coast is characterized by extensive sand beach with small patches of mangroves at Kunduchi and Tegeta river mouth. A much larger mangrove stand occurs beyond Ras Kiromoni. A number of tourist hotels are located along the coastline (e.g. see Fig. 4).

3.2 The *intertidal zones in the DMR*

The intertidal zone is very extensive around the reserves. The largest intertidal area is found around Mbudya (2,111,709 m^2) followed by Bongoyo (1891139 m^2), Fungu Yasini (1,653,390 m^2) and Pangavini (287,699 m^2). Most of the intertidal areas are rocky and inhabited by animals and plants of various kinds. Animals in the intertidal flats include octopus, mussels, variety of bivalves and gastropods, rock crabs, etc. Algae were the prominent vegetation on the rocky intertidal area. The lower intertidal is richer in animals and plants than the upper intertidal zone. Seagrass dominate the sandy lower intertidal zone in Pangavini, Fungu Yasini, eastern Bongoyo and eastern Mbudya. While *Halodule* was common on the upper intertidal, the lower intertidal and subtidal was inhabited by *Thallasodentron ciliatum* and *Thalassia hemprichii*. The lower intertidal zone is also marks the start of coral reefs on the western sides of Mbudya and Bongoyo. About 10% of

the coral on the reef flats of Mbudya and Bongoyo are exposed during spring low tides. Extensive algal mats and soft corals occur on the lower intertidal zones on the exposed eastern sides of Mbudya, Bongoyo and Fungu Yasini.

3.3 The *distribution of Coral reefs in the DMR*

3.3.1 Pangavini Marine Reserve

The upper intertidal of Pangavini is rocky while the lower intertidal on most areas is sandy except where there is coral growth. Small patchy reefs with coral cover of more than 35% were observed at three sites: the southwest, the northwest corners and the central east of Pangavini Island (see Fig. 3). Coral cover on the rest of the subtidal area was between 5-35% with seagrass growing on sandy habitat as the dominant vegetation. The coral reefs around Pangavini can be described as patchy and without a well-defined reef slope.

The live hard coral cover on Pangavini SW coral patch decreased after the bleaching event from 78.2% (Kamukuru, 1998) to 57.1% in 1999 (Wagner *et al.*, 1999) and is presently recovering (65.7%) (Table 2). However, the species composition has changed drastically from an abundance of branching *Acropora* in 1997 (Kamukuru, 1998) to *Montipora aequiturbaculata* dominance in the present study. Similarly, the present study revealed more that 90% of the live coral cover was *Montipora* growing on top of dead *Acropora.* While Wagner *et al* (2000) found abundant seagrass on transects, this study found seagrass to occur beyond and not within the coral patch. Longer transects would have included seagrass. Other benthic categories including dead coral contributed less than 8% (see Table 2).

Wagner *et al.*, 2000 recorded live hard coral cover of 19% on the northwest coral patch in 1999 and it was only about 4% in the present study. Seagrass cover (48-54%) was highest followed by soft coral (14%) and non-living cover or substrate (rock, sand and rubble) contributed between 9-27%. Dead coral cover ranged between 8-10% (Table 2). The cover of other benthic categories was generally low. There is no benthic cover data collected before the bleaching event for the NW patch for comparison purposes.

Although quantitative data was not collected on the coral patches on the east side of Pangavini, observations during manta tows indicated coral cover to range from 3-10%, which is much lower than observations in 1997 (Muhando and Johnstone unpubl data). In general, the subtidal area of Pangavini has less coral cover compared to seagrass bed areas resulting in the ecology of the area being dominated by seagrass.

3.3.2 Bongoyo Marine Reserve

The upper intertidal zone around Bongoyo Island is rock except where there is a sandy beach. Seagrass beds cover the lower intertidal zone on the exposed eastern side where it is sandy or covered by algae, encrusting corals and soft corals and other organisms that can withstand high wave and current energy on rocky areas. The lower intertidal zone on the west and north sides also marks the upper portion of coral reefs.

The live coral cover was high (more than 35%) on the sheltered western side and on the northwest of the islands where it covers an area of 220,299 m^2 (or 1.8 km extension) and 43,687 m^2 (0.2 km length), respectively. Coral cover was generally less than 5% on the eastern and southern parts of the Bongoyo Island (see Fig. 3).

