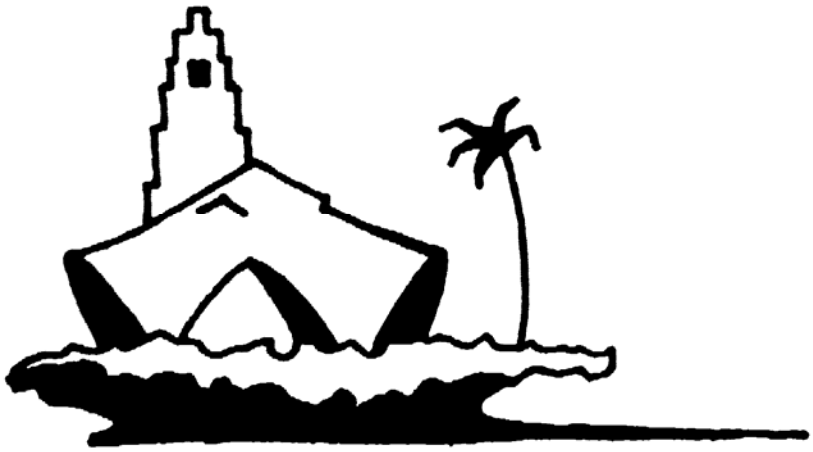
MARINE SCIENCE UPDATE



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October 2004

MARINE SCIENCE REPORT

Update report for DFMR
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Ranger reports

1. Introduction

Rangers reports have been maintained by Chumbe Island Coral Park rangers since 1993. The main purpose of these reports is to record any poaching incidents within the Reef Sanctuary and subsequent actions taken. The structure and detail of these reports have developed a lot over the last 11 years. The report system is much more uniform now and includes the following aspects…

- Date and time of incident (including whether day or night)
- Type of vessel (Ngalawa, canoe, dhow, snorkel)
- Number of people (if possible to see)
- Number of gear in total or per person e.g. 2 fishing lines per person / 1 spear per person / 1 large net per boat (kojani, spear, line, cage, travel, help, anchor)
- Name of poachers, poachers' village name(s) and boat identification
- Action from the rangers
- Consequence of action i.e. did the poachers fish, leave, threaten? Were the police from the island involved and if so, who?

These reports are photocopied and given to DFMR on a regular basis, which CHICOP hopes helps with their records too.

2. Results

A full analysis of the ranger reports is currently underway at CHICOP and DFMR will be notified when this is ready. The database will be completed with the above details so that calculations can be easily made for many aspects such as poaching / anchoring attempts within a month, gear types, boat types and frequency of each village or district poachers within the area.

It is obvious that the number of poachers has declined vastly since 1994, when the marine area was first gazetted as a Reef Sanctuary. In the early years, groups of 20 fishermen would come to the island and personally threaten the rangers. Thankfully threats are not often received any longer although some poachers have gained a reputation for their persistent nature. Usually intervention by DFMR and their Fisheries Officers helps cease repetetive poaching problems around Chumbe.

3. Conclusion

CHICOP rangers reports will continue to be completed to a high standard. DFMR will continue to receive copies of these reports and will also receive a copy of the full analysis when complete.

Bleaching, disease and damage

1. Introduction

Bleached colonies of Scleractinian corals were noted on the very shallow areas of Chumbe Island's Reef Sanctuary in April 2004. Once a methodology for assessment was established, surveys were conducted (14th and 16th April 2004), and return observation visits have been made since at regular intervals between May and October 2004.

There were two main patches of reef that were affected by bleaching; 91m^2 and 314m^2 in total surface area. Both these areas are exposed during low spring tides, so are very shallow. They are situated in the northern half of the reef (i.e. north of the jetty) approximately 200m apart from each other. The predominant coral genera is staghorn *Acropora,* which is a relatively fast-growing Scleractinian coral.

2. Method

Each bleached patch (northern area (N) and southern area (S)) was assessed using several 1m^2 quadrats. Within each 1m^2 quadrat, the following details were noted for each coral colony...

- Coral identification (to species if possible)
- Size of coral colony
- % cover of tissue states
    - Normal
    - Pale
    - Bleached
    - Dead
    - Algae cover on bleached area
- Other information e.g. soft corals, zooanthids, urchins, disease, scars

Where possible (i.e the area was big enough), ten quadrats were assessed on each bleached patch.

3. Results

Table 1 summarises the size of each bleached patch, number of quadrats assessed and the percentage algae cover of the overall bleached area.

Table 1: Summary of surveyed bleached patches

Area	Size of bleached patch / m	No. of quadrats assessed	Approximate % of bleached coral with algal cover
N1	11 x 7	10	60
N2	4 x 3.5	8	80
S1	20 x 15	10	40
S2	4 x 2	5	70
S3	3 x 2	2	70

Table 2 summarises the range and average percentage of the tissue states within each bleached area. It should be noted that all percentage estimates were of the whole 1m^2

area except for algae. Algae cover was calculated as a percentage of each bleached colony within the quadrat, not of the whole $1m^2$.

Table 2: Summary of average tissue states for each bleached patch

Area	Statistic	Percentage cover / %				
		Normal	Pale	Bleached	Dead	Algae *
N1	Average %	4.3	11.3	67.9	13.1	31.7
	Range %	0 – 10	2 – 25	33 – 84	0 – 45	5 - 50
N2	Average %	26	4.9	50	2.4	38.3
	Range %	0 - 10	0 – 20	0 – 100	0 – 12	0 – 100
S1	Average %	0.5	2.3	43.4	52.6	32.5
	Range %	0 – 2	0 – 9	7 – 97	2 – 93	0 – 96
S2	Average %	1.2	10.8	78.2	11.4	46
	Range %	0 – 4	0 – 15	64 – 89	1 - 23	0 – 79
S3	Average %	2	15	73.5	8.5	43
	Range %	2 – 2	15 – 15	71 – 76	7 – 10	20 - 66

** NB Algae cover was calculated as a percentage of each bleached colony, not of the whole $1m^2$ area*

The results show that normal tissue states were very low in all patches. This was expected as the assessment areas are very flat, in shallow water during most tidal states, and were therefore virtually totally bleached. Some tissues were pale in colour so may show some recovery in future but the majority of the tissues were bleached and almost half these areas were covered in algae. There were not so many dead coral tissues as this assessment was conducted within the first couple of weeks of noting the bleaching event.

