Biodiversity Surveys of Hard Corals (Scleractinia) in the Mafia Island Marine Park, Tanzania

Conducted by:

David Obura

CORDIO East Africa
P.O.BOX 10135 Mombasa, Kenya
Tel/fax: 005-41-5486473
dobura@cordio.info

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SUMMARY

The Mafia Island Marine Park (MIMP) is located in southern Tanzania, in the center of the East Africa Marine Ecoregion. Coral reefs in the MIMP are restricted to a relatively narrow band fringing the island and reef slopes, concentrated from about 6-18 m depth on outer reefs, and from the surface to 8-12 m depth on the inner banks, depending on the depth of the sand bottom surrounding reef areas. These areas suitable for coral growth vary from 10s to up to 180 m wide, and form a very small proportion of the overall subtidal shallow area of the Mafia Island system. Two small conservation reserves were established in 1970, Chole Bay Marine Reserve and Tutia Island Marine Reserve, in the The Fisheries Act (1970), however no management was implemented. By the late 1990s the Government of Tanzania had established the Mafia Island Marine Park as the first multiple-use marine protected area in Tanzania. Prior to the El Niño and coral bleaching in 1998, coral reefs in Mafia were healthy and robust, with coral cover levels upwards of 50% on most reef areas, and a count of 46 scleractinian genera. However, following widespread bleaching in 1998, coral cover fell by over 50%, with high mortality noted on the sheltered reef area on Kitutia reef but low mortality in Chole Bay.

In this study coral species diversity was sampled using timed searches and documentation with an underwater digital camera. A nominal list of 273 species in 63 genera and 15 families were identified (Table 2, Appendix 2). The Faviidae and Acroporidae were the most species-rich families with 66 and 60 species, respectively, decreasing down to 1 or 2 species in a family for the Astrocoenidae and Oculinidae. *Acropora* was the most species-rich genus (41 species), followed by *Montipora, Favia, Favites, Fungia, Pavona* and *Porites,* with 12-13 species each. Based on species accumulation curves, species diversity is predicted to exceed 300 with sufficient sampling. The highest diversity site for hard corals in the MIMP is the southwestern slope of Mange reef, with 167 species counted, where there is an extensive hard substrate shallows and a steep high-current slope. The lowest diversity site, accounting for sampling time, was Darusi, on the outer reef slope. Regionally, these surveys in Mafia documented the highest number of coral species yet recorded for a single area, being marginally higher than records from Mnazi Bay, and significantly higher than records from Songo Songo and Pemba, Mozambique. However further taxonomic work is needed to reconcile lists from the different sites and obtain more consistent species richness estimates.

Of the core zones of the MIMP, Kitutia Reef and Chole Bay, Chole Bay has a high diversity of coral species, as it includes the high-diversity sites Msumbiji, Milimani, and the long term monitoring site, as well as extensive shallows and channel reefs. Kitutia Reef had a low diversity of coral species compared to other sites, while the highest diversity site, Mange, does not have special protection status. While Kitutia Reef was reported to be diverse and robust before the El Niño, it suffered very high mortality and has subsequently been overgrown by thick fleshy algae that may inhibit coral recovery. Additinoally, the framework of Kitutia reef, having been dominated by branching *Acropora* spp. is loose, further inhibiting coral recovery.

INTRODUCTION

The Mafia Island Marine Park (MIMP) is located in southern Tanzania, in the center of the East Africa Marine Ecoregion (Kemp 2000). The South Equatorial Current meets the African mainland in southern Tanzania and northern Mozambique, after crossing the Indian Ocean from the east (figure 1). Here the main current splits north and south, forming the East African Coastal Current (EACC) and the Mozambique Current (MC), respectively. These currents flow in one direction throughout the year, though with seasonal variation in speed (and latitude for the SEC), forming a one-way conveyor for marine larvae dispersed by the currents. Because of this, southern Tanzania and northern Mozambique are considered the centers of biological diversity for the East African coast, being the first arrival point for marine species carried across the Indian Ocean. The MIMP is therefore located at the northern limit of the source point for the EACC, with strong consequences for the accumulation and subsequent dispersal of marine organisms for East Africa.

Geologically, Mafia Island and its environs are on the continental shelf off the Rufiji River, with a shallow channel (< 50m) separating it from the mainland. . The outer fringing reef is relatively continuous with the Songo Songo archipelago and reef system to the south, forming a partial barrier trapping outflow from the Rufiji in the large basin (Darwall and Guard 2000). As a result, the western side of Mafia Island is heavily sediment influenced, while the eastern part is under more oceanic influence. Most of the Mafia Island platform varies between 6-12 m deep (Gaudian and Richmond 1990), though with deeper channels in some locations, thus strong currents occur due to tidal forcing in the semi-diurnal tidal regime of the area, with complex patterns and flows through the various channels between the islands.

Coral reefs are restricted to a relatively narrow band fringing the island and reef slopes, concentrated from about 6-18 m depth on outer reefs (Gaudian and Richmond 1990), and from the surface to 8-12 m depth on the inner banks, depending on the depth of the sand bottom surrounding reef areas. These areas suitable for coral growth vary from 10s to up to 180 m wide (Gaudian and Richmond 1990), and form a very small proportion of the overall subtidal shallow area of the Mafia Island system. Coral reef, seagrass, intertidal and mangrove surveys conducted by the Frontier-Tanzania programme in 1990-1991 established that most of the shallow waters within the Mafia Island system are soft-substrate (Gaudian and Richmond 1990, Horrill and Ngoile 1991) dominated, with a mixture of algal, seagrass and sponge beds and bare sand, with scattered coral bommies and rubble with live coral where suitable substrate is exposed.

