Rufiji Environment Management Project[1]

Environmental Management and Biodiversity Conservation of Forests, Woodlands, and Wetlands of the Rufiji Delta and Floodplain

Status of the marine habitat and resources adjacent to the Rufiji River outflow

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[1] The Rufiji District Council implements Rufiji Environment Management Project with technical assistance from IUCN – The World Conservation Union, and funding from the Royal Netherlands Embassy.

Rufiji Environment Management Project – REMP

Project Goal

To promote the long-term conservation through 'wise use' of the lower Rufiji forests, woodlands and wetlands, such that biodiversity is conserved, critical ecological functions are maintained, renewable natural resources are used sustainably and the livelihoods of the area's inhabitants are secured and enhanced**.**

Objectives

- To promote the integration of environmental conservation and sustainable development through environmental planning within the Rufiji Delta and Floodplain.

- To promote the sustainable use of natural resources and enhance the livelihoods of local communities by implementing sustainable pilot development activities based on wise use principles.

- To promote awareness of the values of forests, woodlands and wetlands and the importance of wise use at village, district, regional and central government levels, and to influence national policies on natural resource management.

Project Area

The project area is within Rufiji District in the ecosystems affected by the flooding of the river (floodplain and delta), downstream of the Selous Game Reserve and also including several upland forests of special importance.

Project Implementation

The project is run from the district Headquarters in Utete by the Rufiji District Administration through a district Environmental Management Team coordinated by the District Executive Director. The Project Manager is employed by the project and two Technical Advisers are employed by IUCN.

Project partners, particularly NEMC, the Coast Region, RUBADA, The Royal Netherlands Embassy and the Ministry of Natural Resources and Tourism, collaborate formally through their participation in the Project Steering Committee and also informally.

Project Outputs

At the end of the first five –year phase (1998-2003) of the project the expected outputs are:

An Environmental Management Plan: an integrated plan for the management of the ecosystems (forests, woodlands and wetlands) and natural resources of the project area that has been tested and revised so that it can be assured of success - especially through development hand-in-hand with the District council and the people of Rufiji.

Village (or community) Natural Resource Management Plans: These will be produced in pilot villages to facilitate village planning for natural resource management. The project will support the implementation of these plans by researching the legislation, providing training and some support for zoning, mapping and gazettement of reserves.

Established Wise Use Activities: These will consist of the successful sustainable development activities that are being tried and tested with pilot village and communities and are shown to be sustainable

Key forests will be conserved: Forests in Rufiji District that have shown high levels of plant biodiversity, endemism or other valuable biodiversity characteristics will be conserved by gazettement, forest management for conservation, and /or awareness-raising with their traditional owners.

Executive Summary

The Rufiji delta and lower floodplain is a natural treasure with a delicate balance of growing human population and threatened unique habitats. A call for action by the local community has initiated a partnership between The World Conservation Union (IUCN) with the Tanzanian and Dutch Governments. This has produced the Rufiji Environment Management Project (REMP), whose aim it is to facilitate and advise the local communities with long term plans, to promote sustainable resource use through management of the environment.

As part of REMP's general environmental and resource use inventory, a survey designed to study the marine environment influenced by the Rufiji river and utilised by local communities, was undertaken during June 2001.

The survey aimed to sample-survey reefs adjacent to the Rufiji river outflow. Of the target area - 6km south of the Rufiji delta, Simaya Island and the nearby Okambara Projection were sites thought to represent the local reefs and thus selected for surveying. The preliminary study, at both sites, included site mapping, littoral surveying, and reef cover review. On Simaya Island where a local fishermen camp is based, resource use such as shell collecting, fisheries and sea cucumber fisheries were investigated.

The survey has indicated Simaya Island has a healthy reef, surviving well the chronically sediment rich conditions emerging from the proximity to the Rufiji delta. Around Simaya Island the reef crest forms an incomplete ring, a similar formation was found at Okambara Projection. Coral cover at the North of the Simaya Island reaches up to 100% with little damage observed. Other areas sustain coral communities typical of turbid water but with lesser cover.

Resource use on Simaya is seasonal although a low level of utilisation exists all year round. Current (off-season) activities are limited to opportunistic lagoon collection and the employment of one boat. Destructive fisheries, such as drag-net (both beach and seine) were observed and extensive sea cucumber and shell collection took place during the investigation.

Given the current lack of knowledge on habitat condition, resource use levels and the information brought to light in this survey, it is recommended that an extensive investigation takes place for further analysis. Setting up a monitoring and facilitating management project for this area, which is run by the local community, should be a priority for the future. Local resource users such as fishermen could be trained to take an active part and be encouraged to undertake surveying, and monitoring of both habitat and fisheries.

Simaya Island, in particular, is largely degradation free and offers an opportunity to undertake conservation before anthropogenic pressure forces action. At this stage it is possible to develop sustainable resource use before the need for an emergency conservation plan arises.

Acknowledgements

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Thank you all

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1 Introduction

The Rufiji is the largest river in East Africa and hosts the largest mangrove forest in the region. It supports a complex environment including woodlands, grasslands, forests, swamps, inland waters and coral reefs. This diversity of habitats and the endemism it hosts, makes the floodplain and delta a prime site for conservation. However, conservation needs to be balanced against the needs of the local human population, which increasingly competes with wildlife for natural resources as well as space. About 100,000 people rely on the natural wealth surrounding the lower floodplain of the river and its delta. Population growth and development in the recent years was followed by an increase in the anthropogenic pressure on the environment. Over-harvesting of existing resources and expanding new developments are problems currently recognised by both the local government and the local community.

A partnership between The World Conservation Union (IUCN), the Tanzanian Government and the Dutch Government has been formed to facilitate and advise the management of the environment by the local communities. The overall aim of the Rufiji Environment Management Project (REMP), is to promote long term plans for sustainable resource use. This will be achieved through wise use of existing resources, creating alternatives for destructive practices and educating the local community for awareness and environmental conservation discipline.

One of REMP's first objectives was to conduct a general environmental inventory determining the condition of the environmental resources and the levels of use or damage already existing. This will facilitate a knowledgeable commencement of advice and actions. However, unlike the far better understanding of the constraints and limitations of terrestrial resource use by the local community, marine management is problematic. In the marine environment, the effects of misuse are not visible or obvious, as they can be on land, which makes it harder for stakeholders, to recognise and accept responsibility.

The local community of Jaja village initiated the call for environmental assessment, of the reefs outside the delta and a survey was undertaken in early June 2001. Unfortunately, the information available for their prime concerns, survey location or underwater conditions during the planning stage of this survey was minimal. The aim of the survey was therefore set to have the first inventory, base line survey at the locations identified as important by the community and provide an initial insight on the level resource use. Simaya Island was identified as a starting point and Okambara sandbar was later visited as representative of Mwamba Mkuu sandbars. Because of adverse conditions (visibility, wave action) the small hard substrate areas north of Jaja river mouth and exploited by the REMP pilot village of Jaja could not be inventoried during this survey.

1.1 Simaya Island

Simaya Island is located North of the Songo Songo archipelago at UTM 37 South S 547581 E 9082388 (table 1). Songo Songo, which is made up of 5 main islands and 20 odd sandbars are directly to the South. The archipelago rests on a relatively wide shelf of 12km of less than 50m depth.

Simaya Island area	32043 m^2
Width	112m
Length	336m
Simaya perimeter	810m
Area of littoral zone	744777 m^2
Littoral zone perimeter	4190m
Distance from coast	8972m

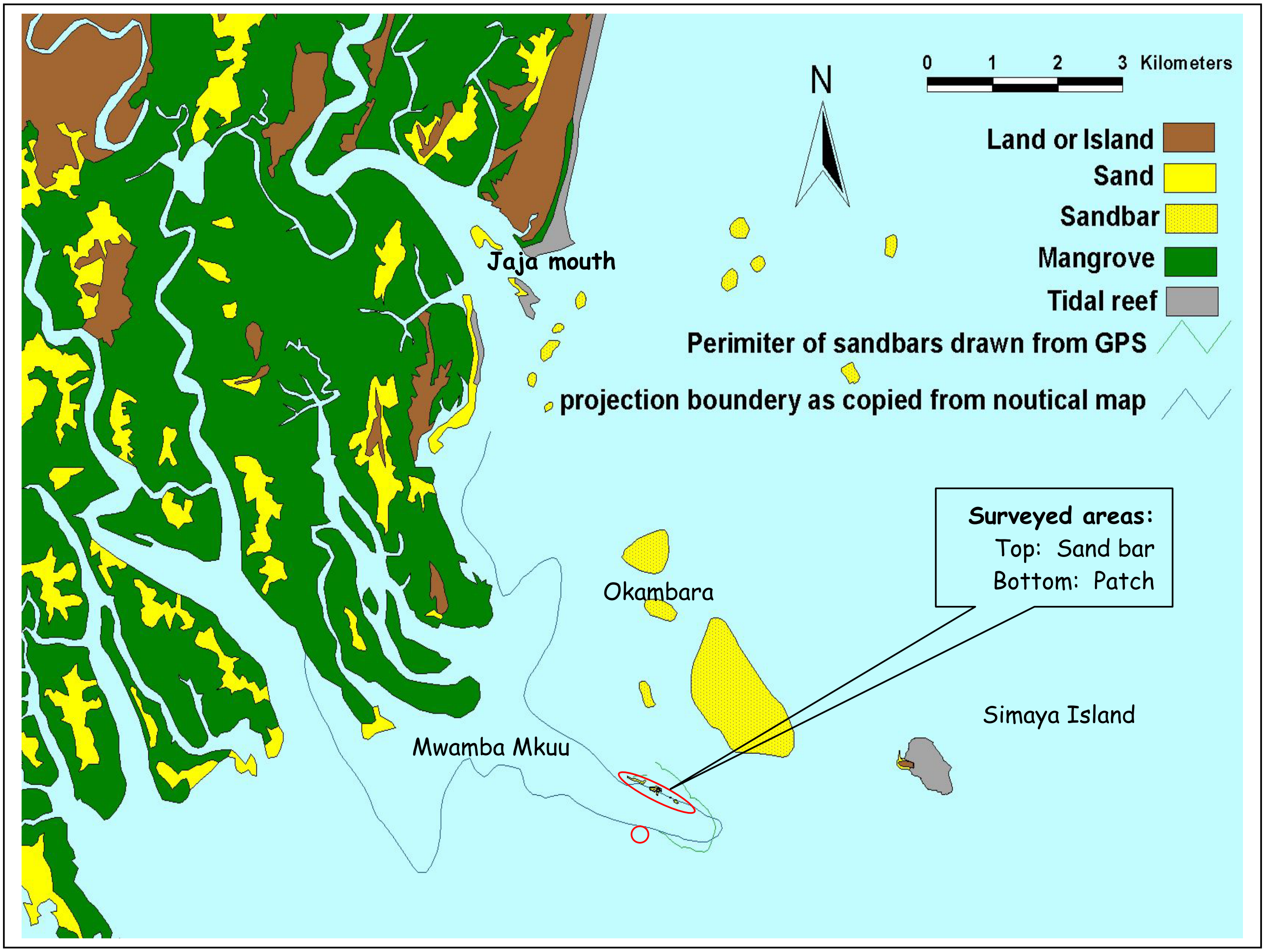
Table 1: Simaya Island Statistics

It is the only island, of a small cluster of sandbars called Mwamba Mkuu East of Ras Pombwa. The position of the archipelago, by the opening of the Mohoro and Jaja rivers and the surrounding depth, which generally doesn't exceed 20m, are both reflected by high levels of turbidity. River output, as seen on the aerial photographs (June 1999) show a band of very turbid and high sediment load carrying water (and probably brackish too) up to 4km from the coast line. The band itself, offers no visibility for surveying, but this condition changes closer to Simaya Island (6km form shore) where visibility increases to 4-6m. Although conditions for coral reefs growth are unfavourable Simaya Island is surrounded on three sides by a healthy ring of reef. The island itself is sand based, which has stabilised over the decades by the protection of its hard coral barrier. It is not unlikely that the other sandbars of Mwamba Mkuu might be developing into similar islands in the geological future.
Simaya was surveyed previously in 1994 by Frontier - a UK based NGO, the results of the one week survey and a second fisheries survey conducted in 1995 are published in a report obtainable from the Frontier office in Dar es Salaam or London.

