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

TRAINNING REPORT

JUNE, 2017

1. Training and capacity building of Marine Parks and Reserves Unit Staff

In order to harmonize and produce accurate field data during the just ended coral reef monitoring exercise, all participants, regardless of their of knowledge status in coral reef monitoring were subject to a four day's intensive training. The training involved class lectures and on-class practices on identification and recording of coral growth forms, fish species, invertebrates and coral bleaching (Plate 1) The training was initiated at Mtwara and Ruvuma Estuary Marine Park with all staff involved. Further in the north conservation areas the intensity of training was reduced but in some circumstances where the need arose.

Plate 1: Initial stages of coral monitoring exercise, A); Class lecture in coral monitoring, B and C); Class assignments, D and E) Demonstrations of coral reef monitoring techniques,

F) demonstration of diving gears handling, G); Controlling of diving gears and moving to field MPAs, and H); Start of the diving exercise in the outer Msanga Mkuu reef. All pictures were taken in Mnazi Bay and Ruvuma Estuary Marine Park area.

In this component, all participants were trained in the identification of all coral reef habitats flora and fauna lifeforms. A stress was emphasised on identification of benthic composition of a reef areas, in which a morphology rather than taxonomy was insisted to ensure collection of high data accuracy due to the difficulty of taxonomic identification for non-specialist surveyors.

1.2 Capacity building of marine park staff

Initially, four marine park staff members who were involved in this work were not very well acquainted with the monitoring techniques. These were Humphrey Mahudi, Musa Ally, Benson Chiwinga (certified diver and still trainee), and John Mwaisaka all of them being certified divers. The rest of the staff, January Ndagala, Margaret Mchome and Julius Pagu were certified diver, experts in benthic monitoring as well as reef fish identification. However, in order to harmonise the working program with regards to the ToRs of this work and bringing everybody to the same level, all staff underwent intensive training in data collection, analysis and report writing. Individuals' reports to attest their capacity are attached hereunder as appendix 1.

2.0 RESULTS

Appendix 1 below is presented as results in terms of reports for each MPRU staff participated in the training in relation to coral reef monitoring and report writing skills. The staff were able to collect data, analyse and write individual reports depicting their qualification after the training.

3.0 DISCUSSION AND CONCLUSION

The training was conducted smoothly and each participant was able to follow and master the course. At the end of the training, all accompanied marine staff members were very well acquainted with monitoring techniques. In order to keep them updated as well as getting regular information from their MPAs, I strongly recommend a monthly coral monitoring program as conducted at the MIMP be adopted throughout MPRU. MIMP has been able to generate and keep data on status of reef in their area. Although the work is done in relatively shallow waters, the sustenance and intensity of data collection provided appropriate and reliable scientific

information upon which some management decisions can be made. In light of limited funding, the same approach is applied in many MPAs within the Western Indian Ocean Region.

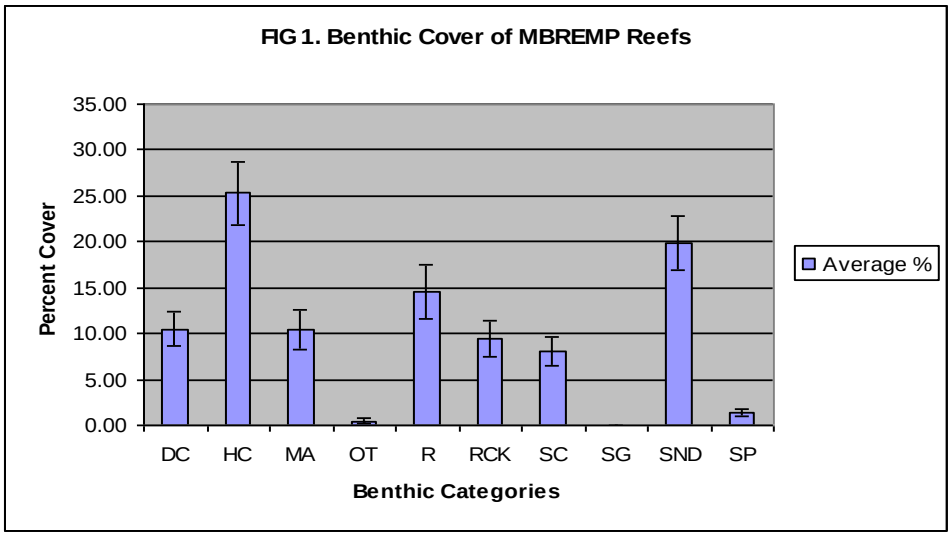
APPENDIX 1: REPORTS FROM MEMBERS OF MPRU

1.1 By Magreth Mchome

1.0 RESULTS

1.1 Benthic Cover

Percent cover of reef obtained using LIT method in four marine parks and reserve stations as shown in figures below. Hard coral cover was significant higher compared to other categories in all the stations ranging from 39% - 25%. The total percentage of dead coral and rubble range between 25% -20%. Also significant percent of Macro algae has been observed in MIMP and TACMP while in MBREMP significant percent of Sand observed.



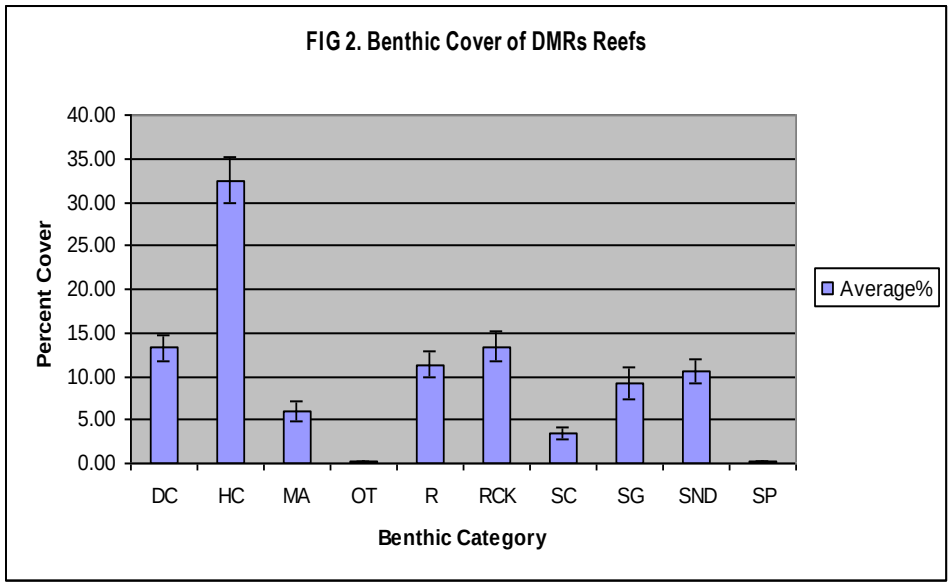


FIG 2. Benthic Cover of DMRs Reefs
40.00
35.00
30.00
25.00
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Percent Cover
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Benthic Category
Average%

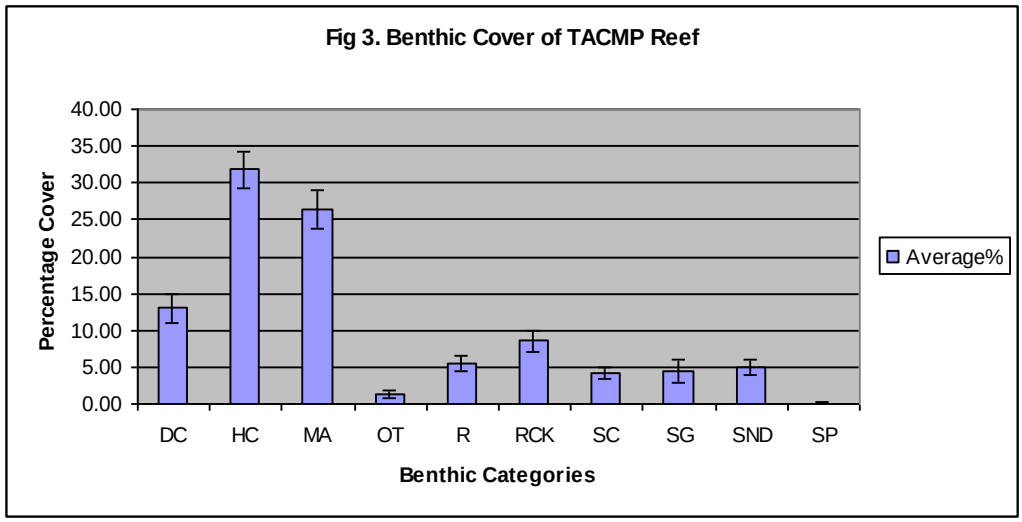
Fig 3. Benthic Cover of TACMP Reef
40.00
35.00
30.00
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Percentage Cover
DC
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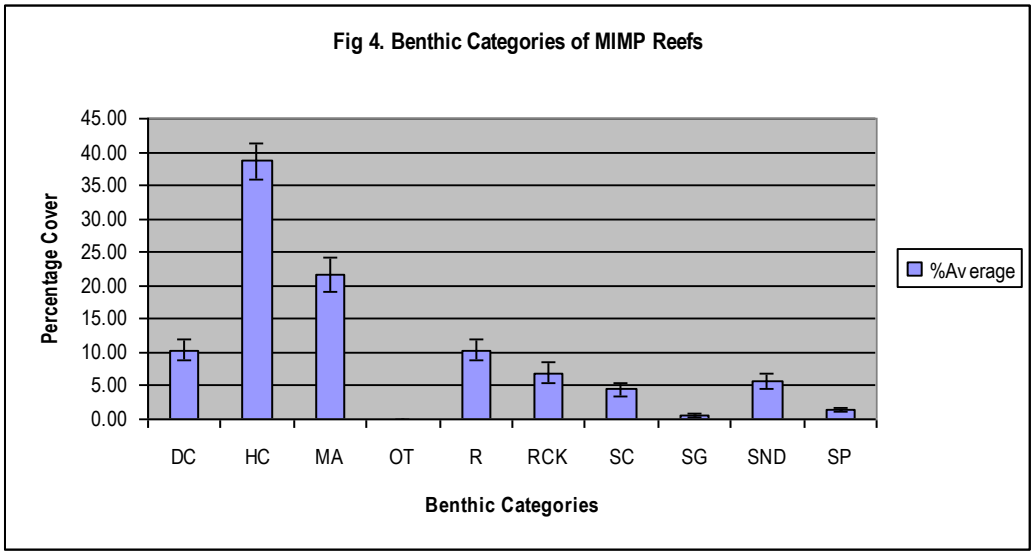
Benthic Categories
Average%



1.2 Invertebrates Density

Invertebrate density was identified using a belt transect method in all the stations as shown in the Table 1, below. Sea urchins observed to have highly contributed to density of invertebrates where in DMRs and MBREMP reefs the density reached up to 0.6 and 0.5 individual in a square meter area respectively.

Table 1: Invertebrate Density

	DENSITY(No. of individual/m^2)			
CATEGORIES	**MBREMP**	**DMRS**	**TACMP**	**MIMP**
Crab	0	0.0008	0.0004	0
Crown Of Thorns star fishes	0	0.0008	0.0004	0
Gastropod	0.0038	0.0061	0.0009	0
Sea Cucumber	0.0048	0.0159	0.0072	0.0004
Sea Urchins	0.5248	0.6216	0.1574	0.1546
Star Fish	0.0029	0.0224	0.0409	0.0092

1.3 Fish

Fish data collected using belt transect method in all the stations as it has been done above. Fish density, families and class size has been found as shown in Table 2 to 4 below.