To meet the threat of growing human population pressure and resource use (Ray 1968, Bryceson 1981) two small conservation reserves were established in 1970, Chole Bay Marine Reserve and Tutia Island Marine Reserve, in the The Fisheries Act (1970), however no management was implemented. In 1990 and 1991 Frontier Tanzania conducted coral reef, seagrass, intertidal and mangrove surveys (Gaudian and Richmond 1990, Horrill and Ngoile 1991, Darwall and Guard 2000), and by the late 1990s the Government of Tanzania had established the Mafia Island Marine Park as the first multiple-use marine protected area in Tanzania, and the coral reefs of the MIMP became a focus for scientific study.

General reef health and condition have been reported for the Mafia Island reefs and area by Frontier-Tanzania (Gaudian and Richmond 1990, Horrill and Ngoile 1991) and the Institute of Marine Science (Mohammed et al. 2000, Mohammed et al. 2002). These reports established that prior to the El Niño and coral bleaching in 1998, coral reefs in Mafia were healthy and robust, with coral cover levels upwards of 50% on most reef areas, and a count of 46 scleractinian genera (Gaudian and Richmond 1990). However, following widespread bleaching in 1998, coral cover fell by over 50% (Mohammed et al. 2000), with high mortality noted on the sheltered reef area on Kitutia reef but low mortality in Chole Bay. A study on coral transplantation that straddled the El Niño found that some genotypes of staghorn *Acropora* were resistant to bleaching and mortality (Lindahl xxx). More in-depth studies of the fish fauna of the island system have been conducted (Talbot 1965, Ohman xxx, Garpe and Ohman 2003), with a list of 395 fish species compiled (Garpe and Ohman 2003). The fish assemblages of the MIMP appear closely dependent on a healthy reef state (Lindahl xxx, Garpe xxx), thus the loss of coral cover and potentially diversity due to the bleaching in 1998 may have significant effects on the integrity of the protected area and the productivity of fisheries.

To date the protected area does not have full species list of corals, nor a clear dataset on differences in coral community structure and health of sites within the park. This survey was conducted to build up a list of coral species for the MIMP as a whole and to identify the most important sites for scleractinian coral biodiversity for potential zoning decisions.

METHODS

The objective of the surveys is to establish an overall picture of the biodiversity and distribution of scleractinian corals in the MIMP. A timed search method recently developed to maximize sampling of coral species was used (Obura, unpublished, Obura 2004, Sheppard and Obura 2003). Searches were conducted by swimming in a zig-zag pattern covering as much area on a reef as possible, to maximize the likelihood of encountering rare species. Swimming speed was kept slow, with the observer alternating between looking several meters ahead and to the sides, to record large colonies and corals with striking morphologies, and examining closely the bottom from within 30-50 cm to record small and cryptic colonies. Documenting coral species diversity was conducted in three ways:

1. ticking off a checklist of all species seen. This was done where time would not allow more detailed methods (#2).

2. recording new hard coral species in consecutive 2.5 minute intervals, thus obtaining both an overall species list (as in 1), and a species accumulation curve over the duration of the sample at each site.
3. where time was restricted, or the site had clearly low diversity, only unusual or previously unrecorded species were noted.

The timed search method (#2) combined with underwater digital photography have been developed to a) maximize areal coverage of surveys in order to increase the likelihood of encountering rare species, b) obtain basic estimates of relative abundance (commonness) of species, c) enable estimates of total diversity from accumulation curves, and d) provide a record of the appearance of corals underwater to aid identification without becoming heavily burdened with coral skeletons. Many authors have recently pointed out that traditional use of skeletons alone in taxonomy of corals, as was used for over a century, is not satisfactory and has led to many problems (Veron 2000, Sheppard and Obura 2003). However, the same can be said of the use of photographs on their own, without collected and cleaned specimens (Sheppard and Obura 2003). The methods used here provide a preliminary, but not definitive, list of coral species.

The search census technique used time intervals of 2.5 min to record the incidence of new coral species in successive intervals. This gives a species accumulation curve with time. The diver swims in a zigzag pattern in a localized area ensuring that no spot is sampled more than once, and moving in one overall direction. Length of sampling varied between xx to 27 intervals, or xx to xx minutes. Where opportunity does not allow timed sampling, then species presence/absence is recorded.

Photography was done with scuba and an Olympus 4040 digital camera in an underwater housing. Over 400 high resolution images were taken to 30 m depth. Identification was done *in situ* for common and clear species, with later verification and further identification using the photographs in conjunction with Veron (2000), Wallace (1999), Sheppard and Sheppard (1991) and Pillay et al. (2001). Effort was focused on a) coral species that could not be identified underwater, b) reference images of known or unusual forms, and c) after the first dives, on species or forms not already photographed.

Both methods are conservative in that a) not all corals can be photographed, depending on their depth, position and lighting, b) similar looking corals (e.g. in the genera *Goniopora*, etc.) that can only be separated by skeletal work tend to be lumped into a few common species or designated as species 1, species 2, etc., c) identifications from photographs that could not be verified were omitted.

In addition to the above species surveys, a second observer recorded depth profiles of hard coral genera, to compile approximate depth ranges and preferred habitats for corals in the MIMP.