A number of studies have reported on the coral reef benthic cover on the southwest and northwest parts of Bongoyo (Table 3). The live hard coral cover appear to have decreased from 70-80% in 1975 (Hamilton and Brakel, 1984) to 36-49% in 1997 (Kamukuru, 1998) and increased to 50-66% in 2000 (Mohammed *et al.*, 2000). The species composition however, has changed in favour of *Montipora aequiturberculata* and species of *Galaxea, Fungia,* and *Porites*, that survived the 1998 bleaching event. The *Acropora* experienced high bleaching and mortality in 1998 and there is poor recovery of these species on most reefs in the DMR. The reef flat and reef crest had the highest number of species and looked much healthier than the reef slope because of high sedimentation and poor visibility. Species of *Montipora*, *Galaxea* and *Porites* dominated the reef slope.

Available quantitative data (Table 3) indicated that the dead coral coverage has decreased from 38-52% in 1997 to 3-25% in 1999 (Mohammed *et al.*, 2000) while the area with non-biotope (rock, rubble, sand) increased from 1-6% in 1997 to 6-12% in 2000. Soft coral and sponge cover contribution remained relatively low, (0-4.5% and 0-2%, respectively).

3.3.3 Mbudya Marine Reserve

The upper intertidal zone is rocky except at two areas where there is sand beach. The lower intertidal zone is mostly rocky and with coral growth on the protected west and with a mixture of seagrass, algae and encrusting coral on the sheltered east side of Mbudya. As in Bongoyo, high coral cover (> 35%) was found on the northwest (121,730 m^2) and on the west side of the island (288,294 m^2), separated by sand at the northwest tip of the island (Fig. 3 and Table 4). There is a very extensive area with between 5-35% coral cover on the northeast (1,397,824 m^2) and on the southwest (179,488 m^2) of the island. Seagrass beds and algae dominated the southern part with coral contributing less than 5%. Beyond the coral distribution areas, the bottom is sandy with patch seagrass beds.

Although Hamilton (1975) reported high coral cover (about 70%), McClanahan *et al* (1999) and Kamukuru (1998) found that the live hard cover declined to between 27-40% on the northwest and on the southwest. Recent studies (Mohammed *et al.*, 2000) estimated live coral cover at 39-59% on the NW and 66-73% on the SW of Mbudya Island. The higher cover on the SW was contributed mainly by *Montipora aequiturberculata*, which appear to flourish well while other species were struggling to survive the sedimentation and turbidity stress. *Galaxea* has survived well on the reef crest and reef slope while *Fungia* is abundant on the reef flat. The dead branches of *Acropora* are now being re-colonised by *Montipora*. As in Bongoyo, new recruits of *Acropora* were observed on the reef flat and not on the reef slope. It appears that there is a shift in the species abundance in favour of *Montipora*. Corallimorpharians were noticed to occupy about 13% of the reef benthic space (Kuguru and Muhando, 2000). Other

benthic categories such as soft coral and sponges contributed little even before the bleaching event.

3.3.4 Fungu Yasini Marine Reserve

The upper intertidal zone is mostly rocky except at the northwest corner where the sand bank is situated. The lower intertidal zone on the west and north is sandy with abundant seagrass mixed together with coral patches and the southeast lower intertidal areas are rocky. During spring low tides fishermen collect different kinds animals for home consumption and for selling at Dar-es-Salaam markets and tourist hotels.

Coral reefs occur on the west as well as on the east of Fungu Yasini sand bank. However, reefs with high coral cover (> 35%) are located on two locations on the southwest, one on shallow water (<10 m) (108,320 m^2) and the other on the deeper waters (462,765 m^2) (Fig. 3). Algae and seagrass dominated most of the subtidal areas on the north and south with little coral cover (1-5%).

Cursory studies using manta tows and reef viewers (Muhando and Johnstone unpublished data) estimated the southeast reef areas SE1, SE2 and SE3 to have more than 35% live coral cover in 1996. The present study, however, revealed that the live coral cover have decreased to 8%, 18.3% and 20% respectively (see Table 5). The hard coral species dominance has changed from *Acropora* to *Montipora* and *Porites*. By observing the dead corals, it was apparent that mortality was much severe in Fungu Yasini than in other reefs in the DMR. *Acropora* was the most affected genus and new recruitment of this species was sparse compared to other species such as *Pocillopora* and *Stylophora*. Soft corals contributed between 22 and 32%, dominating the biotic reef benthic cover. The contribution of sponge cover in Fungu Yasini SE (4-8%) was higher than Mbudya, Pangavini or Bongoyo areas. The dead coral contributed 10% to 23% while the non-living substrate (rubble, rock and sand) contributed between 18-27%.