Table 2: Fish density in MPAs

	Fish density/ha	**SE**	N
MIMP	596,613.2	**5919**	12
MBREMP	21,230	**128.89**	12
TACMP	12,723.2	**88.23**	13
DMRS	4222	**24.587**	11

Table 3. Fish family in the MPA

	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)								
	3-10	10-20	20-30	30-40	40-50	50-60	60-70	>80cm	**TOTAL (%)**
MIMP (Size class (%)	98.62	1.11	0.13	0.09	0.01	0.02	0.01	0.01	100.0
TACMP (Size class (%)	82.49	16.11	1.31	0.10	0	0	0	0	100.0
MBREMP	92.28	6.70	0.97	0.03	0	0	0	0	100.0

(Size class (%)									
DMRS (Size class (%)	80.88	15.76	3.27	0.09	0	0	0	0	100.0

2.0 Discussion

2.1 Benthic Cover

Coral reefs are amongst the most important ecosystem in Tanzania both ecologically and socio-economically (Wagner 2004). Throughout the world coral reefs have been degraded through anthropogenic and natural course (Muhando,2009, Wagner 2004). In Tanzania various efforts to protect and conserve coral reef has been made which involve declaration of MPAs (Marine Protected Areas) and Collaborative Management Units (BMUs) (Muhando, 2009). Coral reef monitoring has been a useful method to provide information on trends of corals, extent of threats, evaluate the impacts of damage, predict future changes and mitigation that help in advising managers for decision making (Wagner, 2004).

2.1.1 Mnazi Bay Ruvuma Estuary

Average percent of hard coral cover in all the MPAs of Mnazi Bay and Ruvuma Estuary was higher compared to other categories but different from other stations the total percent of hard coral was 25%. Previous studies show that hard coral cover in Mnazi Bay reached up to 40% before bleaching event with other areas reached up 60%. Together with that still there were areas with extensive degradation of hard coral that end with the cover of 10 and, the cause seem to be illegal fishing mainly dynamite fishing (Guard et al., 1998, in Wagner 2004). Also another drop was observed after 1998 bleaching event which affected 15 to 25% of coral cover and after bleaching coral survived by 50% (Wilkinson1998 in Wagner 2004).

Coral reef in these areas is dominated with Sand that reached up to 20%. This could be explained by the inflow of the fresh water from the river to this MPA via Ruvuma estuary. Significant

percent of dead corals, rubbles and rocks provide opportunity for substrate for recruitment of coral hence coral recovery.

2.1.2 Dar es Salaam Marine Reserve

In DMRs average percentage of hard coral cover was about 33%. Coral reef degradation through destructive fishing and over-exploitation of has been reported to be practiced in DMRs in 1980s and 1990s by various researches (Wagner 2004). Areas like Fungu yasin(wagner, 2004) and Sinda and Makatube (Muhando 2008) has been reported to be highly degraded. Also these areas have been reported to be affected by coral bleaching event of 1998 (Wagner 2004) and invasion of crown of thorns star fishes Muhando (2004). Despite the use of destructive fishing methods, coral reefs have persisted and in some areas the coral cover have increased (Kamukuru, 1998 in wagner 2004.

2.1.3 Tanga Coelacanth Marine Park

From this study, hard coral cover in TACMP has an average percent of 31%. By the history, Tanga reefs were in poor conditions with an average of 10-20% coral cover by 1987 Bensted-Smith R (ed) (1988) and the degradations was also reported by other writers (Sheppard and Wells, 1988; Horrill et al., 2000; Muthiga et al., 2000) in (MC Clanahan et al., 2009). In 1995 the conditions were still bad and by the year 1998 there were a decline from bleaching by elnino and then coral disease in 2003. In 2006 coral cover increased to 40-50% in richer coral reef areas and this could be explained as an attainment of management by Tanga Coastal Zone Development Program ((Makoloweka and Shurcliff, 1997; Wells et al., 2007) in MC Clanahan.et al., 2009). In 2007, dynamite fishing resurfaced and hence coral degradation (Kaehler et al 2007/8).

2.1.4 Mafia Island Marine Park

Before 1998, Mafia reported to have good corals since 1995 above 50%. However afterwards, coral bleaching caused death and live hard corals reach up to about 10% ((Gaudian & Richmond, 1990; Obura, 2004) in Gill et. all., 2015, Garpe & Ohman (2003) and (Wilkinson, 1998 in Wagner 2004). From 1999 to 2001 it was found that coral reef was between 20% -30% (Mohammed et al., 2000, 2002 in Wagner 2004). The findings by Gill et. Al., 2015 indicate that

the mean percentage cover of Hard Coral reefs within the MIMP to be 44.5%; 33.9% in the General zone, 52.5% in the Specified zone, and 35% in the Core zone, respectively and Macro and increased percent of Macro Algae. This monitoring show an average hard coral cover of 39% within MIMP and 23% of Macro Algae.

2.2 Invertebrates

From Table 1, result show average density of invertebrates in all the stations with limited to variety of invertebrates. Among all the invertebrates' sea urchins was observed to be dominated invertebrates with density up to 0.52 and o.62 individuals/m^2 in DMRs and MBREMP respectively. Although the density of sea urchins is higher compared to other macro invertebrates, previous studies show the density of sea urchins in places like Mbudya and Bongoyo is decreasing over the years that is in 1999density of sea urchins was 56 and 21.5 individual in M^2 and in 2004 it was 21.5 and 12.3 individual in M^2 in Mbudya and Bongoyo respectively (Julius et al 2008). An increase in sea urchins could be due to overfish of their predators and hence successful settlement or recruitment (McClanahan, 1998 in MC Clanahan et al., 2009).

3.0 References

1. Garpe K.C & Öhman M.C (2003 Coral and fish distribution patterns in Mafia Island Marine Park, Tanzania: fish–habitat interactions *Hydrobiologia* 498**:** 191–211.
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3. Julius A, Ndagala J and Muhando C (2008) An assessment of coral reefs in the Dar es salaam marine reserves**,** CRTR – Zanzibar Center of Excellence, Institute of Marine Sciences, Zanzibar 17pp
4. Machano H (2011) Programme status of coral reefs in Rufiji, Mafia and Kilwa, Report on coral reef vulnerability monitoring, WWF RUMAKI SEASCAPE. 21pp
5. MC Clanahan T. R., Muthiga N. A, Maina J, Kamukuru A.T. and Yahya S. A.S (2009) Changes in northern Tanzania coral reefs during a period of Aquatic Conserv: Mar. Freshw. Ecosyst. 19: 758–771
6. 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

1.2 By Musa Ally

1.0 RESULTS

1.1 Benthic categories

1.1.1 MBREMP

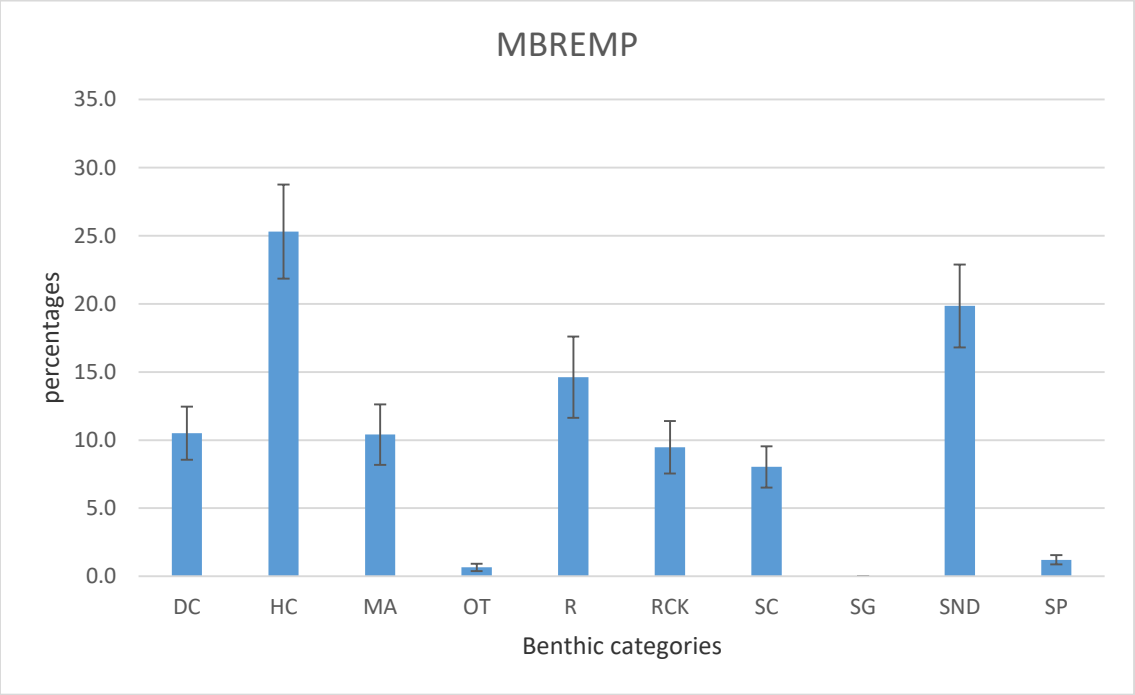


Figure 1

From LIT finding show that the percentage cover of hard coral is relatively large among the benthic categories, followed by sand. The number of rabbles and dead coral is relatively high where by small amount of sponge were found (figure1.

1.1.2 DMRS

LIT result reveal that in DMRS there is high percentage cover of hard coral than other categories however there are significant number of rabbles and dead coral. Sponge have least percentage cover in DMRS (figure 2).