RESULTS

Two to three reef sites per day were sampled for coral species diversity, for 8 days in February 2004. (Table 1, Appendix 1). Sites were a mix of outer fore reef, sheltered slopes and sheltered lagoon and patch reefs. The Mafia Island reef systems are impacted by turbid water from the Rufiji Delta as well as from local mangrove systems, giving sheltered reef areas the appearance of being subject to sediment and nutrients.

A nominal list of 273 species in 63 genera and 15 families were identified (Table 2, Appendix 2). The Faviidae and Acroporidae were the most species-rich families

Table 1. Survey sites in the Mafia Island Marine Park. The ‘main’ depth represents the depth at which the majority of sampling was done.

Date	Site	Zone
7-Feb-04	Kitutia	Sheltered Coral Gardens
7-Feb-04	Kitutia	Sheltered slope
8-Feb-04	Yuyuni	Outer reef
8-Feb-04	Kisiwa Kikubwa	Lagoon
8-Feb-04	Darusi	Lagoon
9-Feb-04	Kitutia-S Pt	Outer reef
9-Feb-04	Kitutia-S Pt	channel
9-Feb-04	Kitutia-E Pt	Outer reef
9-Feb-04	Kitutia	Sheltered slope
9-Feb-04	Mange-NE	Reef crest and slope, sheltered
10-Feb-04	Mange-S reef crest	Reef crest and slope, semi-exposed
10-Feb-04	Mange-wall	sheltered fore reef
11-Feb-04	Msumbiji	patch reef
11-Feb-04	Chole-CG	see above
11-Feb-04	Chole wall	lagoon/channel wall
12-Feb-04	Milimani	patch reef
13-Feb-04	Kikutani	Outer reef
13-Feb-04	Dindini	Outer reef/channel mouth
13-Feb-04	Monit-site	patch reef
14-Feb-04	Mange wall	see above

with 66 and 60 species, respectively, decreasing down to 1 or 2 species in a family for the Astrocoenidae and Oculinidae. *Acropora* was the most species-rich genus (41 species), followed by *Montipora, Favia, Favites, Fungia, Pavona* and *Porites*, with 12-13 species each. Some ecologically significant genera and families have very few species, such as *Galaxea* (Oculinidae) and *Hydnophora* (Merulinidae). A number of the species records presented here are as yet unconfirmed partially due to the need for detailed taxonomic work, but also because of computer breakdowns that have prevented full analysis of photographs taken *in situ*. The records will be updated as they become available.

At the end of the survey, the species number was still climbing (figure 2) and it can be expected to increase signicantly, perhaps to 300 coral species in the Mafia Island reef system. Compared to Mnazi Bay, which was sampled some 3 months previously, Mafia appears to have a more diverse coral fauna. However these differences should be viewed cautiously, for the following reasons: a) in Mnazi Bay, the observer was conducted other work simultaneously, thus could not focus so intensively on hard coral diversity, and b) each field session clarifies a number of identifications such that the next ones include differntiation of more species. The sudden increase in the Mafia graph at site 8 was due to this being the first sample at Mange Reef.

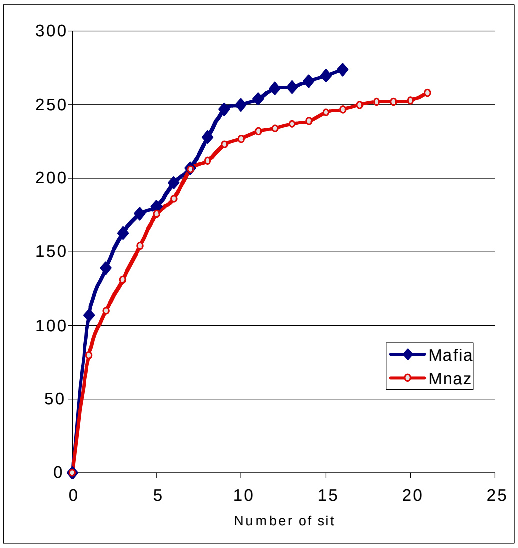


Figure 2. Coral species accumulation curves for each successive site sampled. A curve for Mnazi Bay (November 2003) is shown for comparison.

Table 2. Number of species per genus and family, Mafia Island Marine Park.

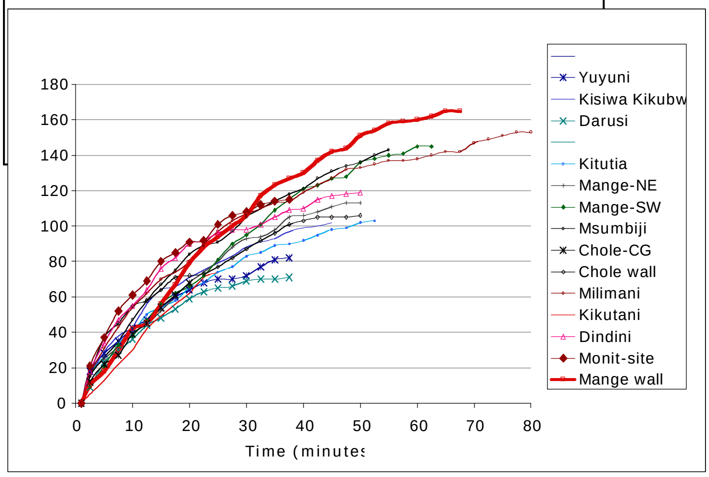
Family	**Genus**	**# spp. gen.**	**fam.**	**Family**	**Genus**	**# spp. gen.**	**fam.**
Acroporidae	Acropora	41	60	Merulinidae	Hydnophora	3	4
	Astreopora	5			Merulina	1	
	Montipora	14					
				Milleporidae	Millepora	5	5
Agariciidae	Gardineroseris	1	19				
	Leptoseris	6		Mussidae	Acanthastrea	5	14
	Pachyseris	1			Blastomussa	1	
	Pavona	11			Lobophyllia	4	
					Symphillia	1	
Astrocoeniidae	Stylocoeniella	1	1		Cynarina	1	
					Micromussa	1	
Caryophilliidae	Gyrosmilia	1	3		Scolymia	1	
	Physogyra	1					
	Plerogyra	1		Oculinidae	Galaxea	2	2
Dendrophylliidae	Tubastrea	2	6	Pectiniidae	Echinophyllia	2	8
	Turbinaria	4			Mycedium	3	
					Oxypora	2	
Faviidae	Caulastrea	1	66		Pectinia	1	
	Cyphastrea	4					

