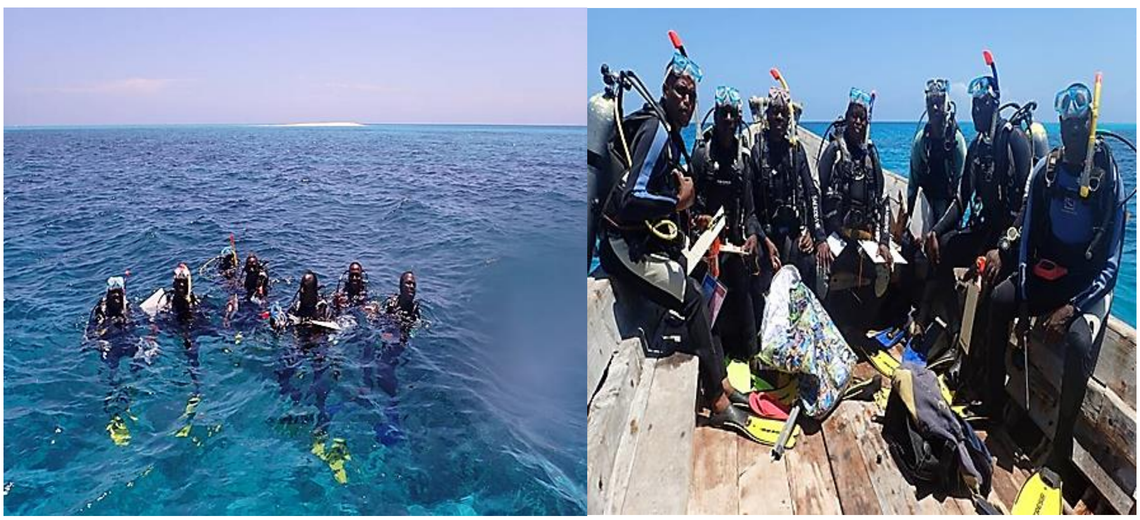
MINISTRY OF AGRICULTURE, LIVESTOCK AND FISHERIES

MARINE PARKS & RESERVES UNIT

CORAL REEF HABITATS IN MARINE PROTECTED AREAS IN TANGA, DAR ES SALAAM, MAFIA ISLAND AND MTWARA, TANZANIA, JUNE - DEC 2016



JUNE, 2017

EXECUTIVE SUMMARY

This survey was supported under the South West Indian Ocean Fisheries Governance and Shared Growth (SWIOFish) project with the purpose of assessing the status of coral reef ecosystems in three marine parks and one marine reserve complex under the jurisdiction of Marine Park and Reserve Unit (MPRU) of the Mainland Tanzania. The survey was conducted over an extended period of time from May 2016 to January 2017. The survey was intensified in the suggested predetermined reefs' MPAs based on the existing General Management Plan within each Marine Protected Area (MPA). The task was carried by Dr. Nsajigwa E. Mbije from Sokoine University of Agriculture (SUA), Morogoro together with Tanzania Marine Parks' and Reserves Unit staff namely;

1. January Ndagala (Acting Warden-in-Charge, Tanga Coelacanth Marine Park)
2. Margaret Mchome (Warden, Dar es Salaam Marine Reserve System)
3. Julius Pagu (Ranger, Mafia Island Marine Park)
4. Humphrey Mahudi (Acting Warden-in-Charge, Mafia Island Marine Park
5. Musa Ally (Park Ranger, Mtwara and Ruvuma Estuary Marine Park)
6. Benson Chiwinga (Park Ranger, Mtwara and Ruvuma Estuary Marine Park)John
7. Mwaisaka (Park Ranger, Mtwara and Ruvuma Estuary Marine Park)

The objective of the survey was to assess the status of coral reef habitats, including associated fish communities, in four marine protected areas in Mainland Tanzania and to analyse trends over time by reference to past surveys. There was a particular focus on assessing coral mortality from the 2016 bleaching event in March-April 2016, in so far as the availability of recent, prior baseline data allowed. The target protected areas were Tanga Coelacanth Marine Park (TACMP), Dar es Salaam Marine Reserves (DMRs), Mafia Island Marine Park (MIMP) and Mnazi Bay & Ruvuma Estuary Marine Park (MBREMP). In order to collect representative data for each area that would show trends over time, monitoring sites were selected based on those for which there existed baseline data from previous monitoring surveys. In each MPA we selected four sites for this purpose The primary survey methods applied were: (1) Line Intercept Transect (LIT) method to assess the percentage cover of various benthic cover categories, both living (hard coral, soft coral, algae, etc.) and non-living (rubble, rock, sand, etc.), (2); a 5 x 10 m belt transect method to assess the density of benthic, motile, macro-invertebrates, (3) a 5 x 50 m belt transect assessing fish diversity and abundance. Results indicated that there were some variations of health status of reefs within MPAs over time. For the case of MBREMP, hard coral cover dropped form 60% in 1987 to 30% and 27% immediately

after the 1997/98 El Nino phenomenon and current study respectively. At MIMP, the recorded hard coral percentage cover of 39% is closely similar to study done 2012 which represents an increase of 19% when compared to post El Nino impact of 1997/98. The recorded 35% cover of hard corals in DMRS represents a 5% drop when compared to an immediate study to the post EL Nino event of 1997/98. Coral cover in TACMP dropped sharply by 50% from the previously reported 30% after the 197/98 El Nino event before recovering to 32% in the current study. Other benthic categories varied over time in respect to changes in coral cover in each MPA but the observed rubbles, besides being possible effects of bleaching on coral reefs, provides picture of existence of bad fishing practices in the MPAs. In general the reef fish survey showed that there is significant difference within MPAs between the current and previous studies. The current study indicated domination by juveniles and damselfish by > 80% for all MPAs, a sharp increase from previously reported 50% in all MPAs. While it is possible that fish abundance was under-estimated as the method did not account for seasonality and nocturnal species such as haemulids, the observation that more than 80% where juveniles is an enough cause for alarm. Similarly, in relation to removal of large fish communities, the invertebrate community was dominated by class Echinoidea whose members are sea urchins. The main sea urchin species were *Diadema setosum*, *Diadema Savignyi*, *Echnothrix diadema* and *Stomopneustes variolaris*. The study concludes that though reefs appear to be in a stable condition, the intermittent pressure on reefs that comes from natural (bleaching) and evil practices (dynamite fishing, ring-nets, etc) within the MPAs, are the major causes for the degradation.

1.0 INTRODUCTION

1.1 Background to SWIOFish Tanzania project

The Government of the United Republic of Tanzania (URT) received funds from the World Bank to implement Phase one of the six-year South West Indian Ocean Fisheries Governance and Shared Growth (SWIOFish) project that run from 2015 to 2021. SWIOFish is a regional project framework for Tanzania, Mozambique, Comoros and Madagascar. The overall SWIOFish Program Development Objective is "*to increase the sustainable economic benefits generated from SWIO marine fisheries, and the proportion of those benefits retained within the region*". SWIOFish has a Project Development Objective (PDO) of '*improving the management effectiveness of selected priority fisheries at regional, national and community level*'.

The SWIOFish Project implementation in Tanzania became effective on 22nd June 2015 and covers marine fisheries in near shore waters of both mainland Tanzania and Zanzibar, as well as deep sea fisheries in territorial seas and the Exclusive Economic Zone (EEZ). The Marine Parks and Reserves Unit (MPRU) is amongst the agencies which is implementing SWIOFish activities, specifically a sub-component that deals with improved management of mixed reef fisheries, as per the SWIOFish priority fisheries above. This is in recognition of the fact that significant coral reef habitats on the coast of Mainland Tanzania lie within the boundaries of the three marine parks and several marine reserves, whose effective management is governed by the Marine Parks and Reserves Act No. 29 of 1994.

Amongst the SWIOFish Project activities assigned to MPRU is to conduct coral reef monitoring in its Marine Parks and Marine Reserves. Coral reef monitoring generates time-series information on the ecological condition of benthic and reef fish communities at selected monitoring MPAs. This information is an important tool in understanding the impact of both natural and anthropogenic pressures on coral reefs and for guiding management decisions for marine parks and reserves. There is also a need to continue building the capacity of MPRU and marine park staff on reef monitoring for future sustainability. Within that, data analysis skills and determining data storage protocols are also important. The monitoring procedures for all aspects are based on internationally recognized monitoring techniques described in the Survey Manual for Tropical Marine Resources edited by English *et al*. (1997).

1.2 Purpose of Monitoring

Monitoring of ecological resources normally aims at improving environmental management. Monitoring facilitates informed decision-making and strategic planning in management. What is important in monitoring is to detect changes or trends over time, with respect to biomass, biodiversity or ecological processes. These may be either negative trends due to human activities or natural disasters or positive trends due to effective management interventions, e.g., protection and restoration. However, for monitoring to be effective, it should be done frequently enough and on a long-term basis in order to detect "reserve effect ratios" for each no take area monitored for live coral cover and fish abundance indices (reserve effect ratio is ratio of the parameter measured, such as live hard coral cover, inside the no-take area versus an area adjacent to the no-take area also to differentiate "noise" (stochastic, cyclic and dynamic variations) from "signal" (precipitous change in a definite, usually undesirable, direction) (Elzinga *et al*., 2001). Furthermore, whenever possible, the carrying capacity of certain natural resources or populations to on-going extraction or utilization should be determined. This is important so that the resource users can make maximum use of the natural resources, while not allowing them to go below the threshold of sustainable utilization levels.

1.3. Previous monitoring in the targeted marine parks & reserves

Historically, coral reef monitoring across the three marine parks and several reserves under MPRU has not always been regular. More work has been done in Mafia Island Marine Park (MIMP) where there is continuous data collection going back to 1990-92 when the work was carried out by Frontier-Tanzania and later every two years from 1999-2015 (WWF and partners). Tanga Coelacanth Marine Park (TACMP) has baseline data dating back to the late 1980s, before the park was established (Benthed-Smith, 1987; IUCN, 1987). Since then there have been irregular assessments as done by Kalombo *et* *al*. (2009); McClanahan *et al*. (2009, 2015). More recent biophysical survey work was also done by Muhando et al, (2009). Baseline data for Mnazi Bay Ruvuma Estuary Marine Park (MBREMP) dates back prior to gazettement (Guard *et al*., 1996; Muhando *et al*., 1998). A follow-up study on its status after the establishment of the park was conducted by Obura et al. (2005). Generally, monitoring has been conducted very irregularly, contrary to provisions in the General Management Plan. However, although data not organized, staff members in collaboration with local community divers have been doing coral monitoring at least once in a year since 2013, under tripartite agreement of Marine Parks and Reserves Unit (MPRU), Pamoja Environmental Focus Limited and BG Tanzania Limited. Dar es Salaam Marine Reserves System (DMRS) is currently comprised of seven (7) Marine Reserves that include Fungu Yasin, Mbudya, Pangavini, Bongoyo, Kendwa, Makatube and Sinda both located along the coastal waters of Dar es Salaam city. The first four reserves were gazetted in June 1975 following recommendations made by Ray (1968) and Hamilton (1975), and the other three in 2007. Coral monitoring has been done by different parties over the years depending on the availability of funds for example Johnstone *et al*., 1998; Ngoile and Horrill, 1993; Muhando, 1995. There were also some initiatives in training fishers communities on reef monitoring in 2004 and 2009.