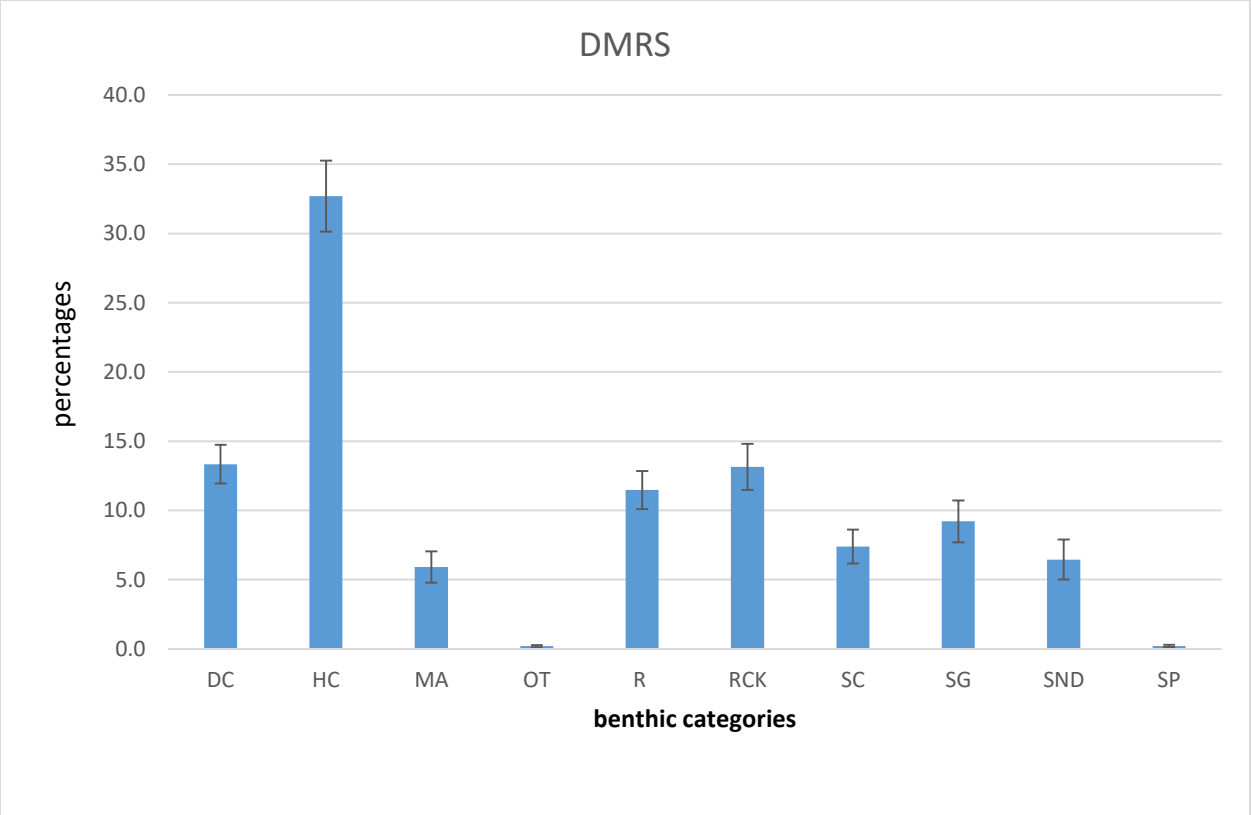


Figure 2

1.1.3 TACMP

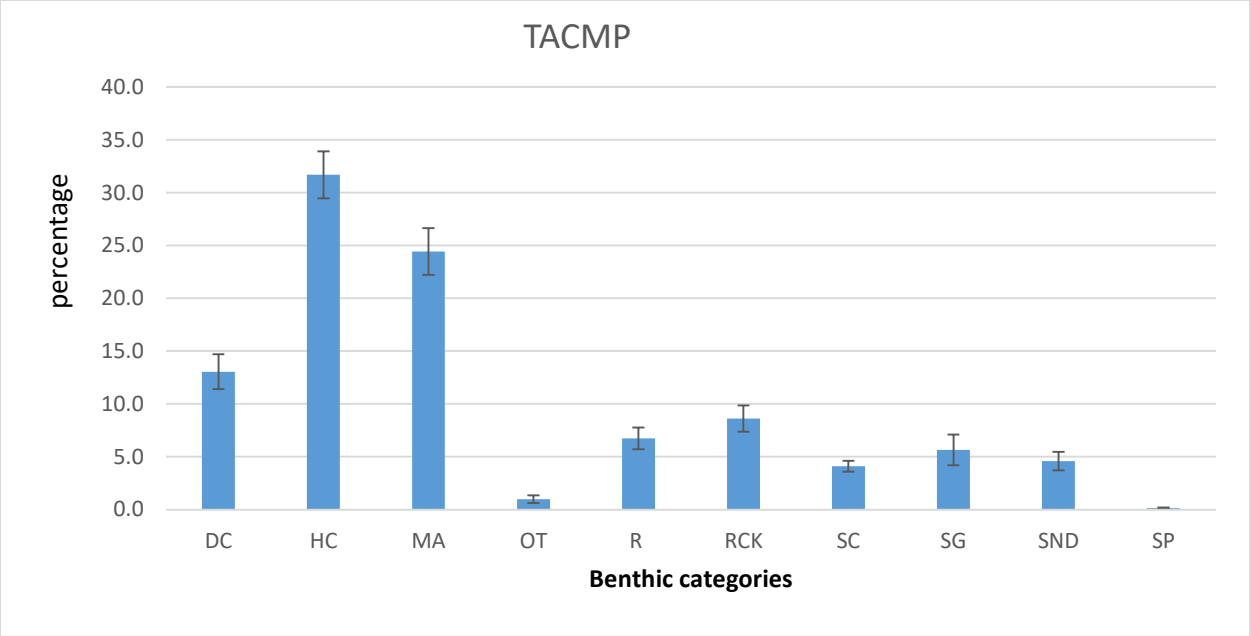


Figure 3

From LIT results percentage of hard coral at TACMP is high than all other benthic categories. Significant amount of dead coral was observed and least percentage cover of sponges (figure 3).

1.1.4 MIMP

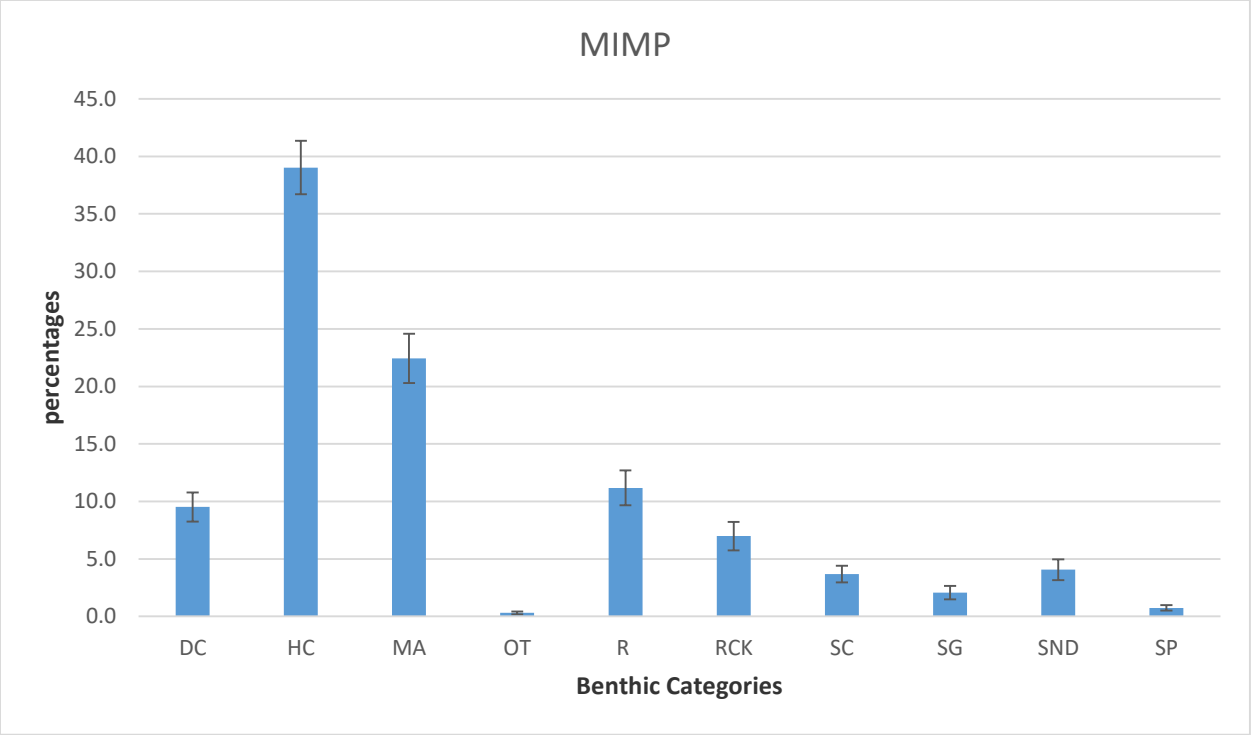


Figure 4

From LIT findings reveal that hard coral percentage cover at MIMP was higher than all other categories followed by Marco-algae. Considerable amount of rabbles and dead coral was observed.

1.2 Invertebrates

Table 1: Invertebrates densities

		NUMBER OF INVERTEBRATES/ SQM					
CATEGORIES	MBREMP		DMRS		TACMP		MIMP	
	INV sum	densities	INV sum	densities	INV sum	densities	INV sum	densities
Crabs	0	0	2	0.000816	1	0.0004	0	0
Crown Of Thorns	0	0	2	0.000816	2	0.0008	0	0
Gastropod	2	0	11	0.00449	3	0.0012	0	0
Sea Cucumber	5	0.000392	39	0.015918	20	0.008	1	0.000392
Sea Urchins	464	0.119608	1136	0.463673	265	0.106	305	0.119608
Star Fish	90	0.03451	442	0.180408	433	0.1732	88	0.03451
tiger cowries	2	0	0	0	0	0	0	0

From belt transect findings show that density of motile invertebrate was relatively small in all four Marine protected areas. Only four categories has been observed (table 1). Sea Urchins is the most dominant invertebrate in all protected areas. Dar es Salaam Marine reserve leading in the abundance of sea urchins and TACMP was least. DMRS also leading on the availability of Star fish followed by TACMP (Table 1). Crown of Thorn observed only in DMRS and TACMP.

1.3 Fish densities

Table 2: Fish densities in four Marine protected areas

MPAs	Fish density/ha	SE	N
MIMP	596613	5919	12
MBREMP	21230	128.89	12
TACMP	12723.2	88.23	13
DMRs	4222	24.587	11
	Fish density/msq		
MIMP	59.66		
MBREMP	2.12		
TACMP	1.27		
DMRs	0.42		
	No. Family	No. Species	
MIMP	36	139	
MBREMP	35	94	
TACMP	27	82	
DMRs	23	66	

From belt transect result reveal that there was high fish density at MIMP, followed by MBREMP where by DRMS is the least in fish abundance. MIMP also leading in the number of family and species observed followed by MBREMP and the least was DMRS.

2.0 Discussion

2.1 Benthic cover

Coral reef is among of keystone marine ecosystem of which most of marine organisms depends on during their development stage of life cycle. More than 70 percent of the fish catch of the country depend on reef fishery. The study was aim to assess the status of the reefs within four Marine protected areas includes MIMP, MBREMP, DMRS and TACMP with aid from World Bank via SWIOFISH project. LIT was used to assess the benthic cover of the reef, a total of twenty one (21) reefs was survey during this study.

Generally live hard coral cover at MBREMP is not in bad condition however result show that there was decline of coral abundance from average of more than 40% after 1998 bleaching event (Guard et al, 1998a, Drwall & Guard, 2000 and Mohammed et al 2000) to lee than 26% (figure 1). Decreas of coral cover contributed by natural phenomena like rise of surface sea temperature (El Nino) of 1998 and 2016. Predation (like Crown of thorn star fish and sea urchins (morgan 1988) also accelerate degradation of the reef. Blasting and using of unsustainable fishing gears (pull nets) is the big threat mostly reduce large population of the reef (guard (2000) and using of unsustainable fishing gears (pull nets)

Result reveal that status of coral at DMRS generally in good condition although there is slightly decrease of coral cover from over 38% after 1998 leaching (wagner, 2004, Mhando, 2009) to

less than 35% after 2016 bleaching (figure 2). Climate change unsustainable fishing and also using of explosive destroy reef structure (Wagner, 2004). Figure 2 show the evidence of practice of unsustainable fishing practices by observing number of rabbles within DMRS, Fungu Yasin mostly impacted by unsustainable fishing among all reefs surveyed in Dar marine Reserves.

Status of the live coral cover at TACMP was in good condition compare the situation after 1998 bleaching where by the average cover was 24% (Wagner, 2004 and Mhando , 2009). Study show that there are significant increase of coral cover from 24% of 1999 to more than 31% 2016. However dead coral and rabbles were observed during this survey (figure 3) which could be result of natural hazards like El Nino and human threats like use of explosive and unsustainable gears (Wagner, 2009).