	Diploastrea	1	
	Echinopora	4	
	Favia	12	
	Favites	12	
	Goniastrea	9	
	Leptastrea	4	
	Leptoria	2	
	Montastrea	5	
	Oulophyllia	1	
	Platygyra	9	
	Plesiastrea	2	
Fungiidae	Cantharellus	1	29
	Ctenactis	1	
	Cycloseris	7	
	Diaseris	1	
	Fungia	12	
	Halomitra	1	
	Herpolitha	2	
	Lithophyllon	1	
	Podabacia	2	
	Polyphillia	1	
Pocilloporidae	Madracis	1	21
	Pocillopora	13	
	Seriatopora	2	
	Stylophora	5	
Poritidae	Alveopora	3	25
	Goniopora	10	
	Porites	12	
Siderastreidae	Anomastrea	1	10
	Coscinaraea	4	
	Horastrea	1	
	Psammocora	3	
	Pseudosiderastrea	1	
TOTAL		273	

The duration of sampling at individual sites varied from 20 to 80 minutes, and the number of species from 70 to 167. The lowest diversity was recorded at Chole wall, which also had the shortest sampling time. Species accumulation curves can be used to compensate for differing sampling intervals among sits, and as indicators of the efficiency of sampling. Here a logarithmic equation was used to obtain a regression line for each site (Table 3, Figure 3). Extrapolation out to a fixed time (for example 90 minutes) gives an indication of similarity or difference among sites. Here, the estimate of coral richness for Mange wall/south west was lower than the actual measurement, though usually extrapolation of the lines yields a higher value, as in the others. The highest diversity sites (Mange wall/SW, Mumbiji, the long term monitoring site and Dindini are very different reef areas: the former is a semi-exposed fringing reef, the middle two are lagoon bommies and raised patch reefs, and the last is an exposed wall and platform. Similarly, low-diversity sites do not appear to follow a particular pattern. Interestingly, Kitutia Reef, which is the best known of Mafia's reefs since it was first studied in the 1960s (Talbot 1965), 1970s (Hamilton and Brakel 1984) and more recently in the 1990s and 2000s (Mohammed et al. 2000, 2002), comes out with only low to moderate coral species diversity. Mange had not been noted previously for its high coral diversity and currently has no special protection status in the marine park.

Table 3. Coral species richness by site, and estimated richness at 90 minutes for sites for which accumulation curves were calculated.

Site	Duration	# species	Est-90 min
Mange wall	67.5	167	158
Msumbiji	55	143	148
Milimani	80	155	147
Monit-site	37.5	116	147
Mange-SW	62.5	152	139
Dindini	50	121	139
Mange-NE	50	113	127
Kisiwa Kikubwa	45	102	121
Chole wall	50	111	121
Kitutia	52.5	103	112



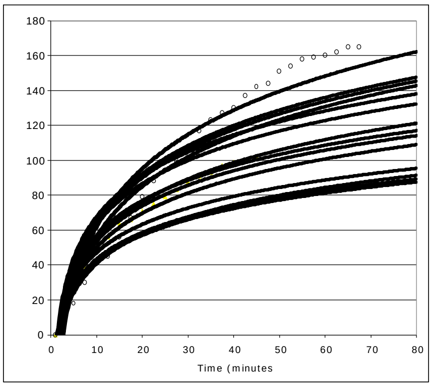


Figure 3. Accumulation curves plotted for each site (left) and logarithmic regression curves (right) for estimating diversity at an arbitrary cut-off point on the x-axis (here we use 90 minutes as a benchmark). In the figure at right, points for Mange wall are shown for reference.

A higher diversity of corals was recorded at Mafia Island compared to other sites in East Africa. However, for the reasons given earlier it is too preliminary to categorically compare diversity levels. The stud at Mafia was the longest survey devoted solely to identifying corals. Other surveys at Mnazi Bay, Songo Songo and Kiunga (Kenya) include other survey components, while the one in Pemba, Mozambique was only 3 days. At all sites, however, the coral fauna is highly uniform (Table 4). Acroporids and faviids dominate East African reefs, with significant numbers of Agaricids (particularly *Pavona*) and Siderastreids (*Coscinarea*).

Coral species with striking observation during the surveys were the following:

Acropora spp. were heavily impacted by coral bleaching and the 1998 El Niño throughout East Africa. In Mafia, and other parts of southern Tanzania (Table 4) they appear to have both suffered less mortality than in other locations and had better recovery. This may be due to a number of factors, among which could be: direct supply of larvae from the open ocean in the South Equatorial Current might result in high recruitment and idversity fo recruitment, as well as high gene flow into the populations, protection from radiation-induced bleaching by the turbid waters from the large rivers and mangrove forests of the southern Tanzanian coast, and perhaps others. Acropora species of note seen here (yet to be verified) but rare elsewhere include *A. stoddarti* and *A. roseni*.