Whilst monitoring within marine parks and reserves in mainland Tanzania has been disjointed, showing uncoordinated and irregular patterns due to limited funding, the current monitoring is undertaken to furnish the authority with updated data so as to have informed decision-making in the management of the parks. The study was specifically aimed at unveiling the status of coral reefs and associated fish communities in reflection of extensive coral bleaching during the El-Nino-related sea warming event in March-April 2016. However, as this report was being prepared, the status report for the East African region had not come out (http://cordioea.net/wio-monitoring/gcrmnwio2015-16/) and therefore important information for comparison purpose is missing.

Table 1: Location of reefs and Geographical Positioning System (GPS) points (UTMs) of MPAs where monitoring was conducted, June - December, 2016.

MPA	Reef sites surveyed	Management status	GPS	
			Eastings	Northings
TACMP	Makome	Core zone	**511643.38**	**9415723.89**
	Taa	General use	**510802.09**	**9413935.5**
	Jambe 1	General use	**518711.56**	**9436152.27**
	Jambe 2	Core zone	**518684.18**	**9437437.85**
MBREMP	Matenga	Core zone	**0649830** **0649865** **0649895** **0649930**	**08858307** **08858298** **08858256** **08858391**
	Chumbu	General use zone	**0649364** **0649398** **0649360**	**08858701** **08858478** **08858397**
	Membelwa outer	Core zone	**0648605** **0646731** **0646965**	**08867232** **08864400** **08905777**
	Membelwa Inner	Core zone	**0648675** **0648591** **0648530**	**08867194** **08867302** **08867343**
DRMS	Bongoyo			
	Mbudya Island		**0527708** **0527574** **0527415**	**09263797** **09263917** **09264023**

		No take areas	**0526879**	**09264793**
	Sinda Islands		**0543102** **0543893**	**09245628** **09245321**
	Nyakatube Islands		**0536670**	**09249323**
	Fungu Yasin		**0525140**	**09270564**
MIMP	Msumbiji	Specified use zone	**0587573**	**09119834**
	Chawe	General use zone	**0585854**	**09123486**
	Mlimani	Specified use zone	**0586602**	**09121261**
	Mange	Specified use zone	**0566455**	**09109671**
	Kitutia	Core zone	**0571668**	**09102453**

2.0 METHODOLOGY

2.1 Selection of study sites

In each park, monitored sites were identified based on their management status, whether no take zone, a core zone, specified use zone or general use reef (Table 1). Furthermore, in order to obtain a statistical representation, at least 25% of the reefs in each park were sampled for monitoring (Kajembe and Katani, 1998). The percentage was obtained by working on data available at each MPA on the size and number of reefs present. All surveyed sites were marked by Global Positing System (GPS) in UTMs units for easy retracing in the future surveys (Table 1).

2.2 Data Collection: Overview

Visual censuses of benthic categories, coral reef fish and invertebrate populations are widely used as a method for establishing the differences in abundance and diversity of the species associated among MPAs (Markham and Browne, 2007). The methodology for undertaking this survey followed an agreed WIO approach for coral reef monitoring which was proposed during a regional workshop for exchanges and coral reef monitoring held in Albion, Mauritius from 24^{th} – 26^{th} January 2015. In this context IOC-biodiversity and IOC- ISLAND projects and IOC project for the sustainable management of coastal zones (GDZC) unified efforts for improved coral reef monitoring suitable for the region following a global standardized approaches as established by English *et al*., 1997. Therefore three types of data collection techniques were applied, (1) the 10-m Line Intercept Transect (LIT) method (Plate 1a,b) to assess the percentage cover of various benthic cover categories, both living (hard coral, soft coral, algae, etc.) and non-living (rubble, rock, sand, etc.), (2) a 4 x 10m (10 * 4= $40m^2$) belt transect method which was used to assess the density of benthic, motile, macro-invertebrates and (3); a 5 x 50m (50 *5 = $250m^2$) underwater visual census for fish. Depending on the reef morphology, using Global Positioning system (GPS) device transects were distributed randomly in order to capture representation as much as it could be possible. The selection of transect points was preceded by a though reconnaissance survey aimed at mapping the reefs. Therefore reef-flats, reef-crests and reef-slopes were taken into consideration whenever is possible. During dives, each participant was able to make two transects, producing a minimum of

12 transects per reef. Specifically, three pairs of divers descended into predetermined reef areas with a 10-meter tape measure. A tape was unwound from zero to ten meter mark and tightly anchored on both ends to the hard substratum (Plate 2). After firmly fixing the tape to both ends divers swam slowly along the tape while careful observing and recording marine categories (Table 2) under the tape measure (Plate 1 b). The reading and recording was based on English et al. (1994) categories. In each reef twelve transects were made and taken for data analysis.

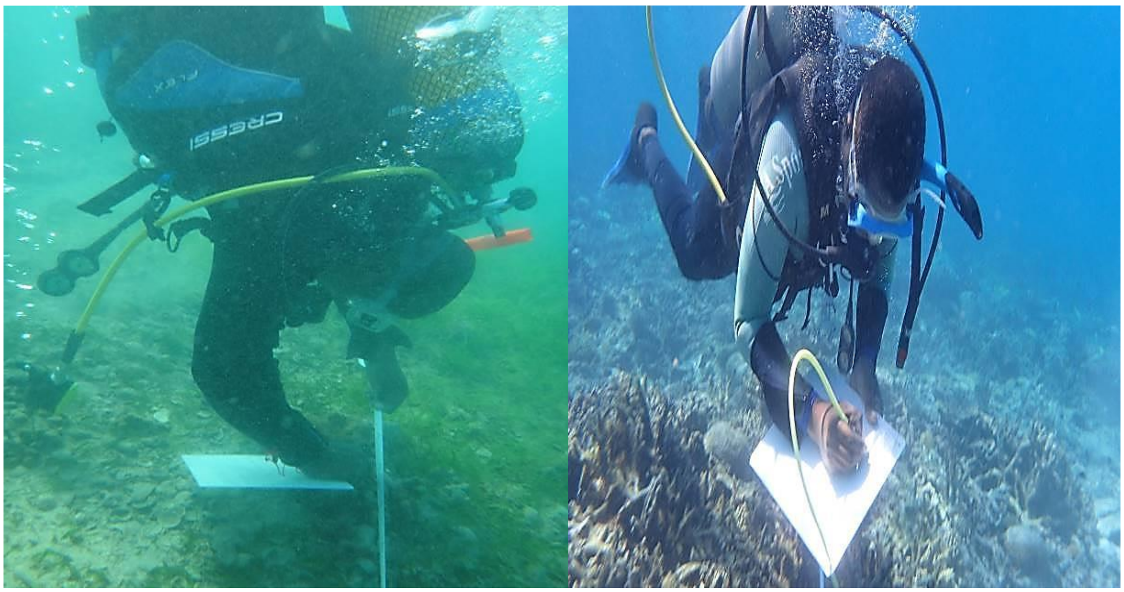


Plate 1. Line Intercept Transect method (a) preparing the transect setup, (b) adjusting data collection tools

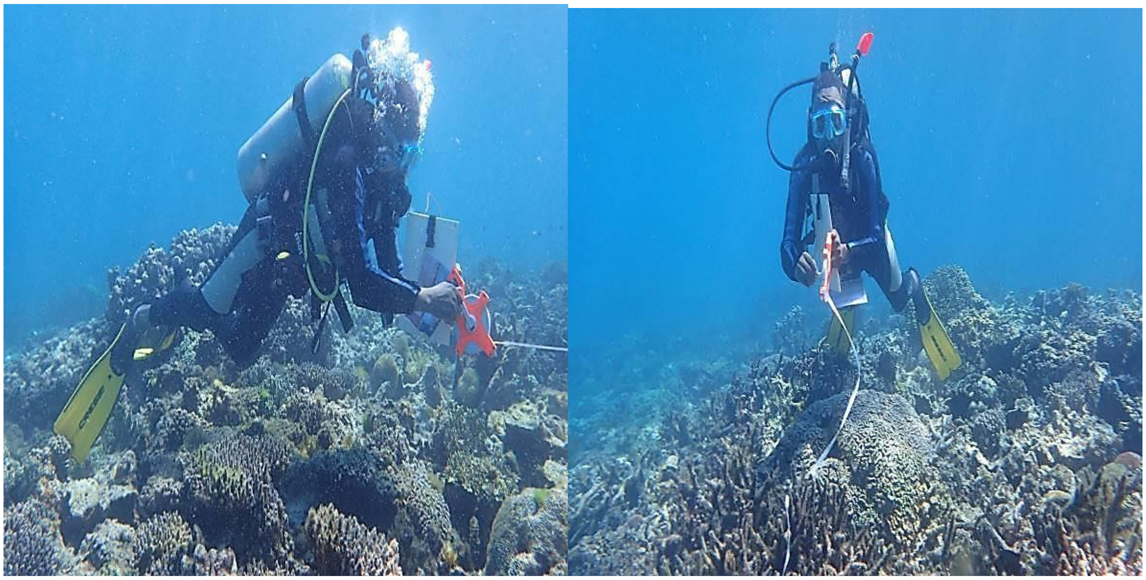


Plate 2; Laying a transect (LIT) for benthic categories study on reef in Kitutia, Mafia

Table 1: Standardized benthic categories and their abbreviations both in common English names.

Abbreviation	Common English name	Species
HC	Hard coral	Identification down to lowest classification category, specifically species, was done
DC	Dead coral	Described as they are
SND	Sand	Described as they are
SC	Soft coral	Identification was down to lowest possible classification category, specifically species.
SP	Sponge	
SG	Seagrass	
MA	Macroalgae	
RCK	Rock	Described as they are
R	Rubble	Described as they are
OT	Other living organisms	Identification down to lowest classification category, specifically species, will be done

2.3 Fish Surveys in the reef areas

Coral reef fish are highly diverse so it can be challenging to census all species on a transect. The method used therefore focused was on: (i) indicator species that play key ecological roles on coral reefs and (ii) on vulnerable species susceptible to fishing effects. In addition to indicator fish species included as described above, censuses included other species which were visually and numerically dominant, without cryptic behaviour, easily identified underwater and are associated with reef habitats (English *et al.*, 1994). Prior to actual data collection for fish, field techniques such as calming down the environment soon after tape measure setup was done for the purpose of allowing fish to reassemble was strongly encouraged. An opportunity search and recording was done for species appearing to be unique in the area though not in the belt transect especially for keystone species and uncommon reef species. While, swimming slowly and cautiously along each transect we recorded a tally of target fish species encountered in 2.5 metres either side and 2 metres above the line on a pre-drawn dive slate. All fish were counted by major categories mostly to species level but when identification was complicated taxonomy ended at major genera and families. Identification was aided with the laminated colour photographs of reef fish. While counting, fish size categories estimated were recorded on a plastic slate. The size categories used were named as Juvenile (0-10 cm), Recruit (11-20 cm), and Adult (21cm-above).