Among four MPAs MIMP has batter live coral coverage than all (figure 4). Since 1998 bleaching event MIMP coral show remarkable recover from less than 18% (Mohammed et al 2000 and Mhando 2009). Despite of having reef in good condition but dead coral and rabbles observed during this study (figure 4). Climatic change and predation could be the reason of coral damage but unsustainable fishing gears, anchor damage and use of explosive has great contribution on destraction (Guard, 2000, Wagner, 2004 and Mhando 2009)

2.2 Invertebrate

Generally results show that there are high sea urchin density in all four MPAs. DMRS observed to have highest sea urchin proliferation than all other MPAs. Presence high densities of sea urchin is the result of unsustainable fishing practice like pull net which lead to overfishing of *Balistidae (yellow striped Trigger fish) mostly reduce population of sea urchin (Mhando,2009 and* Mcclanahan, 2009), (table 1). High density of urchin will increase rate of predation of live

hard coral result degradation of reef structure (Mcclanahan, 2009). Small population of other invertebrates may be contributed by destruction of the reef structure mainly support living of large number of marine life (Mhando, 2004, Mcclanhan, 2009, Mhando, 2009 and Frontier, 2015) (figure 1-4).

2.3 Fish densities and species richness

Study show that MIMP have relatively high density and number of species observed than all other MPAs within the country (Table 2) (Frontier 2015). Other protected areas has relatively low densities but DMRS has least fish availability (Table 2). Reduction of fish densities along the coast of Tanzania highly cause by unsustainable fishing practice include sein net fishing and dynamite fishing from late 1980's to the mid of 2000 (Garpe, 2003 and Mcclanhan 2009). Degradation of coral reef due to climatic change (El Nino 1998 and 2016) and predation and also use of dynamite especially in Mtwara, Dar es Salaam and Tanga (figure 1-4 and Table 2) (TCMP, 2001, Garpe, 2003 and Mcclanahan, 2009). Generally number of species in MPA's is relatively small (table 2), use of dynamite and sein net fishing could be the reason of degradation of the reefs hence impacted the reduction of fish communities and other marine organisms (Iswalala, 2016).

1.3 By Julius Pagu

1. RESULTS

1.1. MBREMP Benthic category

Benthic category in Mnazi Bay Ruvuma Estuary Marine Park (Figure 1) it describes high level of Hard coral cover which is about 25% than other category in the given MPA. The lowest percentage category was other category with less than 1%. Line intercept transect (LIT) by English et al 1994 was adopted.

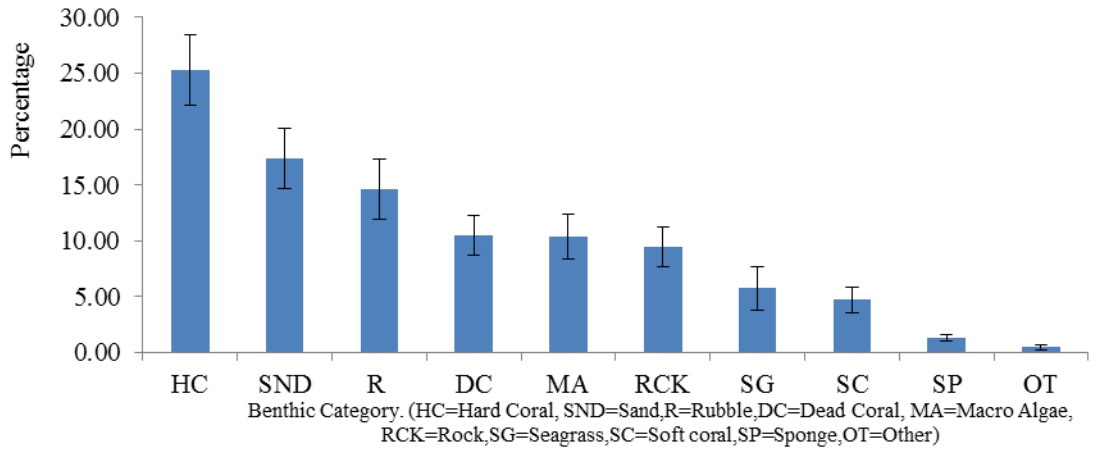


Figure 1: MBREMP Benthic category.

1.2. TACMP Benthic category

Hard coral (HC) which is about 32% was the highest in MBREMP (Fig2) than other benthic category followed by Macro algae. However lowest parentage category were sponge with less than 1%. Also line intercept transect (LIT) by English et al 1994 was adopted.

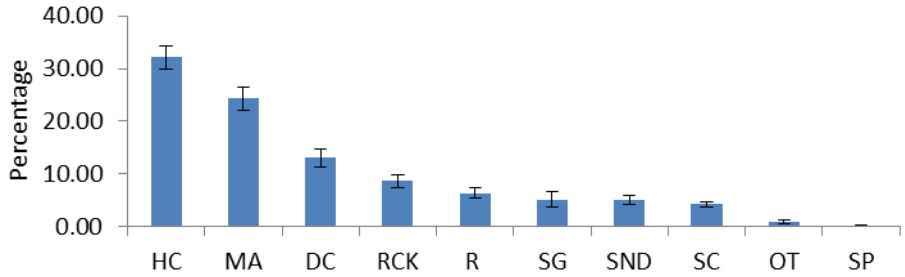


Figure 2: TACMP Benthic category

1.3. MIMP Benthic category

High level of Hard coral (HC) about 40% followed by Macro algae (MA) above 20% was revealed (Fig.3). The lowest parentage category was sponge and others 1%. Line intercept transect (LIT) by English et al 1994 was adopted

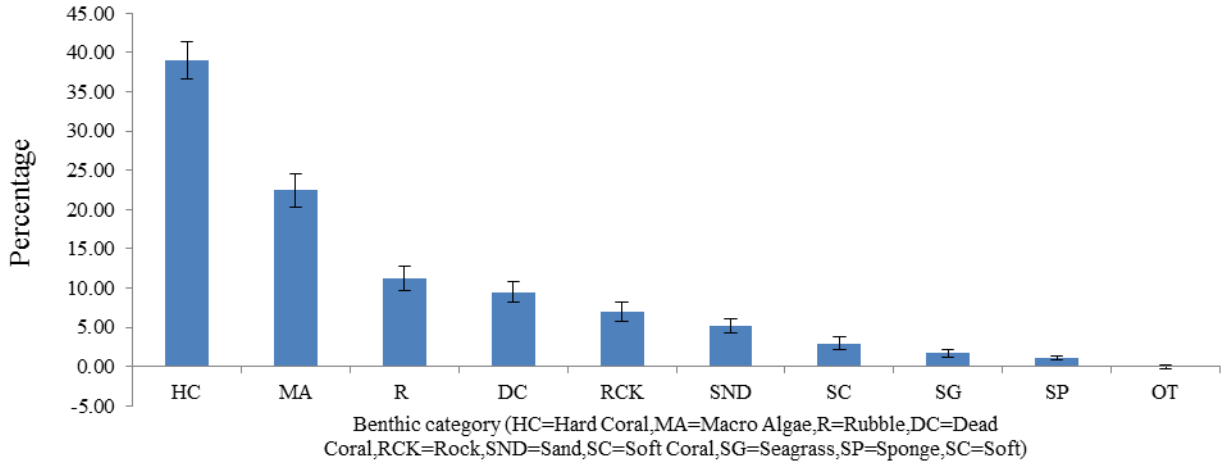


Figure 3: MIMP Benthic category

3.4. DMRs Benthic Category

Hard coral cover category was the highest among others (Fig. 4). Rock, Dead coral Rubble and seagrass was almost similar in level. Line intercept transect (LIT) by English et al 1994 was adopted

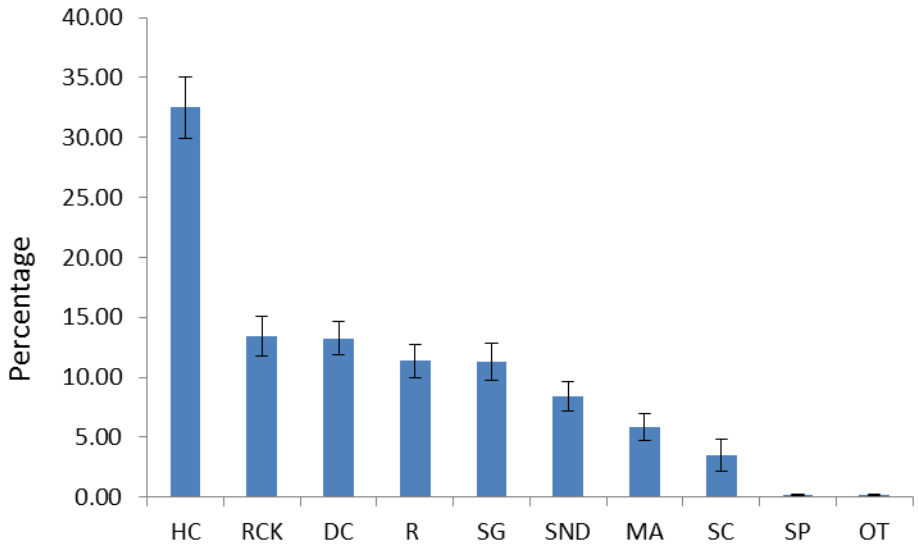


Figure 4: DMRS Benthic category

1.5. Fish Population

1.5.1. Fish density

Fish was assessed in 50*5m transect size with 12 transect at MIMP and MBREMP,11 in DMRs and 13 in TACMP both resulted to 596613 fish/ha in MIMP, 21230 in MBREMP,12723 in TACMP and 4222 in DMRs or Approx 59.66fish/msq,2.12fish/msq,2.27 fish/msq and 0.422 fish/msq in the MPA respectively. Also fish family structure in the MPAs reflected similar trend (Table1) and (Table 2) respectively. For size class more than 80% were small bodied fish members mostly damsel fishes (Fig 3).

Table 1: Fish density in MPAs

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

Table 2. Fish family in the MPA

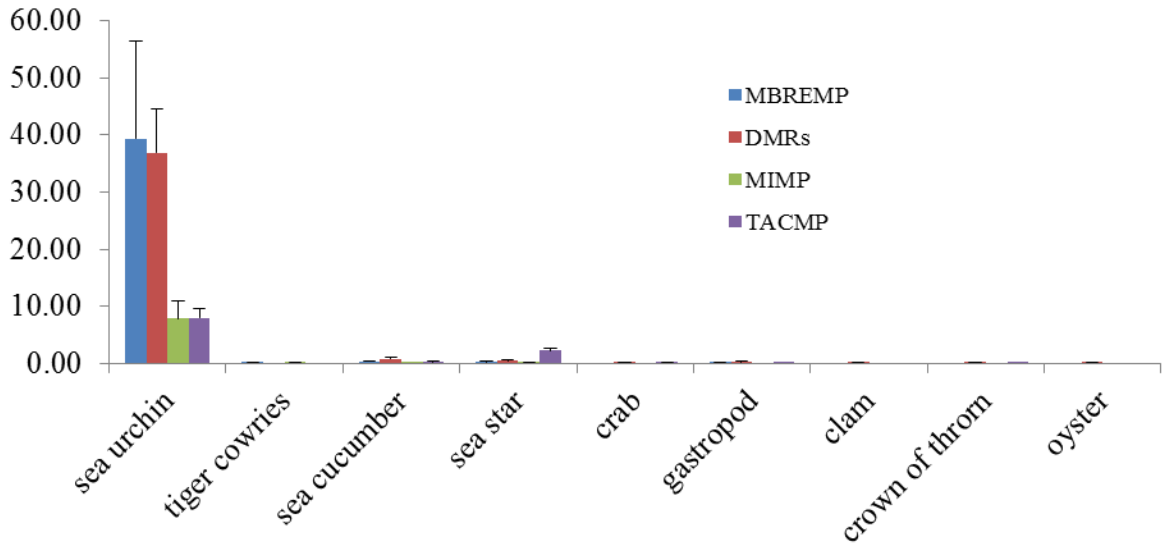
	MIMP	MBREMP	TACMP	DMRs
No. Family	36	35	27	23
No. Species	139	94	82	66

Table 3. Fish size class in MPAs

	SIZE CLASS (CM)								
	3-10	10-20	20-30	30-40	40-50	50-60	60-70	>80cm	**TOTAL (%)**
MIMP (Size class (%)	98.62	1.11	0.13	0.09	0.01	0.02	0.01	0.01	100.0
TACMP (Size class (%)	82.49	16.11	1.31	0.10	0	0	0	0	100.0
MBREMP (Size class (%)	92.28	6.70	0.97	0.03	0	0	0	0	100.0
DMRS (Size class (%)	80.88	15.76	3.27	0.09	0	0	0	0	100.0

1.6. Invertebrates

Invertebrates were counted in 10*2 m belt transect at MIMP where 33 transect, DMRs 34,MBREMP 14 and 32 transect at TACMP. Sea urchin was leading population in all MPAs however was at different level (Fig 5).