3.4 The coral reef macro-invertebrates

The abundance of macro benthic invertebrate in the DMR was very low. The density of commercially important invertebrates such as lobsters, ornamental shelled gastropods, bivalves and sea cucumbers was below 4 animals per 100 m^2. Sea cucumbers were found only in Fungu Yasini, lobsters were not encountered in all sites, clams (*Tridacna* spp) were scarce (less than 1 individual per 100 m^2) in all sites (see Table 6). Surprisingly, even invertebrates of no commercial value such as sea stars (Asteroidea) were not abundant on the DMR reefs. The crown of thorn starfish (COT) were not encountered on transects, although Mohammed *et al.* (2000) reported observing one starfish during manta tows in 1999. Such low density of macro-invertebrates in the DMR has not been reported before.

The density of sea urchins varied between 5 to 65 individuals per 100 m^2, much lower compared to 96-512 individuals per 100 m^2 observed by McClanahan *et al.* (1999) and Kamukuru (1998) in 1997. Highest density in year 2000 was found in Mbudya (65 indiv/100 m^2) and not in Bongoyo (512 indiv./100 m^2) as it was before the bleaching event (see Table 7). Maximum change in sea urchin density

has occurred in Bongoyo sites (see Table 7.) and smaller changes were recorded in Pangavini. Lowest densities were recorded in Fungu Yasini (Table 7).

3.5 *Reef fish*

Although reef fish count were not conducted during this study, previous studies by McClanahan *et al* (1999), Kamukuru (1998) and Mohammed *et al* (2000) counted reef fish in some of the DMR. Kamukuru (1998) found fish density to vary from 348 to 773 individuals per 500m^2 with predominance of small-bodied (<15cm) fish such as Pomacentridae (58%), juveniles of Labridae and Scaridae (24%) (see Table 9). In 1999, the reef fish density decreased to 88 individuals per 500 m^2 in Mbudya west and about 170 individuals per 500 m^2 in Bongoyo west, according to Mohammed *et al*. (2000). Herbivores contribution increased after the bleaching event to 64.4% in Mbudya and 54.7% in Bongoyo. Planktivores were more in Bongoyo (35.4%) than Mbudya (5.6%) (see Table 8). Reef species richness in the DMR appears to have decreased to a record low. Manta tow observations during this study tend to agree that fish density was very low on most surveyed coral reefs areas in the DMR. Besides very low fish catch rates, hook and line fishermen were busy fishing. One fisherman told us that lack of alternative employment is forcing them to fishing.

Fish density and species composition on the exposed eastern side of Mbudya, Bongoyo as well as around Fungu Yasini has remained unknown because of lack of quantitative data from these sites, mainly due to strong currents and waves action.

3.6 *Habitats adjacent and beyond the coral reefs*

Beyond the coral reef distribution area the sea bottom was sandy with or without seagrass beds. As it was observed by Mohammed *et al*. (2000), the sea bottom at the end of the reef slope on the west of Mbudya and Bongoyo was characterised by fine/silt sediment forming a muddy bottom. The muddy deposition was up to one metre deep in some places. This type of fine sediment deposition adjacent to the protected west sides of Mbudya and Bongoyo reefs has not been reported before and may be a result of terrestrial sediments deposited by nearby rivers during the wet season. The habitat type beyond coral reef on the exposed east and south of the reserves was rocky with or without corals or sandy with or without seagrass. There was no sign of vegetation beyond 25 m.

3.7 *Physical processes influencing life in the DMR*

The sea around the DMR is less than 20m deep except between Mbudya and Fungu Yasini (Fig. 2). The biological productivity is potentially high due to synergetic effects of water column and benthic primary productivity. Fisheries in the DMR to a large extent appear to be sustained by benthic productivity (especially the seagrass habitat). The ocean currents in the DMR flow northwards throughout the year and the effect of reversing tidal currents is weak, unlike other reef areas where tidal current reverses during ebb and flood tides. Stronger currents are experienced during southeast monsoons (May-October). Northward

movement of water implies that land based pollutants from Dar-es-Salaam are moved northwards through the DMR. Waves are stronger on the exposed east and south sides of the islands making these sides dangerous (inaccessible) to artisanal fishermen during certain times of the year. Wave action is responsible for bottom stirring and reducing water clarity in shallow areas. The water visibility was generally very low with seichi disc disappearing at 2 m during flood tides at the end of the reef slopes of Mbudya, Bongoyo, and Pangavini west sides. According to Mohammed *et al.* (2000) and Wagner *et al* (2000), the frequent high speed ferry boats near coral reefs (< 150m) could be responsible for favouring muddy deposition adjacent to reefs (through sediment stirring and sorting processes mediated by currents and waves).