2.4 Invertebrate survey method

This survey method was applied in conjunction with the 10 metre LIT benthic survey described in section 2.2.2 such that data collectors undertook invertebrate counts along the same transects used for benthic data collection. Specifically, this was conducted by a pair of divers swimming along the same 10 metre tape while observing invertebrates within an estimated 2 m distance on either side of the tape (10m * 2m area=20m^2) as used in the benthic survey described by English *et al.* (1994). All invertebrates were counted and identified to species level. An opportunistic search and recording was also done for species appearing to be unique in the area though not in the belt transect (refer to section 2.2.6 below). This was done in order to supplement data on the status of invertebrates available in each reef as, some for example CoTs, have significant ecological impact.

2.2.5 Coral Bleaching

Coral bleaching data was collected based on 2016 CORDIO assessment protocols (www.cordioea.net). The application of the CORDIO approach was important for comparison purposes with other Western Indian Ocean (WIO) areas where reef bleaching have been reported to have occurred.

2.2.6 Opportunistic Surveys

High importance was placed on recording opportunistic incidences appearing either along transect or close to them. In most studies this approach is ignored but its importance cannot be over emphasized for provision of outlier information-not registered in survey transects. This means during the monitoring exercise any unique or peculiar observations were noted and recorded. Examples of this are the occurrence of crown-of thorns starfish.

2.2.7 Data Analysis

Various statistical analyses were applied to the data collected. MS excel was used to calculate mean percentage cover of benthic categories in each reef and MPA as well as standard deviation and error. Further to this, simple descriptive statistics i.e., ANOVA, KRUSKAL WALLIS and FRIEDMAN'S test were used to make comparisons within and among MPAs.

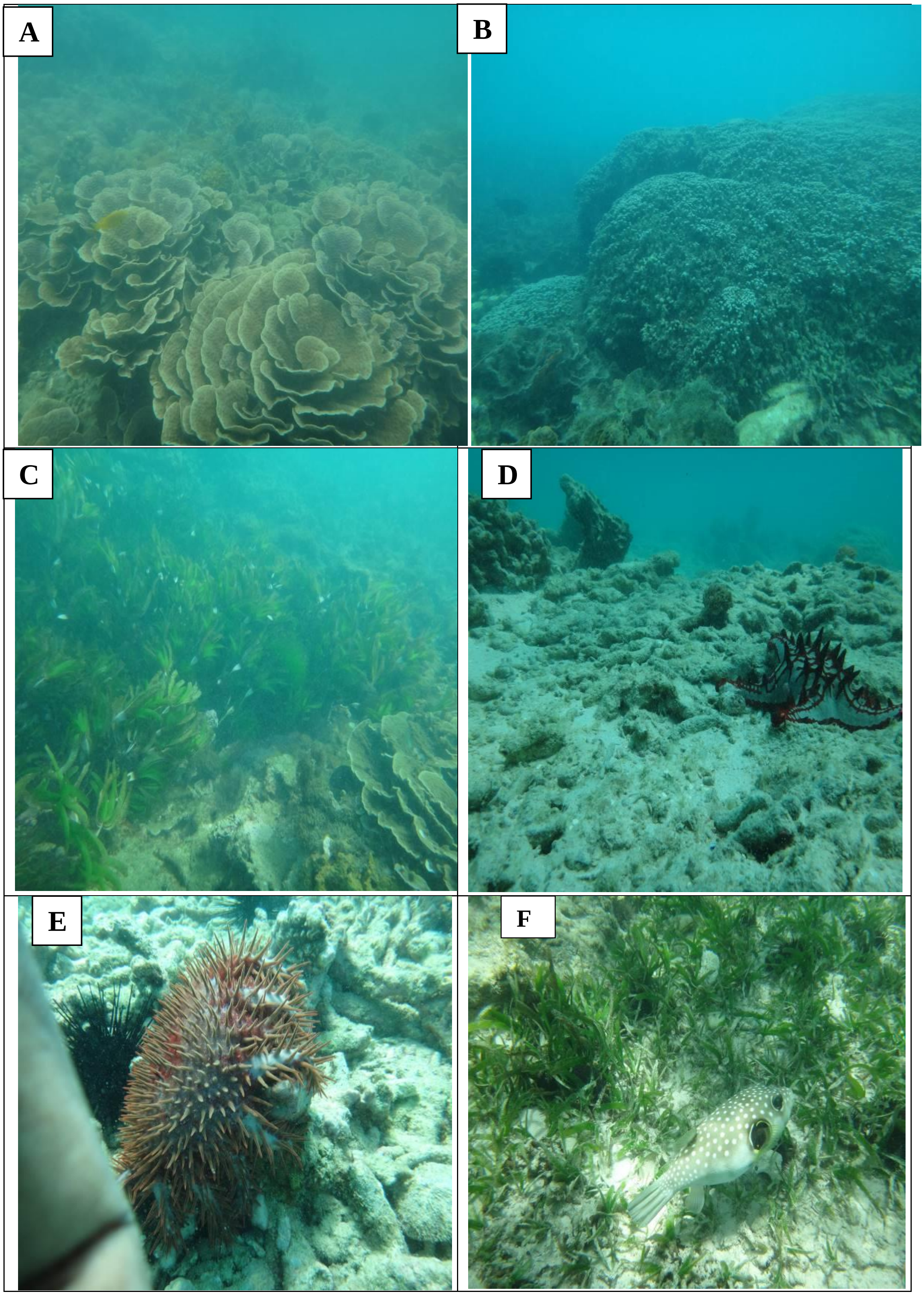
3.0 RESULTS

3.1. General overview of reef status

This section provides summaries of all the findings described in the previous methodology section. While comparison between MPA is summarized, actual trends including variance over time for coral reefs status in each MPA is provided below starting in section 3.1.1.

Generally there was great variation in number of coral genera and their percentage cover relative to MPA and MPAs within. Statistically, there was a significant difference in percentage coral cover among MPAs (Kruskal Wallis's test H, $P < 0.011$) in which MIMP has the highest cover while MBREMP had the least. Similarly, the coral diversity varied among MPAs showing significant differences whereby MIMP had the highest diversity. While seagrasses was the next significant category in terms of abundance in this, the soft corals cover was very low in most MPAs. Rubbles present were mainly results of bad fishing practices in the MPAs, these included but not limited to dragnets and dynamite blasting.

Fish survey showed that there was significant difference among MPA (Kruskal Wallis test; $P < 0.001$). Furthermore, the results indicated that MIMP had the highest diversity with 139 species recorded while DRMS had the least with only 66 species. In most MPAs fish were represented by juveniles whereby damselfish was the most abundant (n = > 80%). Invertebrate community of the surveyed reefs was represented significantly by the phylum Echinodermata whereby the class Echinoidea whose members are sea urchins, were the most conspicuous and very abundant in all MPAs. Statistical analysis showed that there was significant difference in the sea urchin abundance among MPAs (Kruskal Walli's test = 36.036, $P < 001$). The sea urchin species which frequently observed in the reefs were; *Diadema setosum*, *Diadema Savignyi*, *Echnothrix diadema* and *Stomopneustes variolaris*. Other members of ecological importance recorded in the reefs include; the Crown-of-Thorn starfish (*Acanthaster planci*) and several sea cucumbers (Class: Holothuroidea). Below (Plate 3) is the illustration of the situation within the reefs;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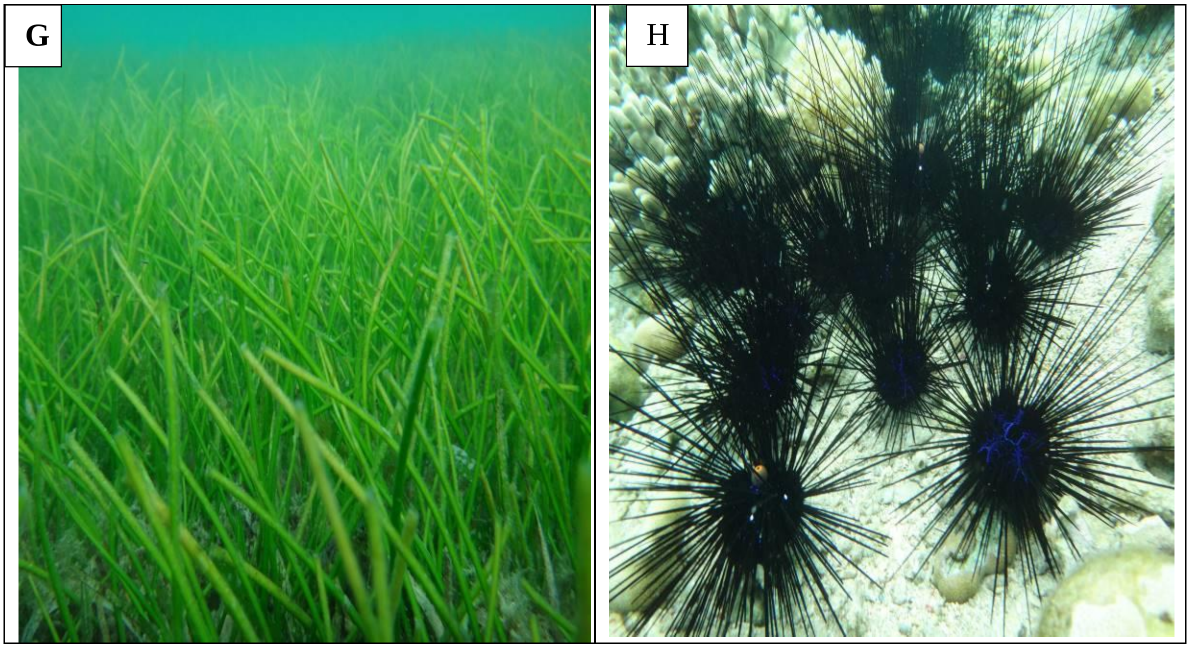

Plate 3: Initial stages of coral monitoring exercise, A and B); coral reefs in DRMS and MBREMP respectively, C) Networks of *Thalassodendron ciliatum* at Mbudya Island, d) Damaged portion of reef at MBREMP, E) Crown-of-Thorn starfish at DMRS, F); Typical non-commercial reef fish at Sinda Island, and G); *Syringodium isoetifolium* in Nyakatumbe and, H) Typical sea urchins, Diadema savigny and S. Setosum in DRMS. All pictures were taken during this survey.

3.1.1 MBREMP Benthic category

Data from Mnazi Bay Ruvuma Estuary Marine Park (Figure 1) showed that the percentage cover of hard coral was 25% followed by sand 18% while the rest of other categories showed a gradual decrease in the order as stipulated in the graph from dead coral to other categories. Kruskal Wallis test showed that there was significant difference in benthic categories cover in the MPA ($P < 0.011$). Matenga and Chumbu showed high proportions of dead cover categories than Membelwa and Kieti. In all reefs, the category rock was a leftover of dead and calcified coral.