2. DISCUSSION

2.1. MBREMP

Live coral cover in MBREMP indicated at (Fig 1) hard coral cover about 25%. In Mnazi Bay, before the 1998 coral bleaching event, the outer reef had an average hard coral cover of 40% and inside the Bay Hard coral cover was 60%, (Wagner, 2004)

Accounting for result on the 1998 bleaching event, 15–25% of corals bleached in Mnazi Bay, with 50% survival of the corals after bleaching (Wilkinson, 1998). At Matenga and Kati, live coral cover dropped from 55 and 60% in 1997 (Guard et al., 1998b) to 28 and 42% in 1999, respectively (Mohammed *et al.*, 2000). However accounting to current finding coral cover were less than 60% possible due to bleaching 1998 and early 2016 bleaching event and unsustainable fishing practice.

2.2. TACMP

Current findings in TACMP reflect high coral recovery if compared to the 1987 reports by IUCN which indicated only 20% live coral cover, while some areas had less than 10%. Also extensive survey conducted in 1995 for 58 reef 12% was completely destroyed by dynamite fishing practice and bleaching event, 12% in poor condition, 52% in moderate condition and 24% in good Condition (Wagner, 2004). Monitoring established by TCZCDP in (2000/2001) Generally

hard coral cover in closed reefs of MPAs it rose from 32% (± 14%) to 51% (± 3%) in 1998 and 2003 respectively. Comparing with current findings about 32% hard coral cover it has an indication of coral decline possibly due to destructive fishing such as drag net fishing observed and dynamite as well as recent bleaching event.

2.3. MIMP

Live coral cover in MIMP indicated at (Fig 3) Hard coral and Soft coral it is about 40% it has a reflection of high abundance to other marine organism in the MPA such as reef fish where by almost 45% if soft coral is accounted it is live coral cover benthic category. Coral reef has been reported useful for nourishment, nursery MPA and hiding places to marine organisms (Beukers & Jones, 1997). This finding reported live coral cover which was revealed with other existing reports about coral healthy particularly before coral bleaching which was 50% (MIMP, 2016). However current status on MPAs coral reef monitoring MPA is about 30% which resulted from impact of the 2016 bleaching event where some monitoring MPAs coral reef most branching coral dead where Bleaching was worse in shallow waters (reef flats) than in deeper waters

2.4. DMRs

Live coral cover in DMRs indicated at (Fig 4) is high compared to rest category 33% it reflect decline if compared to recent studies in the DMRs 2014/15 before bleaching indicated 47% (Julius). Decline possibly due the early 2016 bleaching event where some branching coral died. Previously maximum percent cover in the reserve were reported to be 81.2% in some MPAs but declined to 37% after the 97/98 bleaching event at west Bongoyo (Kamukuru, 1997). Carrying out rapid assessment around Mbudya entire circumference was 40–60% hard coral structures had died because of 1998 bleaching event (Wagner *et al*., 2001). At Pangavini the reef was primarily rubble (77.5%), due to extensive damage by dragging seine nets, dynamite fishing and storms (Mrema, 2001). Fungu Mkadya was dominated by coral rubble (60%), probably mainly a result of dynamite fishing (Bipa, 2000). At Fungu Yasin, a large area on the southwest side was almost 100% rubble, which may be attributed to a combination of destructive fishing and coral bleaching (Peter, 2002). Evaluating both 1998 and 2016 bleaching event with facts above the 1998 event was worse.

2.5. Fish Population

Fish were counted along 50m long line transect using SCUBA based on common visual census technique (McCormick & Choat, 1987) with maximum of 13 transect and four sampling days. All fish within 2.5 m on each side of the line transect were counted, and keeping an average swim speed of 2.5 m/min and the total length of individuals was estimated to the nearest 10 cm length interval (3-10 cm, 10-20 cm, 20-30 cm, etc.). Identification of fish species was made based on Liske & Myers (2002). Fish <3 cm was not included in this survey, since identification of juvenile fishes from this size category is hard using this technique.

Fish population structure revealed significant differences in fish abundance, distribution and composition between the MPA's in terms of density and class size MIMP revealed high level followed by MBREMP however DMRs wa the least, Similarly for size category MIMP has most size class to above 80cm individuals length but the rest MPAs maximum length observed was 40cm. Some species possibly under estimated due to the nature of the study did not account for seasonality and nocturnal fishes most active at night such as haemulids is among of individuals possibly under estimated by this study. Other study in Tanzania MPAs revealed similar trend where Pomacentridae (damselfishes) was the most numerous fish family in coral reefs (Skoglund, 2014; Julius et al., 2016) as revealed by current findings where population was dominated by member from family Pomacentridae in all MPAs (Annex 1). Similarly four families (butterfly fish=Chaetodontidae, damsel fish=Pomacentridae, surgeonfish=Acanthuridae and wrasse=Labridae) among of family with most species of typical coral-reef fishes was revealed by other study (McClanahan, 1999).

2.6. Invertebrates

Invertebrates were high at MBREMP and DMRs whereby was approx 40individuals/20msq and were few at MIMP and TACMP with Approx of 8 individuals per/8msq. High sea urchin population at MBREMP and DMRs is an indication of overfishing of Triggerfish where by fish data reveals the two MPAs had the lowest population in Triggerfish (Annex 1).Specifically This is largely attributable to the reduction of the red-lined triggerfish Balistapus undulatus and other sea urchin predators by fishing (McClanahan *et al*, 1999). Furthermore it has association with

rubble substratum category were by the two MPAs were among of the highest rubble percent (Annex 2). Sea urchin abundance in DMRs and MBREMP is approaching status reported in 1999 by McClanahan when compared protected and un protected areas population was six times higher than in unprotected area. Accounting for current status it is about five times higher in DMRs and MBREMP than in TACMP and MIMP. Here, sea urchins are spatially constrained herbivores and typically consume algal turfs and macroalgae intensely on a small spatial scale (Humphries, 2015) which was revealed at DMRs and MBREP with least Macro algae MPAs (Annex 2). Sea urchins are bioeroders 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). Accounting for invertebrates in all MPAs urchin was only at high level and rest was minimal population. Other study reported it resulted in sea urchin proliferation, leading to their being more abundant (with an average density of 2individuals per m^2 (Kamukuru, 1997) which is similar to current findings

ANNEX 1. FISH FAMILY

	MPAs			
Fish family	**MIMP**	**TACMP**	**DMRs**	**MBREMP**
Acanthuridae	14	5	1	5
Apogonidae	5	1	3	3
Aulostromidae	1	0	0	0
Balistidae	6	2	0	1
Blenniidae	2	2	3	2
Caesionidae	2	1	0	1
Carangidae	1	1	0	1
Centriscidae	1	0	0	1
Chaetodentidae	18	12	8	13

Cirrhitidae	2	2	1	2
Clupeidae	1	1	0	1
Dasyatidae	0	0	1	1
Diodontidae	2	0	0	1
Ephippididae	0	0	0	1
Echeneidae	1	0	0	0
Fistulariidae	1	2	2	1
Haemulidae	1	1	1	2
Holocentridae	11	2	0	4
Kyphosidae	1	1	0	1
Labridae	11	10	9	6
Lenthrinidae	5	3	3	2
Lutjanidae	4	2	3	4
Monacanthidae	2	1	1	1
Monodaclylidae	0	0	0	1
Mulliade	3	3	1	3
Muraenidae	1	0	0	1
Nemipteridae	1	0	1	0
Ostraciidae	0	0	0	1
Pemhheridae	1	1	0	0
Pinguipedidae	1	1	1	1
Plotosidae	1	0	1	1
Pomacanthidae	3	0	0	5
Pomacentridae	18	17	18	16

Scaridae	3	4	1	4
Scorpaenidae	1	1	1	1
Serranidae	7	1	0	1
Siganidae	1	1	1	1
Synodontidae	1	0	1	0
Tetraodontidae	4	4	3	3
Zanclidae	1	0	1	1
TOTAL	**139**	82	66	94

ANNEX 2. BENTHIC CATEGORY IN ALL MPAs

1.4 By Humphey Mahudi

1.0 RESULTS

The survey of reef status in Tanzania Marine Protected Areas was through examining benthic categories and reef invertebrates composition using LIT and belt transect respectively.

1.1 Benthic categories

The results for survey of benthic categories in all Tanzanian MPAs (MIMP, DMRs, TACMP and MBREMP) generally showed that the percentage of live hard coral cover is above 25%.

1.1.1 Benthic categories at Mnazi Bay and Ruvuma Estuary Marine Park

The results showed that live hard coral cover is higher than other benthic categories at about 25% while higher percentage of sand cover (> 15%) was observed as compared to other MPAs (Figure 1)

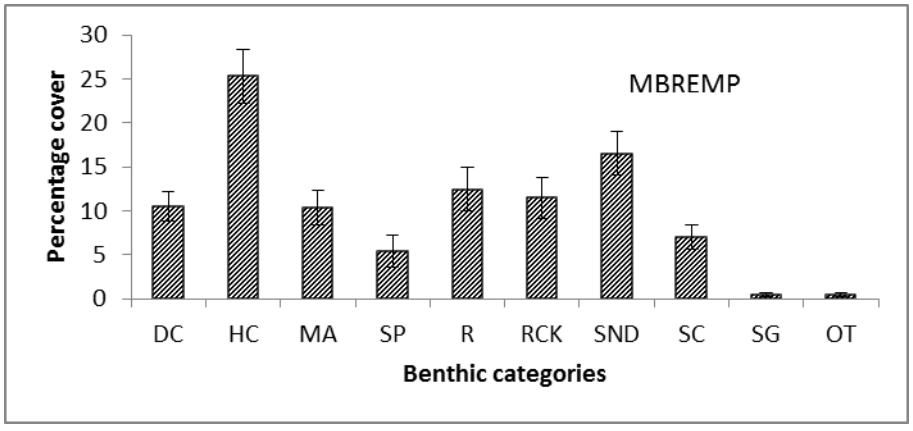


Figure 1: The average benthic cover in five coral reef MPAs at Mnazi Bay and Ruvuma Estuary Marine Park

1.1.2 Benthic categories at Dar es Salaam Marine Reserves

In DMRs live hard coral cover was observed to be relatively higher (30%) than other benthic categories (Figure 2).