1.2 Okambara sandbar

The Okambara projection penetrates almost 6km into sea (map 1). It is about 700m wide and is made of two main sandbars (dry during low tide) separated by channels. At low tide, the structure consists of a somewhat higher, thinner (40m) broken sandbar at the North end and a slightly lower seagrass field to the South. Surveys were based at the Western point of the easternmost bare sandbar located at UTM 37 South, S 5415560 E 9082080.

Map 1: Okambara and Mwamba Mkuu



2 Materials and method

The surveys were undertaken in three days forcing the use of rapid assessment methods aimed to maximise sampling area. Very little was known of the water conditions or expected findings.

The first two days were spent on Simaya and the last at Okambara sands. As the desired output for this survey was a map outlining the different class zones (such as algae fields, seagrass or coral reef) the use of the Global Positioning System (GPS) and Geographic Information Systems (GIS) was combined with traditional baseline biological survey.

One of the first priorities was to generate a map of the island and its littoral zone. Using a hand held GPS, the boundaries of the high and low water were marked using numerous way-points. These were then joined together to form a polygon on two GIS programs - ArcView and MapInfo - resulting in a base map of the island. The littoral survey that followed was conducted using the same technique, so the boundary of the lagoon, sandy area and other attributes were added to the original layer. For the littoral zone survey there was no particular method pattern (e.g. transect or quadrate) and invertebrate presence was recorded.

Underwater surveys were conducted by team effort, which included a snorkeller (Tamir Caras), a GPS person and a data recorder person. The planned method was an adjustment of the rapid assessment in Horrill (1995) to fit the spatial objectives (sample data sheet - see appendix 9). However, poor physical conditions (visibility & current) prohibited respectively the use of manta-tow technique and shortened the time allocated to each spot check to seconds. The resulting method was based on drifting Northwest (with the South-easterly monsoon winds) and limited observation time. This method is somewhat similar to surveying technique used by frontier and reported at Darwall et al (1996) and therefore results are thought to be comparable.

As often as possible the snorkeller would make an observation of an area within his visible limits (typically $5m^2$) and relayed it to the boat. For every point, a GPS and a spot survey included depth, visibility, bio cover (% in groups), coral dominance (genus), dominant substrate and a general description. When current speed allowed, more detailed information was collected and photographic record taken.

These were then analysed and summarised in Excel and similarly to the base map (Appendix 1), the observation points were plotted onto the baseline map. Contrary to the original intent, the data range had to be much simplified. Depth measurements were taken using a dive computer and a contour topographic map was generated (Appendix 6).

Unfortunately, due to the survey time limitation only the North aspect of the island was relatively well surveyed and the data was good enough to create a coral density map. At the South aspect, only one drift survey was conducted resulting in a patchy dataset, the South-easterly point was not surveyed at all.

The sandbar of Okambara was surveyed during low tide slack. Similarly to the base map of Simaya, the sandbar boundary was marked using a GPS and then algae field boundaries were marked in the same manner. A few skin dives at the reef of the Southern part have provided a general feel to the coral build of the coral reef boundary. Finally, by sailing the boat around, the approximate boundary of the projection was marked.

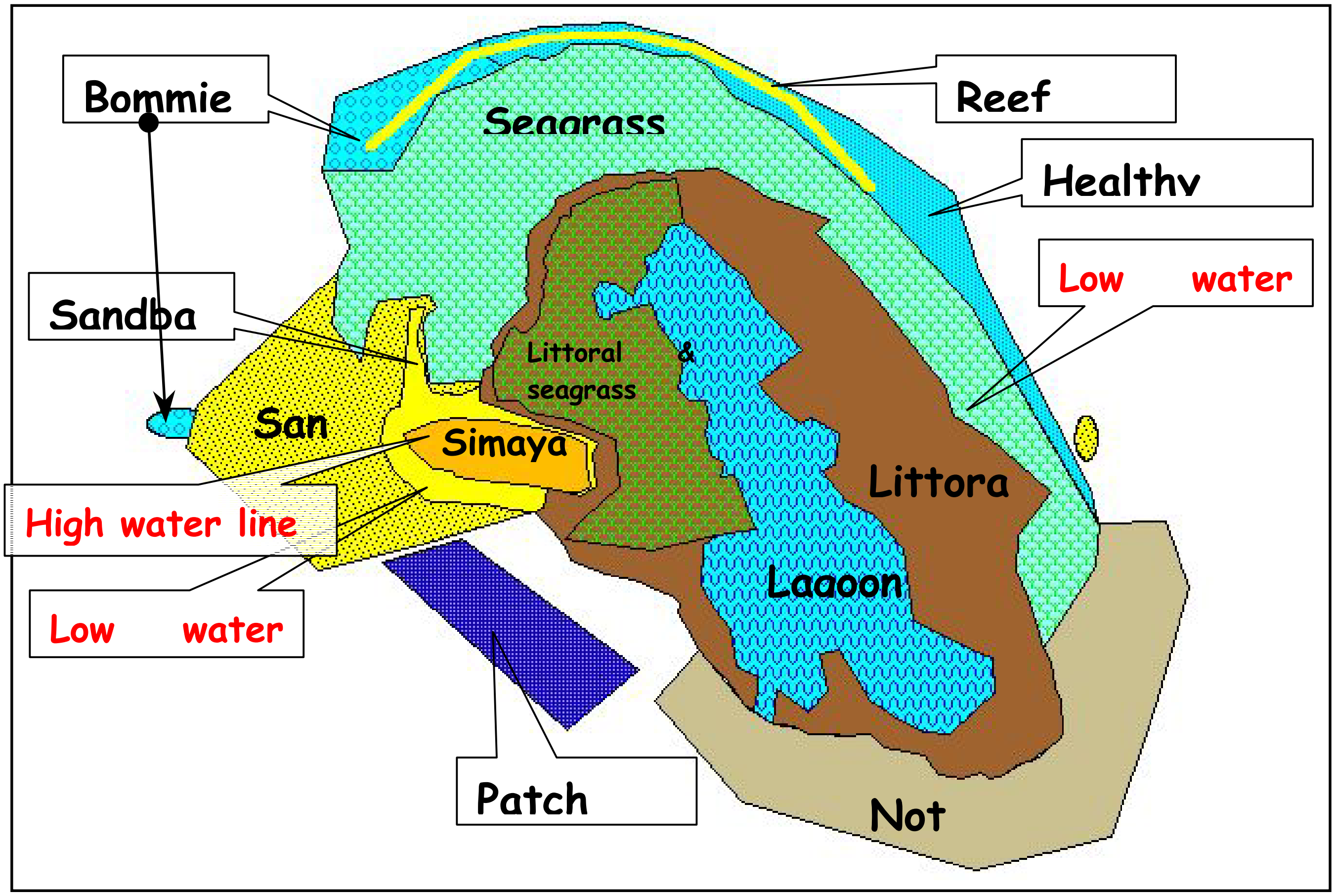
Resource use survey was conducted both by interviews of the local fishermen (figure 1) and by passive observation of catch and debris (figure 2). The fishermen were fairly accommodating and co-operated fully; therefore useful information has been gathered on the sea cucumber fishing and trade.

Figure 1: Fishermen and pull net catch (in action - figure 15)

Figure 2: **Assortment of fish and octopi collected from the lagoon**

3 Habitat Status

3.1 Simaya Island



Map 2: Simaya Island and the main habitat zones identified during this survey.

3.1.1 The littoral zone

General description: This area is almost 15 times the size of the island itself, consisting of a rock-base, much like a platform, with scarce patches of sand and rubble (and of course, the lagoon - figure 3). The rocky pavement is mostly bare except for very low cover of the seagrass *Thallasia* (5% on average), sometimes scattered with the urchin *Echinometra*. Due to time constraints, a thorough investigation only encompassed the western part of the littoral zone, thus the seagrass extent on the baseline map (map 2).

Figure 3: View to East - littoral platform and lagoon

Although fairly level, the platform is fringed at the edge with a step of 40cm at low tide where many tidal pools can be found. Here a variety of fish and invertebrates reside or get trapped by the tide (Appendix 3) producing a harvestable supply to fishermen.
Dominant genera: seagrass- Thallasia hemprichii, Thalassodendron ciliatum; urchin- Echinometra
Dominant substrate: rock

Figure 4: Rocky area of the lagoon at low tide - *Pavona* coral heads

3.1.2 The lagoon

General description: The lagoon is a fringed edged conglomerate of pools and channels, which flows from North to South in the centre of the intertidal zone. It is knee deep at low tide, when it is mostly isolated from the sea by the rocky plate making the littoral zone (map 2). The substrate is mostly coarse sand (and no silt) scattered with small bommies, submerged even during low tide (figure 4).
The lagoon is very diverse, both in resident species and non-resident - trapped species that feed there.

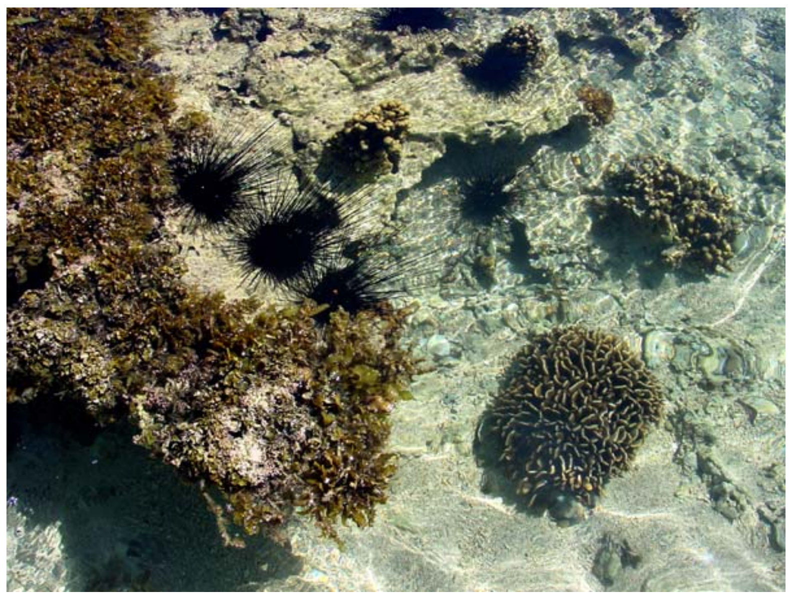


Figure 5: Typical lagoon edge - sandy bottom, rocky edge, *Sargassum* algae & *Diadema* sea urchin

The lagoon is characterised by a distinct community of corals such as *Pavona* and *Porites*, algae mostly consisting of *Sargassum, Turbinaria* and *Cystoseira* while the dominant urchin is *Diadema*. However, the rim of the lagoon has a distinct band of the seagrass *Thalasia* and the urchin *Echinometra* is dominant.