Table 4. Contrast of genus and species richness among scleractinian coral families at different points of the East African coast. All surveys were done between January 2003 to April 2004, except for Kiunga, for which surveys have extended over 6 years since 1998. Sources: Richmond et al. 2003, Obura 2003, Obura and Church 2004, Obura et al. 2004.

	Kiunga	(long term	Mombasa	(long term)	Mafia I.(8 days)		Mnazi Bay	(10 days)	Songo Songo	(8 days)	Pemba, Mozambique	(3 days)
Family	# gen	# spp..	# gen	# spp..	# gen	# spp..	# gen	# spp..	# gen	# spp..	# gen	# spp..
Acroporidae					3	60	3	65	3	58	3	48
Agariciidae					4	19	4	23	4	13	4	16
Astrocoeniidae					1	1	1	2	1	1	1	2
Caryophilliidae					3	3	4	4	3	3	2	2
Dendrophylliidae					2	6	2	8	1	1	1	2
Euphyllidae											1	1
Faviidae					13	66	14	64	13	54	12	60
Fungiidae					10	**29**	9	19	5	13	8	17
Helioporidae									1	1		
Merulinidae					2	4	2	3	2	3	2	4
Milleporidae					1	5	1	3	1	2	1	3
Mussidae					7	14	4	12	6	12	5	10
Oculinidae					1	2	1	2	1	2	1	2
Pectiniidae					4	8	4	8	4	7	4	7
Pocilloporidae					4	21	4	17	3	13	3	10
Poritidae					3	25	3	19	3	18	3	15
Siderastreidae					5	10	3	9	2	4	3	9
TOTALS (15)					63	273	59	258	53	205	54	208

The number of Fungiids recorded in Mafia is higher than elsewhere, due to improved sampling and recogniation of species. High diversity of many fungiids inside Chole Bay enabled a targeted search for colonies of each species to compare alongside each other. Previously the author has not paid special attention to fungiids, and their diversity is underestimated at the other sites.

Of the core zones of the MIMP, Kitutia Reef and Chole Bay, Chole Bay has a high diversity of coral species, as it includes the high-diversity sites Msumbiji, Milimani, and the long term monitoring site, as well as extensive shallows and channel reefs. Kitutia Reef had a low diversity of coral species compared to other sites, while the highest diversity site, Mange, does not have special protection status. While Kitutia Reef was reported to be diverse and robust before the El Niño (Talbot 1965, Hamilton and Brakel 1984), it suffered very high mortality and has subsequently been overgrown by thick fleshy algae that may inhibit coral recovery (Muhando 1999, Mohammed et al. 2000, 2002). Additinoally, the framework of Kitutia reef, having been dominated by branching Acropora spp. is loose, further inhibiting coral recovery. The southwest corner of Mange Reef, because of the steep wall and high currents also houses large schools of schooling snappers and jacks, and large groupers at depth. It is apparently a popular fishing site, but is so far relatively protected by its distance from Mafia Island. Some level of protection for this site might be appropriate.

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APPENDIX 1 – Detailed site descriptions. GPS fixes are to be extracted from the GPS following repair.

Date	Site	Depth			Description
		Main	Min	Max	
7-Feb-04	Kitutia	2	0.5	4	sheltered reef slope, from crest/sandbank to reef base on sand at 8-12m. Extensive dead Acropora beds from EN mortality, recovery in patches v high w. acr, ech, others. CORDIO monitoring site
7-Feb-04	Kitutia	4	1	10	same, sampling down to sand at 12m
8-Feb-04	Yuyuni	15	8	25	Sloping bottom - mainly rubble at 25m w. HS patches w S/H corals. Main coral belt from 18-10m at 80% HS cover, increasing bra HC and SC cover from 12m, and larger dead bommies. From 8m, increasing rubble, 60% SC cover. Method 2.
8-Feb-04	Kisiwa Kikubwa	1.5	0.1	7	coral gardens and shallows/bommies in a pool off the main channel. High top.compl, strong currents -> diverse and abundant H/S corals. Main sampling along vertical slopes and bases of the islands/rocks and a submerged pillar in the middle. Method 2.
8-Feb-04	Darusi	2	0.5	4	more exposed island wall than Kkikubwa. Sampled along sloping HS and along base at sand. Method 2.
9-Feb-04	Kitutia-S Pt				Manta tow off S point of reef. IN shallows, dead acr patches w. new S/H corals (sparse) in sand. Low complexity/interest. Method 1.
9-Feb-04	Kitutia-S Pt				sand/rubble bottom. Method 1.
9-Feb-04	Kitutia-E Pt	16	10	18	rubble/sand at 18m w. patches of higher HS/rocks with corals. Low coral div/cover. Gently sloping with slightly greater HC/rocks from 15m shallower. Coral sampling only for additional/new species (method 3), not full diversity.
9-Feb-04	Kitutia				Same as 7/2. Method 2.
9-Feb-04	Mange-NE	3	1	8	Semi-exposed reef front, uncons framework of dead Acr/other. At reef base on sand (8m), patches of HS/rocks w. corals. High div but low HC cover.
10-Feb-04	Mange-S reef crest	8	1	14	Reef slope from 10-14m, sand at 14. Platform shallows gently to intertidal crest/backbone. At N end of backbone (end of dive) v. high C cover/div, decreasing Swards. Method 2.
10-Feb-04	Mange-wall	18	8	25	steep reef slope v. close to reef crest - on W side of platform that extends south from reef tip, so wall faces first W then SW - shape shown by turbullent/boiling water. Strong SE current at all tides. Hcdiv moderate on slope, high in shallows, same as Mange-backbone. Long whip corals. V. high diversity walls – highest in MIMP area. Method 2.
11-Feb-04	Msumbiji				*(Field notes absent)*
11-Feb-04	Chole-CG	5	1	3	Shallow coral gardens area between channels into Chole Bay (Ch. Wall to north). Some stands of 100% cover, but old coral mortality evident, and break-up by waves and swell. V. high recruitment of coral - diverse coral gardens community. Interspersed with seagrass.
11-Feb-04	Chole wall	14	2	8	Back reef/channel wall in turbid conditions, to channel floor at 14 m. High coral cover.
12-Feb-04	Milimani	10	3	7	Patch reef system on sandy bottom of Chole Bay, extending from bottom to near surface. High and diverse coral cover, complex topography over hills and bommies
13-Feb-04	Kikutani	25	12	18	Deep outer reef slope from sand bottom at 25-30 m, gentle slope to shallows. Near a channel mouth, with high turbidity. In shallows (<12m) high cover of soft corals, evidence of wave breakage.