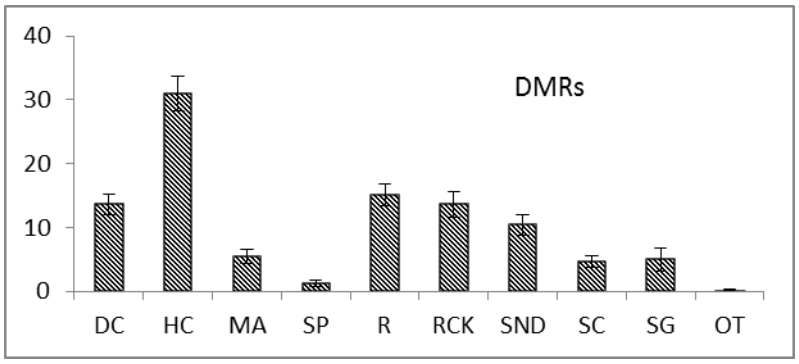


Figure 2: The average benthic cover in five coral reef MPAs at Dar es Es Salaam Marine Reserves (DMRs)

1.1.3 Benthic categories at Dar es Salaam Tanga Coelacanth Marine Park

The assessment of benthic categories showed that the live hard coral constitutes 33 % and higher macro algae (25%) than in other MPAs. (Figure 3)

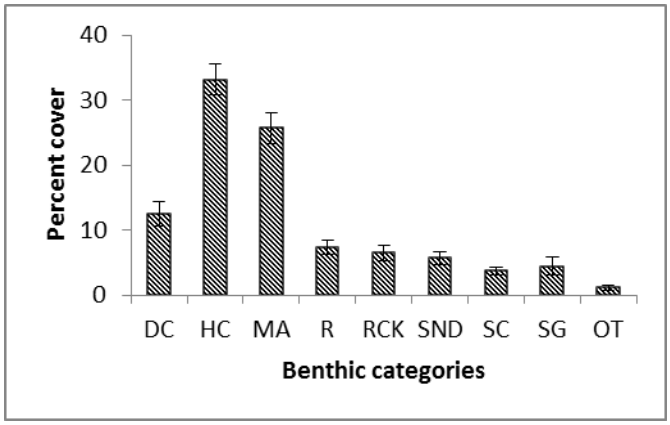


Figure 2: The average benthic cover in six coral reef MPAs at Tanga Coelacanth Marine Park (TACMP)

1.1.3 Benthic categories at Dar es Salaam Mafia Island Marine Park

The results revealed that MIMP have the higher live hard coral cover at above 35% and highest to other MPAs (Figure 4)

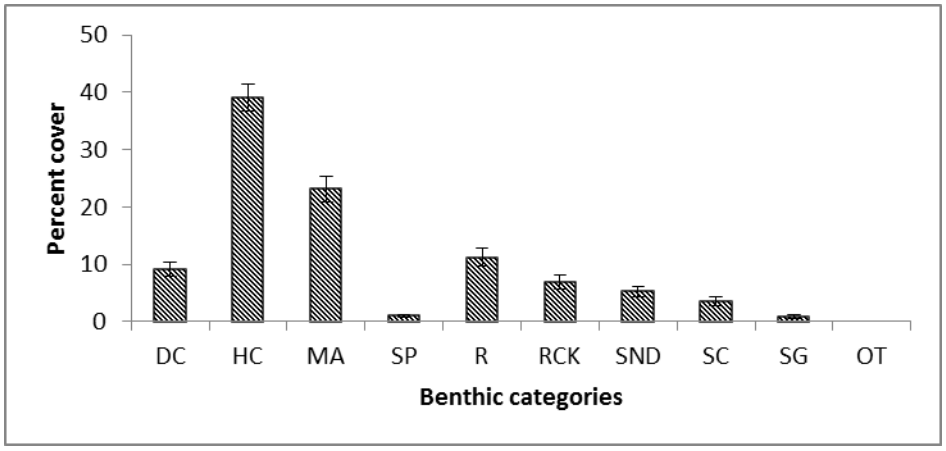


Figure 4: The average benthic cover in six coral reef MPAs at Mafia Island Marine Park

1.2 Survey of reef invertebrates

The assessment of reef invertebrates using a belt transect of $50m^2$ in all MPAs revealed that sea urchins are predominant invertebrates in all MPAS, however higher numbers (> 20 indv /50 m^2) was observed in MBERMP and DRMS (Figure 5)

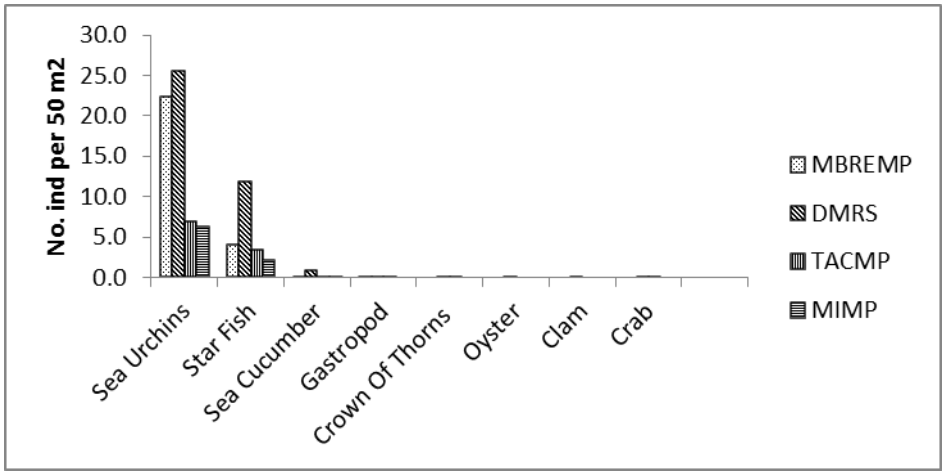


Figure 5: average number of reef invertebrates as surveyed in MBREP, DMRs, TACMP and MIMP

2.0 DISCUSSION

2.1 Benthic cover in three MPAS

Corals are the major building blocks of coral reefs by excretion of calcium carbonates from their bodies which eventually piles and forms hard structures which are generally known as live hard coral. Coral reefs have fundamental ecological importance for marine life as it serves as habitat, breeding, feeding and nursery grounds.

Benthic cover in three MPAs was assessed through the use of LIT method as described in the methods.

The results indicates that in all MPAS the coral cover is more the 25 % which is above average coral cover in Western Indian Ocean reefs which 22.1 % in 1997 (Bruno and Seling 2007). This is because the surveyed reefs are in the protected areas in which there is maximum level of protection for more than 10 years hence regeneration and recruitment of coral can occur with minimal physical disturbance. Furthermore, almost of the MPAs are archipelagos hence the coral reef allow flow coral larvae between the reef hence high coral productivity (……..).

2.1.1 Benthic categories at Mnazi Bay and Ruvuma Estuary Marine Park

The results for benthic categories indicates that MBREP has 25% live hard coral cover while sand cover is above 15% which is higher than what found in other MPA. The result for live hard coral relatively conforms to 28% that observed in 1997 (Guard *et.*, 1998). The earlier surveys indicates that in MBREMP live hard coral ranged from 45- 70% (in Muhando and Francis 2000 *unpublished report*) and recorded a drop over time include the elnino struck in 1999 which dropped from to 16-42 % (Mohamed 2000 and Kamkuru 1998). The other reason of this

may be due to stress resulted by destructive fishing such as pull net fishing, coral bleaching event observed in February to April 2016 and also in this study portrayed that MBREMP has high sand cover 15% than other MPRs reefs which implies that there is less hard substratum which is a condition suits for coral larvae to settle and initiate growth.

2.1.2 Benthic categories at Dar es Salaam Marine Reserves

In DMRs live hard coral cover was observed to be 30% which is higher than other benthic categories, while rubbles, dead coral, rocky and sand are above 10%. This result was also observed in 1997 and 1998 in which live hard coral cover range of 27-40% (Mclanahan, 1998) and (Kamkuru, 1999). However the live coral cover has been decreasing from 70 -80% in 1975 (Hamilton and Brakel, 1984) to 36-59% (Kamkuru, 1998) and 50-66% (Mohamed, 2000). The decrease was contributed to many reasons including bleaching event of 1999 which killed a number of *Acropora* and during coral regeneration the composition changed to *montipora, Fungia, Porites* and *Galaxea* (Muhando and Francis, 2000 *unpublished report*). Other factors to unsustainable fishing practices such as beach seine and occasional blast fishing, Also DMRs Islands receives many tourists hence impacts coral through trampling and crusing speed boats by action of propeller breaks coral and suspends turbid water that retard proper coral growth.

2.1.3 Benthic categories at Tanga coelacanth Marine Park

Benthic cover at TACMP is 33% live hard coral cover and followed by Macroalgae 25% and other categories are less than 15% cover . The finding of live hard coral cover in this study conform to that observed in a range of 45- 70% (in Muhando and Francis, 2000 *unpublished report*). High macroalgae cover (25%) particularly that overgrow on coral has implication on coral regeneration

2.1.4 Benthic categories at Mafia Island Marine Park

According to survey conducted in earlier MIMP was indicated to have higher coral cover (39%) than in other MPAS (Figure 4) which also observed in 1997 (Kamkuru, 1998) . coral cover at Mafia reefs was high for example at Kitutia live coral cover was more than 80% in 1980s , then degraded to 15% in 1999 however inside Chole bay was >30%. Live coral cover degaration was due elnino in 1999.

In addition, higher dead coral was detected at MIMP was attributed by coral bleaching, anchor damage, fishing pressure and destructive fishing. In addition Mafia higher amount of dead coral was contributed to bleaching phenomenon that occurred during March – April 2017 and slow and no recovery (MIMP annual report 2016). However dead coral in Mafia particularly at Kitutia reef was dominated by coralline algae which is an indication for coral regeneration

Higher percent of rubbles was observed at MIMP than in other MPAS this implies that coral damaged exists at higher due to increase no of tourism and other factor mentioned dead coral section. Recently MIMP receives an average of 4000 visitors per year in which approximately more than 50% visit the reefs as recreational MPA (MIMP report 2016).

2.2 Reef invertebrates

In counting invertebrates using a belt transect of 50 m^2 in all MPAs, the results revealed that sea urchin were found in every MPA whereas higher density was found in DMRs and MBREMP, 25 and 22 individuals per 50 m^2 respectively . Sea urchin density has ecological significance in which they graze on coral reef, the density of $> 2/ m^2$ will have significant effect to coral reef healthy (McClanahan, 2014) . The higher numbers indicates a decrease of reef predators which

is orange stripped triggerfish (Balistadae). The sea urchin density 25indv/50 m^2 in DMRS conforms to 2 – 32 individuals per 50 m^2 observed in 1997 (Muhando and Francis, 2000). DMRS and TACMP have been impacted by destructive fishing such as beach seine along the reserves (Kamkuru, 1998) hence decreases fish densities.

Crown of thorns was also observed in DRMs and TACMP by 0.09 and 0.03 individuals per 50 m^2 respectively> the number is below the critical number (8 individuals per 80 m^2) to be as an outbreak (Baird *et al.*, 2013).

1.5 By Benson Chiwinga

1.0. RESULT.

Line intersect Transect (LIT) method was used in all MPAs (Fig 1-4) annex1grph of corals. Findings showed that hard coral (HC) cover percentage was distributed higher than other categories.

1.1. BENTHIC COVER.

Assessment of benthic coverage in management MPAs Fig 1-4), the outcome of this assessment revealed that hard coral cover percentage in MBREMP is lower than other percentage cover in management MPAs (Fig 1)

1.1.1. MBREMP.

Findings from the management MPA showed that hard coral (HC) cover percentages recognized is less than 25%. (Fig 1).