There were a total of 21 soft coral colonies observed within the ten quadrats at site N1. These were all small in size (approximately 5 – 10cm diameter) so may have started to recruit in this area with the stressed, bleached hard corals creating increased space and decreased competition in this area. Only 1 soft coral was observed in N2, with 1% *Turbinaria* sp. (brown algae) in one quadrat.

Area S1 had an approximate average of 0.4% / m^2 algae cover recorded within all the quadrats assessed (i.e. 4% of the assessed $10m^2$ area), 0.5 *Echinometra mathaei* urchins and <1% soft coral cover. S2 was recorded with approximately 0.4% algae cover within all the quadrats observed (total area assessed was $5m^2$), with <1% soft coral cover and <1% zooanthids. S3 was recorded with approximately 2.5% zooanthid and <1% soft cover over the total $2m^2$ area. There was a large patch (approximately $3m^2$) of turf algae within and around the S3 bleached area.

Since the surveys were conducted in April 2004, these affected sites have been re-visited on a regular basis and will continue to be monitored over the coming months. To date (October 2004) the majority of *Acropora* colonies within all the affected patches appear dead and have a cover of dark, green, tufty algae. However, there are a few coral recruits growing within these patches e.g. *Pocillopora* and *Seriatopora* and *Echinopora* sp.

4. Conclusion

Future assessment of these areas will be made to monitor recovery of the bleached patches. The affected areas were all very shallow and the time of this bleaching

incident coincided with fairly severe storms, spring tides and high water temperatures (see section Sea temperature data). All these factors would ordinarily result in corals becoming stressed and therefore bleached. The fast growing nature of *Acropora* means that this genera tends to recover fairly quickly (tens of years rather than hundreds of years for massive species such as *Porites lutea*). The presence of juvenile Scleractinian corals in the affected areas shows that hard coral recruitment is occurring, which is also a positive sign.

Sea temperature data

1. Introduction

A temperature logger was installed on Chumbe's reef on 15th December 2003. The logger automatically records temperature data every half hour. It is placed in a fixed location with a water depth ranging between 2 - 6m of water, depending on the tide. It is removed every three months and the data is downloaded at IMS.

2. Results

Table 3: Average temperature data for Chumbe's reef sanctuary between Dec 03 and Aug 04

			Temperature / °C			
Date start	**Date end**	**Month**	**Average**	**Max**	**Min**	**Range**
12/15/03	01/14/04	Jan-04	28.60	34.54	27.13	7.41
01/15/04	02/14/04	Feb-04	28.86	30.24	27.13	3.11
02/15/04	03/14/04	Mar-04	28.81	30.62	27.67	2.95
03/15/04	04/14/04	Apr-04	28.58	30.24	27.31	2.93
04/15/04	05/14/04	May-04	28.20	29.31	26.77	2.54
05/15/04	06/14/04	Jun-04	27.12	28.58	25.72	2.86
06/15/04	07/14/04	Jul-04	25.55	26.6	24.51	2.09
07/15/04	08/14/04	Aug-04	25.24	30.43	24.16	6.27

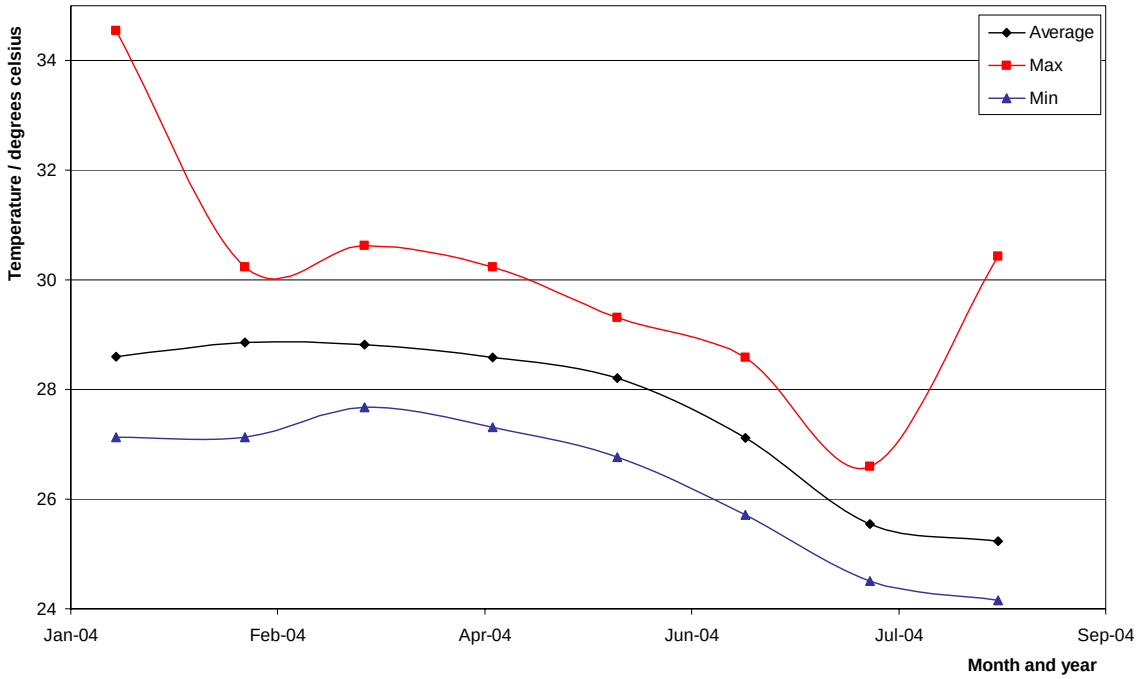

Figure 1: Chart of average temperature data (°C) per month, mid-December 2003 to mid-August 2004

Error! Reference source not found. and **Error! Reference source not found.** show the range and average monthly temperatures on Chumbe's Reef Sanctuary between 15th December 2003 and 9th August 2004. The maximum average monthly sea temperatures for this perioed were recorded in February 2004 (28.86 °C) (16th January - 15th February). However, the maximum single temperature was recorded on 16th

December at 1500hr. This may be an anomoly as the temperatures within half an hour either side were 31.58 °C and 29.13 °C. However, there were high temperatures recorded throughout this month with some recordings between 30 – 31 °C. The average for most days in the second half of December was between 28.2 °C and 29.9 °C.