13-Feb-04	Dindini	25	4	12	Wall along outer section of N channel into Chole Bay. Spectacular topograph y and abundant coral growth on shallow platforms, wall edge, and bottom slope at 20-25m. Schooling fish abundant.
13-Feb-04	Monit-site	10	3	7	Similar to Milimani, series of raised patch reefs over sand bottom. High complexity and coral diversity.
14-Feb-04	Mange wall	25	1	12	Further along SW tip of Mange, off the exposed intertidal ridge rock. Steep high current wall with low coral development at depth/bottom of wall. Shallows in this area the most diverse coral community seen in the Park
15-Feb-08	Mange wall	25	1	12	Further along SW tip of Mange, off the exposed intertidal ridge rock. Steep high current wall with low coral development at depth/bottom of wall. Shallows in this area the most diverse coral community seen in the Park

APPENDIX 2 – CORAL SPECIES AND LOCATIONS FOUND, MAFIA ISLAND MARINE PARK

			7-Feb	8-Feb	8-Feb	8-Feb	9-Feb	9-Feb	9-Feb	10-Feb	11-Feb	11-Feb	11-Feb	12-Feb	13-Feb	13-Feb	13-Feb	14-Feb
			Kitutia	Yuyuni	Kisiwa Kikubwa	Darusi	Kitutia Ept	Kitutia	Mange-NE	Mange-SW	Msumbiji	Chole-CG	Chole wall	Milimani	Kikutani	Dindini	Monit-site	Mange wall
Both		***# species***	109	83	102	71	16	103	113	152	143	70	111	155	74	121	116	167
Family	***Genus***	***Species***																
Acroporidae	Acropora	abrotanoides		1				1		1		1	1	1				1
		aculeus		1	1			1			1					1	1	1
		appressa						1			1							
		arabensis						1	1		1	1	1					1
		austera	1	1	1			1	1	1		1	1	1			1	1
		branchi		1								1		1				
		bushyensis/subulata				1												
		cerealis		1								1					1	
		clathrata	1	1				1	1	1		1		1				1
		copiosa	1					1	1	1								1
		cytherea	1	1	1			1	1	1	1	1	1	1	1	1	1	1
		digitifera	1			1		1	1	1	1			1			1	1
		divaricata									1		1	1		1		
		florida						1	1	1			1	1				
		gemmifera	1		1			1	1		1	1						1
		grandis	1		1				1	1				1			1	1
		granulosa	1	1	1			1	1	1	1	1	1	1	1	1	1	1
		humilis	1															
		hyacinthus								1	1					1		1
		intermedia	1					1	1	1	1	1	1			1	1	1
		irregularis									1	1	1	1			1	1
		latistella	1					1	1	1	1	1	1	1			1	1
		listeri		1						1		1	1	1				1
		loripes																1
		lutkeni												1			1	1
		muricata	1					1	1	1		1	1	1			1	
		nasuta	1		1	1		1	1	1	1							1
		palifera							1	1	1	1		1			1	1
		pharaonis	1					1	1	1	1		1	1	1	1	1	1
		retusa	1	1	1	1		1	1	1	1			1	1		1	1
		robusta								1								1
		rosaria						1		1	1				1	1	1	1
		roseni												1			1	
		samoensis	1		1			1	1	1	1	1	1	1	1		1	1
		secale	1	1	1			1		1	1	1	1	1	1	1	1	1
		selago				1		1	1	1	1			1			1	1
		solitaryensis	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1
		squarosa															1	
		subulata							1					1		1		
		tenuis	1		1	1		1	1	1	1	1	1	1		1	1	1
		valida	1	1	1	1		1	1	1	1	1	1	1				