1.1.2. DMRS.

The survey revealed that domination of hard coral cover percentage in this management MPA is less 35% (fig 2)

1.1.3. TACMP.

The assessment of this management MPA is covered that hard coral (HC) cover percentage is less than 35% (fig.3)

1.1.4. MIMP.

Hard coral coverage percentage in this management MPA is high than 35% compare with other categories.

1.2. Invertebrates

Invertebrates survey was performed in four management MPAs (Fig.1-4) by using LIT method.

1.2.1. MBREMP

Result of invertebrates in management MPA (fig 1) showed that sea urchin appeared to be higher in umbers than other categories. In percentage stands on more than 90%.this is due to two surveyors.(Musa and Mage)

1.2.2. DMRS.

Findings stated that in this MPA (fig. 2), sea urchin observed to be more than 80% of other category in area of management. Due to 3 surveyors (Chiwinga, Mage, Mussa)

1.2.3. TACMP

Sea urchin in management MPA (fig 3) observed to be more than 50%, due to data collected by three surveyors. (Chiwinga, Mage, Mussa)

1.2.4. MIMP.

Findings showed number of sea urchin in the area of survey is very low, under 0.001%

1.3. Fish.

Fish survey was performed by using transect of 50m which layed on reef and count fish and species along the line and 2.5m either sides.

1.3.1. MBREMP.

Result of surveyed area (fig 1) revealed that density of fish per msq is 2.12 without looking in fish which can be indicator of status of coral reef.

1.3.2. DMRS.

On (fig 2) findings showed that fish density per meter squared is 0.42.

1.3.3. TACMP.

Assessment on the management MPA (fig. 3) recognized that fish density in the area of management is 1.27.

1.3.4. MAFIA

The outcome of. Surveyed area, the density of fish per msq is 59.66 with different species

2.0 DISCUSSION.

Benthic line intersect transect was used to asses benthic communities on all MPAs, 10m transect line was used to survey reef and 3 transect were employed in every reef starting to deep water or

under reef to up reef, however every MPA, five reefs were surveyed except MIMP was six reef, there for total transects per MPA was 15. Also invertebrates was surveyed by using a same method and line, a surveyor swim along the transect line and identifying any invertebrate that fall within the survey area at 2.5m either side of the transect line and taking care to look under crevices and coral where invertebrates normally found..

In general, the hard coral (HC) results indicates that in all management MPAs the coral cover is more than 25% except MBREMP is less 25% (fig.1, 3-4) which is above average coral cover in MPRU this shows health of live corals observed by (Obura and Melta 2008 codio project). This because reef in protected areas are in high level of protection mechanism than outside of MPAs.MMP has high hard coral cover percentage (fig 4) almost 40% than other management MPAs, Coral reefs have fundamental ecological importance for marine life as it serves as habitat, breeding, feeding and nursery grounds. A study observed that MIMP has high fish species density per msq about 59.66 (Pagu Fig 01 Fish species 2016). Distribution and abundance of sea urchin in three MPAs of MBREMP, TACMP and DMRS (fig 1-3) is in high this is due to three surveyors, this indicates that coral reef is in risk but in MBREMP is only MPA identified there are trigger fish which fight with sea urchin and help coral to sustain and to be healthily (MetthewRichmond 2002, 2nd edition)

Dead corals were observed to be somehow high coverage percentage in MBREMP, TACMP and DMRS almost <10%, this contributed by high fishing pressure uses unsustainable gears like beach seine nets and explosive for postures from outside the Parks (bad fishers) due to reports(DRMS, MBREMP and TACMP annual Report 2015. Micro algae observe to be covered on dead coral help coral lavas to touch on this and regenerate, as observed by (ECO2 report 2007)

Graph of Corals

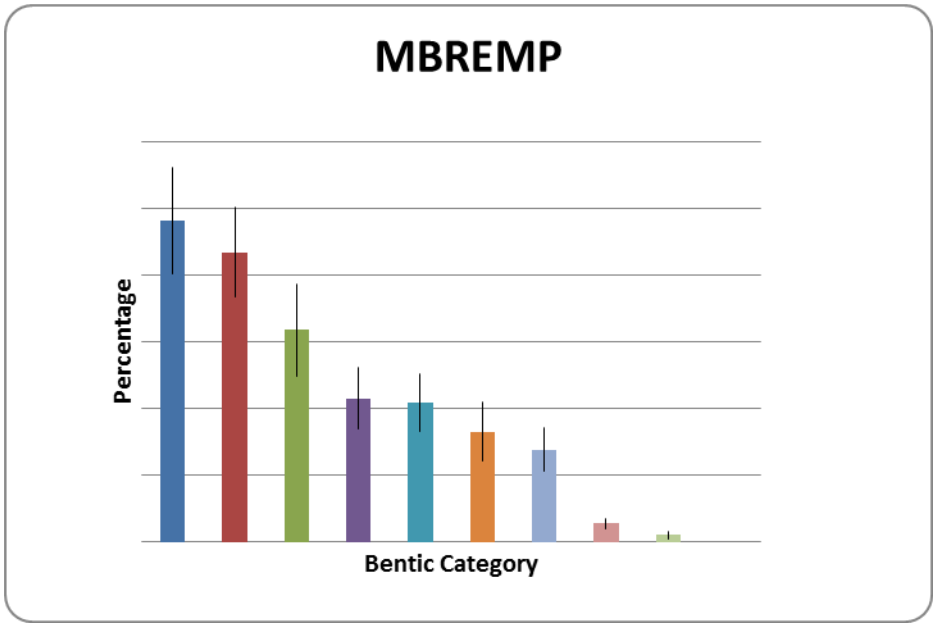


Figure 1- MBREMP

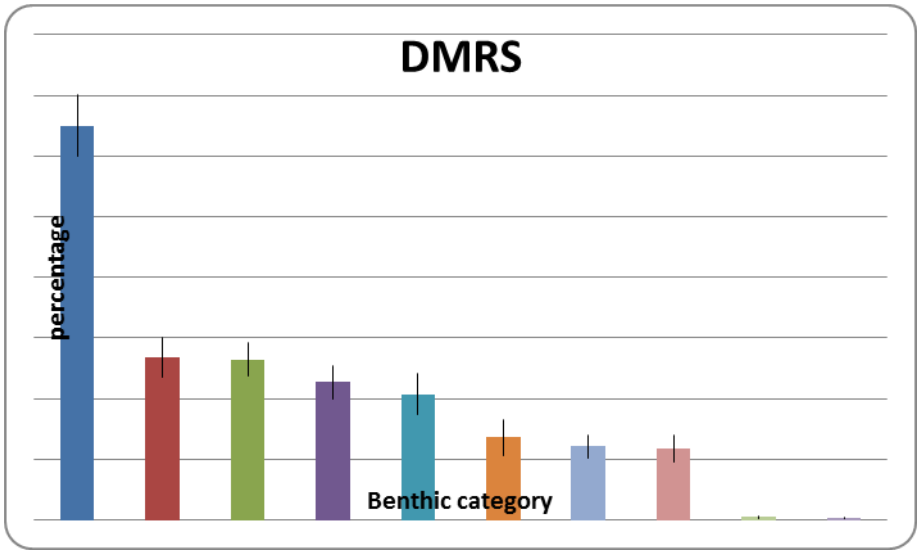


Figure 2- DMRS

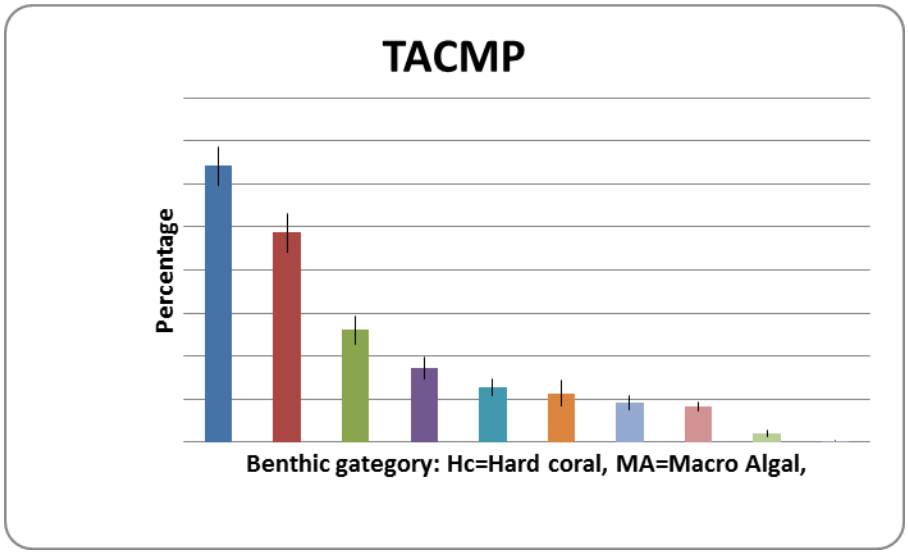


Figure 3- TACMP

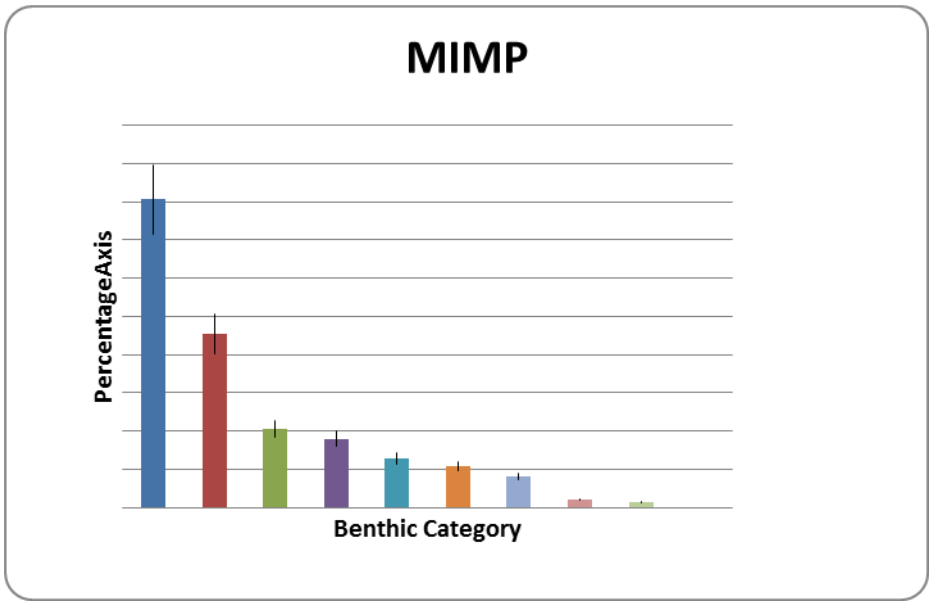


Figure 4- MIMP

1.6 By JANUARY NDAGALA

1. Result

1.1. Benthic cover - All MPAs, All MPAs

Results show that hard coral (HC) had the highest percentage cover 33.1% followed by macro algae (MA) 17.6% and dead coral (DC) 11.5%. Slight differences in benthic cover percent were shown among three categories, rubbles (R), rock (RCK) and sand (SND) but they all generally ranged between 9.2% - 10.2%. The rest of the categories had benthic cover below 5%, with other invertebrates (OT) and sponge (SP) showing significantly low contribution to the overall benthic cover.

Figure 1. Benthic cover (%) estimates overall – All survey MPAs' data pooled to provide an overall benthic cover estimates within MPRU.