3. Conclusion

March 2004 was recorded with similar average, maximum and minimum temperatures to February 2004. These high temperatures explain at least some of the reason for Scleractinian bleaching observed within Chumbe's Reef Sanctuary in April 2004. Such temperatures indicate that the shallower corals would have been under stress at this time. However, temperature data collected in 1997 by Dr Chris Muhando at IMS shows similar readings for January - August so the corals that grow in this area would be adapted to such annual fluctuations. Perhaps the added stress of freshwater from heavy rains during low spring tides resulted in the bleaching.

The temperature logger will continue to record data for the next few years. This dataset will be an excellent source for any further problems observed on the reef, which may be related to sea temperature.

Crown-of-thorns (*Acanthaster planci*) starfish

1. Introduction

Adult COTs starfish

The Crown-of-thorns (COTs) starfish is thought to reside on most reefs at low levels and often go un-noticed. However, when they reach maturity after approximately two years, they are about 25cm in diameter and are more obvious. If COTs successfully reproduce over a few years they can rapidly increase their population and cause mass devastation of reefs. It is usually obvious where the COTs have been from the white, bleached coral - the 'feeding scars' they leave behind.

The COT is a specialist coral feeder although occasionally (particularly when corals are in short supply) it may feed on other organisms (eg. soft corals, algae, gorgonians and other encrusting organisms). It is called an extraoral feeder since in order to feed it forces its stomach through its mouth. This membranous structure is positioned around the irregularities of the coral with the help of the starfish's tube feet. The stomach is then thought to secrete an enzyme which breaks down the coral tissue, unlocking the major energy reserves of the coral (which are in the form of waxes). This material is then transported by cilia (small hairs) to the caeca where they are absorbed. The feeding process may take 4-6 hours. Once digestion is complete the stomach is retracted and the starfish moves off, leaving a white coral skeleton behind.

Coral reef with numerous COTs feeding scars

Since 1995 Zanzibar has experienced outbreaks of COTs of increasing severity, mainly on the reefs around Bawe, Changuu and Pange. For the first time, CHICOP rangers saw this creature over Chumbe's reefs in May 2004. Once initial sightings were followed up it was established that there were two aggregations within the Reef Sanctuary: one towards the north of the island, but in the shallower areas behind the main reef; one on the southern Reef Sanctuary border, in deeper water, on the coral reef.

After national and international discussions, and literature and scientific research, it was decided that the best course of action was to remove the COTs as such a management plan could be controlled within the controlled Reef Sanctuary. Surveys were undertaken to assess COT the densities, corals being eaten, sizes of individual COTs and damaged patches, and COTs distribution. A total of 547 COTs (392 from

the south, 155 from the north) have been removed to date (October 2004), and these have ranged in size from 8cm to 45cm in diameter.

2. Methods

CHICOP have set up permanent transects on the east and west side of Chumbe. These areas are as follows...

- Four permanent transects on the east of Chumbe, about 400m from the north point
- Each east transect is 50m in length and 10m in width and there are two control sites where no COTs are removed (two southern transects), and two removal sites (two northern transects) where all COTs are removed within the 10m x 50m belt transect area

- Two, 100m long transects are setup on the west, i.e. within the northern section of the Reef Sanctuary, about 300m from the north point
- Both transects are removal sites and are assessed as a belt transect (10m x 100m each), which has the same total area as the east transects

Each belt transect is surveyed with a buddy pair by snorkelling over one side of the transect tape, at a distance of 5m apart. Each snorkeller looks out for COTs within their adjacent 2.5m wide area. If a COT is found, the following data is recorded on an underwater slate...

- Transect name
- Distance along the linear transect tape (N / S)
- Distance out from the tape measure i.e. along the perpendicular 5m rope (E / W)
- Coral genera that the COT is eating, or resting on or by
- COT diameter (include legs)
- Size of coral colony (length (l), width (w) and height (h) *OR* diameter (d) and height (h))
- Size of damaged section of colony ((l) and (w) *OR* (d))

If any COTs are found on these transects, they are removed or left, depending on whether the transect is a control site. If removed, COTs are then buried on the mainland of Zanzibar.

Following on from completed COTs surveys, the substrate is assessed by placing $1m^2$ quadrats at 5m intervals from 0m to 45m (or to 95m if an 100m transect). Within each quadrat the following substrate categories are measured in terms of percentage cover...

- Bare rock
- Live coral
- Recently killed coral
- Sand
- Silt
- Rubble
- Sponge
- Soft coral
- Seagrass
- Macroalgae

3. Results

COTs were found in large aggregations in April and May 2004, mainly within the south end of the Reef Sanctuary, virtually on the southern boundary. Groups of 5 – 15 COTs were found in some areas, clustered together on the same coral colony. The most 'preferred' coral genera for the COTs to feed on was *Acropora* (see Table 4).

Table 4: Percentage of substrate preference where COTs were found on the reef

Coral genera / substrate type	Reef area and % of each substrate where COTs were found		
	South	North	Both North and South
Acropora	43	60	46
Alveopora	2	0	1
Echinopora	13	0	10
Hydnophora	3	0	3
Millepora	3	8	3
Montipora	18	0	15
Mushroom	4	8	5
Mycedium	2	0	1
Pachyseris	1	0	1
Pocillopora	1	0	1
Porites	4	8	5
Seriatopora	2	0	1
Dead coral	0	12	2
Rubble	0	4	1
Sand	5	0	4

The average diameter of COTs within each reef area is listed in Table 5, which also shows the percentage of adults removed (i.e. greater than 26cm diameter). There was a greater % of adult COTs in the northern area of the reef in comparison to the southern area, for which the population consisted mainly of immature COTs, probably less than 2 years in age.

Table 5: Average COTs diameters for each reef area

	COT diameter / cm				
Reef area	Average	Max	Min	% ≥26	% <26
North	26.3	45.0	8.0	61.0	39.0
South	23.3	35.0	15.0	26.2	73.8
Both N&S	24.1	45.0	8.0	36.0	64.4

4. Conclusion

Chumbe's Reef Sanctuary is being regularly surveyed for COTs infestations. It is hoped that the removal of over 500 to date will prevent a large population reproducing during the next season. Monitoring surveys will continue on the east and west coast of Chumbe and data from these will be used to assess the population structure over time.

