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CORAL REEF MONITORING AND MANAGEMENT IN MOZAMBIQUE

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INTRODUCTION

MICOA, in conjunction with a number of other institutions and donors, have recently initiated a project for the development of a National Coastal Zone Management Programme (NCZMP). This program encompasses the entire coastal zone and is multi-disciplinary in its approach. Further, it is envisaged that one of the components of this NCZMP will focus on the critical ecosystems that comprise the coastal environment such as coral reefs. Consequently, a management plan for coral reefs is being formulated concurrently with the National Coastal Zone Management Plan (NCZMP). In this programme, four activities stand out as being vital for the achievement of the main goal of sustainable management of coral reef resources:

- Capacity building within the relevant fields required for effective sustainable management;
- Collection and synthesis of relevant information and scientific data to support sound management;
- Development of an appropriate and effective network for the co-ordination and sustenance of coral reef management related activities; and
- Identification, characterisation and mitigation of current and eventual problems faced by coral reefs and their management.

It is within this framework that recent activities on bleaching on coral reefs in Mozambique as well as capacity building were undertaken. This paper presents the activities and respective summary results within the framework of the coral reef management programme during 1999. Technical support for those activities was provided by ORI (Oceanographic Research Institute, Durban, South Africa) and CORDIO and funding was provided by CORDIO and DANIDA.

Mozambique possesses the third longest coastline along the Western Indian Ocean, extending 2700 km, much of which adjoins areas of coral reefs. The northernmost section of the coast extends for 770 km from the Rovuma River in the north (10º 20' S) to Pebane in the south (17º 20' S). In this section coral reefs constitute an almost continuous fringing reef on the eastern shores of the islands and the more exposed sections of the mainland coast. The central section of the coast between Pebane (17º 20' S) and Bazaruto Island (21º 10' S), a distance of about 950 km, is classified as a swamp coast. Twenty-four rivers discharge into the Indian Ocean along this section, each with an estuary supporting well established mangrove stands. The coastal waters are shallow and this, combined with the sediment loading from the rivers, causes high turbidity levels. As a consequence, coral reef formation in this area is severely limited. The southern section stretches for 850 km from Bazaruto Island southwards to Ponta do Ouro (26º 50' S). The coastline is characterized by high dunes, north facing bights and barrier lakes. The distribution of

reefs along the coast and near-shore islands is patchy and the reefs are more sparsely inhabited by corals.

This ecosystem constitutes an important biological resource in terms of their complex biodiversity and is also the basis for tropical fisheries and marine eco-tourism industries. Today, about 6.6 million people live within Mozambique's 48 coastal administrative districts, and the number is expected to grow at 3% p.a. (INE, 1999). Although this represents 42% of the current population of Mozambique (15.7 million), only 2% - 3% are fishermen or collectors. Nevertheless, Mozambique's economy is largely dependent on fisheries as shrimp exports contribute significantly to the GDP (~USD 100 million p.a.). Tourism, on the other hand, is a growing industry and most of its development occurs in coastal areas and in activities such as diving and snorkelling.

CORAL REEF RELATED ACTIVITIES IN MOZAMBIQUE DURING 1999

Preliminary assessment of coral bleaching

The survey of coral bleaching was undertaken between March 24 and April 8, 1999, at the end of summer. At each of 17 reefs, evidence of past and present bleaching was sought and visual estimates made of reef type, cover of benthic organisms and the extent of damage caused to the reef by bleaching and Crown-of-thorns starfish (COTS).

The effects of El Niño bleaching in Mozambique were most extensive on exposed reefs in the north and diminished further south except at Inhaca Island where serious recent bleaching was encountered. Extensive COTS damage was also found at Bazaruto and Inhambane. The consequences of the El Niño bleaching are going to be even more serious as coral mortality on the northern reefs was as high as 99% and eventual collapse of reef structure on these reefs is anticipated. The biodiversity of these sites will be impaired as coral recruitment was essentially absent and only observed at the Bazaruto COTS-affected site.

Fish populations on the damaged reefs, the basis of many of Mozambique's valuable artisanal fisheries, were also poor. Affected reefs had proportionately more herbivorous fish, correlated with heavy colonization by algae. Both the fisheries and the tourism value of these sites will be affected, the extent of which will have to be quantified.

The reefs least affected by bleaching were those in sheltered embayments. Such bays are characterized by level of nutrient enrichment and turbidity from terrestrial runoff, as well as natural heating from insulation their shallower reaches. Thus, considerable bleaching embayments should be expected, particularly if the rate of water exchange is low. However, the coral communities which survived on these reefs generally consisted of species that are tolerant of these parameters. The reef Pemba Bay was most typical of this environment (Schleyer *et al*., 1999).

Training Course

A training course was held in August 1999 at the Center for the Sustainable Development of Coastal Zones, Xai-Xai (MICOA) under the auspices of CORDIO and MICOA. The course was attended by a number of participants from MICOA itself, the Institute of Fisheries Research and

Eduardo Mondlane University. The lecturers were from ORI and CORDIO and the material presented covered the taxonomy of fish and invertebrates well as survey and monitoring methods. Some of the participants were later integrated into the team that started the monitoring programme.