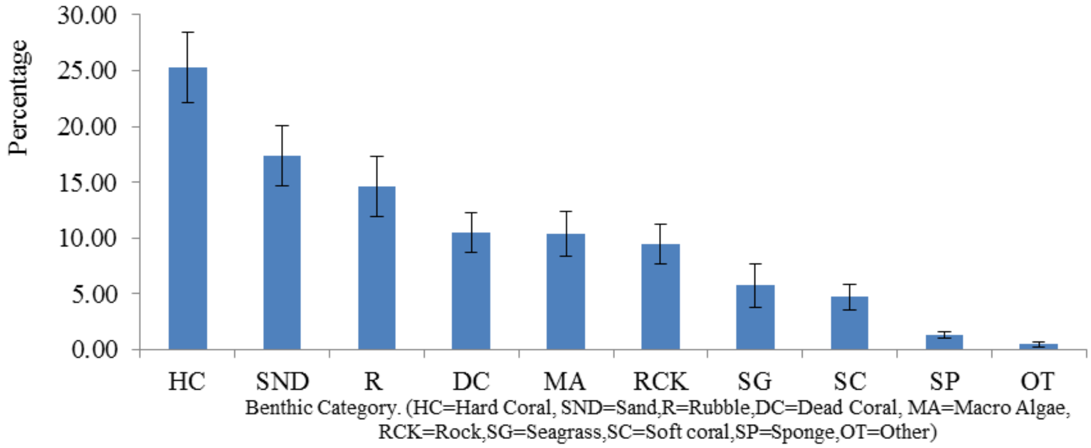

Figure 1: **Percentage distribution of LIT benthic categories' cover at MBREMP. Error bars represent standard errors (SM ±).**

Major coral genera identified in transects measured during the survey in this MPA included *Acropora, Porites, Millepora, Favia, Favites, Pocillopora, Seriatopora, Stylophora and Fungia* as per identification guide by Veron (1998). Staghorn Acropora forms were very abundant at Kieti reef slopes while in other reefs were altogether absent. Segrasses were observed in Membemelwa Outer and Inner were mostly *Syringodium isoetifolium* spreading extensively in a lower reef portion. Furthermore, the dead corals and rubbles were significantly visible in many areas.

3.1.2 TACMP Benthic category

In the TACMP, hard coral (HC) which was about 32% was the highest (Fig. 2) than other benthic category. Macro algae had relatively unusual higher than other categories' representation (25%). The lower parentage categories were others (not listed in table 1 but recorded in the reefs) and sponge which together accounted for less than 1%. Statistically, there was difference in percentage cover among the categories (Kruskal Wallis test, $P < 0.012$)

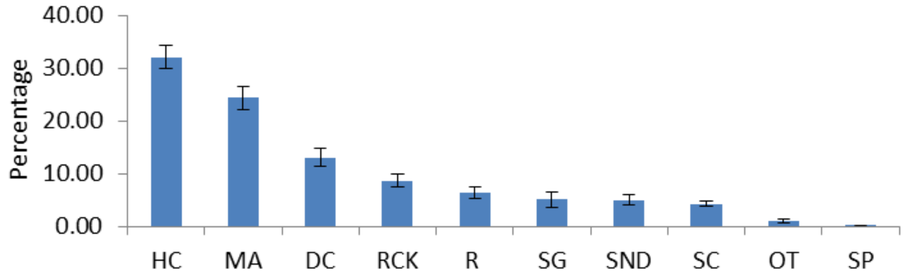

Figure 2: Percentage distribution of LIT benthic categories' cover at TACMP. Error bars represent standard errors (SM ±).

The species of coral encountered varied between one reef and another the major category were *Galaxea*, *Millepora*, *Seriatopora*, *Acropora*, *Porites*, *Galaxea* and *Montipora* with other uncommon (not abundant) reef species interspersed among them. Monospecific stands of *Montipora* and *Galaxea* were common at Jambe. Patches of holes in reefs, dead coral and rubbles (Fig. 2) were a common siting, an indication of heavy presence of dynamite fishing. Statistics indicated that there was significant difference in percentage of coral cover among categories (Friedman's test ($P < 0.001$)

3.1.3 MIMP Benthic category

In the MIMP, percentage of hard coral (HC) was 39% with all other categories representation falling below 20% (Figure 3). The Macro algae (MA) was about 23% followed by rubbles (10%) the rest being below 10%.

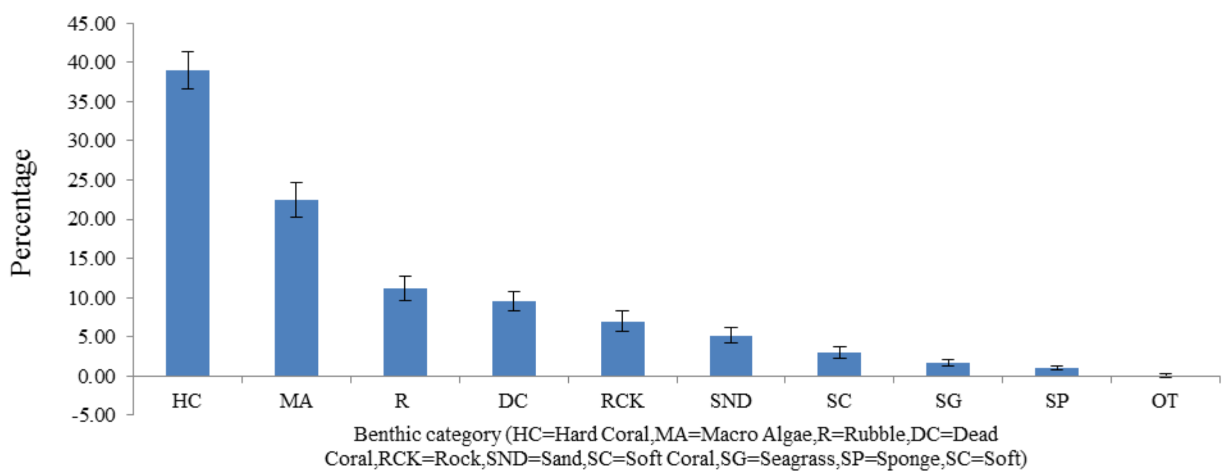

Figure 2: Percentage distribution of LIT benthic categories' cover at MIMP. Error bars represent standard errors (SM ±).

This is the most diverse reef, in terms of coral species and fish. Common coral species observed during the survey were in the genera *Acropora*, *Porites, Montipora, Pavona, Pachyseries, Leptoseries, Plerogyra, Mycedium, Pectinia, Pocillopora, Echinopora, Goniopora, Seriatopora, Stylophora, Galaxea, Symphillia, Hydnophora, Goniastrea, Leptastrea, Platygyra, Favia, Favites and Fungia*. The observed dead coral was a result of bad fishing practices mainly dragnets. Invertebrates were represented by the Class Asteroidea mostly *Pentaceraster tuberculatus*,P. *mammillatus*, *Culcina schmideliana* and *Linckia laeigata*.

3.1.4 DMRS Benthic Category

A survey at DMRS revealed that hard coral cover category had the highest percentage cover, approximately 33% among others (Fig. 4). Furthermore, there was a significant differences among rock, dead coral, rubble, seagrass and sand sponges and others were insignificant in the reefs within the area.

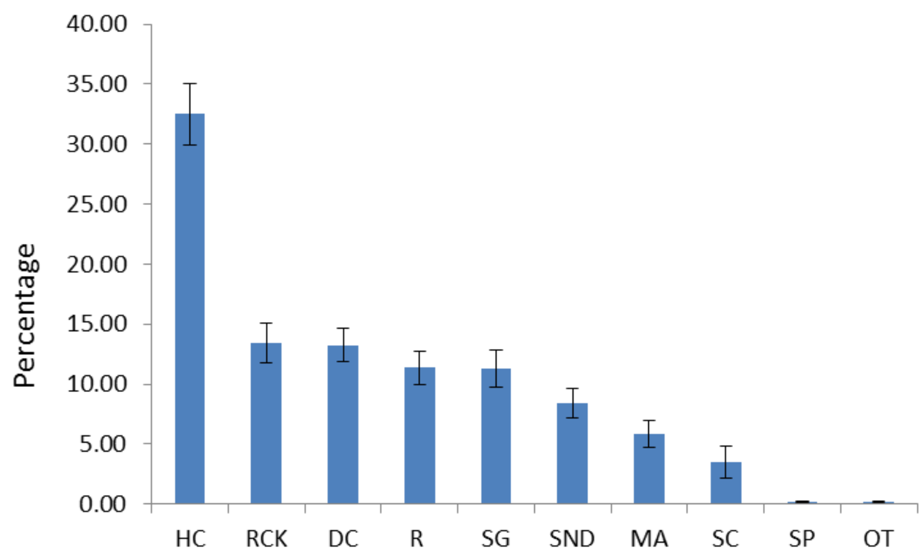

Figure 3: Percentage distribution of LIT benthic categories' cover at DRMS. Error bars represent standard errors (SM ±).

In this MPA, the different reefs had significantly varied status in terms of coral species. Northern reefs of Fungu Yasin, Mbudya and Bongoyo harbor *Galaxea*, *Montipora*, *Porites, Acropora, Pavona, Pachyseries, Seriatopora, Leptoseries, Plerogyra, Mycedium, Pectinia, Pocillopora and Echinopora.* The Southerns reefs of Sinda and Nyakatumbe were mostly dominated by *Porites* and *Acropora* with other genera appearing scattered around dead bommies and fragments. Similarly, seagrass were abundant in all reefs with *Thalassodendron ciliatum* showing high abundance.