Sargassum and coral recruitment

1. Introduction

Chumbe experiences annual dense growth of *Sargassum* sp. approximately November – March. This is mainly located midway between the north and south of the western reef; below the education centre. This ecological situation has been the same for many years. Usually the algae is pulled off the reef annually by strong winds during the rainy season (April – June) and is therefore unlikely to have a permanent affect on the reef ecosystem as it is does not seem to be extending it's area of cover. However, Chumbe has started to survey this marine macroalgae to monitor the effects that it may have on coral recruits as it can prevent coral recruitment and development by touching and scraping coral polyps.

2. Method

The first survey was conducted by a MSc student (Anne Grete Rostad) from Norway as a follow-on from her study on coral recruits around Chumbe and Bawe (supervisor in Zanzibar: Dr Chris Muhando). This was completed in July 2004 and Anne Grete will return to Chumbe to re-survey the area in December 2004.

The method employed was assessment of coral recruits within ten, $1m^2$ quadrats (divided into 100 squares) in an area susceptible to *Sargassum* growth. First, each quadrat was placed exactly in a north-south direction, and precisely 5-metres apart so that the exact areas could be re-surveyed in December 2004. The assessment within each positioned quadrat involved measuring colonies <10cm in size (i.e. recruits and not adults) and noting genera for *Pocillopora*, *Acropora* and *Porites* only. Recruits of all other hard coral genera were recorded as 'other' on the slate

The position of each colony recruit within the quadrat was drawn on a replica grid on an underwater slate. The maximum width, length and height of the coral surface of each colony (measured in millimetres) were recorded on the slate table. *Sargassum* was then removed from non-control plots.

The follow-up survey in December 2004 will re-locate and re-assess the same ten quadrat areas for: growth of previously assessed recruits; presence, size and genera of new recruits; and missing or dead recruits that were previously assessed.

3. Results

Table 6 shows the preliminary results from coral recruitment studies undertaken in the Sargassum area within Chumbe's Reef Sanctuary. This data was collected in July 2004, with *Sargassum* removed from quadrat areas B, D, F, G, and I. The remaining quadrat areas (A, C, E, H and J) are control sites with no removal of *Sargassum*.

Table 6: Preliminary results from coral recruitment study in Sargassum area

Genera	Number	Length / mm	Width / mm	Height / mm	Comments
Other	A1	32	23	0	
Soft coral	B1	0	0	0	not interesting
Porites	C1	50	40	0	half dead
Other	C2	38	21	0	
Other	C3	16	13	0	
Other	C4	36	19	0	
Porites	D1	15	12	0	
Other	D2	67	63	0	
Echinopora	E1	70	47	0	
Porites	F1	50	35	0	
Other	F2	39	29	0	
Other	G1	35	17	0	
Porites	H1	28	23	0	
Porites	I1	54	24	0	

4. Conclusion

This study will be repeated by Anne Grete Rostad and Omari Nyange in December 2004. Assessment will be made of coral recruit growth, new recruits, and missing or dead recruits. Future monitoring will continue from this study to assess whether the *Sargassum* growth is affecting coral recruitment.

Intertidal species list

1. Introduction to survey

The intertidal area around Chumbe has a diverse array of fauna and flora but can sometimes be unjustifiably overlooked. CHICOP has been surveying this area with the view towards monitoring any changes and acting upon these appropriately. Also, purely for information such as species diversity, monitoring surveys are an excellent way to find different species to add to the list.

2. Method

The survey method being employed by CHICOP involves assessing quadrats at calculated intervals along a linear transect, which is laid perpendicular to the shoreline. The total maximum intertidal length is first calculated at a low spring tide. This length is then divided by eight so that a resulting nine stations can be surveyed and are easily separated into the three intertidal zones: high intertidal, mid intertidal and low intertidal. Once the distance between the nine stations has been calculated, $1m^2$ quadrats are used to assess the percentage cover, abundance and presence/absence of a pre-determined fauna and flora list.

Whilst conducting the quadrat assessments, any previously unidentified new species are identified where possible and noted so that they can be added to the species list, which also notes the distribution of each species. There are many organisms that cannot be identified in the field so this would require detailed notes and preferably photos for further analysis by experts.

To date, five transects have been assessed with two quadrats at each survey station. These transects have all been positioned in the the west, north and south areas; none to the east as yet. The lengths of the five surveyed transects and some of the GPS locations are shown in Table 7.

Table 7: GPS points for intertidal transects (WGS 84 Map Datum) and total transect lengths

GPS name	S: Degrees / Minutes / Seconds in decimal	E: Degrees / Minutes / Seconds in decimal	Distance to low water at low spring tide / m
INTN-	06° 16’ 24.9”	39° 10’ 38.0”	175
INT-E1	06° 16’ 36.2”	39° 10’ 39.5”	
INT-E2	06° 16’ 39.1”	39° 10’ 40.0”	
INT-E3	06° 16’ 48.1”	39° 10’ 43.0”	
INT-E4	06° 16’ 54.7”	39° 10’ 43.5”	
INTS-1			240
INTS-2			
INTW1-	06° 16’ 29.5”	39° 10’ 34.7”	44
INTW2-	06° 16’ 39.1”	39° 10’ 35.2”	89
INTW3-	06° 16’ 48.4”	39° 10’ 35.1”	139
INTW4-			

3. Results

Substrate

In summary, quadrats assessed along the northern transects predominantly consisted of sand whereas the southern transects were mainly made up of coral rag.

Sessile organisms

Barnacles, oysters, mussels and chitons were observed on the high intertidal areas for all transects.

Algae

Seagrasses were mainly located in the lower intertidal area, predominantly along the north transect and the two northerly transects assesed on the west (W1 and W2).

There was some green and brown algae in the middle intertidal on the north transect. All other transects were observed with a similar transition from green to brown to red algae as the distance from shore increased. The red algae, however, did not seem to follow any trend and was observed in the top of transect N and W2 and in the middle of W3 and S.

Sponges & Anemones

There were some anemones on all these transects and sponge cover on the lower intertidal area of W1 and W2. Sponges were fairly evenly distributed over the W3 transect between 17m and 137m from the coral rag of the island.

Urchins

No urchins were recorded on the northern transect or W2. The most surveyed (approximately 15 in the whole transect) were on the southern transect, with a few present in the low intertidal of W1 and W3.

Seastars

The only seastars were recorded on the south transect: *Protoreaster lincki* and *Linckia guildingi.*

Sea cucumbers

The only record of sea cucumbers was in the middle of the south transect.

Crabs

No crabs were observed in the north transect. A few hermit crabs were found in the middle, top and lower intertidal on W1, W2, W3 and South transects.