Monitoring and monitoring station installation

Sites were selected for permanent monitoring during a preliminary survey (Schleyer *et al*., 1999) according to number of criteria, the sites being:

1. Representative of Mozambican coral reefs, (i.e. typical of exposed Mozambican fringing reefs or of sheltered, specialized coral communities in sheltered embayments adapted to high nutrient levels, turbidity and thermal and saline stress).
2. Evenly distributed along the extensive Mozambican coastline in areas in which corals occur.
3. Reasonably accessible.

The field work was conducted during 22 days between August and September, 1999. For the first year of monitoring, nine "core" reefs were selected for annual survey. These reefs were widely distributed throughout the coast and represent different reef types (Figure 1).

METHODS

Reef surveys

Surveys were carried out using the GCRMN-recommended strategy of recording benthos, invertebrates and fish off the same transects (English *et al*., 1994). A major modification was to use video transects to sample benthic cover. These were done using a Sony Hi-8 Handycam video camera in a housing using S.C.U.B.A. or snorkel. The underwater housing had a spacer bar fitted to maintain a working distance of 110 cm from the reef, thus ensuring that a frame size of 0.5m x 0.5 m was filmed. minimum of 150 m of reef was recorded during snorkel transects and 5 m x > 20 transects surveyed during S.C.U.B.A. transects. The photography was undertaken perpendicular to the reef and the transects were filmed in a straight line within a depth contour or zone of the reef at a velocity of approximately 0.25 m•second^{-1} Simultaneous with the transect, an observer would conduct a general survey t establish a species and cover-type list to assist later analysis of video images. The Hi-8 footage was transferred to VHS tape for onscreen analysis.

This was undertaken by stopping the video randomly every four seconds, or when a new field was on screen if a surge had slowed the transect progress below the desired speed. The life form category (English *et al*., 1994) was recorded at each freeze frame under four random spots placed within each quadrant of the television screen. Estimates of percent cover were determined by the proportion of the total number of sampling points for each category. Means and standard deviations were calculated based on the number of transects at each site.

Fish and reef invertebrates

The fish surveys were conducted using the method described by English *et al*. (1994). Transects 50 m long by 5 m wide were laid (250 m^2) and weighted at both ends. The observer started at one end of the transect, recording target species from a previous determined species list. The total size of each individual was estimated and grouped under one of each of three size classes:

0-10 cm; 10-20 cm and >20 cm. After the first pass of the transect, the observer made a second pass in the reverse direction to record species that were not seen in the first run. Swimming speed was kept at approximately five minutes per 50 m pass. Target fish species included commercial species, useful indicator species and visually and numerically dominant non-cryptic species. If conditions were too rough to lay a transect line, a point count method was used. Circles with a radius of 7 m (area = 153 m^2) were used, sampling two point counts for each transect to a total area of 306 m^2 instead of 250 m^2. On one occasion, due to very poor visibility and reef fish community, a 30 minute random survey was undertaken instead of the two methods described above.

Data were analysed focusing on abundance (total number of individuals per family), diversity (total number of species per family), trophic groups (total number of individuals belonging to a specific trophic category) and size classes (total number of individuals from a specific size class for each family).

Mobile invertebrates included echinoderms (sea urchins, sea stars and holothurians), molluscs (giant clams), lobsters, and sea anemones. The visual census was conducted following the fish using a 2.5 m wide band along the 50 m transect, giving a total area of 125 m^2. If conditions were too rough to lay a transect, the point count method was used.

RESULTS AND DISCUSSION

The condition of reefs surveyed varied between healthy to heavily impacted by natural and anthropogenic factors (Table 1). Many reefs are degraded from bleaching and the ravages of crown-of-thorns starfish. Coral cover was highest on the reefs of northern Mozambique and in marine protected areas (Figure 2). The high cover of rock and algal surfaces reflects mortality that was reported at these sites in earlier surveys (Figure 2, and Schleyer *et al*., 1999). There is evidence of recovery on some reefs on which soft corals are the primary colonisers. Fish populations in the north and in protected areas were dominated by carnivores (Figure 3), following a similar pattern to that of coral cover. High fishing pressure on the other reefs was shown by the small size classes of fish and the dominance of herbivores, which are least preferred by fishermen.

The results show that reefs in protected areas are in better condition than unprotected reefs. However, considering the size of the Mozambique coastline, very little is protected in only three protected areas. Protected areas are important sources of invertebrates and fish larvae to adjacent areas. In addition, the fact that almost no turtles and few large fish were seen on the reefs surveyed is indicative that management measures need to be taken. Also, it should be taken into consideration that tourism and diving are growing industries in this country. Thus, there is an urgent need for establishment of more protected areas and sanctuaries to conserve biodiversity and provide breeding reservoirs. To ensure the successful management of Mozambique's coral reefs monitoring, of the type reported here, must continue and be expanded to include additional sites and also more detailed studies conducted on priority issues.

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