Typical biocover: overall- seagrass 2%, algae- 20% hard coral & soft coral bommies 10%.
Dominant genera: seagrass- *Thalasia hemprichii*, ; hard coral- *Pavona decusata* and *Porites lutea* ; algae- *Sargassum* & *Cystoseira*, ; urchin- *Diadema* (figure 5).
Dominant substrate: sand 70%, rock 15%, rubble 15%.

3.1.3 Seagrass bed

General description: This area, has a relatively dense seagrass bed that covers the majority of the North and East sections (map 2). The seagrass occurs from the low water mark through to the coral reef with occasional sandy or rubble patches. Patches are usually edged (particularly on rubble patches) with algae. Throughout the area the urchin *Diadema* is common but other invertebrates such as *Echinometra* urchin and *Holotherian* sea cucumbers can be encountered. Soft and hard corals can be counted mostly in small and scarce bommies on rubble patches and includes *Porites*, *Acropora* and *Montipora* genera. The seagrass is the feeding ground for a variety of grazing fish like are Rabbitfish (*Siganidae*), Emperors (*Lethrinidae*), Goatfish (*Mullidae*) and thus has an important economic value.
Typical biocover: seagrass 80% hard corals and soft corals <5%
Dominant genera: seagrass- *Thalasia hemprichii* ; algae- *Turbinaria* and *Sargassum* (figure 6). Dominant substrate: sand and silt 70%, rubble and rock 30%.

Figure 6: Seagrass of the species Thalasia, just underwater at low tide - edge of the bay, North side

3.1.4 Western sand

General description: The entire area west of the island is dominated by a sand projection (map2). The substrate is mostly sand with fields of seagrass mixed with the occasional bommie becoming more frequent and concentrated towards the north.
Typical reef biocover: overall- seagrass 1%, (at seagrass field- cover- 70% hard coral and soft coral bommies 10%).
Dominant genera: seagrass *Thalasia hemprichii* ; hard coral - *Porites, Acropora*
Dominant substrate: sand 90%, rock 10% (figure 7 & 15).

Figure 7: View west, sand bar carries on the right (North) fishermen hut left to centre

3.1.5 Healthy reef (North & West):

General description: This is a very healthy coral reef with a defined crest, which is somewhat surprising, considering the turbidity and the level of sedimentation. Moreover, there was no sign to the bleaching event, devastating the entire East African coast in 1998. There were no obvious signs for human activity despite reports of dynamite fishing in the Frontier survey. The coral reef starts with a shallow reef flat at 1m, 10-30m wide and coral cover close to 100%.

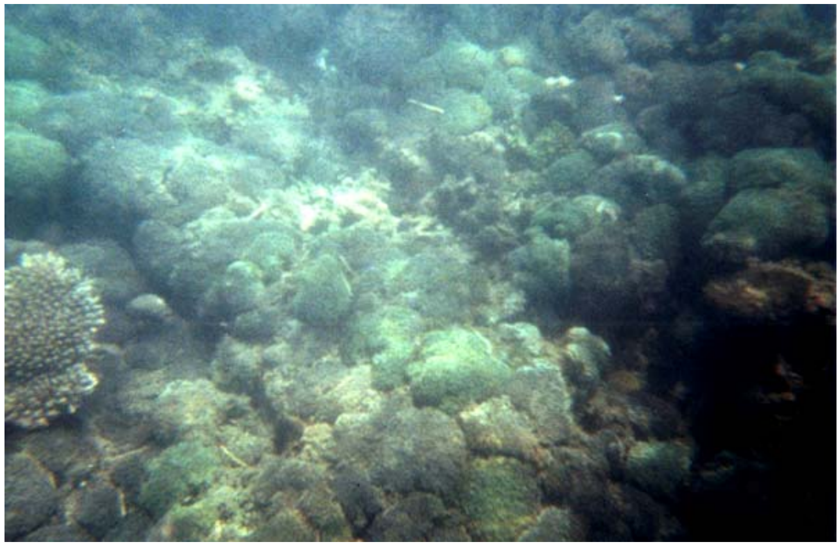


Figure 8: North aspect of reef crest - close to 100% cover

The reef crests between 3m to 10m with an average slope of 30˚ drops to a hard coral cover of 80%, turning further on into isolated bommies on a sand and silt sea bed (survey limits at 12m) and coral cover drops to below 60%. Towards the West, the reef crest changes into scattered bommies (map 2). Coral cover ranges from 60% to 100% (average 75%) composed mostly of *Acropora* staghorn and branching at the reef flat, *Acropora* tables and a variety of other corals down the slope. The lower part of the slope is dominant by more massive and submassive species like *Porites* and *Galaxea*.
Typical reef bio cover: Hard Coral 75% ; Dead Coral <5% ; Soft Coral and Sponge 10% ; Hydroid 10% (figure 8). Dominant genera: Hard Coral- *Acropora* tables, branching and staghorn, sub massive *Porites* and *Galaxea* ; Hydroids- sea whips and *Millepora*, ; Soft Coral-*Tubiphora* ; Algae- *Turbinaria*, *Sargassum*. Dominant substrate: rock and silt 10%, biocover 90%.

3.1.6 The patch reef (South)

General description: This reef consists of damaged hard and soft corals mostly in the form of bommies. This indicates areas of high sedimentation and degradation. The Eastern part illustrates the end of the reef crest, presumably carrying on the coral ring through the unsurveyed area to the North section (map 2). The damaged reef consists of *Acropora* (both branching and staghorn forms) which dominates the crest. Elsewhere dead coral patches, overgrown with algae (*Sargassum* and *Turbinaria*) and soft corals (eg: *Lithophiton*) occur.

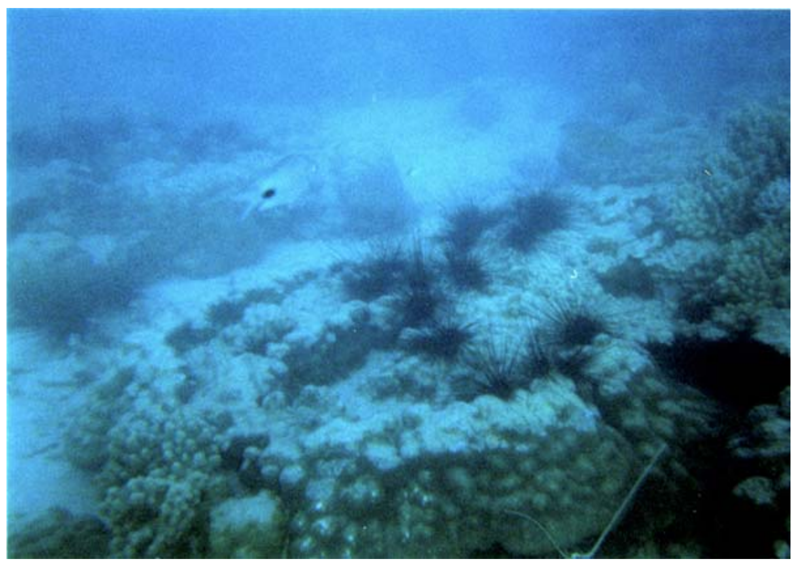


Figure 9: *Porites* bommie with it's top portion dead, typical for damaged reefs. Further erosion inflicted by large number of the urchin *Diadema*. Spot the lobster ate the very bottom of the picture.

The reef bottom at 10m, is silt and sand with no obvious biocover.

Towards the west the reef becomes less defined and is dominated by sub massive corals such as *Porites* and *Galaxea* (both robust and silt insensitive corals - McClanahan & Obura 1997). This section lacks the crest but is made of a more "bommie" arrangement of corals. Hard coral cover proportionally is low while soft coral cover and algae are both high. High population density of the urchin *Diadema* is present in this area.
Signs of reef damage exist at both East and West parts of this section. Degradation is mostly exhibited in what seems to be anchor damage while sediment related natural coral mortality is common.
Typical reef bio cover: Hard Coral 30% ; Dead Coral 30% ; Soft Coral and Sponge 20% ; Algae 20% (figure 9).

Dominant genera: Hard Coral- *Porites*, *Acropora*, *Montipora* ; Soft Coral - *Sinularia*, *Sarcophyton* ; Hydroids- Sea Whips, Algae - *Turbinaria*, *Sargassum*.
Dominant substrate: rubble and sand (50%), biocover 50%.

3.1.7 Bommies

General description: Two areas of bommies were identified, both at the Northwest of Simaya (map 2). Bommies by definition are a small isolated rock surrounded by sand / silt substrate. Most hard and soft corals need a hard substrate to which to attach themselves. Many species of algae also require a hard substrate surface for the same purpose.

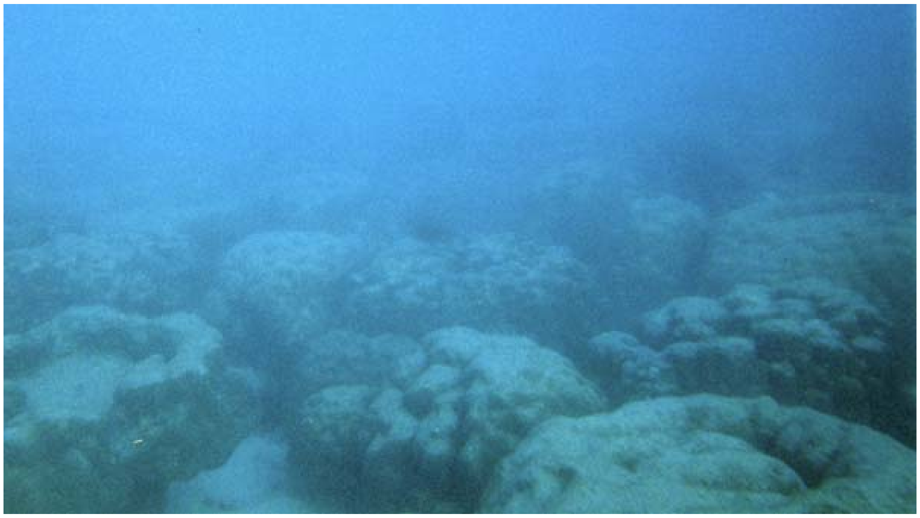


Figure 10: A concentration of Porites bommies in fairly healthy condition. The formation of a crater at the top of a colony is sometimes referred to as 'mini atoll' as seen on the bottom left hand colony

The bommie area East of the coral crest is made up of large 2-5m^2 mounts, sometimes dead *Porites* colonies which have been overgrown with other organisms. They cover less then 20% of the area but are important for the stabilisation of the sand and silt of their surrounding area.

Typical bio cover: Seagrass 50% ; algae 30% ; Hard Corals and Soft Corals 20%.