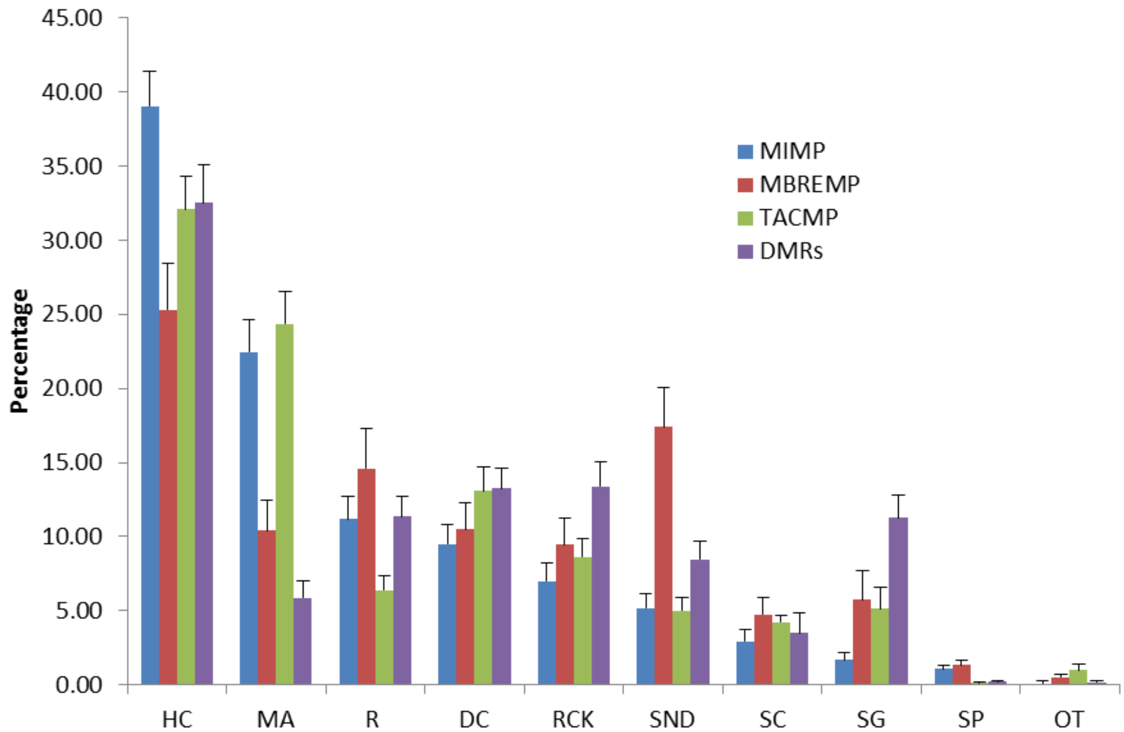

Figure 4: Comparison of percentage distribution of LIT benthic categories' cover among MPAs. Error bars represent standard errors (SM ±).

Macroalgae and rubbles were the second and third most important categories respectively in all MPAs with the exception of MIMP and MBREMP. Statistical comparison in DC coral cover revealed that there was no significant difference among MPAs (H, P = 0.12).

3.2. Fish Population densities among and between the MPAs

An assessment of fish was done in the 50*5m belt transects whereby, a number of transects were made twelve each at MIMP and MBREMP, eleven at DMRs and thirteen at TACMP. For the purpose of analysis, 11 transects were used for each site. The results indicate that MIMP had the highest fish species diversity (139), followed by MBREMP (94), TACMP (82 and DRMS (66). Furthermore, the results indicated that densities of fish expressed in fish/ha were: MIMP 596613, MBREMP had 2123, TACMP had 12723 while DRMS had 4222 (Table 2). When these are conventionally converted they represent approx. 59.66, 2.12, 2.27 and 0.422, all expressed as fish/m^2 in MIMP, MBREMP, TACMP and DRMS respectively (Table 3).

Size class for surveyed fish species indicated that the family Pomacentridae (3-10 cm) were the most abundant taking more than 80% of the fish population in all MPAs (Table 4). No fish measuring above 60 cm was observed in the transects.

Table 2: Fish density in MPAs

	Fish density/ha	**SE**	**Number of Transect**
MIMP	596613.2	**5919**	12
MBREMP	21230	**128.89**	12
TACMP	12723.2	**88.23**	13
DMRS	4222	**24.587**	11

Table 3. Fish diversity in the MPAs

	MIMP	MBREMP	TACMP	DMRs
No. Family	36	35	27	23
No. Species	139	94	82	66

Table 4. Fish size class in MPAs

	SIZE CLASS (CM) percentages								
Size Class	**3-10**	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**	**>80cm**	**T**
	Pomacentridae	Chaetodontidae	**Other families**						
MIMP	98.62	1.11	0.13	0.09	0.01	0.02	0.01	0.01	1
	Pomacentridae	Acanthuridae & Labridae	Scaridae	Other families					

TACMP	82.49	16.11	1.31	0.10	0	0	0	0	1
	Pomacentridae	Acanthuridae & Labridae	Other families						
MBREMP	92.28	6.70	0.97	0.03	0	0	0	0	1
	Pomacentridae	Scaridae Mullidae	Labridae	Other families					
DMRS	80.88	15.76	3.27	0.09	0	0	0	0	1

In order to follow trends over time, an in-depth analysis is provided in the discussion section.

3.3. Invertebrates

Data for invertebrates' densities taken at MIMP, DMRs, MBREMP and TACMP is presented in Figure 6. The average numbers for each MPA depicts the actual status for the invertebrates and was compared between MPAs. From the figure, sea urchins were the most abundant throughout MPAs but so much represented in MBREMP and DRMS than in TACMP and MIMP. The same information for individual MPAs within each MPA is shown in the appendices below.

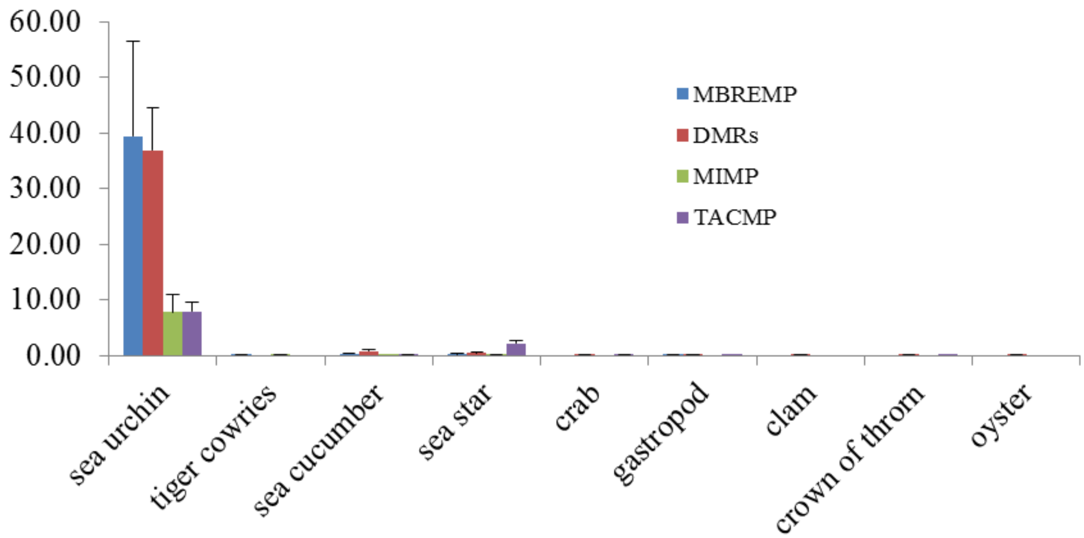

Figure 6: Average density of invertebrates when all MPAs are combined. Error bars represent standard errors (SM ±).

4. DISCUSSION

4.1 The status of benthic cover, fish and invertebrate densities in each MPA

During this survey, three marine parks and one marine reserve were visited on which monitoring survey of the reefs was conducted. The current survey, involving eight marine science experts doubles as was the most extensive and wide spread of all others done before in the MPAs. Detailed analysis of current situation is provided for each MPA and comparisons are done to the previous surveys and are provided in the sections below for each MPA. Furthermore, in order to avoid likely distortion of the information on the actual trends of coral reef status, a careful selection of the previous studies is taken for comparison purposes. Similarly and for the same reasons, graphical comparison was intentionally avoided except in MIMP were clear and reliable previous information is available. The main problem with comparison based on the previous information is based on the fact that there has not been regular monitoring in the surveyed reefs therefore very hard to make a scientific trend over time. To compensate for this a thorough literature review is done as per sections below.

4.2 Historical baseline data and trends over years of benthic cover, fish community and invertebrate for each surveyed MPA

4.2.1 MBREMP

Various studies have been conducted in this marine park to explain its physical and biological features. A study by Guard et al. (1997) in MBREMP indicates that hard coral cover which extends beyond 3 m depth ranged from 85 to 95 % comprising about 36 genera most dominant being *Acropora*, *Porites*, *Favia*, *Favites* and *Echinopora*. The study further acknowledges that habitat damage was minimal in the area, especially those on the outer fringing reef sites. However, the same study stresses that the inner reef within Msimbati Bay which consisted about 40% of hard coral cover was partly damaged from human activities, bleaching and crown of thorn attacks. The aftermath of 1997/98 Eli Niño phenomenon revealed a sharp drop in hard coral to 30%, but when compared to other affected areas it was still considered as one of the most diverse of all MPA in the Eastern African marine water (Obura et al, 2000, 2004). Even after the El Niño perturbation, the area is still dominated by some hard coral species considered as highly heat susceptible such as *Acropora* (staghorn), *Stylophora* and *Seriatopora*. By comparisons, members in the Genus *Acropora*, especially staghorn and tabulate forms, were among the hardest hit and completely decimated in most reefs. Besides those mentioned above, other species observed in high abundance during this study include *Porites, Millepora, Pavona, Favia, Favites, Pocillopora, Stylophora and Fungia.*

The slight decline of coral percentage cover (25%) during this study when compared to post 1998 Eli Niño cover (30%) besides confirming existence of effective management it also entails that MPA is protected by virtue of its position. The survival of these coral may have been a result of the physical condition of the reefs in the area, especially those related to depth where warmer than optimum temperature waters during the regularly recurring Eli Niño might have not reached them. Additionally, the physical structure of the bay provides for faster movement of waters thus shorter retention and therefore temperature modulation.

On the other hand, the MBREMP reef is known for its high topographic complexity cover (MBREMP GMP, 2011). Generally, diversified topographic complexity of the benthic substratum is important determinant parameters for fish and other organisms' diversity and abundance (Muhando & Mohammed, 2002; Garpe & Ohman, 2003; Pittman & Brown, 2011). While efforts were made to follow reef status indicator fish species, the diversity was evasively skewed to fish of non-commercial importance. The fish density at 21230individuals/ha and with a domination of family Pomacentridae was one of the lowest among MPAs studied during this survey indicative of occurrence intensive overfishing in the area. This is in contrast to a study by Guard et al. (1997) where reef fish diversity was considered high especially in the upper water column up to 10 m in the pristine outer fringing reef. In this study, there was no observed fish species larger than 50cm long thus eliminating the possibility of finding some reef keystone species such as triggerfish in the family Ballistidae. A closer scan on the fishing gears it was revealed that a community in the area apply a combination of traditional and modern fishing techniques which included wando (mtego), - kukusanya, - jarife, - zulumati, -

karabai, - ulumba (sumu), - kutanda, - mshipi (line fishing), - mwenge, - madema (traps), - kuchokoa, - juya, - zuio. The techniques exert different pressure to the reef fish community and therefore affecting differently the trophic levels which may be a leading cause for the observed overfishing.

Following removal of major fish species, some of which play important role as top predators, the abundance of invertebrates was very much skewed whereas sea urchins showed very high proliferation in the MPA. This is a mirror image to fish abundance described above. These sea urchins, members of the class Echinodermata, are herbivores ecologically known for intensive consumption algal turfs and macroalgae on a small spatial scale (Humphries, 2015). The animals are also bio-eroders due to their feeding habits and the abrasive movements of their spines during locomotion; thus, where they are numerous, they can cause significant erosion of coral reefs (Wagner 2002). This factor can also account for the the decline of coral over as reported above.