1.2. Benthic cover - MPA data

MPA specific data indicate that, hard corals dominated benthic cover categories in every MPA surveyed (Fig. 2), ranging from 25.3% in Mnazi Bay-Ruvuma Estuary Marine Park (MBREMP) to 28.9% in Mafia Island Marine Park (MIMP).

Macro algae cover was highest in Tanga Coelacanth Marine Park (TACMP, 24.3%) followed by MIMP (22.4%) while in MBREMP and Dar es Salaam Marine reserves (DMRs) were (10.4% and 7.6%) respectively. In all MPAs, the percentages of dead corals were fairly low, ranging in from 9.5% benthic cover in MIMP to 13.2% in TACMP.

The sand (SND) category of benthic cover 19.9% was the second dominant category after hard coral cover in MBREMP. However, the proportion of sand within all MPRU MPAs surveyed was low. Sea grass (SG) was exceptionally high in DMRs compared to other MPAs although its overall cover 10.6% was however low.

Figure 2. Benthic cover (%) estimate by MPA – Each MPA's data pooled.

2. Discussion

The observed dominance, overall, of hard coral cover in each of the MPAs surveyed is an indication of good coral condition in these areas. Most of the survey MPAs were selected in such a way to include either core zone or specifies use zones. Both zone types receive fairly high protection status or certain level of use-restrictions, which could consequently have contributed

to the overall coral cover dominance by keeping at-bay most of the activities that cause coral damage and/or mortality. Within MIMP, such MPAs are also located within Chole bay and are therefore sheltered from the influence of strong waves from the open sea, while constantly receiving cold water from tidal waters channels. The two factors further contribute to survival and replenishment of corals within Chole bay and was probably the reason for the highest (38.9%) coral cover observed in MIMP.

The lowest coral cover observed in MBREMP is probably due to a large space being occupied by sand (Fig 2). Two MPAs, Membelwa inner and Kieti are characterised by shallow reef flat with highly patchy reefs and broken reef colonies. Large portion of sand substratum leaves little, unstable space suitable for coral recruitment and growth.

The 17.6% macro algae cover was slightly above 50% the overall coral cover, and was largely contributed by TACMP and MIMP (Fig. 1). However, one MPA in MIMP - Yuyuni (outer Juani) was the largest contributor to macro algae cover in MIMP probably because the MPA has relatively deeper water exposed to strong tidal waves from the open sea which does not favour high coral larval settlement rate, hence, leaving more space for macro algae colonisation. On the other hand the higher percent of macro algae cover in TACMP could probably be due to rapid colonisation of macro algae following extensive coral damage and mortality through blast fishing, which as well end-up out-competing corals for space.

1.7 By John Mwaisaka

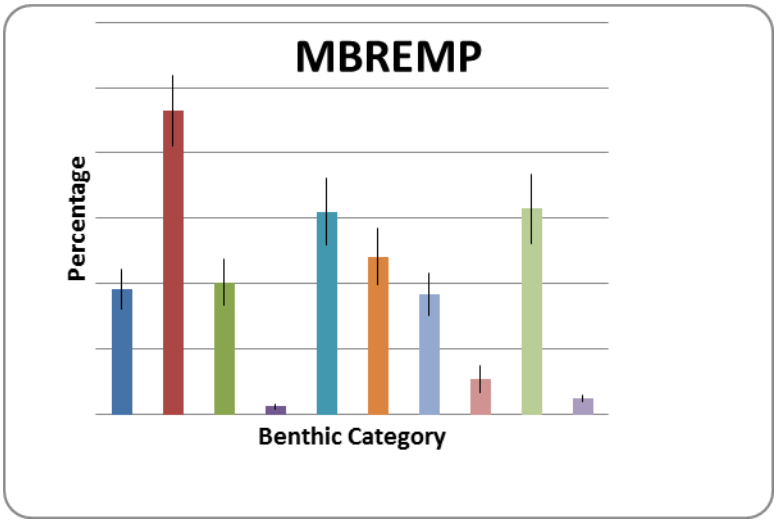


Fig.1

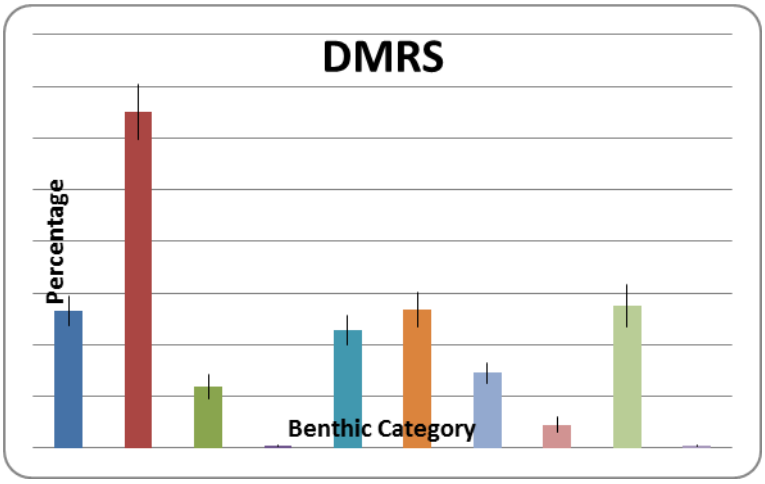


Fig. 2

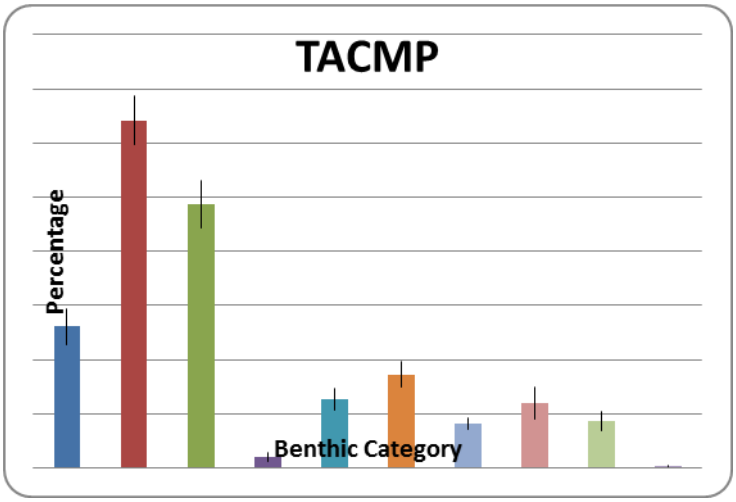


Fig. 3

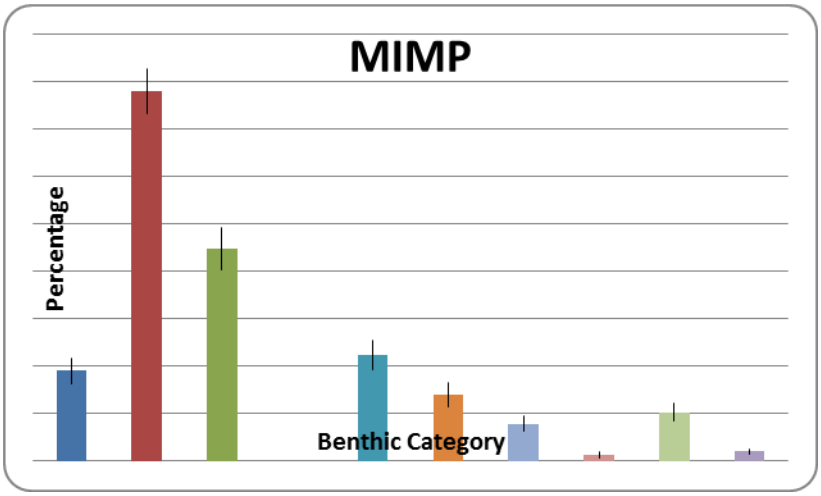


Fig. 4

1.0. RESULTS

1.1 Benthic cover

1.1.1. Benthic cover in MBREMP

From the LIT findings that were observed in Mnazi Bay Marine Park (MBREMP), indicates that ten benthic categories were observed. In the observation hard coral (HC) was dominating followed by sand (SND) and rubbles (R) categories. (Annex 1, Fig. 1)

1.1.2. Benthic cover in DMRS

With reference to the findings which were observed from Dar es Salaam Marine Reserve Systems (DMRS), hard coral was the leading cover category of the whole reef, followed by sand (SND), rock (RCK) and dead coral (DC) cover categories, while sponge (SP) had minimal cover than others. (Annex 1, Fig. 2)

1.1.3. Benthic cover in TACMP

From the findings that were observed in Tanga Coelacanth Marine Park (TACMP), it was revealed that hard coral (HC) covers the biggest area of the reefs which were viMPAd by the team. This was followed by macro algae (MA) and dead coral (DC). Sponge (SP) was the latest cover in the Park with very minimum coverage. (Annex 1, Fig. 3)

1.1.4. Benthic cover in MIMP

During the reef survey in Mafia Island Marine Park (MIMP) showed that hard coral (HC) was the leading benthic category cover in the Park. It was followed by macro algae (MA), dead coral (DC) and rubbles (R).While sponge (SP) and sea grass (SG) showed a small percentage cover in the Park. (Annex 1, Fig. 4)

1.2.0 Invertebrates

Invertebrates are animals with without back bones (Njau 1995)

1.2.1. Invertebrates in MBREMP

During the reef survey in MBREMP, It showed that sea urchins was the leading category of invertebrates at a very high range compared to other invertebrate categories and was followed by star fish category. (Annex 2, Fig. 1)

1.2.2. Invertebrates in DMRS

From the findings observed in DMRS, sea urchins was the leading category followed by star fish and then by sea cucumber categories. (Annex 2, Fig. 2.)

1.2.3. Invertebrates in TACMP

From the findings that were observed in TACMP sea urchins was the leading category. Other categories were star fish and sea cucumber. (Annex 2, Fig. 3.)

1.2.4. Invertebrates in MIMP

During the reef survey that was observed in MIMP, sea urchins were leading invertebrate category in the Park and was followed by star fish. (Annex 2, Fig. 4)

2.0 DISCUSSION:-

From the observations it show that percentages of hard coral(HC) cover and soft coral(SC) cover, when mixed together give up a good coral cover in MIMP of about 43%, followed by DMRS about 39.8%, TACMP and MBREMP beeing 36.2% and 32.4% respectively.

When dead corals (DC) and rubbles (R) are considered that they were live corals in some time ago, and also become mixed together with hard and soft corals, DMRS could had leading for about 64.4% followed by MIMP about 63.8%. MBREMP and TACMP having about 57.5% and 55.6% respectively. (Annex 1). All in all, hard corals were the leadind benthic cover in all Parks.

Rubbles were serius phenomenon in MBREMP as about 15.5% was obseved follwed by DMRS about 11.37% was observed. Also about 11.18% and 6.37% were observed in MIMP and TACMP respectively. The precence of rubbbles is the main indicator of illegal fishing especilly dynamites and seine net that was operated in the past. (Guard et al 1998).

The presence of dead coral(DC) in all parks which range between 9.51% (in MIMP) and 13.24% (in DMRS) was due to the impact of climate change on East African coral reefs. The primary threat identified was increasing water temperature. (Obura 2004).

During the survey a total of 40 families of fish were identified in all MPAs(Annex 3) whereby families of Pomacentridae and Chaetodontidae were the richest in all MPAs. This richness was followed by Labridae, Acanthuridae and Tetraodontidae.

3.0 REFERENCES

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