Beach seining is practiced in all parts of the DMR and is disturbing the bottom environment and its resources. It was commonly applied in Pangavini and Fungu Yasini (Kamukuru, 1998). Dynamite fishing is still being practiced in the DMR. We heard one blast while carrying out reef benthic assessments in Fungu Yasini (June 2000). In addition, dynamiting was seen to be taking place on NW corner of Fungu Yasini and in SW of Mwamba Mkadya in the last 7 months (Richmond pers. comm.). Anchor damage from fishing boat and tourist boats has remained a problem since there are no moorings.

Pollution from land-based sources was not investigated, however, it must be noted that effluents from industries and domestic sources are discharged in Msasani Bay and in the DMR through rivers and sewage pipes. This study did not come across any pollution study in the area.

4. DISCUSSION AND RECOMMENDATIONS FOR DMR

In this presentation, reference is made to results from different surveys conducted in the DMR. It is important to note that survey methods were not identical and the extent of spatial coverage were different. Thus, although comparisons were made and some possible causes suggested, there is still room for errors emanating from the fact that different methods can give different results in the same study site, or the same method can give different results depending on the sampling point chosen. The coral reef environment is very complex and sample size must be large enough to include representative information and this has always been the limiting factor in the study program carried out in the DMR. If management is to benefit from scientific observations, a long term monitoring program adopting a constant study methodology at carefully selected monitoring sites must be initiated. Intensive scientific discussions must be preceded before adoption of any reef environment and resource monitoring procedures.

The DMR also includes the vegetation on the islands. So far there has been no mention on how to sustainably utilise this and other island resources. It may be appropriate at this stage to survey and describe in details the vegetation types and other resources with a view of finding possibilities for economic ventures, such as establishment of nature trails for tourism or education purposes. Additional activities on the islands might alleviate pressure on the coral reefs.

Intertidal resources of the DMR have not been surveyed in greater details as yet. These resources are probably over-exploited and in need of management. Lack of information on resource type and abundance might complicate the setting up of management strategies and enforcement mechanisms. It must be understood that intertidal activities may have a direct influence on the coral reef ecosystem as well.

Seagrass beds dominate the subtidal areas in Pangavini, Fungu Yasini and on the east areas of Mbudya and Bongoyo. Similar observation was made by Kamukuru (1998) who suggested that the fisheries in the DMR are probably sustained by seagrass beds rather than coral reefs. Wherever coral reef, mangroves and seagrass beds occur adjacent to each other, there is a likely hood of ecological dependence. Seagrasses act as buffer or temporary refuge for some reef organisms, especially fish and also stabilises sediments that would otherwise negatively impact neighbouring coral reefs. Thus, management of coral reefs in the DMR should take into consideration management of seagrass beds as well. Seagrass mapping could be an important management activity.

Most of the information on coral reef location and percent of live hard coral cover was obtained from Muhando and Johnstone coral reef mapping survey in 1996 (unpublished). Additional information was obtained from dive operators in and around the DMR. Although Silversand Dive operators using GPS cross-checked the reef location data, coral area covers given in this report are first estimates that need to be reviewed with a more refined survey. However, the coral reef areas that require attention should be obvious from the maps in this study.

The live hard coral cover seemed to have increased on surveyed reefs in Pangavini, Bongoyo and Mbudya, despite the occurrence of coral bleaching and mortality in 1998 (Tables 2, 3 and 4). Mohammed *et al* (2000) suggested that higher coral cover observed in 1999 could be accounted for by differences in methodology and special location of study sites. Unlike *Acropora*, Muhando (1999a) noticed that *Montipora aequiturberculata*, *Fungia* sp. and *Porites* sp. survived the bleaching event in Zanzibar. It is possible these species also survived in the DMR and therefore maintaining their dominance (see Kamukuru, 1998). The drastic change in coral dominance in favour of *Montipora* in Pangavini and Mbudya (Mohammed *et al*., 2000) suggests that this species is favoured by the existing conditions. Deposition of fine sediments and the passage of passenger boats are new phenomena that may be associated with low visibility and murky water. While other species appear to stressed, *Montipora aequiturberculata* appears to be growing fast and covering the dead branches of *Acropora* (Mohammed *et al*., 2000). Unlike McClanahan *et al*. (1999) who found no evidence to suggest loss of coral species after continued destructive fishing in the DMR, the coral bleaching event of 1998, the new finding of low visibility and a drastic change in species composition, loss of coral species does seem likely. A repeat of coral taxonomy work as Hamilton (1975) is required to accurately reveal possible loss of coral species in the DMR.