Bivalves

No Bivalves were recorded on either the north transect or W2. There was, however, a zig-zag clam (*Hyotissa* sp.) identified in mid – to – low intertidal of W1 and a giant clam (*Tridacna* sp.) in the lower intertidal of W3 and the south transect.

Mollusc

The predominant mollusc was *Morula granulata*, which was recorded high on the north transect; middle to higher areas of the intertidal on W1, with other unidentified

molluscs in the middle region; middle to high on W3 and high on South transect, which also had cowrie high and conch low on this intertidal area. Other molluscs (unidentified) were found on W2 but no *M. granulata*.

4. Species list to date

The following (Table 8) is only a preliminary list and needs further verification on some species…

Table 8: Preliminary list of intertidal species around Chumbe Island

Species	Common name
Acanthopleura brevispinosa	Chiton - brown
Acanthopleura gemmata	Chiton - short spicules
Actinopyga miliarus	Sea cucumber - black
Anadora spp.	Bivalve
Caiteiiospongia foliascens	Sponge
Carteriospongia foliascens	Sponge - foliose
Caulerpa recemesa	Green algae
Cellana radiata	Limpet - striped
Clypeomorus bitasciatus	Snail
Codium ? geppi	Green algae
Conus miles	Cone shell - stripey
	Cone shell - white w/black dots
Cypraea annulus	Cowrie - gold ringer
Cypraea tigris	Cowrie - tiger
Cypraea vitellus	Cowrie - brown with white spots
Dolabella auricularia	Seahare
Echinometra mathaei	Urchin
Echinostrephus molaris	Urchin
Engina mendicaria	Snail
Fusinus colus	Snail - Distaff spindle
Gonodactylus spp.	Mantis shrimp
Grapsus albolineatus	Crab - mottled rock
Halimeda macroloba	Green algae
Halophila ovalis	Seagrass - broad leaved
Hyotissa hyotis	Clam - zig zag
Lambis lambis	Conch
Linckia guildingi	Seastar
Lobophora variegata	Brown algae
Macropthalmus spp.	Crab - speckled sand
Mitra spp.	Snail
Morula granulata	Snail
Nerita spp.	Snail
Noupella vagosa (Drupella rugosa?)	
Padina spp.	Brown algae
Patelloida piotunda	Snail - slipper
Pilumnus verspertilio	Crab - hairy
	Crab - red eye
Porites solida	Hard coral
Prionocidaris baculosa	Urchin (tapered pencil)
Protopalgthoa nelliae	Anemone - tube
Protoreaster lincki	Seastar

Spheciospongia globularis?	Sponge
Species contd.	**Common name contd.**
Stichopus honens	Sea cucumber - white
Strepsichoidaia radiata	Sponge
Tedania anhalens	Sponge - chilli
Tetraclita squamosa	Barnacle - acorn
Thalassia spp.	Seagrass
Tridacna maxima	Giant clam
Tridacna squamosa	Giant clam
Tripneustes gratilla	Urchin
Turbinaria conoides	Brown algae
Turbinaria decurrens	Brown algae
Turbinaria ornata?	Brown algae
Uca lactea annulipes?	Crab - white speckled
Ulva pulchra?	Green algae
Zostera spp.	Seagrass

5. Conclusion

The above methods will be continually employed to monitor the intertidal region of Chumbe Island Coral Park. It is hoped that this will identify trends and changes within the intertidal area so that successul management can be adjusted accordingly.

Urchins

1. Introduction to survey

Studies on sea urchins within Chumbe's Reef Sanctuary have been conducted on a few occasions in the past. These have usually been through the School of International Training (SIT) programme students; May and December 1998, December 2000, November 2003 and April 2004. More recently the methods for surveying urchins around Chumbe have been standardised so future studies will be comparable and more representative of the area.

There has been a noticebale increase in urchins within the Reef Sanctuary, which has prompted more standardised and frequent monitoring of the area. Studies conducted in November 2003 and April 2004 used the same methodologies but there were a few teething problems. It is hoped that these have been sorted out now and future monitoring will prove effective.

2. Methods

Urchin species distribution and abundance are assessed using a linear transect with analysis of quadrats at certain distances along it. An 150m transect line is laid perpendicular to the shore, 20m away from the coral rag wall. Starting at 0m and then at 20m intervals, three circular quadrats ($10m^2$ total area for each) are assessed for urchin species and abundance.

The following urchin species are counted within each quadrat. Any species different to these is also noted and identified either on the survey or back on site with the aid of identification guides...

- *Diadema setosum*
- *Diadema savignyi*
- *Echinometra mathaei*
- *Tripneustes gratilla*
- *Echinothrix sp.*
- *Toxopneustes pileolus*
- *Salmacis bicolor*

Once eight sets of three quadrats have been assessed (three circular quadrats every 20m along the 150m line, beginning at 0m, ending at 140m), the substrate is sampled. This is completed by using the same technique of point sampling as the substrate survey in Reef Check monitoring.

3. Results to date

Ten urchin transects were surveyed during the last two studies: 4 on the east coast; 4 on the west; 1 in the south; and 1 in the north. The following results are from the survey conducted in April 2004. Table 9 lists the average numbers of urchins found within a $10m^2$ quadrat at each distance interval for each area surveyed (north, east, south, west).

Table 9: Summary of average number of urchins at distance intervals for each transect

		Distance / m								Overall
Transect	**Urchin species**	**0**	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**average**
East	***D.setosum***	8.50	8.50	51.00	44.67	39.72	11.44	6.44	7.56	22.23
	D.savignyi	-	-	1.00	3.00	1.00	-	-	-	1.67
	E.mathaei	47.83	3.00	1.89	4.17	1.83	1.00	-	-	9.95
	Tripneustes	-	-	-	1.00	-	-	-	-	1.00
West	***D.setosum***	-	-	2.00	4.00	10.50	32.78	44.33	63.44	26.18
	D.savignyi	-	-	-	-	-	3.50	-	1.50	2.50
	E.mathaei	-	26.67	26.00	5.58	1.67	15.00	20.38	40.17	19.35
	Echinothrix	-	-	-	-	7.00	1.00	1.25	1.00	2.56
	Tripneustes	-	1.00	1.00	2.00	4.67	1.00	41.33	-	8.50
	Toxopneustes	-	-	-	-	-	-	2.00	-	2.00
	Salmacis bicolor	-	-	-	-	11.00	-	-	-	11.00
North	***D. setosum***	-	-	-	-	-	-	-	1.00	1.00
South	***E.mathaei***	-	-	25.00	78.67	89.67	50.00	2.00	78.00	53.89
	Echinothrix	-	-	-	-	1.00	-	-	1.00	1.00
	Tripneustes	-	-	-	-	-	-	-	1.00	1.00

Data shows the greatest diversity of urchin species in the west of Chumbe, with a total of seven urchin species identified during these surveys. Although low in species diversity, the southern transect showed the highest average density of urchins per species (approximately 54 *Echinometra mathaei* in $10m^2$). The most abundant urchins on the west and east coast were *Diadema setosum*, followed by *E. mathaei*.