		zp						1					1					1
	Astreopora	expansa									1							
		listeri		1		1		1		1	1		1	1	1	1		1
		moretonensis								1	1							1
		myriophthalma		1	1	1			1	1	1			1	1	1	1	1
		ocellata								1				1		1		1
	Montipora	aequituberculata	1					1		1	1	1	1					1
		calcarea							1									
		caliculata														1		
		efflorescens	1	1		1		1	1	1		1	1	1	1	1	1	
		floweri				1					1		1	1	1	1		1
		hoffmeisteri									1							
		informis	1			1				1								
		millepora				1				1			1					
		monasteriata	1	1	1			1		1	1				1	1	1	1
		nodosa				1				1								
		spumosa									1							
		tuberculosa	1	1	1				1	1	1		1	1	1	1	1	1
		undata		1	1	1				1	1		1	1	1	1	1	1
		verrucosa								1	1		1	1	1			1
		zgreen								1								
		zp		1														1
Agariciidae	Gardineroseris	planulata	1		1	1		1	1	1	1	1	1	1		1	1	1
	Leptoseris	explanata						1	1					1				1
		hawaaiensis		1				1	1			1				1		1
		incrustans	1	1		1		1	1	1	1	1	1	1	1	1	1	1
		mycetoseroides	1	1	1					1	1	1		1		1		1
		scabra	1											1				
		tubulifera															1	
	Pachyseris	speciosa	1	1	1			1		1	1		1	1	1		1	1
	Pavona	bipartita								1				1				
		chiriquiensis??						1	1							1		
		clavus	1		1			1					1	1		1	1	
		diffluens						1								1		
		duerdeni	1	1	1			1	1	1			1	1	1			1
		explanulata	1	1	1			1	1		1		1	1	1	1	1	1
		gigantea					1						1	1				
		maldivensis	1	1	1			1					1	1			1	1
		minuta	1															
		varians	1	1	1			1	1		1	1	1	1	1	1	1	1
		venosa	1	1				1							1	1		1
Astrocoeniidae	Stylocoeniella	armata	1	1				1					1	1	1	1		1
Caryophilliidae	Gyrosmilia	interrupta				1				1								
	Physogyra	lichtensteini			1	1			1	1								
	Plerogyra	sinuosa			1				1	1	1					1	1	1
Dendrophylliidae	Cantharellus	doederleini										1						
	Tubastrea	coccinea		1	1									1		1	1	1
		micrantha			1		1			1				1		1		1
	Turbinaria	mesenterina																1
		peltata														1		
		reniformis		1	1									1		1		1
		stellulata			1				1	1	1		1	1	1	1	1	
Faviidae	Caulastrea	connata												1				
	Cyphastrea	cf-extended						1										1
		chalcidicum	1	1	1				1	1			1	1		1		1
		microphthalma			1			1		1	1					1	1	

	serailia	1	1	1	1				1	1	1		1	1	1		1
Diploastrea	heliopora		1						1								
Echinopora	forskali									1			1		1		1
	gemmacea	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1
	hirsutissima			1	1		1		1	1		1	1		1	1	1
	lamellosa	1		1			1	1	1		1	1	1			1	
Favia	albida			1													
	danai		1		1			1	1								1
	favus	1	1	1	1	1	1		1				1	1	1		1
	lizardensis		1					1		1							
	maritima								1	1				1			1
	matthai	1	1		1		1			1		1	1		1	1	1
	maxima											1					
	pallida							1	1	1		1					1
	rotundata					1				1			1	1		1	1
	speciosa	1		1			1	1	1	1		1	1	1		1	1
	stelligera	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1
	truncatus			1	1	1		1	1	1			1	1	1		1
Favites	abdita						1	1	1	1	1	1	1	1	1	1	1
	chinensis	1											1				1
	complanata		1	1	1	1			1	1		1	1		1	1	1
	flexuosa	1		1	1	1	1	1	1	1			1		1	1	1
	halicora									1					1		
	paraflexuosa		1		1			1	1	1		1	1	1	1	1	1
	pentagona			1				1	1		1		1	1	1		1
	peresi		1		1			1	1	1	1	1	1	1	1	1	1
	russelli		1	1					1	1			1	1	1	1	1
	spinosa			1	1				1	1			1	1	1	1	1
	stylifera													1			
	vasta	1	1	1				1	1	1		1	1	1	1		1
Goniastrea	aspera	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1
	australensis	1		1				1	1	1		1	1		1	1	1
	columella							1									
	deformis			1					1				1		1		
	edwardsi		1	1	1		1	1	1	1			1				1
	minuta														1		
	pectinata						1										
	retiformis			1		1		1	1	1	1		1	1	1		1
	thecata														1		
Leptastrea	aequalis		1	1				1		1		1	1			1	1
	pruinosa	1	1	1	1		1			1			1	1	1	1	
	purpurea	1		1	1		1	1	1	1		1	1	1	1	1	1
	transversa									1							
Leptoria	irregularis	1															
	phrygia	1		1	1			1	1		1	1	1	1	1	1	1
Montastrea	annuligera		1													1	
	curta				1												1
	magnistellata							1	1				1				
	salebrosa				1			1	1								
	serageldini			1	1		1	1	1				1				1
Oulophyllia	crispa	1	1	1				1	1	1			1	1	1		1
Platygyra	acuta	1					1	1	1	1		1	1		1	1	1
	contorta									1	1		1				
	crosslandi	1	1					1					1	1	1	1	1
	daedalea			1	1		1	1	1		1	1		1			1
	lamellina	1		1			1	1	1	1		1	1			1	1