Reefs in the exposed windward side play an important role in protection of the coastline environment against ocean currents and waves. Yet these reefs have received little attention so far. Besides Muhando and Johnstone coral reef

mapping (unpublished data) (see Fig. 3), and this study, there is no other information on coral abundance and species composition on the exposed east sides of Bongoyo, Mbudya and Fungu Yasini. Results from Fungu Yasini indicated that reefs in exposed areas experienced higher mortality and recovery is slower than in sheltered areas. Soft coral and algae cover dominate the benthic cover. This environment has been observed in reef areas characterised by high wave and current energy, e.g. Mange and Tutia in Mafia (Muhando 1999b).

The reasons that prevented scientists from studying reefs on the exposed areas of DMR are likely to limit activities of fishermen. Some people believe that the ocean conditions on the exposed reef are so harsh that it is unlikely that blast fishing takes place there. If it does occur, it must be during spring low tides, otherwise collection of blasted fish could be problematic. It may be agued that it is very difficult to associate blast fishing around Kunduchi with beach erosion since most of blast fishing is done on protected reefs that have little effect on prevention of oceanic waves. More studies should be directed to the exposed sides of the DMR to reveal the state of the reef damage there, if any.

Soft coral, algae and corallimorpharians which compete with hard corals for space have taken the space of hard corals after the 1998 mortality, for example in Fungu Yasini. While recent studies indicate algae and soft coral cover is not important (< 3%), corallimorpharians cover has increased to up 13% in Bongoyo and 7% in Mbudya (Kuguru and Muhando, 2000). Higher abundance of corallimorpharians is a threat because they can effectively compete and prevent coral recruitment of hard corals. Any coral reef monitoring program in the DMR should take into consideration corallimorpharian and other coral reef competitors

Count of invertebrates of commercial importance such as lobsters, ornamental and edible molluscs, and sea cucumbers in 1999 revealed that these resources have almost disappeared on the reefs (Mohammed *et al.* 2000). It seems likely that Malthusian overfishing (McManus, 1997) has already occurred. Unless assisted, recovery of these stocks may take a long time. Harmless starfish and the notorious coral-eating crown-of-thorn-starfish, *Acanthaster planci*, were observed to occur at very low densities even before the bleaching of 1998.

The sea urchin density was surprisingly very low (5-66 individuals per 100 m^2) in recent studies (Table 7) compared to 96-512 individuals per 100 m^2 observed by Kamukuru (1998) and McClanahan *et al.* (1999). It is not likely that the decline was caused by triggerfish predation, because these fish were not abundant in the area (Mohammed *et al.* 2000). Factors affecting the population dynamics of sea urchin are not clear, but could be associated with factors influencing changes in coral species abundance and composition.

Reef fish biomass and species diversity was generally low, even before the bleaching event. Habitat destruction and overfishing were suggested to be responsible. The reported increase in coral cover however, did not influence reef fish positively. Mohammed *et al* (2000) reported even lower estimates of reef fish densities and diversity in the DMR. It has been reported that noise from engines can threaten or even chase fish away from their normal habitats. Fishermen in Zanzibar prefer setting basket traps on boat routes because when threatened by

boat noise, fish confuse the traps as refuge. Specialised opinion should be requested to determine the negative effects of boat passage. Fishermen are directly affected by boat passages.

In conclusion, the finding of this analysis supports what has already been suggested by McClanahan *et al* (1999) and Kamukuru (1998), that the DMR still has high potential as a Marine Protected Areas or Reserves. Appropriate steps must now be taken to make the long-awaited dream of managing resources in the DMR a reality.

5. THE STATUS OF CORAL REEFS IN OTHER MPA IN TANZANIA

5.1 *Background*

The unprecedented coral bleaching and mass mortality, which occurred between March and June 1998, resulted in substantial degradation of many coral reefs in Tanzania (Wilkinson *et al*., 1999; Muhando 1999a 1999b). The extent of bleaching and mortality differed between species and sites (e.g. between Chole Bay and Tutia reef in Mafia, or between Chumbe, Pange and Bawe reefs located within 15 km, or between the east coast and west costs of Unguja and Pemba islands). *Acropora, Pocillopora, Seriatopora* and *Stylophora* were among the most affected genera. In some areas the coral cover of *Acropora cyntherea* (Tutia) and *Acropora hyacinthus* and *A. humilis* (Chumbe) have been reduced substantially.