4.3 TACMP

Coastal and marine ecosystems in Tanga Coelocanth Marine Park have been studied for a couple of decades. The pioneers for reef studies in the area were the Tanga Coastal Zone Management Project (IUCN (1987). A relatively earlier intensive study by Benthed-Smith (1987) reported a coral cover of 30% in TACMP reefs while later on a study by Horril (2000) in the same reefs revealed that 12%, 64% and 24% as being destroyed, in poor condition and healthy, respectively. It is obvious that the massive damage was a result of the unprecedented sea surface water temperature increase (El Nino) of 1998 where, according to the report, 50% of the coral was wiped out leaving only 12% of the reef as healthy. The magnitude of the damage was felt across the Western Indian Ocean Region (WIO) where majority of corals, especially the branching species such as *Acropora* were completely wiped out (Mbije et al. 20013). Although later on Tanga Coastal Zone Management Project reported an increase of 50% in some protected areas, the overall coral cover has further been dwindling due to the continued heavy dynamites and other fishing malpractices especially after the project closure (Verheij & Kalombo, 2004; Wells et al, 2005; Kaehler 2007, 2008; Muhando 2008; Martin, 2011). The most affected were areas close to Kigombe and Tanga City where there is increased human activities (Ribbink & Roberts, 2006). Reports from hoteliers along the Pangani beach confirm regular blasts happening very close to the beach. The proliferation of Seagrass and dominance of dead corals as indicated in the figure 2 is a clear testimony of coral damage in the area.

The current study reveals an increase of coral cover from the 12% previously reported in the year 1998 after El Nino to 32% (This study, 2017). While we commend Marine Park Authority on the observed increase of which we link to the timely establishment and operation of the Tanga and Coelocanth Marine Park in the area, we still insist that the authority should work hand in hand with stakeholders to see that dynamite fishing comes to halt.

Furthermore, studies show that fish diversity has significantly dwindled in the area. Studies done by Spalding et al (2001) and Mhitu (2007) revealed that about 380 species existed in Tanga waters where a significant percentage was from reef areas within. Reef species reported to occur in the area include Lethridae, Siganidae, Lutjanidae, Labdridae and Mullidae (Othina and Samoyls, 2005). However, significant changes in fish species diversity and abundance have been observed over time (Kaehler 2007, 2008) resulting to a sharp decline to 53% as observed in the year 2001. Besides absence of reef keystone species such Ballistadae which are important as top predators controlling sea urchins, the size class as also reported to go down whereby 75% of the catches were below 20cm long. Concomitantly, the current study shows that 85% of the fish species ware below 20 cm long, most of which found the family Pomacentridae. This calls for designing a more proactive and effective management protocols in the area.

4.4. MIMP

When compared to other MPAs in Tanzania, regular monitoring has at least been conducted in this MPA (Marine Park report, 2-5). It started in 1999 and was repeated in 2001, 2003, 2005 and during this study. A few other isolated studies have been conducted by various conservation groups including (Ngoile et al. 1988; Lindahl, 1998; Mohammed et al. 2000, 2002, 2006; WWF through Ruvuma, Mafia and WWF-Kilwa Marine Eco-region (WWF-RUMAKI) 2011, 2012, Frontiers TZ , Wildlife Conservation of Mombasa and Cordio East Africa. For the purpose of following trends in the performance of monitored parameters, this study reviews some which a closely comparable in order to minimise errors and bias.

Generally, the MIMP is one of severely hit MPAs with major part of its coral reefs severely damaged by the 1997/98 unprecedented sea surface temperature. In this episode, the one-month sustained above 33 Celsius temperature caused massive bleaching along the whole WIO region (Lindahl, 1998; Muhando, 1999; Mohammed et al. 2000, 2002) which culminated in death and reef framework disintegration. Kitutia reef with its abundant branching staghorn *Acropora* species was the most severely hit in which its coral cover dropped to 17% (Horrill and Ngoile 1994; Muhando and Mohammed 1996, 2002; Muhando, 2005; Fig. 7) from the previous estimates of 55% (person comm). Less severely hit were the Chole Bay reef sites (e.g., Utumbi and Mlimani), probably surviving out of possible temperature modulation through strong tidal current following through the bay on daily basis.

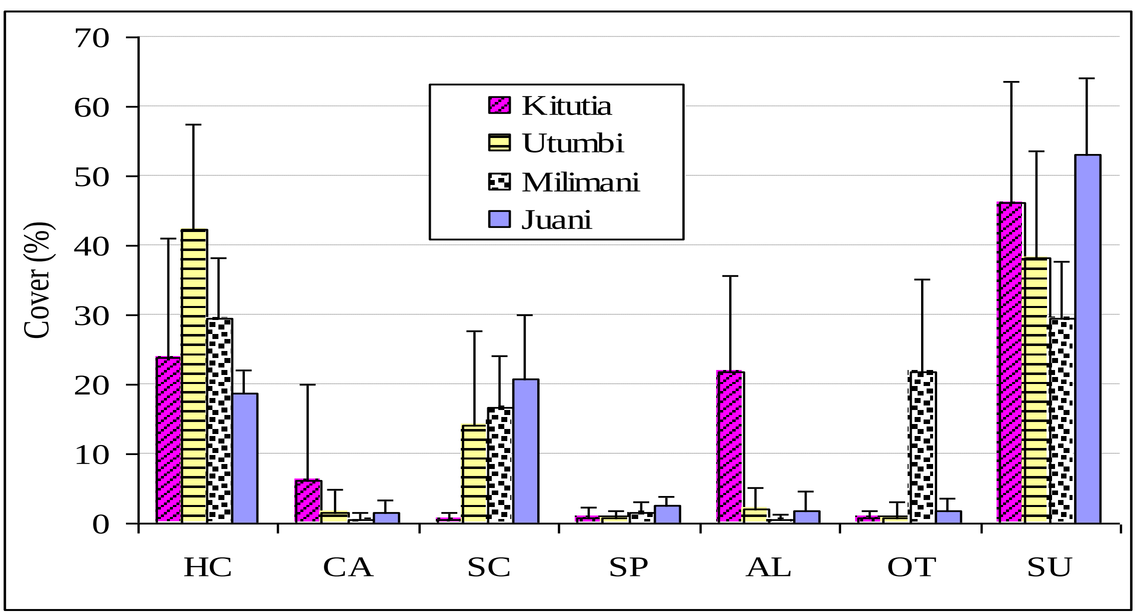

Fig. 7 Reef benthic cover (%) in monitored sites **in 2005**. Error bars = + SD. (Copied from Muhando, 2005)

Recent studies (Mhando, 2005, WWF-Rumaki, 2012 and the current have indicated significant recovery in MIMP's areas. While a study by Muhando (2005; Fig 7) and WWF-RUMAKI (2011) report average of 29% and 39% respectively for hard coral cover in MIMP, the current study show that the average coral cover for the MPA stands at 39%. This presents an increase of 10% for the period of 6 years when a study by RUMAKI (2011) is taken into account while remaining the same for the next 6 years in comparison to the current study. In evaluating coral status immediately after bleaching event (Monitoring, 1999), coral cover have progressively increased over time from the recorded 19% to the current state of 39% (+ 20%). It is important to note that the intensity of coral study varied among the monitoring periods thus may cause some errors, however, the closeness of presented data acceptable results for guiding the management the park.

A more recent study by WWF-RUMAKI (2012) indicates that reef fish in MIMP comprised of 87 species whereby the density was 515.5 individuals per 1,000 m2. This is lower than the previous studies done by WWF-RUMAKI (2007, 2009) by 40%. In the current study, MIMP had the highest species diversity (139 species) of four studied MPAs. Though more than 85% of the species recorded in the current study are members of the small-sized and non-commercial of the family Pomacentridae, this marks a significant increase when compared to WWF-RUMAKI (2007, 2009 and 2012). Furthermore, comparison to other MPAs visited during this survey, the observed patterns of the fish sizes in this MPA is much better. While there were no members of of the size class above 40-50cm in other MPAs, we could observe a few in Mafia Island Marine Park.

Studies by WWF-RUMAKI (2007, 2009 and 2012) links the absence of commercial fish and poor distribution in terms of class sizes to presence of "Mitando" nets and hand lines which normally target larger fish particularly *Lethrinus mahsena*, goatfish, emperors and acanthurids. The fishing gears targets certain trophic levels, especially herbivores thus potential for destabilising the food chains and webs. However, as noted above, the comparison may not necessarily reflect the actual picture on the ground as the difference may have resulted from the timing of monitoring (season) as well as intensity of the sampling.

Furthermore a survey by Muhando (2005) on invertebrate densities indicates that the main contributor is sea urchin (Figs. 6 and 8). The other species were significantly very low in the reef.

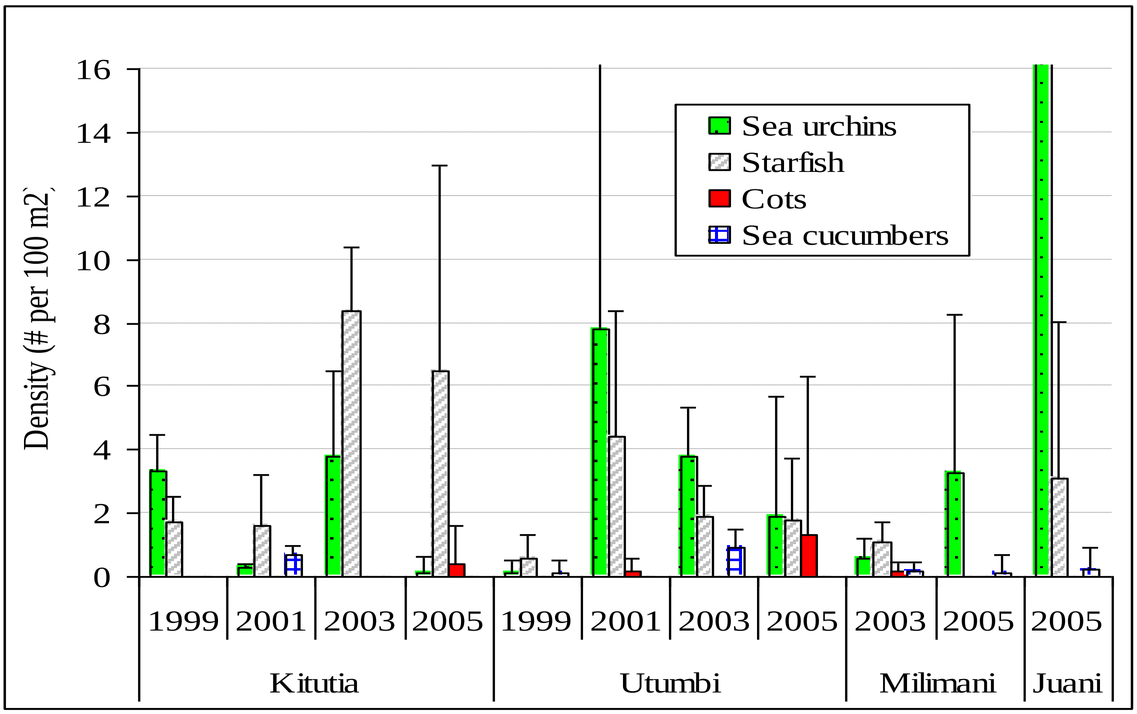

Fig. 8: The density (# per 100 m^2) of sea urchins, sea stars, sea cucumbers and Crown-of-thorns starfish in 1999, 2001, 2003 and 2005 in Kitutia, Utumbi and Kilimani reefs. Error bars = + SD.