Dominant genera: Seagrass *Thalasia hemprichii ;* Algae- *Turbinaria, Sargassum ;* hard corals- *Porites* (figure 10).
Dominant substrate: rock 20% sand & silt 80%.

3.2 Okambara projection

Although the visit of Okambara projection was very short, a few observations were made on the resource use found there. The entire projection benefits from a patchy coral reef, which has managed to survive the highly sediment rich waters (2m visibility) and acts as physical protection (map 3). The sand is bound together by algae and seagrass and there is no conclusive evidence that there has ever been a more extensive cover of corals within the projection. Due to the regular South to North currents, the sandbars act as a barrier, which together with the seagrass and algae reduce the turbidity of the water. The coral community is typical to high sediment areas and in some places is in very good condition.

Map 3: Okambara projection

The two bare sandbars, at 80cm above datum low water mark, are surrounded by fields of seagrass and patches of **algae (figure 11).**
The reef starts as shallow as 1.5 meters below low water mark to 7-10m in a gradient of 30˚ for 15m. Characteristic for a highly disturbed reef, soft corals make a high proportion of the biocover and sea whips are abundant.

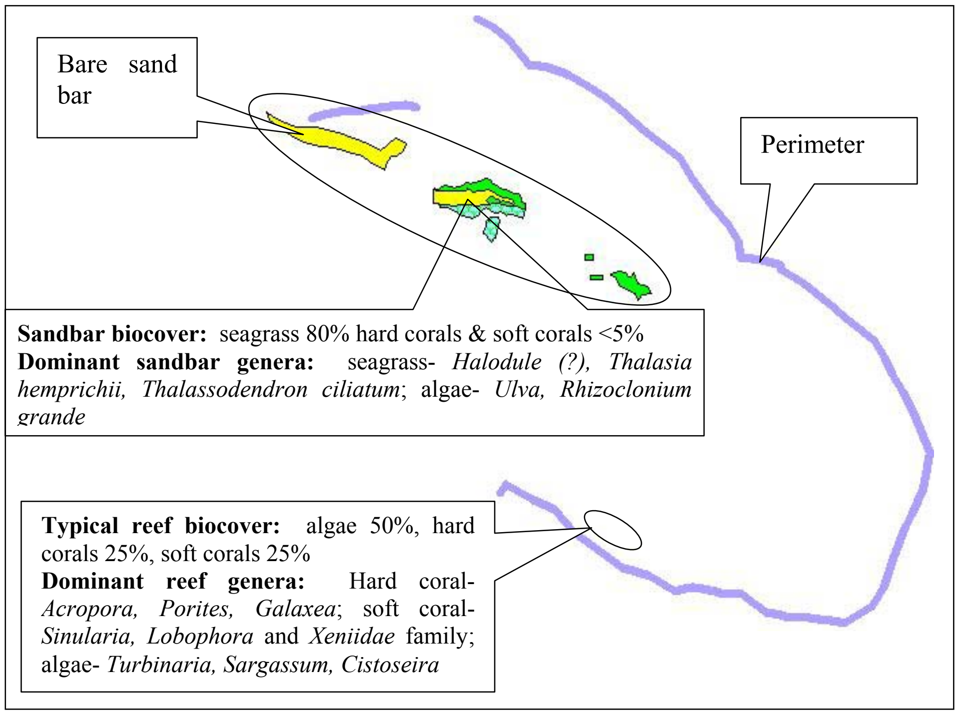


Figure 11: The seam between the seagrass and algae beds at Okambara projection marked in the map above

4 Status of Resource Use

All data concerning resource use was collected in the two day island survey. The resulting data is a combination of both observation and fishermen interviews.

There are two main seasons for fishing on the East coast of Tanzania - the main one from July to October and a minor season around January. Traditionally, there has been a moderate amount of fishing migration for the seasonal periods usually to uninhabited places such as islands without water supply. These offer low fishing pressures but hard living conditions, in turn for good value of time/effort spent during the high season. Population growth and the depletion of local resources forces migration of fishermen from their local fishing sites to more productive ones even in non-seasonal periods. This migration is sometimes futile as fishermen often follow rumours and traditional routes, not always realistically founded. This in turn can lead to local depletion due to over attendance and fishing pressure. Fishermen may travel as far as 600km in search of fishing grounds. In Mtwara, at the far South of Tanzania, fishermen from Zanzibar and Mozambique arrive during the dry season (June to September) while Tanzanian fishermen go regularly to Quirimba archipelago in Mozambique.

The fishermen currently occupying Simaya actually originate from the Kilwa region and not from the closer Rufiji delta. However, reports from previous surveys by Frontier in 1994 and 1995 recorded fishermen arriving from Lindi and Mtwara regions. Frontier recorded a temporary resident population of 20-40 fishermen on the island using a fleet of 5-10 Dhows. Although, not quantitative, the survey draws an alarming picture of over-fishing of a highly productive fishing site. Conducted interviews, clearly showed the fishermen had noticed a decline of catches from the previous few years.

During the time this investigation took place (early June), there were only 6 fishermen living on the island and another 6 "commuting" to the main land on the only Mashua active in the Simaya area.

Figure 12: Fishermen hut. The majority of the burn wood is imported from land

The "resident" fishermen only spend short periods on the island and camp in a small hut at the Northeast side of the island opposite the bay (figure 12). Most of their activities take place in the littoral flats and the immediate surrounding area (typically at low tide). Their activities comprise of mostly collecting seashells, octopus fishing and catching fish or sea cucumbers trapped in the lagoon pools. They are also responsible for the processing of the collective catch including the drying of fish and octopus and the boiling and drying of sea cucumbers.

4.1 Littoral resources

The collection of sessile or trapped animals on littoral areas, dates to the beginning of mankind and potentially, at low human densities, this practice is sustainable. However, at present (Simaya is just one good example) the collecting pressure is too high. Whilst highly mobile animals like fish can get in and out of the littoral zone easily (where they come to feed), others less mobile are lagoon residents. As a resource use, this limited habitat (in space) can be depleted very quickly and thus forms a sink to the neighbouring areas. If however, the littoral zone is a breeding site, its exploitation can have accelerated effect in the depletion of particular species or groups, as is the case with sea cucumbers.

Figure 13: Sea cucumber are left in the sun where they deposit their internal organs

4.1.1 Sea cucumber fisheries

Collection of sea cucumbers (usually a nocturnal animal) is predominantly a night activity involving snorkelling and collection in the lagoon pools and is coupled with octopus spearing (Appendix 2). This method is similar if not identical to how these two main fisheries take place on the reef. The fishermen walk around pools or use dugout canoes (Mtumbi) using a tilly lamp (Kalabai) for illumination. Once a target individual has been identified, it will be collected by hand or at sea by snorkelling. Once caught, sea cucumbers are spread in the sun until they extricate their internal parts (a defence mechanism aimed to distract the predator - figure 13). They are then placed in a pot of boiling seawater where they are cooked for a while resulting in reduction to half-length. They are then placed over slow burning fire to dry (see figure 16) which will reduce their weight by 90-95% (Aya 1999).

Figure 14: Fairly large octopus hanging to dry

4.1.2 Octopus fisheries

Octopus spearing is done in a similar way and both are undertaken also in the daytime. For octopus, the fishermen look for turbulent water exiting the octopus's siphon, which gives its location away. He will then use one spear to penetrate the animal's body and sometimes use a second one to dig it out. Others of the Cephalopods family (squid and cuttlefish), are phototaxis positive (attracted to light) and collected by spearing or netting when they approach the boat light at night.

In Simaya, 6 very large octopuses were caught during the two survey days (assuming non have been shipped or eaten) and were hanging to dry (figure 14).

4.1.3 Shell collection

Low mobility, and ease of collection has made gastropod fisheries an activity from the beginning of time and in Tanzania, cowries were used as currency. Shell collection was another identified resource that can potentially be exhausted. It is an opportunistic resource with few possible extracts. From the brief observation in Simaya, it is unlikely that the shells are collected for the cowry trade as fishermen were observed cooking the tiger cowry, which is a much desired species for the cowry trade, in open fires for personal consumption. Most of the gastropods collected seemed to be used on the island for food or as bait, as all the specimens observed were either boiled or burned in the fire. The species common for these were - *Chicoreus ramosus* (jagged shell), *Pleuroploca trapezium* (tulip shell) and *Tonna spp*. Large *Cypraea spp* were found being used for line fishing (Mshipi) and/ or for traps (Mdema). A peculiar collection of the shell cover (operculum) from the tulip shell (*Pleuroploca trapezium*) was found to be profitable as natural incense for the far Eastern market. A rather encouraging observation is the relatively high (?) densities of giant clam *Tridacna spp*. on and adjacent to the littoral zone.

4.2 Reef fisheries

The other fishermen use the Mashua as a base for drag-net fishing at the surrounding reef like the bommies at the Northwest, the sea grass at the West or East and the south west reef. In the daytime they employed Juya and Kojani nets both from the boat (SE reefs) and on the seagrass bed West of the sand bar (see figure 15 for method and figure 1 for catch - on a good day…).

4.3 Turtles

During the survey, evidence of turtle activity or hunting was not found. It was perhaps too early in the turtle-breeding season (July to September) and no nest sites were found.