In 1999, through the CORDIO project, coral reef surveys were carried out to determine the extent of coral death and assess the effects of coral death on reef benthos and fish as well as the effects on the socio-economy (tourism and fisheries) of coastal communities. The study areas included reef sites in Pemba Island, Unguja Island, Dar-es-salaam, Mafia Island, Mnazi Bay in Mtwara (see Mohammed *et al*., 2000; Kuguru and Muhando, 2000), Tanga coast and on Songosongo archipelago (Mbije, *In prep*; Moh'd, *In prep*). Results from the surveys above are summarised in Tables 10, 11, 12, and 13. Some of the surveyed sites were located in MPA (e.g. Mafia Island Marine park (MIMP), Menai Bay Conservation Area (MBCA), Chumbe Marine Sanctuary, Misali Conservation Area (MCA)). Results from recent studies were analysed and compared with previous similar studies to evaluate the current status of coral reefs in the MPAs of Tanzania.

5.2 *The current condition of coral reefs in some of the MPA*

5.2.1 Misali Conservation Area (MICA), Pemba.

The live coral cover on Misali reefs in Pemba declined from 51-74% to 7-17% while the non-living substrate (rubble, rock or sand) increased from average of 20% in 1994 to 53% in 1999 (Table 10). The relative cover of other benthic organisms such as fleshy algae, coralline algae, sponges and soft corals did not appear to have changed much after the bleaching event. Despite coral mortality, reef fish species richness and abundance was high compared to other areas that were less affected by the bleaching event (Table 13).

5.2.2 Chumbe Marine Sanctuary (CHICOP), Zanzibar.

According to Mohammed *et al.* (2000), the extent of live coral cover on Chumbe Marine Sanctuary decreased from 51.9% to 27.5% in 1999 mainly because of the bleaching event. Chumbe reef is one of the sites that experienced high mortality in Zanzibar mainly because it was dominated by *Acropora*, which suffered greatest mortality after the bleaching event. The contribution of *Acropora hyacinthus*, *Acropora cyntherea* and *Acropora humilies* has been reduced to low levels. Recovery of *Acropora* species is generally low compared to other coral species. The fleshy algal (mostly *Sargassum, Turbinaria, Dictyota, Stypopodium zonale)* cover increased from 8.8% to 18.4% on Chumbe reefs whilst outside Chumbe and Menai Bay area, fleshy algal cover did not change significantly (Muhando, 1999; Mohammed *et al.*, 2000). Despite high mortality of corals on Chumbe reef compared to other reefs off Zanzibar town (e.g. Bawe, Changuu, Chapwani), the reef fish density and diversity was highest. Because of effective management, Chumbe Marine Sanctuary has attracted and retained high biological diversity. High catch rates were realised by fishermen setting 'dema' traps on the peripheral of the sanctuary. Besides being a successful management story, two natural calamities, sedimentation and fleshy algal cover threaten the sanctuary ecosystem.

5.2.3 Mafia Island Marine Park (MIMP)

After the 1998 bleaching event, the live coral cover at Tutia (Kitutia) and Mange reefs decreased from 80% in 1991 to 15.1% in 1999 while on Msumbiji and Utumbi reefs about 10km apart (in Chole Bay) the live coral cover was relatively high (30%) (Mohammed *et al.*, 2000). The fleshy algae increased substantially on Tutia reef from 1% in 1996 (*pers. obs.*) to (15%) in 1999. The most abundant algal species in Tutia reef were *Stypopodium zonale*, *Turbinaria*, *Dictyota* and *Sargassum*. Increase in fleshy algae was not very obvious in Chole Bay. As in other parts of Tanzania, *Acropora* species were badly affected. Parts of the dead coral skeleton are been overgrown by soft corals, especially where the water current is relatively strong. Coral recovery expected due to a favourable environment of intact coral skeleton, clear water, availability of recruits, especially in Chole Bay. Despite higher mortality of corals, Ohman *et al.* (1999) reported an increase in reef fish abundance and change in species composition in favour of herbivores.

5.2.4 Mnazi Bay Park (MBP), Mtwara

Live coral cover on Matenga (Chamba cha Matenga) and Kati (Chamba cha Kati) decreased from 55% and 60% in 1997 (Guard *et al.*, 1998) to 28% and 42% respectively (Muhando 1999b). After the bleaching event most of the corals along the Kitelele channel reef died. Mohammed *et al* (2000) observed that most of the dead coral were intact and have not yet been overgrown by fleshy algae, a promising condition for coral recovery. Soft coral, corallimorpharians and sponges were noticed to grow on the dead skeletons or on rocky substrate covering up to 22% of the reef. Although Guard *et al* (1998) reported high fish diversity and abundance in 1996/1997, Mohammed *et al.* (2000) reported lower reef fish abundance and diversity. On the other hand, Muhando (1999b) reported on the abundance of pelagic fish stocks and lower abundance of reef fish. As in other reef areas, it is likely that the abundance of herbivores increased due to increased space for algal growth.