4. Conclusions

There has been a noticebale increase in urchins within the Reef Sanctuary, which may be a result of overfishing on the east coast. When predators of urchins such as certain *Balistapus undulatus, Coris formosa, C. aygula, Cheilinus trilobatus* and *Lethrinus mahesen* are overfished the urchins have been observed to increase their numbers rapidly, particularly *Echinometra mathaei*. At ecologically sound population levels urchins benefit the reef by grazing on algae that usually compete with corals for settlement space. However, in high densities urchins will clear vast areas by grazing and therefore also clear any settling corals.

It is important that the subtidal areas are surveyed in the same way during future monitoring. This will allow comparisons of urchins abundance, distribution and species diversity to be made over the coming months and years.

5. Clearance of urchins

In an effort to reduce the density of *Diadema* sp. within the Reef Sanctuary, removal of urchins was carried out by the rangers from June 04 – August 04. This was because a large increase of *Diadema* were noted in the Reef Sanctuary prior to these months. Since August 04, an increase of *Echinometra mathaei* has also been noticed

within similar areas, both of which are reflected in the relatively high densities observed during the surveys in April 04.

A total of 31,000 urchins were removed (21,000 *Diadema setosum*, 9,000 *Echinothrix* and 922 *Diadema savignyi*). This removal work has been put on hold as it is hoped that the population will naturally decrease. However, the rangers will be checking on the urchin populations very closely and will respond accordingly in the future.

Reef Check surveys

1. Introduction

Reef Check is a global monitoring system for assessing the status of coral reefs throughout the tropics. CHICOP personnel have been involved with the organisation of Reef Check within Tanzania for a number of years and recently organised training with CHICOP rangers. This was with the view that the rangers would use the Reef Check techniques to monitor Chumbe's Reef Sanctuary on a regular basis in the future.

Reef Check surveys can be carried out anytime but need to be submitted to the Headquarters in USA by December 31st of any given sampling year. This is to ensure inclusion of the data into the global database and regular reports.

2. Methods

There are four types of surveys conducted for Reef Check. All collected data is then transferred to standardised, electronic data forms. Prior to underwater surveys (whether by SCUBA or snorkelling), a site description is completed, which includes anecdotal, observational, historical, location and other data. These data are extremely important when HQ interpret global correlations in the data.

For the underwater surveys, a 100m transect is laid along the contour of the reef. The transect line is divided into four sections by surveying the first 20-metres, then swimming over the next 5-metres, and repeating this another three times. The following surveys are conducted along each of the four 20m transects sections...

1) **Fish belt transect**. Sampling fish species within four, 20m long by 5m wide (centered on the transect line) segments. The fish being assessed are typically targeted by fishermen, aquarium collectors and others. Fish seen up to 5m above the line are counted. This is always the first survey to be completed

2) **Invertebrate belt transect**. The same four, 20m long by 5m wide (centered on the transect line) segments as in the fish belt transect are sampled for invertebrate species typically targeted as food species or collected as curios

3) **Substrate line transect**. Using the same transect line as the fish and invertebrate belt transects, but this time, points are sampled at 0.5m intervals along the linear transect to determine the substrate types on the reef

The categories determined during the substrate surveys are as follows...

Hard coral (HC): Includes fire coral (*Millepora*), blue coral (*Heliopora*) and organ pipe coral (*Tubipora*) because these are reef builders.

Soft coral (SC): Include zoanthids, but not sea anemones (the latter go into "Other"). Sea anemones do not occupy much space in the same manner as zoanthids or soft corals. In the Atlantic, this category is for zoanthids.

Recently killed coral (RKC): The aim is to record coral that has died within the past year. The coral may be standing or broken into pieces, but appears fresh, white with corallite structures still recognizable, only partially overgrown by encrusting algae etc.

Nutrient Indicator Algae (NIA): The aim is to record blooms of algae that may be responding to high levels of nutrient input. Examples of these types of algae are *Ulva*, various blue green algae, and bubble algae. Algae that are a normal part of a healthy reef, such as *Sargassum* and Halimeda should **NOT** be recorded as NIA. Instead, record the substrate directly beneath the algae and note this in the comments section.

Sponge (SP): All sponges (but no tunicates) are included; the aim is to detect sponge blooms that cover large areas of reef in response to disturbances.

Rock (RC): Any hard substrate whether it is covered in e.g. turf or encrusting coralline algae, barnacles, oysters etc. would be placed in this category. Rock will also include dead coral that is more than about 1 year old, i.e. is worn down so that few corallite structures are visible, and covered with a thick layer of encrusting organisms and/or algae.

Rubble (RB): Includes rocks between 0.5 and 15 cm diameter. If it is larger than 15 cm it is rock, smaller than 0.5 cm and it is sand.

Sand (SD): In the water, sand falls quickly to the bottom after being dropped.

Silt/Clay (SI): Sediment that remains in suspension if disturbed. Note that these are practical definitions not geotechnical. Often, silt is present on top of other indicators such as rock. In these instances, silt is recorded if the silt layer is thicker than 1 mm or covers the underlying substrate such that you cannot observe the color of what is underneath. If the color of the underlying substrate can be discerned, then the contact will be counted as the underlying substrate NOT silt.

Other (OT): Any other sessile organism including sea anemones, tunicates, gorgonians or non-living substrate.

The above suite of surveys were repeated at three different sites along Chumbe's Reef Sanctuary: north; middle; south. All the sites were approximately the same depth; 5m.

3. Results

Surveys at three sites were completed by a team of three volunteers from Holland (Marc Schols, Juuls Pas, Reuben Geutjes) and Carol Daniels (Conservation Co-ordinator, CHICOP). These were conducted using SCUBA equipment near to the edge of the reef on 27th and 29th July and 9th August 2004.