4.4 Okambara projection

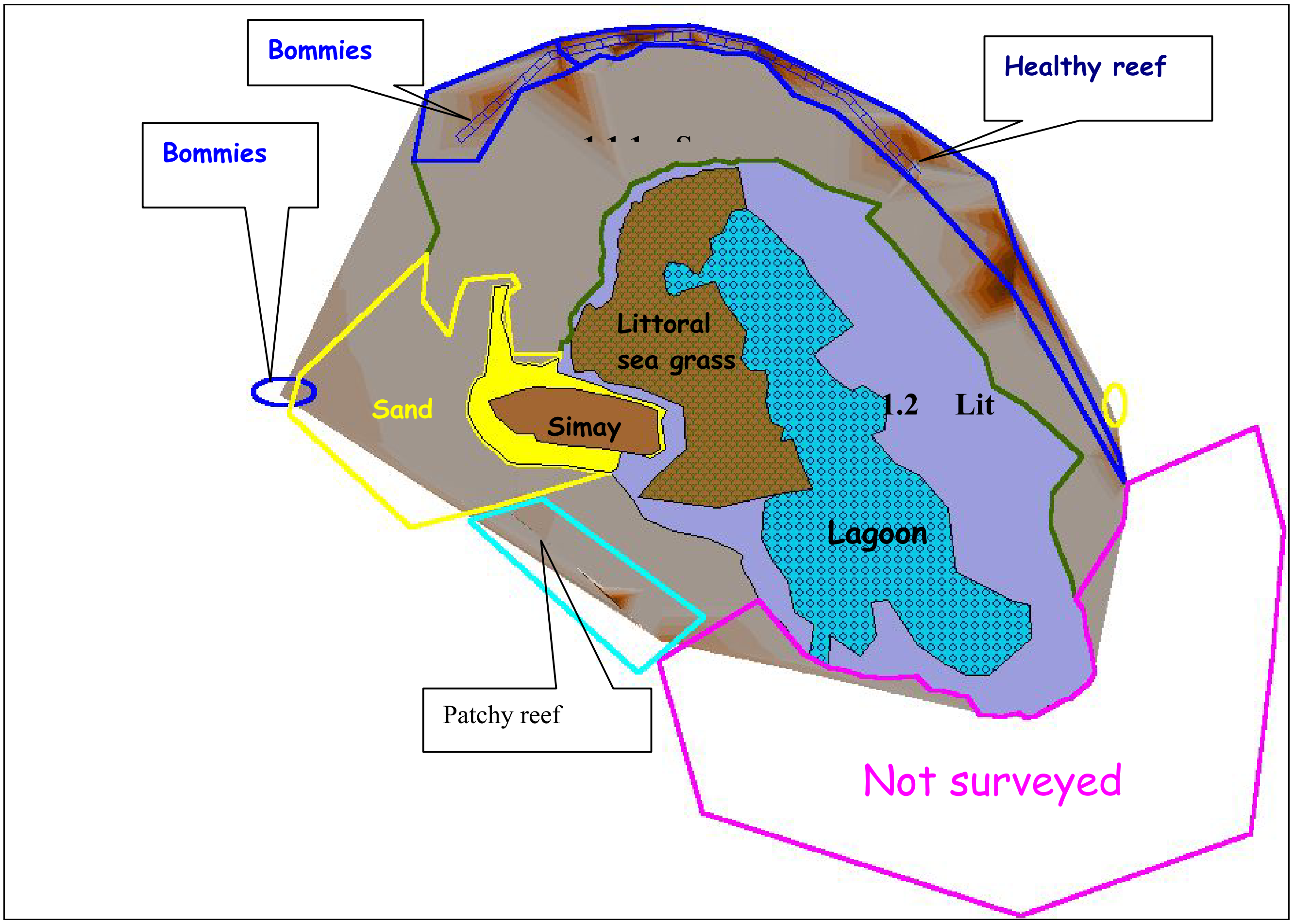
Although the visit of Okambara projection was very short a few observations were made on the resource use found there. The seagrass fields found around the projection and in fact all the sandbars of Mwamba Mkuu, offer similar conditions and yield to equivalent seagrass fields at Simaya Island. The sand bar is marked with a pole suggesting human activity. Occupants of Simaya Island in the fishing season, utilise the entire area and therefore, all comments and suggestions on fishing methods, are applicable for Mwamba Mkuu too.

Figure 15: Pull net fishing by the western sand bar (looking north)

5 Discussion

The purpose of this survey was to gain base line information on the underwater environment within the coastal region. It was also intended to make preliminary assessment of the status of resource use within the surveyed area.

Coral reefs in Songo Songo Islands (of which Simaya is part) were reported to carry 25-50% live coral cover at some sites surveyed by the Institute of Marine Science (IMS) (Muhando and Francis 2000).



Previously a live coral cover of 20-55% was reported by Darwall et al (1996) showing a little change in coral cover (although the two studies do not necessarily overlap in location). This general decline in coral cover throughout Tanzania is attributed to the massive bleaching event devastating the East African coast in the spring of 1998 (Wilkinson et al 1999, Muhando 1999, Muhando and Francis 2000).

Darwall's (et al 1996) report was a general survey for the Songo Songo archipelago undertaken by Frontier Tanzania. A section of that document is dedicated to the surveying of Simaya and is often referred to in this report. It provides a good insight to the habitat existing at the time and although not spatially accurate, observations and results can easily be compared to the current status.

Simaya Island was identified as having the most potential for coral reefs and subsequently was the focus of the enquiry. The findings were surprisingly positive and coral cover seemed to be similar to Frontier's previous report, which suggests the bleaching event has not affected the reefs surveyed. Recovery from an event of this size would take years and evidence in the size and composition of corals would confirm the above statement (map 4).

The reason for Simaya reef's escape from bleaching is not clear. It can be attributed to local hydrodynamics, currents and perhaps the proximity to river outflow. It is suggested that the bleaching event has struck the hardest on the reefs, which were in the best condition like Misali Island for example (Muhando and Francis 2000).

Sedimentation and high turbidity will restrict coral speciation to more tolerant species (McClanahan and Obura 1997) which is demonstrated nicely in the reefs surrounding Simaya (table 2). It is possible that this is the reason the reef remained unaffected by the bleaching event.

Sediment tolerant species:	Healthy reef North aspect	Patch reef South aspect	Other
Echinophora	Lower reef slope	present	
Galaxea	Lower reef slope	present	
Hydnophora			littoral
Millepora	Reef crest	present	
Platygyra			
Intermediate species			
Acropora	Reef flat & crest	present	Okambara
Astropora			
Favites			
Porites	Lower reef & bommies	dominant	Okambara
Intolerant species			
Favia			
Pocillopora			
Montipora	Reef flat		

Table 2: Sediment tolerance (McClanahan and Obura 1997) and dominant coral genera recorded during the survey

The type and size of colonies encountered in both Simaya and Okambara indicate a healthy reef under continuous but tolerable high sedimentation levels.

Coral and other invertebrates usually reproduce by releasing gametes into the water column where they fertilise and the resulting planulae are suspended in plankton form usually in the top layer of the water column. Having limited mobility the maturing planulae will slowly be transported by currents far from their origin reef.

Simaya's position at the northern fringe of the Songo Songo archipelago and shelf (sea appendix 7) places it in a venerable position in terms of planulae recruitment. Shown in appendix 8 is the East African water movement and current map (taken from Richmond 1997). If we set aside the possibility of interference and deviation of currents from the general trend, we find that Simaya is at the all-receiving end of the archipelago's output (called 'sink'). Thus coral, fish and other invertebrate recruitment at Simaya can drop as a result of reproductive potency decline elsewhere in the archipelago (called 'source'). Consequently, any conservation effort in the area should account for the source-sink dynamics and include in its plan the area as a whole.

5.1 Resources use

Resource use is always a problematic issue. It is typical to get the "others will do it if I don't" response, whenever the question of sustainability and responsibility for resource depletion is brought into conversation. The fishermen interviewed during the survey in Simaya were no different. Although co-operating and willing to listen to a long-winded explanation of why not to fish during the breeding season, without education and introduction of alternatives, conservation is nothing but alienation for these people.
Fisheries in Simaya are typical for the East African coast. Because the survey was conducted not in the full swing of the fishing season only the basic most common fishing methods were practised and thus recorded. In most cases, there is a lack in knowledge to place catch figures on a sustainability scale.

Sea cucumber collection: Sea cucumbers are an easy fishery to target as sea cucumbers are slow moving and have hardly any defence mechanisms. In Tanzania they are not used for food and therefore considered a cash crop like other exotic extracts. Their prices vary upon species (see appendix) from 18000/kilo to 300/kilo so, considering the easy and risk free collection method, the preparation and transport requirement (basically, a bag) this is a prime merchandise. However, this is also the fisheries' weakest aspect. The fishermen have reported a far smaller catch nowadays than in previous years while elsewhere fishermen reported a size reduction in individuals caught (Aya et al 1999). The Frontier report even mentioned the use of SCUBA diving for the collection of sea cucumbers and octopuses (up to 35kg per diver per day!!!). Similar reports can be found by Aya (et al 1999) for Bongoyo Island North of Dar es Salaam.

The export of sea cucumbers records in the last few years go as far back as 1988 by the Fisheries Division at the Ministry of Natural Resources (of which data is published -Aya et al 1999, see appendix 4). Whilst the export records fluctuate, striking figures peak a high in 1994, at 530 tons in a value of $884,169. Between the years 1988-1996 average dry weight registered was 238,693kg at a declared value of $463,426, one could calculate value per kg to $2 (=tzs 1553) assuming all species collected had the same value. Similarly to our finding, reported by Aya et al (1999), price range start at tzs1600 to 20000, while Darwall (1996) reports price magnitude of tzs750 to tzs10000 (appendix 2). This suggests an increase in unit price paid to fishermen although prices are set for specific species of which breakdown is not available for comparison.

Figure 16: Sea cucumber are let to dry, boiled and then are smoked as above. This is virtually finished product

Apart from the alarming statistic of the total quantity exported, it is surprising to note that in all years recorded, the declared price of export per kilo is lower then the lowest cash paid to fishermen per kilo! Furthermore calculated out of the same dataset (Aya et al 1999 appendix 4) export value has decreased from an average of tzs2660 to tzs1512 between the years 1988-1996. Whether these reported values are true or not, the decreasing trend of value per kg raises a further question - if a resource is depleting (we know it is from the fishermen we interviewed on Simaya and from Aya et al 1999) - wouldn't the "per unit" value increase? The fisheries for sea cucumber are a relatively new business where the catch is far more valuable then what it is worth as food. It is possible that sea cucumber fisheries are still on the rise in popularity amongst fishermen and thus, since competition is high, monopolising traders can pay less for the same kg of ready to ship sea cucumbers. It is also possible that depletion of high value species forces the collection of less desired species resulting in decrease of the value per kg reported above (an option not supported by our findings see appendix 2). Suspiciously, the incomplete data represented by the Fisheries Division at the Ministry of Natural Resources, obscures the true state of the fisheries of sea cucumbers and leaves many unanswered questions.

The catch itself is transported to a variety of destinations headed by Hong Kong, Singapore and then Taiwan. The management and regulation of the sea cucumber trade (otherwise known as beche-de-mer) is largely absent. There are no restrictions on this fishery at present and considering the decline in catch, management of this resource is crucial.

Figure 17: Red helmet and a giant clam are not a rare sight (they are in other less isolated areas)

Flesh of both is usually used for bate only although the shells are commercially valuable.

It is not only the economy that is to suffer from the disappearance of sea cucumber due to depletion. Since sea cucumber of economic value are deposit feeders (some other species are suspension feeders) their environmental value as sand cleaners (although never studied) is not to be underestimated. Furthermore, unlike the Chinese culture, which sees them as a delicacy, sharks, turtles, triggerfish and some molluscs are amongst their predators although they do probably not use them as an aphrodisiac. Breeding seasons follow increase in water temperature, so in Tanzania this would be November to January (Horsfall 1998). It is interesting to note that Aya et al (1999) suggest two seasons for collection - October to December and April to May. Fishermen on Simaya, have declared July to August as the beginning of the season for them. Either way, collection coincides with the breeding season through opportunistic activities (fishermen are quick to adapt to these trends) with adverse effects to be expected. Restriction in collection during this time (to be determined) must be the first step in the management of this economically vital resource. Further information can be found at - Aya et al 1999, Conand 1997 and Horsfall 1998.

Shell collection: A list of species collected by Frontier was largely similar to the one compiled during this survey (figure 17). Little details are known on the biology of specific species of targeted species and the effect of fisheries on their density. To date, the fisheries lack basic quantitative information to pass regulatory protection law or have the control needed to effectively enforce such laws. Not surprisingly, the ornamental shell trade itself is recorded in Tanzania only to bulk weight. At this stage there is no conclusive evidence of active shell fisheries for trading in Simaya Island. The current situation is largely small scale collection for local consumption and it is impossible to offer an educated and responsible course of action - beyond the urgent need for further research.

Further information on the shell trade and gastropod associated fisheries, can be found in papers by - Aya et al 1999, Newton et al 1993 and Wells 1988.