5.2.5 Tanga reefs

Results from four monitored reefs (Upangu, Taa, Chanjale and Kitanga) showed an average live coral cover decrease from 67% in 1997 to 12.5% in September 1999. The biggest falls were associated with reefs with highest original cover. Invertebrate counts, including sea urchins have seemed relatively stable despite the increase in substrate for growth of filamentous algae. Reef fish counts have shown marked increase in Siganids and other herbivores (Chris Horrill *pers. comm.*)

5.2.6 Songosongo archipelago reefs

Coral reef surveys on some coral reefs in the Songosongo archipelago in March 2000 (Mbije and Moh'd, *pers.comm.*) revealed the live coral cover to be between 25-50% compared to 20-55% reported in Darwall *et al* (1996) implying that coral mortality was less compared to Misali and Tutia reefs. Higher coral mortality was observed on reefs located offshore compared to that on inshore reefs. No information exists on reef fish status from Songosongo area.

5.2.7 Summary

In summary, the coral degradation was highest in areas previously described as excellent (e.g. Misali, Tutia). Invertebrate counts including sea urchins, sea cucumber, sea stars, gastropods, bivalves, octopus and lobsters seemed relatively stable despite the increase in substrate for growth of filamentous algae. Ornamental shelled molluscs, sea cucumbers and other invertebrates of commercial importance were few probably due to other reasons such as overexploitation (Johnstone *et al.*, 1998). Crown-of-thorn-starfish, *Acanthaster planci,* were encountered but at relatively low densities in all MPA. The abundance of fleshy algae (*Sargassum, Turbinaria, Ulva, Dictyota, Stypopodium zonale*, etc.) increased on Tutia reefs (Mafia), Kwale, and Chumbe (Unguja) and not in other sites. Corallimorpharian distribution and abundance appear to have increased on most reefs in Tanzania (Kuguru and Muhando, 2000). Fish counts have shown marked increase in Siganids and other herbivores, which may be due to one or a combination of increased food (Ohman *et al.,* 1999) and/or cessation of dynamite fishing pressure (Horrill *pers.com.*). The herbivores group, according to Mohammed *et al.*, (2000) contributed more than 50% of the reef fish population in most sites.

5.3 Effects *of coral mortality on Fisheries and Tourism*

More than 95% of marine fish catch landed by artisanal fishers (Jiddawi, 1998) and about 70% of this catch is harvested on or adjacent to coral reefs (Ngoile and Horrill, 1993). The mass mortality of corals was predicted to influence coral reef based fisheries, however, the surveys conducted so far have not revealed negative effects (Ohman, 1999). Interviewed fishermen in Tanga, Mafia and Mnazi Bay claimed that there has been a slight increase in catch landed in early 1999 compared to previous years. The increased catch, according to them was a result of prevention of dynamite fishery and was not associated with coral mortality.

There was fears that Misali coral reefs in Pemba may have lost its touristic value after the 1998 coral mortality (Muhando, 1999b), however, most dive operators and fishers have indicated that most tourists and fishermen were not aware of the bleaching and mortality until when they were told. The abundance of fish on reefs

and the intact reef structure still make dead reefs interesting to fishermen and tourists. Coral reefs still play a crucial role in the tourism and fisheries as before. Tourism that depends on coral reef is actually increasing in Zanzibar (Khatib, 1998).

5.4 *Prospects for coral recovery*

Experiments on Unguja Island reefs have shown that coral settlement mainly occurs in crevices and under reef structures (Franklin *et al.*, 1998) indicating that successful settlement and growth of corals could be influenced by the structural complexity of the reef. This implies that destructive activities (e.g. fishing), which will flatten the intact coral reef structures may not only enhance algal growth (Turner, 1995; Done, 1992) but also hinder successful coral settlement.

Recent surveys (Muhando 1999b; Mohammed *et al.*, 2000) indicated that there were considerable regeneration or growth of surviving corals in all the visited sites. On Tutia and Mange reefs (in Mafia) and to a less extent on reefs in Mnazi Bay, survived colonies of some coral species (e.g. *Echinopora*, *Montipora* and *Merulina*) were observed growing fast and covering the dead parts of the colony and cementing together dead branches of *Acropora*. On some Dar-es-salaam reefs (Mbudya and Pangavini) species dominance has shifted in favour of *Montipora* species.

New coral recruits (less than 5 cm canopy width) were scarce on most reefs suffering high coral mortality. In Mafia and Mnazi Bay, the few recruits that were observed were *Pocillopora*, *Stylophora*, *Millepora* and encrusting *Montipora* species. It appears that coral recovery has begun on all reefs but at different levels. The environment on most reefs seems to be conducive for coral recruitment (e.g. clear water, less fleshy algae, intact reef structures). More research is required to reveal the recovery rates and factors influencing it.