		pini	1				1	1	1	1	1				1	1	1	1
		ryukyuensis	1	1	1	1			1	1	1		1			1		1
		sinensis	1	1	1	1		1	1	1	1		1	1			1	1
		verweyi		1	1	1		1	1	1	1			1		1		1
	Plesiastrea	devantieri			1	1			1	1	1	1	1	1	1	1	1	1
		versipora			1					1	1			1	1	1		1
Fungiidae	Balanophyllia	zp.												1				
	Ctenactis	echinata							1									
	Cycloseris	costulata								1	1	1		1		1	1	1
		curvata											1					
		cyclolytes									1			1	1	1		
		erosa									1		1	1		1		
		patelliformis											1	1		1	1	1
		somervillei									1		1	1		1		1
		tenuis															1	
		zp	1	1					1									1
	Diaseris	distorta											1					
	Fungia	corona									1	1	1	1				
		danai	1		1				1	1		1	1	1			1	1
		fungites	1		1			1		1	1	1	1	1			1	1
		granulosa	1					1		1			1		1	1	1	1
		horrida								1	1		1	1		1	1	1
		klunzingeri												1			1	
		paumotensis		1	1			1	1		1		1	1			1	1
		repanda	1		1			1			1	1		1		1	1	1
		scabra			1									1			1	1
		scruposa										1	1					
		scutaria	1									1	1	1	1	1	1	1
		seychellensis						1						1			1	1
		zp.									1							
	Halomitra	pileus	1					1	1	1	1	1	1	1		1	1	1
	Herpolitha	limax	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1
		weberi	1											1		1		
	Lithophyllon	mokai								1	1	1	1	1		1	1	1
	Podabacia	crustacea												1				
		motuporensis	1	1					1	1	1		1	1		1	1	1
	Polyphillia	talpina	1															
Merulinidae	Hydnophora	exesa	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1
		microconos	1		1	1			1	1	1	1	1	1		1		1
		pilosa								1								
	Merulina	ampliata	1					1	1	1	1		1	1			1	
Milleporidae	Millepora	dichotoma										1	1	1		1	1	
		exesa	1		1	1					1	1	1	1	1	1	1	1
		f.knobbly											1					
		platyphylla		1	1		1	1		1	1	1		1			1	
		tenella	1	1	1	1		1	1	1	1	1	1	1			1	1
Mussidae	Acanthastrea	brevis			1											1		
		echinata	1	1	1		1		1	1	1		1	1		1		1
		faviaformis								1	1		1	1	1		1	1
		hemprichii											1					
		ishigakiensis				1					1						1	1
	Blastomussa	merletti							1	1						1		1
	Cynarina	lachrymalis					1						1					
	Lobophyllia	fabelliformis									1		1	1				
		hataii	1	1						1	1							
		hemprichii	1	1	1				1	1	1		1	1	1	1	1	1

		robusta								1			1				1	
	Micromussa	amakuensis																1
	Scolymia	vitiensis	1															
	Symphillia	erythraea		1			1			1				1	1		1	1
Oculinidae	Galaxea	astreata	1					1	1	1	1	1					1	1
		fasicularis	1	1	1	1		1	1	1	1		1	1	1		1	1
Pectiniidae	Echinophyllia	aspera	1	1	1			1	1	1	1	1	1	1			1	1
		echinoporoides							1	1								1
	Mycedium	elephantotus						1			1			1		1	1	1
		mankaoi	1	1					1	1	1		1	1			1	1
		umbra	1						1	1								
	Oxypora	glabra						1	1		1		1	1		1	1	1
		lacera	1	1		1		1		1				1		1		
	Pectinia	africanus							1	1	1		1	1				1
Pocilloporidae	Madracis	kirbyi												1				
	Pocillopora	damicornis	1		1	1		1	1	1	1	1		1		1	1	1
		danai		1									1	1	1	1	1	1
		elegans		1	1									1		1		
		eydouxi	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1
		fungiformis	1															1
		indiania			1	1		1	1		1	1		1				
		ligulata								1								
		meandrina	1		1	1		1		1		1	1	1	1		1	1
		verrucosa	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1
		woodjonesi		1														
	Seriatopora	caliendrum								1	1							
		dentritica								1								
		guttatus												1				1
		hystrix	1		1			1	1	1	1	1	1	1			1	1
		stellata	1			1		1		1	1	1						
	Stylophora	danae		1														
		madagascarensis			1	1					1	1						
		pistillata	1	1	1	1		1	1	1	1			1			1	1
		subseriata			1			1				1	1					1
		wellsi	1															
		zp.									1							
Poritidae	Alveopora	allingi	1						1									
		spongiosa						1										
		tizardi	1							1	1							1
	Goniopora	albiconus					1		1									1
		columna				1		1								1		1
		djiboutiensis								1	1							1
		lobata				1			1	1	1				1	1		1
		planulata									1					1		
		somaliensis		1	1				1	1	1			1	1	1		1
		stokesi	1			1				1	1							1
		stutchburyi								1								
		tenella								1								1
		tenuidens				1												
		zp					1											1
	Porites	annae			1			1	1						1			
		australensis						1							1	1		1
		cylindrica			1				1	1	1					1		
		densa								1								
		lichen											1					
		lutea	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1

		monticulosa	1							1	1		1	1		1	1	1
		nodifera			1	1												
		profundus	1	1	1		1			1				1	1		1	1
		rus	1	1	1	1		1		1	1	1	1	1	1	1	1	1
		stephensoni	1								1					1		
		vaughani	1					1										
		zp(mtp)?									1							
Siderastreidae	Anomastrea	irregularis								1								
	Coscinaraea	columna		1	1				1	1	1		1	1	1	1	1	1
		crassa	1		1	1			1	1								
		mcneilli									1					1		
		monile				1		1	1		1				1	1		1
	Horastrea	indica								1								1
	Psammocora	haimeana	1		1			1	1		1			1		1	1	1
		niestraazi	1					1			1		1	1		1	1	
		stellata															1	
		zp (exp??)								1								
	Pseudosiderastrea	tayami														1		