Training was also completed in snorkelling Reef Check survey techniques, mainly with Omari Nyange (Head Ranger) but also to some extent with Khamis Khalfan (Assistant Head Ranger) and Khamis Ali (Trainee Ranger).

As this is the first Reef Check survey conducted on Chumbe's reef it is not possible to compare data to previous years. However, the following is a summary of the data collected for each survey type, where at least each site can be compared...

Fish belt transect

	North			Middle			South		
	Total	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Mean**	**SD**
Chaetodontidae / Butterflyfish	32	8.00	3.83	19	4.75	2.63	12	3.00	3.37
Haemulidae / Sweetlips	16	4.00	5.66	14	3.50	3.11	5	1.25	2.50
Lutjanidae /Snapper	7	1.75	1.50	2	0.50	1.00	1	0.25	0.50
Barramundi cod	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Grouper	8	2.00	1.83	1	0.25	0.50	2	0.50	0.58
Humphead wrasse	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Bumphead parrot	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Scaridae / Parrotfish	16	4.00	2.58	8	2.00	1.83	24	6.00	3.92
Moray eel	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00

In summary, Chaetodontidae, Haemulidae and Scaridae were the most abundantly sampled fish during these surveys. The most Chaetodontidae and Haemulidae were observed along the northern transect whereas the southern transect was recorded with the most Scaridae. Groupers and Lutjanidae were most abundant along the northern transect too.

Invertebrate belt transect

	North			Middle			South		
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD
Banded coral shrimp	1	0.25	0.50	0	0.00	0.00	0	0.00	0.00
Diadema	51	12.75	4.35	335	83.75	14.80	828	207.00	89.21
Pencil urchin	5	1.25	1.26	0	0.00	0.00	0	0.00	0.00
Sea cucumber	5	1.25	0.50	5	1.25	0.50	12	3.00	2.00
Crown of thorns	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Giant clam	6	1.50	0.58	5	1.25	0.50	14	3.50	2.08
Triton	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Collector urchin	0	0.00	0.00	0	0.00	0.00	3	0.75	0.96
Lobster	0	0.00	0.00	0	0.00	0.00	1	0.25	0.50

The most striking result from the invertebrate survey is the abundance of *Diadema* urchins along the southern transect, and their fairly high numbers along the middle transect. The majority of giant clams (*Tridacna* sp.) were found in the south area as

were collector uchins (*Tripneustes* sp.) and sea cucumbers (Holothuroidea). It should be noted that only two species of Holothuroidea are included in the Reef Check survey; Prickly redfish (*Thelenota ananas*) and Greenfish (*Stichopus chloronotus*). No Crown-of-thorns starfish (*Acanthaster planci*) were observed within any transect segment or in any area.

Substrate point sampling

	North			Middle			South		
	Total	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Mean**	**SD**
HC	111	27.75	4.35	34	8.50	3.416	66	16.50	2.08
SC	1	0.25	0.50	0	0.00	0.00	0	0.00	0.00
RKC	0	0.00	0.00	3	0.75	1.50	0	0.00	0.00
NIA	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
SP	0	0.00	0.00	1	0.25	0.50	0	0.00	0.00
RC	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
RB	18	4.50	1.73	66	16.50	3.11	74	18.50	4.80
SD	27	6.75	5.85	56	14.00	6.38	20	5.00	6.38
SI	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
OT	3	0.75	0.50	0	0.00	0.00	0	0.00	0.00

Substrate assesment shows the majority of hard coral to be located in the northern transect, followed by the south and then the middle. There were few or no recently killed corals, soft corals, nutrient-indicator algae or sponges observed. The predominant substrate types were hard corals, rubble and sand in all transects, with rubble dominating in the middle and south transects although hard coral was fairly highly represented in the southern transect.

4. Conclusions

The presence of the dominant fish (Chaetodontidae, Haemulidae and Scaridae) within the transects indicates a 'healthy' reef with representation from a number of genera that are usually under pressure from overfishing and usually occur in groups rather than remaining solitary such as the grouper, humphead wrasse and barrumundi cod. The fact that most observed fish were recorded in greatest abundance in the northern section is not surprising as this has the most dense, rugose and diverse Scleractinian coral cover of the whole of Chumbe's protected reef. This area is very popular for snorkelling guests with the rangers as it is also sheltered for most of the year. Results from these surveys are a positive indication that the guests are not having an adverse affect on the reef fish within this area.

Results from the invertebrate survey raise some concern over the number of urchins (Echinoidea), particularly in the southern half of the reef. A large spike in the urchin population has been noted on Chumbe since April 2004. This has been discussed in this document (see Urchins section) and may be a result of weather and temperature conditions or influence from other, degraded areas such as the east coast of Chumbe and other islands to the west of Zanzibar such as Bawe, Prison and Changuu.

However, there are also many positive outcomes of the invertebrate survey such as the number of giant clams, particularly in the south, and the fact that no Crown-of-thorns

starfish were observed. There are many other edible sea cucumbers on Chumbe's reef than the two species observed in these surveys. It would be worthwhile including these in future monitoring so there is no mis-representation of the abundance of these creatures on the reef. They are an important part of the ecological system because, for example, they recycle and turn over loose substrate, which prevents it from becoming anoxic.

With the substrate survey, as with the conclusions of the fish surveys, it is no surprise that the northern transect had the most hard coral point samples. The southern reef is very diverse but is more spread out in patches of coral communities whereas the northern section is much more continuous in terms of coral cover. The middle area has less coral cover as it is the transition area between the patchy reef to the south and the continuous reef in the north. This is an area subject to frequent *Sargassum* growth and senescence and the coral cover is quite low (low rugosity). The absence of nutrient-indicator algae and infrequency of soft corals indicates a well-established reef with hard coral being more dominant than the faster colonising soft corals and algae.

In summary, a preliminary assesment of the Reef Check data seems positive in terms of the 'status' of Chumbe's Reef Sanctuary. The one problem that was highlighted was the abundance of urchins, which had already been noted by CHICOP and is being accordingly.

Demarcation and lifesaving mooring buoys

1. Introduction

Three unlit, demarcation cardinal buoys were positioned on the boundaries of the Chumbe Island Reef Sanctuary on 28th and 29th September 2004. These were requested by fishermen and CHICOP rangers to aid visualisation of the boundaries for the fishermen and during regular ranger patrols within this area. At the same time, two smaller buoys were prepared so that fishermen could tie their boats to these and shelter from poor weather conditions. One of these lifesaving mooring buoys has been deployed in the north of the island. The other will be positioned in the south but unfortunately rough sea conditions have prevented this deployment to date.