This also similar to this study where the invertebrates density were significantly very low in the reefs (Fig. 6)

4.5 DRMS

Various studies have been carried out in the DMRS. The earliest study was by Hamilton (1975) who described the coral fauna of the East African Coast. In his study, DMRS was considered as one the most diverse reefs in East Africa. Following mass coral bleaching of 1997/98 Kamukuru (1997) and McClanahan et al. (1999) carried out assessments of the biological status of the DMRs and the effect of Marine Parks and fishing on coral reefs respectively. A number of other studies issued later on and most dwelt on investigating and monitoring the trend and status of DRMS coral reefs (Kamukuru, 1997; Muhando and Francis, 2000; Mohammed et al., 2000; Wagner, 2004; Mchome, 2006; Julius et al, 2008; McClanahan et al., 2009; Kamukuru, 2009).

The pre-bleaching data shows that reefs of DRMS were in good condition (Hamilton, 1997). Studies by Muhando (1999, 2004) and Julius at al., 2008) show fluctuations over time in cover among reefs within the reserve. While 1997/98 bleaching decimated cover to 37%, the studies indicated an upward trend on hard coral cover in Mbudya sites from 49.4% in 1999, to 50.0 % in 2004 to 57.5 % in 2008, while a fluctuating trend was observed in Bongoyo sites from 41.4 % in 1999 to 53.5% in 2004 but finally a drop to 50.0% in 2008. Like in most reefs where Acropora was heavily impacted, similarly, in this MPA there was an increase in non-Acropora coral cover in all reefs. A study by Pagu et al (2016) indicates that lower intertidal zone comprises of *Montipora aequiturberculata*, *Acropora*,*Montipora*, *Galaxea*,*Fungia* and *Porites* all in good health. Furthermore, soft coral, corallimorpharians and algae were more significant in Fungu Yasini than on the more sheltered sides of Mbudya, Pangavini and Bongoyo. The same was confirmed during this study. Results also showed a consistent low percent of algal cover in the Mbudya while in Bongoyo sites, located in Msasani Bay, algal cover showed an upward trend

Similarly, located close to the major urban area, the MPA is one of the most severely inflicted by anthropogenic activities. The reefs in the areas has been severely subjected to intensive degradation agents such as bad fishing practices, over-exploitation of certain key species and climate changes (Pagu et al. 2016). Furthermore, irresponsible coastal development, unplanned tourism as well as lack of awareness, lack of trained and experienced personnel available for reef management and lack of resources have contributed towards coral reef degradation. Despite the various environmental pressures exerted on reefs and the use of destructive fishing methods, coral reefs still persist in most areas where bleaching effects were severe (Wagner and Mbije, 2001; Mohammed et al. 2001; Muhando et al. 2004).

Studies in DMRS reef fish indicate that fish populations have always comprised small sized species and juveniles (Lugendo et al. 2005); Igulu et al. 2013; Kimirei et al. 2013; Pagu et al 2016). This is similar to the current study where fish in DRMS wshowed to comprise majority of small sized and of less commercial value. Sea urchin was the dominant macro-invertebrate, followed by gastropoda and clams. Unlike in 2004, there was no crown-of- thorns starfish (COTS) observed in transects in 2008. This is a result of continued exploitation and use of severely destructive fishing techniques. The removal of large predatory species is the main cause for the proliferation of sea urchins.

4.6 Coral Bleaching

This survey reports nothing here of bleaching episode for 2016 year as by the time we went for coral monitoring survey most of the bleaching had already stopped. It is hard to predict or guess the impact of the just ended bleaching to the coral reefs as there are multiple stressors operating at the same time. A number of unverified verbal communications have reported of high survival rates of reefs after the bleaching but none states precisely which one survived or died.

5. CONCLUSION

5.1 Reef status

The study attempted to describe the current status of Tanzanian reefs, specifically on marine protected areas located within the jurisdictions of MPRU. The vitality of a reef depends on complex relationships among corals, fishes and the benthos. When changes occur in the community dynamics of one of these components, other components respond such that ecosystem balance is disrupted. To **evaluate the condition of a reef**, we examine multiple indicators of the coral-benthos-fish relationship. When the live coral cover, as a measure of healthy reef (Pittman & Brown, 2011) is taken into account, the general picture generated from the survey indicates that coral reefs in the MPA are in stable condition as trends indicates minor variations even after the 1997/98. Equally, live coral cover supports diversified topographic complexity of the benthic substratum which provides habitat for fish and other organisms (Garpe & Ohman, 2003). Therefore, any damage of the reef is likely to twist the ecological balance of the reefs leading to its demise.

However, when coral reef health is measured as habitat to a diverse array of organisms, a significant stress and decline is observed. The damage, especially those caused by human interferences brought about by massive destructive methods such as dynamite fishing and dragnet entangling remain the most serious threat to the survival of the ecosystem in all surveyed reef ecosystems. Furthermore, the uses of fishing gears which are selective to certain species are posing serious threat to ecosystem balance. For example, removal of top predators by spear guns and also removal of herbivores through application of basket traps popularly known as “demas” have been responsible for the observed proliferation of sea urchin and also growth of algae which altogether prevent recruitment as well as growth of live coral; an important pillar for reef development. During this study we observed the situation to be very severe in MBREMP and DMRs. In several incidences we could see actions happening close to us when we were collecting data. We observed several blasts close to the reefs of Sinda and (Makatube), some going for only one juvenile fish. Similar occurrences have been reported in the reefs of Tanga. Furthermore, regular complaints are received from hotel and dive operators on dynamite fishing and ring-nets application in reefs of Tanga, Dar es Salaam and Mtwara. The only MPA were these malpractices were not reported is MIMP. Somewhere else in Tanzanian coastline, dynamite fishing and other bad fishing practices have been reported to be very rampant (Mbije and Rinvevich, 2013). Furthermore, climate induced changes are already having strong impacts on the natural world including marine ecosystem (IPCC, 2007). The combined impacts have created one the World's fastest ecosystem peril, which according to experts, if appropriate measures are not taken now, reef will perish by 2050 (IPCC, 2007). The maximum recorded percentage cover about 40 of the MIMP and the lowest 25 of MBREMP, is a clear submission that reefs in our MPAs require greater attention than the one being offered currently.

5.3 RECOMMENDATIONS

The observed decline necessitates the need for intensification of management techniques. The scarcity of rangers coupled with financial constraints has been cited as a major bottleneck to the management of the MPA's resources. The study recommends therefore;

1. Establish effective monitoring programs in all MPAs within MPRU
2. Conduct regular training to staff to update on the current situation of their working environments
3. Equip the MPAs with appropriate monitoring and research gears. These include compressors, diving sets, modern motorized boats and appropreiate marine stationeries
4. Recruit more staff to deal with increasing human pressure on reefs.

6.0 REFERENCES

Bipa, J. D. (2000) Habitat survey and distribution of coral genera, fish and invertebrates on the fringing reef of Pangavini Island. A report submitted in partial fulfilment of the Degree of Bachelor of Science at the University of Dar es Salaam. Department of Zoology and Marine Biology, University of Dar es Salaam. 15 pp.

Bryceson, I. (1978) Tanzania Coral Reefs at Risk. New Scientist: 80: 115

Bryceson, I. (1983) Polution of Dar es Salaam Coastal Enviornment by industrial and domestic effluent. In Status and problems of marine resources and development in Tanzania ediated by Mainoya, J.R., University of Dar es Salaam. Pp 32-41.

Elzinga, C.L., Salzer, D. W., Willoughby, J.W. and Gibbs, J.P. 2001. Monitoring Plant and Animal Populations. Blackwell Science, Inc., Oxford. 360 pp.

English, S. Wilkinson, C. and Baker, V. (eds.) 1997. Survey Manual for Tropical Marine Resources, 2nd Edn. Australian Institute of Marine Science, Townsville. 390 pp.

Francis, J., Wagner, G.M., Mvungi, A., Ngwale, J. and Sallema, R. 2001. Tanzania

National Report, Phase I: Integrated Problem Analysis. GEF-MSP Sub-Saharan Africa Project on “Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa. 60 pp.

Guard, Martin & Mwajuma Masaigana (1997) Dynamite Fishing in Southern Tanzania. Geographical variation, intensity of use and possible solutions., in VIEWPOINT, A Marine Protection Bulletin Vol. 34, No. 10 pp 758 - 762, 1997. UK.

Hamilton, H.G.H., and Brakel (1984) Sturucture and coral fauna OF East Africa Reefs. Bulletin of Marine Science 34: 248 – 266.

Horrill, J.C., Kamukuru, A.T., Mgaya, Y.D. and Risk, M. 2000. Northern Tanzania and Zanzibar. In: McClanahan,h T.R., Sheppard, C.R.C., and Obura, D.O. (eds.) Coral reefs of the Indian Ocean: Their ecology and conservation. Oxford University Press, Oxford, U.K., pp. 167-198.

Humphries AT, McQuaid CD, McClanahan TR (2015) Context-Dependent Diversity-Effects of Seaweed Consumption on Coral Reefs in Kenya. PLoS ONE 10(12): e0144204. doi:10.1371/journal. pone.0144204

IUCN (1987) The Coastal Resources of Tanga Region Tanzania: report of the preliminary study of the status and utilization of Tanga's coastal natural resources, with management recommendations. IUCN EARO, Nairobi, Kenya. 37 pages.

Inter-Government Council for Climate Change (2007) Climate Induced Changes Across Marine Ecosystem-A Global Perspective.

Julius, P (2016) Assessment of reef fish biomass and density in the Dar es Salaam Marine Reserves, Tanzania. Dissertation submitted in partial fulfilment of the MSc Degree in Fisheries and Aquaculture at the University of Dar es Salaam. Department of Aquatic Sciences and Fisheries, University of Dar es Salaam.105 pp.

Julius P, Ngoile M and Mfilinge P (2016) Temporal and Spatial variability in Reef fish Density and Biomass within the Dar es Salaam Marine Reserve System, Tanzania. WIO Journal of Marine Science 15 (1) 69-78

Kaehler, S, Rabbink, A and Scott, L. (2008) ACEP Final Report 2007/2008: Nearshore and Offshore Studies in the Western Indian Ocean. Final Scientific Cruise Report, African Coelocanth Ecosystem Programme, Grahamstown, South Africa. 290 pages

Kamukuru AT 1997 Assessment of the biological status of the Dar es Salaam Marine Reserves System off the Kunduchi coast, Tanzania. Report to the Western Indian Ocean Marine Science Association (WIOMSA), Zanzibar and IOC/UNESCO Paris, France. 31 pp.