Turtles: The Frontier survey reported a thriving market for turtle meat in Songo Songo archipelago, some of which arrived from Simaya. Turtle landings are common in other places along the coast and are not always the result of deliberate turtle hunting. Sharks and ray nets (large mesh size nets) are some of the most important turtle killers. Turtles get their head stuck in the net and drown, becoming an unfortunate bycatch. Eggs are also collected, as another easily collectable source of protein as well as a delicacy. Since female turtles will always return to their hatching site to nest, concentrated activity in an isolated island can quickly bring the local population to extinction.

Reef fishing: The use of Juya and Kojani is very popular on the East African coast although they were made illegal in Tanzania and Kenya in the late 1990's. The dragnets in a variety of mesh sizes are used to surround the fish but the Juya and Kojani differ in the way fish are aggregated. They are practised either on the reef flat (using two boats as a base) or on sea grass bed - from boats or the beach. Although low in cost (especially from the beach) it is highly effective (and destructive). The net is set suspended in the water having floats on top and weights at the bottom. It is placed usually towards the low tide slack, so as the water level drops fish get trapped in the net, which is then pulled at both sides and lifted onto the boat or beach. To accelerate the above process snorkellers swim around the net to scare the fish into it (Juya), or by using poles to hit the bottom and coral heads (Kojani). The net-pulling causes the bottom of the net to drag on the substrate which is extremely destructive. On a seagrass bed the net will dislodge the seagrass, collect sea urchins and lift sediments into the water column. Even when the nets have larger size mesh they collect everything trapped within them (due to the stretching of the mesh) resulting in very high bycatch. When practised on the reef flat, poles are used to free the net from coral heads, which leaves the coral dislodged and broken. Particularly with small mesh size, all fish are taken and if not economically desired, are used for feeding the fishermen or for trap bait. The fish families targeted over seagrass areas are Rabbitfish (*Siganidae*), Emperors (*Lethrinidae*), Goatfish (*Mullidae*) and occasionally Jacks (*Carangidae*). On the reef, schooling fish like Parrotfish (*Scaridae*) - figure 18, Fusiliers (*Caesionidae*), and Unicornfish (*Nasinae*) are targeted. The seagrass and the reef are a nursing ground of many reef fishes as well as schooling pelagic fish and the depletion of this environment and its physical destruction will eventually have a toll on the area's productivity.

Other fishing methods, although not observed, would be practised during the fishing season. Control over the fishing practices and catch can only be effective when a guard is both mobile and present at all times (or at least in the fishing season). It is not inconceivable to educate the fishermen on the value of conservation and adopting sustainable catch methods and extraction levels. However, in Simaya this has no permanent residence and thus no continuity or sense of belonging it would be next to impossible.

The extent of fisheries pressure can only be quantitatively measured during the fishing season and by close to permanent monitoring. Landing sites vary during that time and might even be outside Rufiji jurisdiction. Though, from the Frontier description, the surrounding reefs of Simaya suffered high fishing pressure during the survey visits in 1994 and 1995. Underwater fish surveys undertaken by Frontier offer basic information on commercial fish abundance relating to the entire island. Jacks (*Carangidae*), Surgeon (*Acanthuridae*), Parrotfish (*Scaridae*) and the combination of Snappers/Emperors and Grunts (*Lutjanidae/Letherinidae/Haemulidae*) are the most abundant on the reef. Current fish surveys are needed to assess and compare the abundance of commercial (and reef fish) on the reefs in Simaya at different times of the year.

Figure 18: A group of medium size parrot fish being dried

6 Conclusion

The survey in Simaya and Okambara projection are of a preliminary nature and give only a basic indication to reef condition and human pressures. The following conclusions can be drawn:

- Simaya Island supports a healthy reef surrounding it on two sides. Particularly in the North and East aspects the reef has very high percentage cover of live corals. The Okambara projection is surrounded by a ring of patchy coral similar to the one found in Simaya's South aspect. This is despite chronic heavy sedimentation that is typical for their location opposite river outflows.

- There are no obvious signs for mass mortality following the bleaching event of 1998. Coral mortality observed on the Southern aspect is likely to be due to chronic harsh sediment condition.

- Judging from the current movement and Simaya's position in relation to other islands in the archipelago, the health of other reefs in the area might affect Simaya's coral and invertebrate recruitment. Conservation and management effort should account for recruitment Simaya's vulnerability.

- Fishermen use the island as a base all year round. Fisheries include littoral collection of sea cucumbers, octopuses and shell collection. On the reef and sandbar illegal drag-net was in use as well as snorkelling for all of the above. There was no sign of dynamite fishing and no obvious signs for turtle hunting.

Further Work and Recommendations

In the view of the records above and to comply with the general aim of REMP for the development of sustainable resource use, the following courses of action are recommended

Stage 1

Because the current survey has only supplied baseline overlook on the current situation for both habitat condition and resource use it is recommend that priority would be put into further investigation of Simaya Island and Mwambwa Mkuu. It is important to stress that the areas surveyed during this study are only sample areas thought to represent the local reefs. Future effort should be put into studying the adjacent sandbars and other potential sites. The linkage to other islands in Songo Songo should be studied too as for most; proximity to Simaya is only a dozen miles.

- On the habitat aspect - this should be more comprehensive and should include reef habitat surveys, invertebrate surveys, and fish surveys. Within those, special attention should be given to coral mortality, community structure and human interference. Because the size of the relevant area is small it would be a good idea to keep to the GIS foundation map and carry on using spatially aware methods.
- It is recommended that further study would establish monitoring sites by laying permanent transects or quadrates and using photographic records.
- On the physical data aspect - it is recommended that monitoring of sedimentation and its fluctuation is started. Other data such as currents and wind should be recorded.
- Resource use - monitoring of fishermen activity in the area studied is a priority. Accurate monitoring of fisheries landed is important especially ones identified as approaching depletion (e.g. sea cucumbers collection).
- Steps should be taken as soon as possible to educate resource users. Most resource users know the consequence of over extraction. The problems always lie in willingness to recognise a problem and admit responsibility and later on - having the discipline to follow collectively agreed guideline and limits.
- Given the concern raised by local community it is imperative that members of the public should be involved in any action taken. There is no reason why fishermen could not be involved in the surveying of the reefs or monitoring their catch. Creation of sense of ownership builds up the capacity to governing and in forming self laid laws.

Alternative modes of income should be assessed, tried and introduced (aquaculture for example).

Stage 2

The development of a management plan should be facilitated by REMP and local government and drawn up by the stakeholders. Monitoring should be put in the hands of resource users.

Lastly:
Control of fishing in marine reserves has a proven effect on fish abundance and subsequently the abundance of invertebrates that are their prey (McClanahan et al 1999). On Simaya Island, where habitat community structure seems robust enough to survive both chronically poor and fluctuating natural conditions (seasonal and global), dynamics of community population on the reef is down to anthropogenic interference.

Unfortunately, Simaya Island is too remote and not big enough to support an economically sound tourism industry. On the other hand it is a strong point for management, monitoring and control, since the island is a base for all the local fisheries.

For the hard substrates exploited by Jaja village it is recommended that a survey be carried out in collaboration with the local community through catch monitoring or using underwater surveys, if possible during calm seas. Furthermore, a closer look and monitoring of the trawling activities in the Mafia Channel should be put as priority as operating boats were observed close to the shore.

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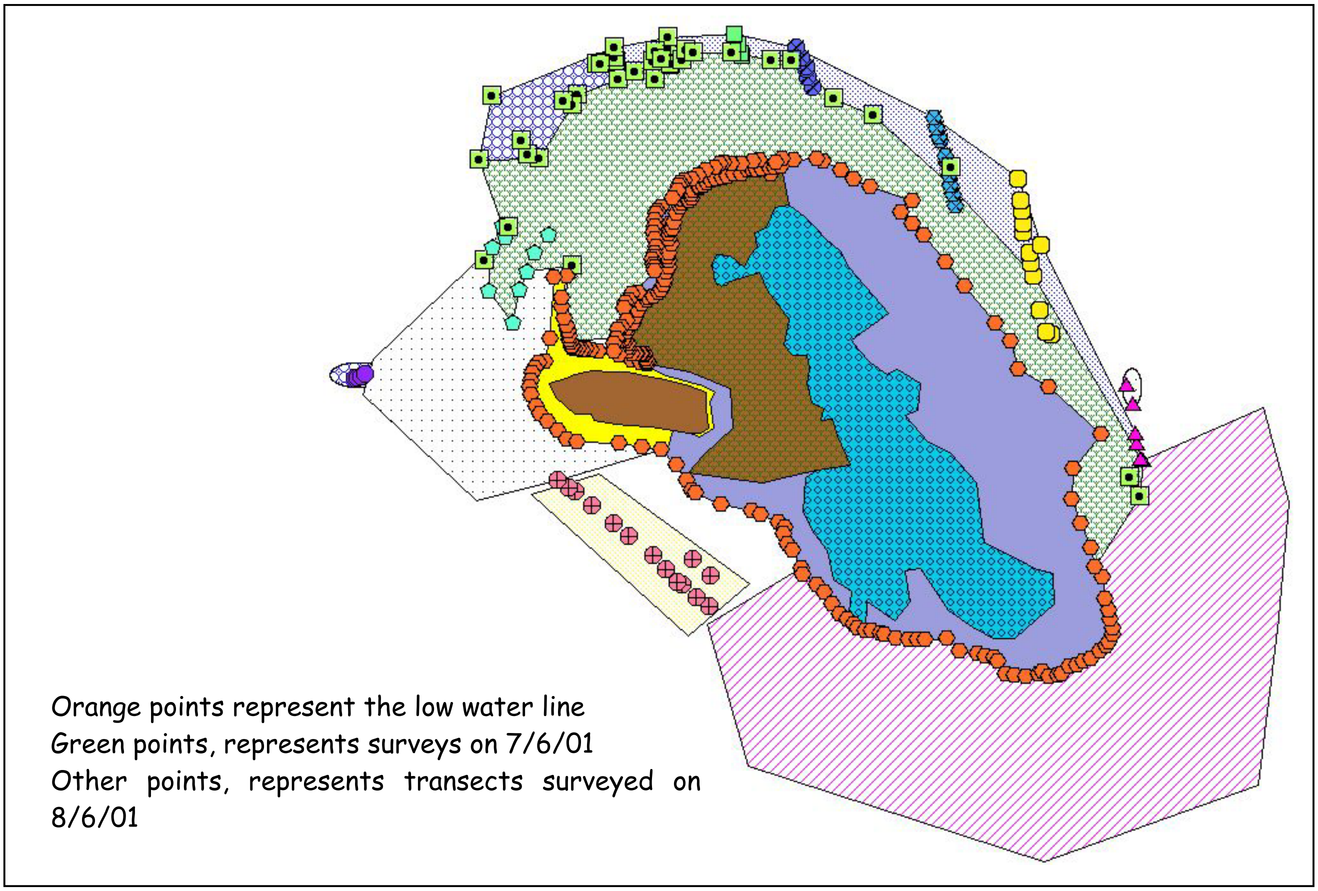
8 Appendices

8.1 Appendix 1: Methods Map



8.2 Appendix 2: Swahilli names, scientific names and catch during the survey

Includes landing value of sea cucumber.

In red names and value taken from Aya (1999).