The demarcation buoys (Figure 2) are made from large, 1,000-litre Simtanks and the smaller buoys from 100-litre strong, household containers. Both have chain secured completely through the centre of the buoys, and a concrete weight on the seabed, also attached by chain. The buoys have been made as strong and thief-proof as possible due to two sets previously being stolen from the Reef Sanctuary. Colouring is plain white for the lifesaving mooring buoys and 'danger east' cardinal marking (yellow and black with two black triangles on the top) for each demarcation buoy. There will also be landmarkers installed on the southern tip of the south islet and on the northern tip of Chumbe's main island. These will show the full boundaries i.e. imaginery line between the cardinal buoys in the north and south and the respective landmarkers north and south.

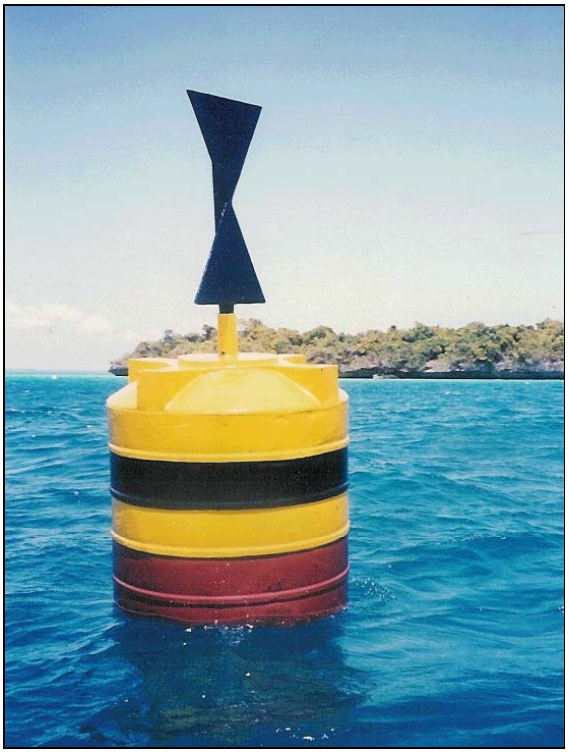

Figure 2: Danger east cardinal demarcation buoy in position to the north of Chumbe

Permission was granted from the Zanzibar Ports Corporation (ZPC) for manufacture and deployment of these buoys. ZPC will inform the UK Hydrographers Office (UKHO) of the installed markers so that this can be incorporated into future records, and maritime charts.

The positions of the demarcation buoys were confirmed (300m directly west of the high-water mark of Chumbe's island mass) using a global positioning system (GPS). Omari Nyange has and will guide the installation team to appropriate positions for the lifesaving mooring buoys. These are positioned close to the island to ensure shelter from the wind. However, the ground weights had to be very carefully placed so as not to damage the coral reef.

2. Location

The locations of each buoy are listed in Table 10, and were positioned using an Garmin, e-trek GPS system.

Table 10: GPS location of demarcation buoys

Buoy description	S: Degrees / Minutes / Seconds in decimal	E: Degrees / Minutes / Seconds in decimal
Demarcation North of MPA	06° 16' 17"	39° 10' 35"
Demarcation Mid of MPA	06° 16' 48"	39° 10' 21"
Demarcation South of MPA	06° 17' 00"	39° 10' 45"
Lifesaving mooring buoy north	06° 16' 24"	39° 10' 33"
Lifesaving mooring buoy south	06° 17' 16"	39° 10' 42"

3. Conclusion

The remaining lifesaving buoy will be deployed as soon as possible, as will the landmarkers. All the buoys will be monitored closely over the coming weeks to ensure they have been successfully installed and do not drift. The ground weights and all stainless steel components will be checked on a regular basis and replaced before they become worn through.

Proposed monitoring schedule

1. Introduction

During the last year, the rangers have received more training in basic survey and monitoring skills. It is hoped that they will continue to develop these skills in addition to undertaking their regular daily duties on Chumbe Island. The following schedule is proposed for continual monitoring of the reef area, which will be conducted by CHICOP rangers.

2. Proposed schedule

The marine monitoring schedule is listed below and indicates the period of repetition for each survey type (Table 11).

Table 11: Proposed monitoring schedule for Chumbe Island Coral Park

Monitoring - CONTINUAL
- Bleaching, disease, damage
- Poaching incidents (ranger reports*)
- Water temperature (temperature logger)
Monitoring – EVERY THREE MONTHS
- Crown-of-thorns starfish
- Sargassum / coral recruitment
Monitoring – EVERY SIX MONTHS
- Buoy maintenance
- Intertidal
Monitoring – ONCE EVERY YEAR
- Urchin species and distribution
- Reef Check: fish, invert & substrate assessment

* This is a priority and has been continually assessed over the last 11 years. The rangers will continue completing their weekly reports with the following details for each poaching incident...

- Date and time of incident (including whether day or night)
- Type of vessel (Ngalawa, canoe, dhow, snorkel)
- Number of people (if possible to see)
- Number of gear in total or per person e.g. 2 fishing lines per person / 1 spear per person / 1 large net per boat (kojani, spear, line, cage, travel, help, anchor)
- Name of poachers, poachers' village name(s) and boat identification
- Action from the rangers
- Consequence of action i.e. did the poachers fish, leave, threaten? Were the police from the island involved and if so, who was involved?

Copies of these reports are conintually made and given to DFMR. CHICOP's fisheries officer (Kheri Mchumi Khamis) is informed of any repeat offenders, which usually results in DFMR approaching individaul Shehas and / or fishermen to rectify

the situation. Most of the time this warning and personal contact is enough to prevent further poaching from the same person / people.

3. Future monitoring possibilities

The following is a list of additional studies that could be undertaken when the above schedule has been fully incorporated into CHICOP's routine duties (also where expertise and equipment permits)...

- Coral recruitment (continuation of Chris Muhando's settlement plates)
- Mangrove recruitment (discuss with Dr Shunula, IMS)
- Reef Check expansion – include more fish species (e.g. complete genus such as butterfly fish (Chaetodontidae) to assess fish diversity), and invertebrate species
- Seagrass (flora, fauna, abundance, distribution)
- Water pH