Kimirei IA (2012) Importance of mangroves and seagrass beds as nurseries for coral reef fishes in Tanzania. PhD Thesis, Faculty of Science, Radboud University Nijmegen, The Netherlands. 204 pp.

Lieske E and Myers R (2001) Pocket Guide for Coral reef fishes, Indo-Pacific and Caribbean. Princeton University Press, Princeton, New Jersey 400pp. ISBN 0-691-08995-7

Lindahl, 1998. Low-tech rehabilitation of degraded coral reefs through transplantation of staghorn corals. Ambio 27(8): 645-650.

Lindahl, U. (2003) Coral reef rehabilitation through transplantation of staghorn corals: effects of artificial stabilization and mechanical damages. *Coral Reefs* **22**: 217-223.

Lugendo BR, Pronker A, Cornelissen I, Groene A, Nagelkerken I, Dorenbosch M, van der Velde G, Mgaya YD (2005) Habitat utilisation by juveniles of commercially important fish species in a marine embayment in Zanzibar, Tanzania. Aquatic and Living Resources 18: 149-158

Markham, H. L. and N. K. Browne (2007). Proceedings of the American Academy of Underwater Sciences 26th symposium, Dauphin Island, AL: AAUS. 13-22pp.

Martin K.D. (2011) Tanga Coelacanth Marine Park participatory management planning: progress and perceptions from the 1st round of stakeholder consultations. Stakeholder workshops with communities and other interest groups in Tanga, Tanzania. 24-25 November 2010. 24 pages

Mbije, N.E. 2001. Patterns in the distribution of hard corals in selected MPAs around Unguja Island, Zanzibar. M.Sc. thesis, University of Dar es Salaam. 108 pp.

Mbije N.E., Wagner G.M., Francis, J., Ohman M.C. and Bergman, K.C. 2002. Patterns in the distribution and abundance of hard corals around Zanzibar Island. Ambio 31 (7-8): 609-611.

Mbije, N.E. 2005. Integrated assessment of suggested Collaborative Fisheries Management (CFM) areas in Bagamoyo. Tanzania Coastal Management Partnership (TCMP). Pp 29.

Mbije, N.E.J, Wagner, G.M., Francis, J., Ohman, M.C. and Bergman, K. (2002). Patterns in the distribution and abundance of hard corals around Zanzibar Island. Ambio 31 (7-8): 609-611.

Mbije, N.E, Rinkevich, B., and Spanier, E. (2013) An initial attempt at restoring denuded, post-bleached reefs in Tanzania. *Estuar. Coast. Shelf Sci.* **128:** 41-51

Mbije, N.E., Rinkevich, B., and Spanier, E. (2010) Testing the first phase of the gardening concept' as an applicable tool in restoring denuded reefs in Tanzania. Ecol. Eng. 36: 713-721.

Mbije, N.E, Rinkevich, B., and Spanier, E. (2013) An initial attempt at restoring denuded, post-bleached reefs in Tanzania. Estuar. Coast. Shelf Sci. 128: 41-51

Muhando, C.C., Kuguru, B.L., Wagner, G.M., Mbije, N.E.J. and Öhman, M.C. (2002). The Environmental Effects on the Distribution of Corallimorpharians in Tanzania. Ambio 31 (7-8): 558-561.

McClanahan, T.R. and Mutere, J.C. (1994) Coral and sea urchin assemblages structure complexity and interlatioship in Kenya coral reef lagoons. Hydrobiologia 286: 109-124.

Mchome, M. (2006) Rehabilitation of Coral Reefs Habitat and its Effects on the Recruitment of Motile Invertebrates and fish. M.Sc. Thesis, University of Dar es Salaam. 108pp.

McClanahan TR, Muthiga NA, Kamukuru AT, Machano H and Kiambo RW 1999 The effects of marine parks and fishing on coral reefs of northern Tanzania. *Bio. Cons.* **89:** 161-182.

Mohammed, M.S., Muhando, C.A. and Machano, H. (2000). Assessment of coral reef degradation in Tanzania: Results of coral monitoring in 1999. In: Souter, D., Obura, D., and Linden, O. (eds.) 2000. Coral Reef Degradation in the Indian Ocean: Status Report 2000. CORDIO. 35-42 pp.

Mohammed, S.M., Muhando C.A. and Machano, H. (2002). Coral Reef Degradation in Tanzania: Results of Monitoring 1999-2002. In: O. Linden, D. Souter, D. Wilhelmsson, & D. Obura (Eds.), Coral Reef Degradation in the Indian Ocean. Status Report 2002 (pp. 108). Kalmar: CORDIO. pp 21-30.

Mohammed, S.M., Muhando, C.A., Wagner, G.M., Mbije, N.E, Jiddawi, N.S., Mohammed, N. and Verhij, E. (2001) Status of Coral Reefs of Tanzania. Paper presented at the International coral reef Initiative Conference: Country Report (Tanzania); Regional ICRI workshop for Indian Ocean, 26 – 28, November 2001, Maputo, Mozambique.

Mohammed, M.S. Muhando C.A. Machano H. (2000) Assessment of coral reef degradation in Tanzania: results of coral reef monitoring 1999. In Souter D, Obura D, Lindén L (eds.) Coral reef degradation in the Indian Ocean: status report 2000. CORDIO, Sarec Marine Science Program, Sweden.

Muhando, C.A. (2004). Biophysical Assessment of the Dar Es Salaam Marine Reserve System. Consultancy Report Prepared for Marine Parks and Reserve Unit, Ministry of Natural Resources and Tourism, Tanzania. 33 pp.

Julius A., Muhando, C.A. and Ndagala, J. (2008) Status of coral reefs In the Dar es salaam marine reserves - September 2008. Marine Parks and Reserve Unit

Muhando, C.A. (2006) Ecological Monitoring of Coral Reefs in Marine no-take and Fished Zones off Bagamoyo coast. (TCMP) Pp 31.

Mrema, W. S. (2001) Coral transplanting and assessment of benthic cover on Pangavini Island reef. A report submitted in partial fulfilment of the Degree of Bachelor of Science at the University of Dar es Salaam. Department of Zoology and Marine Biology, University of Dar es Salaam. 37pp.

Wagner, G.M. and Mbije, N.E. (2001) Management and Conservation of Dar Es Salaam Marine Reserve. Paper presented at the International coral reef Initiative Conference: Regional ICRI workshop for Indian Ocean 26 – 28, November 2001, Maputo, Mozambique

Obura, D., **Mbije, N.**, Church, J., Ngowo, R., King A. and Nur**,** M. (2006) Ecological Status of Coral Reefs of the Mnazi Bay - Ruvuma Estuary Marine Park, Tanzania. Proceedings of 10th International Coral Reef Symposium, Okinawa, Japan. June 28-July 2, 2004. 1077-1086 pp

Othina A & Samoilys M (2005) Impacts of management on coral reefs in Tanga. IUCN-EARO, Nairobi, Kenya. 38 pages + appendices.

Muhando, C.A. (2009) Coral reef monitoring in Tanzania: an analysis of the last 20 years. Western Indian Ocean J. Mar. Sci. Vol. 8, No. 2, pp. 203 - 214, 2009

Ngoile, M.A.K., P.O.J. Bwathondi and E.S. Makwaia (1988) Trends in the exploitation of marine fisheries resources in Tanzania. Pp 93 -100. In Mainoya, J.R. Ecology of bio-productivity of the marine and coastal waters of East Africa. University of Dar es Salaam, Dar es Salaam.

Obura, D., Mbije, N., Church, J. and Nur, M. (2005) Coral and fish survey in Mtwara and Ruvuma Estuary Marine Reserve.

Pauly, D. (1995) Anecdotes and the shifting baseline syndrome in fisheries. Trends Ecol Evol 10:420

Pinnegar, J.K., & Engelhard, G.H. (2008) The 'shifting baseline' phenomenon: a global perspective. Rev Fish Biol Fisheries. 18:1-16

Ribbink, A.J. & Roberts M. (2006) African Coelacanth Ecosystem Programme: An overview of the conference contributions. South African Journal of Science 102; 409- 415.

Ruvuma, Mafia and Kilwa –RUMAKI (2012) Fish catch monitoring status report 2006 – 2011. WWF Status report 2016 – 2011.

Semesi, I. (2000) Growth rates of coral transplants in restoration MPAs at Mbudya Island and quantification of reef liforms. A report submitted in partial fulfilment for the degree of Bachelor of Science at the University of Dar es Salaam. Department of Zoology and Marine Biology. 20pp.

Skoglund, S (2014) Effects of different marine protection levels on fish communities in tropical seagrass beds and coral reefs. Master's Degree Thesis, Marine Ecology Master's programme in Biology Department of Ecology, Environment and Botany Stockholm University 32pp.

UNEP (1989) Coastal and Marine environment problems of the United Republic of Tanzania. UNEP Regional Seas Reports and Studies No. 106, UNEP.

Wagner, G.M. 2004. Coral reefs and their management in Tanzania. Western Indian Ocean Journal of Marine Science 3(2): 227-243.

Wagner, G.M. 2005. Participatory monitoring of changes in coastal and marine biodiversity. Indian Journal of Marine Sciences 34(1): 136-146.

Wagner, G. M., Mgaya, Y. D., Akwilapo, F. D., Ngowo, R. G., Sekadende, B. C., Allen, A., Price,N., Zollet, E. A. & Mackentley, N. (2001) Restoration of coral reef and mangrove ecosystems at Kunduchi and Mbweni, Dar es Salaam, with community participation. *In:* Richmond, M. D. & Francis, J. (eds.) Marine science development in Tanzania and eastern Africa. Proceedings of the 20th anniversary conference on advances in marine sciences in Tanzania, 28 June - 1 July 1999, Zanzibar, Tanzania. Institute of Marine Sciences (University of Dar es Salaam) and Western Indian Ocean Marine Science Association (WIOMSA), Zanzibar, Tanzania. pp. 467-488.

Wells, S.M. 1995. Science and management of coral reefs: Problems and prospects. Coral Reefs, 14: 177-181.

Verheij E & Kalombo H (2004) Assessing the impact of a community-based network of marine protected areas through long term monitoring of coral reef resources. Proceeding of 10th International Coral Reef Symposium, Okinawa, Japan: 1396-1404.

Wells S, Makoloweka S & Samoilys M (eds.) (2007) Putting adaptive management into practice: collaborative coastal management in Tanga, Northern Tanzania. IUCN EARO, Nairobi, Kenya. 197 pages.

Wells S, Samoilys M, Makoloweka S & Kalombo H (2010) Lessons learnt from a collaborative management programme in coastal Tanzania. Ocean & Coastal Management 53: 161–168

Zollet, E.A. 1999. Coral reef restoration and ecotourism potential at Mbudya Island. Department of Zoology and Marine Biology, University of Dar es Salaam and the School for International Training, College Study Abroad, Tanzania: Wildlife Ecology and Conservation, Arusha, Tanzania. 35 pp.