Swahili Name	Scientific Name	Taken In 1.5hr 8.6.01 Night	Size (After Collection)	Taken 8.6.01 Day	Size	Price P/K
bama			10			
barango	*Bohadschia vitiensis*			1		17500
dole	*B. spp.*	5	12	2	5	3000/ 1600
jongoo maji	*Holotheria atra*	41	9	5	3 to 7	17500
kibaka		5	4	5	2 to 5	7000
kichwa	*Holotheria leucospilota*	1	6			
kijino	*Actinophyga miliaris*					
limbo	*Holotheria marmorata?*	76	4	3	8	
mbama		30	10			
mbura			6	27		
mbura khaki	*Actinophyga mauritiana*	31	9			5500
mbura kipara	*Actinophyga lecanora?*	13	6.5			
ngusa, spinyo mama	*Thelenota anax*					
pwani nyeusi	*Holotheria nobilis*	4	12			18000
small spinyu	*Holotheria chloronotus*	9	4			5000
spinyo	*Thelenota ananas*					5500
tairi	*Stichopus hermanni*					5500
tili kutwa/pauni	*Holotheria scarab*	1	18			5500
tili mawe	*Holotheria spp.*	76	6			

8.3 Appendix 3: Invertebrates from the littoral zone

Group	Sub group	Common Name	Scientific name
Sponge	Sponge	Sponge	*Lendenfeldia dendyi*
Zoanitherian	Zoanitherian	Palythoa Spp.	*Palythoa natalensis*
Hydroid	Hydroid	Fire coral	*Millepora*
Corals			*Acropora*
Corals			*Hydnophora (exesa?).jpg*
Corals			*Leptastrea*
Corals			*Millepora*
Corals			*Montastrea*
Corals			*Pavona cactus (?)*
Corals			*Pavona clavus*
Corals			*Pocilopora*
Corals			*Porites (lutea?)*
Corals			*Porites spp.*
Soft Coral	Soft Coral	Heteroxenia	*Heteroxenia spp.*
Mollusk	Bivalves	Chiton	*Acanthopleura gemmata*
Mollusk	Bivalves	Zigzag Clam	*Lopha*
Mollusk	Bivalves	Pen Shell	*Pinna*
Mollusk	Bivalves	Gient Clam	*Tridacna spp.*
Mollusk	Cephalopods	Octopus	*Octopus*
Mollusk	Cowry	Annal Cowry	*Cypraea annalulus*
Mollusk	Cowry	Spp.	*Cypraea spp.*
Mollusk	Cowry	Riger Cowry	*Cypraea tigris*
Mollusk	Cowry	Egg Cowry	*Ovula ovum*
Mollusk	Gastropod	Sundial Lined Spiral	*Architectonica prespectiva*
Mollusk	Gastropod	Frog Shell	*Bursa*
Mollusk	Gastropod	Jugged Shell	*Chicoreus ramesus*
Mollusk	Gastropod	Conus	*Conus spp.*
Mollusk	Gastropod	Red Helmet	*Cypraecassis rufa*
Mollusk	Gastropod	Non Spiny Murex	*Haustellum haustellum*
Mollusk	Gastropod	Spider Conch	*Lambis chirgra*
Mollusk	Gastropod	Spider Conch	*Lambis lambis*
Mollusk	Gastropod	Mitra	*Mitra mitra*
Mollusk	Gastropod	Mitra	*Mitra spp.*
Mollusk	Gastropod	Snail Shell	*Nerita*
Mollusk	Gastropod	Spindle	*Pleuroploca spp.*
Mollusk	Gastropod		*Strombus spp.*
Mollusk	Gastropod	Thin Shell	*Tonna perdix*
Mollusk	Gastropod	Tulip	*Pleuroploca trapezium*
Mollusk	Gastropod	Vase	*Vasum spp.*
Echinoderm	Sea Cucumber	Sea Cucumber	*actinopyga (miliaris?)*
Echinoderm	Sea Cucumber	Black Willy	*Holotheria atra*
Echinoderm	Sea Star	Pink Pillow	*Culcita novaeguineae*
Echinoderm	Sea Star	Pink Pillow Blue	*Culcita schmideliana*
Echinoderm	Sea Star	Sea Star	*Leister coriaceus*
Echinoderm	Sea Star	Knobbly Star Red	*Protoreaster lincki*
Echinoderm	Urchins	Espiny Urchin	*Diadema spp.*
Echinoderm	Urchins		*Echinometra mathaei*
Echinoderm	Urchins	Echinometra	*Echinometra spp.*
Echinoderm	Urchins	Echinotherix	*Echinotherix spp.*
Crustacean		Mantis Shrimp	*Squilla mantis*
Fish	Fish	Brown Stripe Eel	*Echidna polyzona*
Fish	Parrotfish	Parrotfish	*Scarus collana???!!!*
Shark	Sharks	Short Tail Nurse Shark	*Ginglymostoma brevicaudatom*

8.4 Appendix 4: Algae and Seagrass from the littoral zone

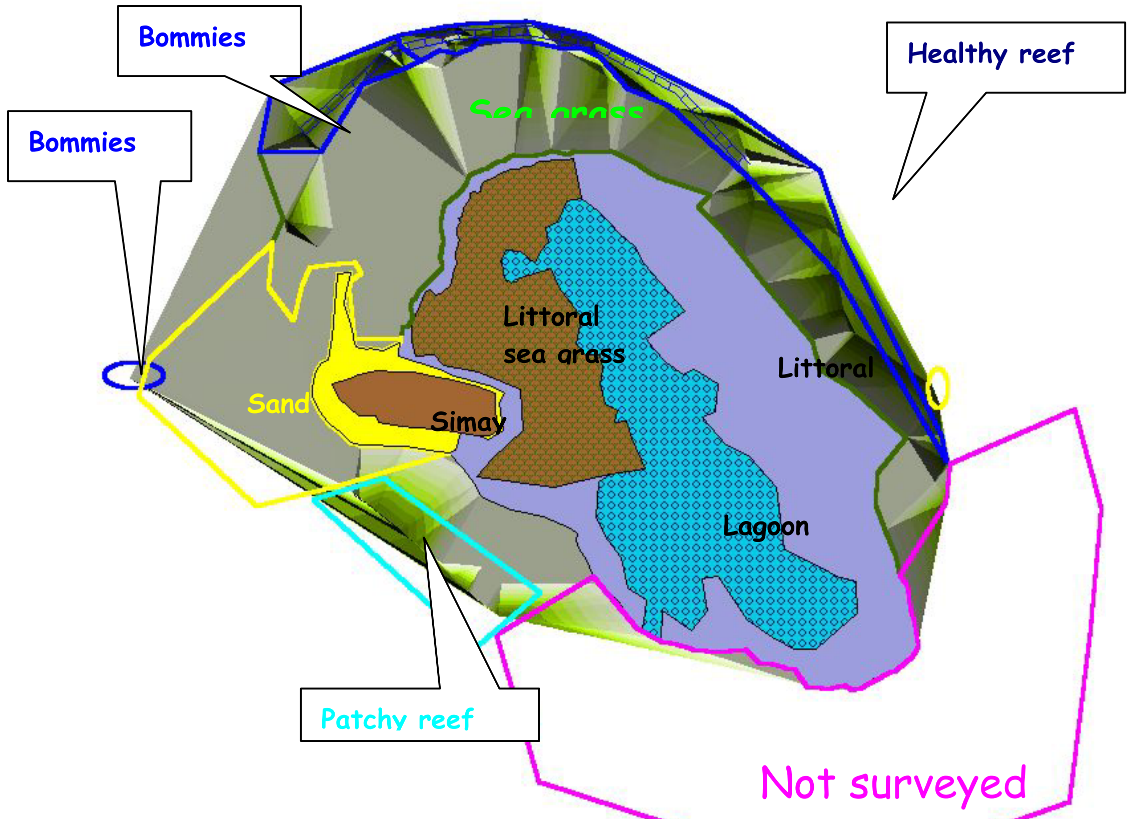
Group	**Common name**	**Scientific name**
algae	actinotrichia	*Actinotrichia fragilis*
algae	coulerpa	*Coulerpa*
algae	cystoseria	*Cystoseira myrica*
algae	cystoseria	*Cystoseria fragilis*
algae	big cells	*Dictyospheria versluysii*
algae	Dyctyota	*Dyctyota*
algae	halemida	*Halemida macroloba*
algae	halemida	*Halemida spp.*
algae	padina	*Padina*
algae	pedina	*Pedina*
algae	sargassum common	*Sargassum binderi*
algae	sargassum big leeaves	*Sargassum ilicifolium*
algae	thalassia	*Thalasia hemprichii*
algae	turbinaria	*Turbinaria conoides*
algae	turbinaria	*Turbinaria spp.*
algae	ulva	*Ulva*
algae	sailor's eyeball	*Valonia ventricosa*
sea grass	Cymodea	*Cymodea serrulata*
sea grass	cymodocae	*Cymodocae*
sea grass	halodule	*Halodule*

8.5 Appendix 5: Sea cucumber export, value expressed in F.O.B = freight on board

Year	**Dry weight (kg)**	**Total value in $**	**Value per kg in $**	**Value per kg in shilingi ($=800Ts)**
1988	133004.00	442335.60	3.33	2660.59
1989	107943.00	333143.75	3.09	2469.03
1990	167326.00	460030.00	2.75	2199.44
1991	142030.00	351299.31	2.47	1978.73
1992	180843.00	414449.22	2.29	1833.41
1993	326620.20	481098.37	1.47	1178.37
1994	530192.00	884169.00	1.67	1334.11
1995	263870.00	353910.00	1.34	1072.98
1996	296410.00	450405.00	1.52	1215.63
Averages	238693.13	463426.69	1.94	1553.21

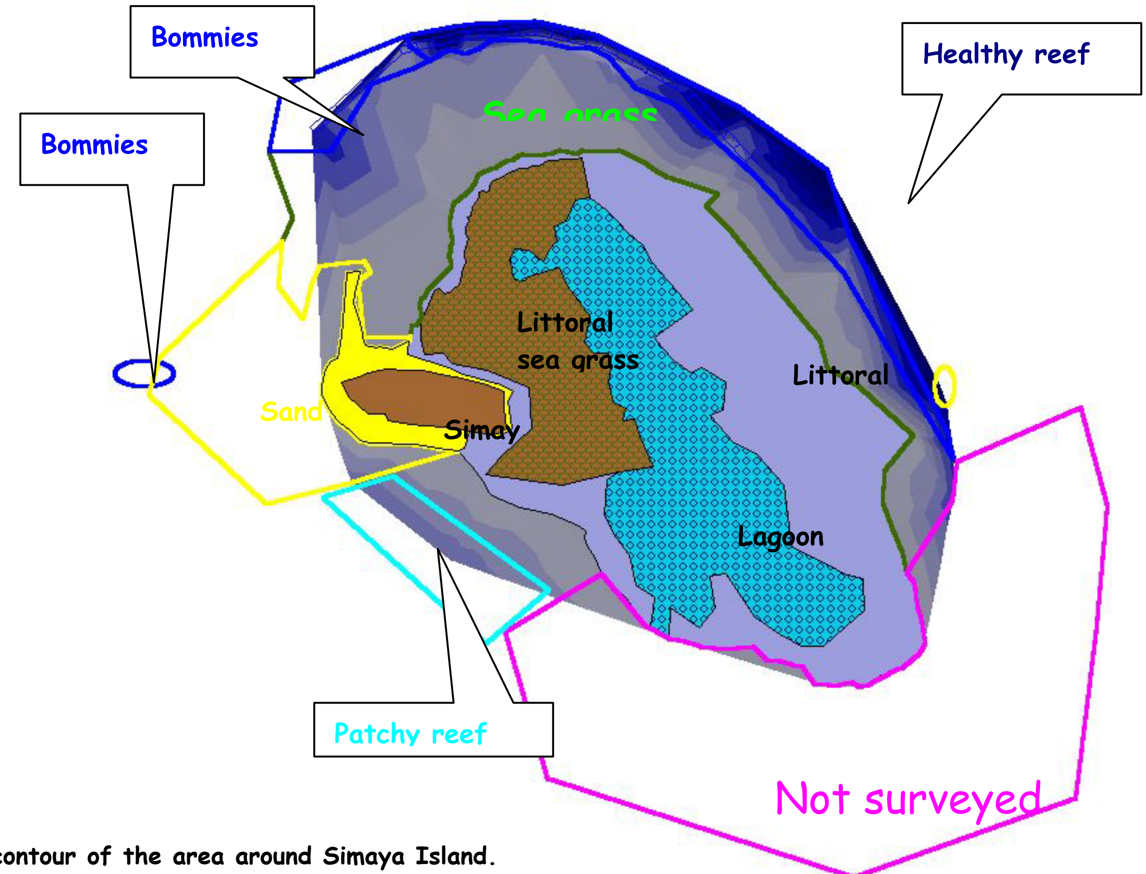
(Source: Fisheries Division Of The Ministry Of Natural Resources And Tourism Found In Aya *et al.* 1999)