Some authors (e.g. Loya, 1976) considered the recovery of coral assemblages disrupted by natural disturbances to be mainly a function of time. While this could be true, it has been demonstrated that human activities can cause a permanent shift towards algal dominated reefs or even extinction (Done, 1992; Glynn & De Weerdt, 1991). In these situations appropriate management can enhance recruitment and shorten the recovery time (Hughes, 1994). This is especially true for the reefs of Tanzania, where destructive reef activities, such as dynamite fishing, dragnet fishing and coral mining are still practiced (Johnstone *et al.*, 1998).

5.5 *Anthropogenic Threats To Coral Reef Biodiversity*

The narrow continental shelf means that the reefs are in close proximity to the land area, therefore strongly subjected to terrestrial influences both human origin and natural (Ray, 1968; Johnstone *et al.* 1998). Some of the threats in the MPA are mentioned below:

- Over-exploitation and over-crowding of fishers, especially on reefs located near urban centres (Johnstone *et al*, 1998, Muhando and Jiddawi 1990). The use of scuba equipment in collecting sea cucumbers, ornamental shelled molluscs, octopus and lobsters appear to over-exploit these species in some reef

areas. Tourism and overseas demand on certain marine resources (e.g. finfish, sea cucumbers and octopus) have increased exploitation pressure of some reef resources (Muhando and Jiddawi 1990).

- Destructive resource harvesting techniques (e.g. dynamite fishing, drag nets, small meshed nets, etc) are still in use. To a large extent, dynamite fishing has been greatly reduced in many parts of the Tanzanian coast after a special campaign to stop dynamite fishing which involved local communities, stakeholders, fisheries officers, and the navy (Horrill and Makoloweka, 1998; Horrill and Kalombo, 1999) However, persistent effort will be necessary to ensure that it does not increase in the future, or move to other remote areas and some areas that are not covered by a special campaign (e.g. Zanzibar, Pemba etc) and that it is eventually completely eliminated. The use of destructive dragnets has remained a problem despite the existence of legislations preventing the use of such nets in coral reef areas.
- Although biological (sewage) and chemical pollution (pesticides and herbicides and industrial discharges, etc.) is a minor problem today, expanding coastal population, the use of agro-chemicals, tourism sector and the construction close to the beaches or on small islands potentially threaten reefs. Vigilance is required for reefs located near urban centres (see UNEP 1982).
- Coral mining continue to be practiced in some areas (e.g. Mikindani, Jibondo, Mji Mwema Dar-es-Salaam, etc.) for lime making (Solandt and Ball, 1999, Mohammed *et al.*, 2000b).
- Anchor damage from both fishermen and tourist boats continues to be a problem.
- Sedimentation and silting as a result of unplanned land use practices (e.g. deforestation, agriculture, coastal constructions), dredging, and passage of cargo and passenger boats near coral reef areas, e.g. Mbudya, Bongoyo, and Chumbe reefs (Mohammed *et al.*, 2000; Kuguru and Muhando, 2000) is a potential problem in the near future.
- Trade of live coral, dead coral and aquarium fish is just starting and there is no indication of any negative impacts from such activities so far. Vigilance is required.
- Use of small islands and sand banks by fisheries or tourism related activities appear to prevent breading of turtles in some areas (Khatib, 1998)

6. GENERAL COMMENTS AND RECOMMENDATIONS

- As the population and economic hardship increases, pressure on resources will increase and stocks might collapse completely as the environmental degradation continues. New management ideas must always be sought to encounter the new developments. Continued research and monitoring is paramount.
- Coral reef environments are like injured person: they require peace to heal properly. Managers should do their best to protect reef from human induced stresses, e.g. destructive fishing.
- Free entry to resource base (coral reef resources) is good, but history tells us that another approach is required. Everywhere where there was free entry, resource abuse is common.

- Enforcement of the existing legislation has been weak and hopes for changes are slim, taking into consideration the existing economic situation. Environmental education (theory and practical) at all levels is an option that should be encouraged.
- Restoration of coral reef programs sounds sweet but it is not, it is a technical and can be dangerous. It has been tried and results are encouraging. MPA managers should consider undertaking further trials in their area of jurisdiction. Technical information is available at the Institute of Marine Sciences and in Zoology and Marine Biology Department of the University of Dar-es-Salaam.
- Centralisation of coral reef information is important. Scientific reports, specifically field data, from foreign-based institutions such as Frontier and others have not been readily available for comparison purpose. Unless it is made available to institutions dealing with marine issues in the country, its use is limited.

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