8.6 Appendix 6: Biocover



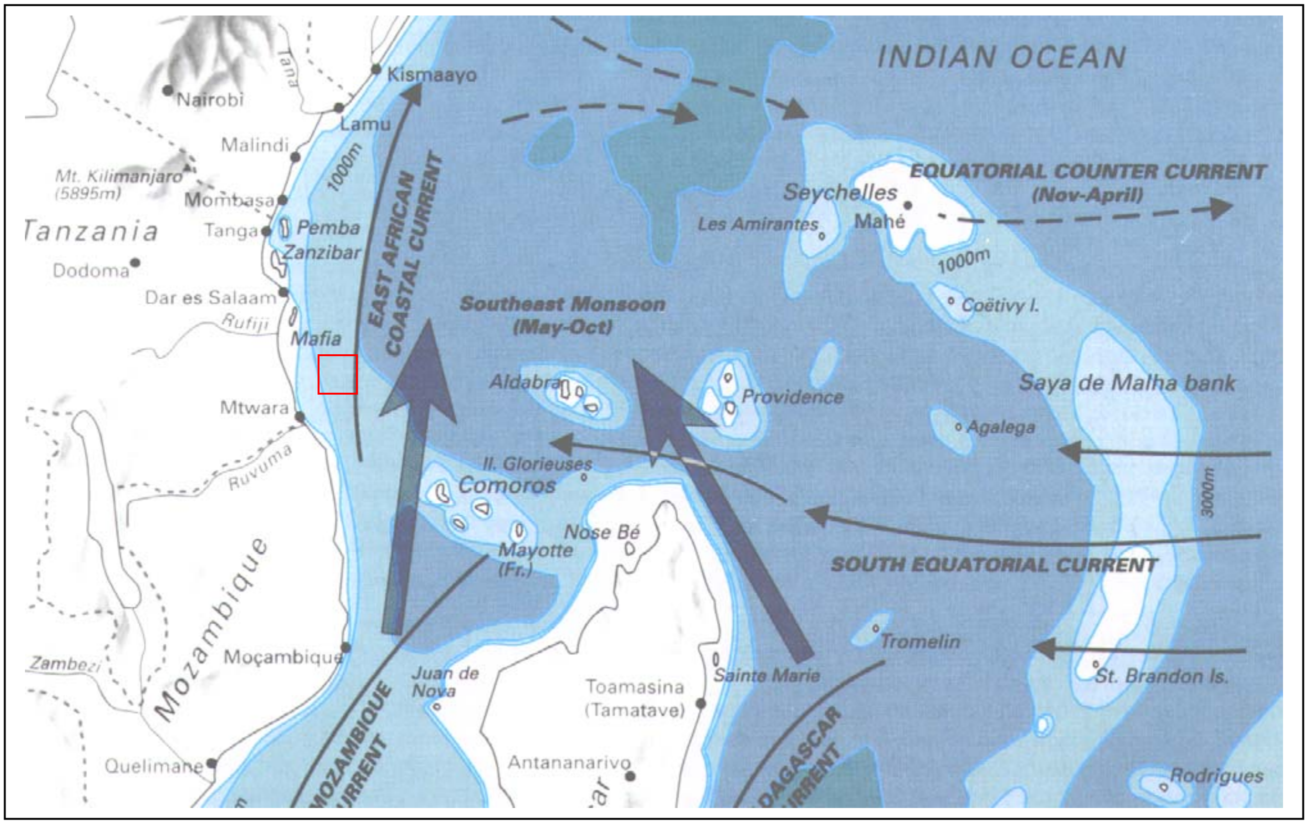
Biocover on a rank scale 0-100 (from grey to dark green respectively). The lack of attributes in some areas is due to simplified, minimalistic data collection.

8.7 Appendix 7: Depth contour of the area around Simaya Island



Depth contour of the area around Simaya Island. Notice the sudden drop in depth where the crestline is. A fair amount of inaccuracy in this computer simulation due to missing survey areas and minimalistic data set.

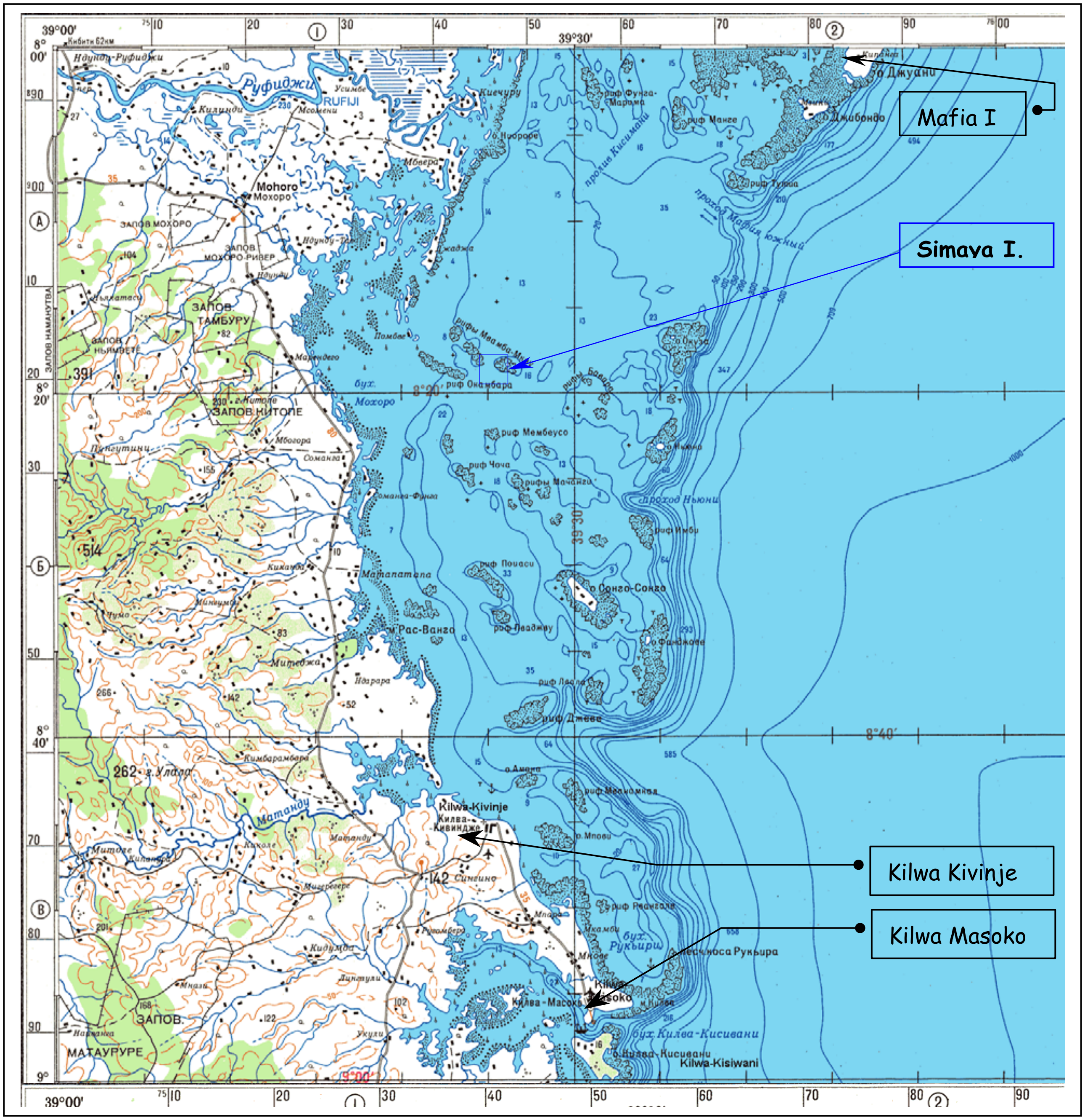
8.8 Appendix 8: The currents map of East Africa Taken from Richmond (1997)



The currents map of East Africa Taken from Richmond (1997). The red boxed area is the area map found in appendix 8 and represents the Songo Songo Archipelago. Current direction in the region is from South to North.

8.9 Appendix 9: Map Kilwa villages

Landing site of the area's fisheries.



8.10 Appendix 10: A sample data sheet

#	X	Y	xwgs84	ywgs84	z	tr	class	Raw notes	slope	time	rog	viz	hc	dc	sc	sp	al	sg	si	sa	pb	rb	rc	rc+hc	hc-dom
185	547277	9082681	547372	9082382			sa	west of sand bank,sa100				4													
186	547268	9082895	547363	9082596			bommies					4													
187	547294	9083031	547389	9082732		?	bommies					4													
188	547517	9083099	547612	9082800		tr	bommies	sea grass				4						100							
189	547538	9083102	547633	9082803	2	tr	bommies	2m-8m, sl30,2m@ top	30			4													
190	547558	9083105	547653	9082806		tr	bommies	hc60,sc*,lots of sc				4	60		30	*									
191	547565	9083068	547660	9082769	2	tr	seem	2m,sl15,hc60-80,sc*,bgining of reef seam with sg&coral				4	70		*	*								70	
192	547556	9083114	547651	9082815	2	tr	seem	same				4	70		*	*								70	
193	547555	9083135	547650	9082836	10	tr	seem	hc60-80,sc*,end of reef (use pve??? Width calc)				4	71		*	*								71	
194	547674	9083097	547769	9082798		tr	sg	sg100				4						100						0	
195	547671	9083101	547766	9082802		tr	reef	hc50,sc*,rb50				4	50		*	*						50		50	
196	547669	9083117	547764	9082818		tr	reef	hc80,sc*,galaxea,pic27				4	80		*	*								80	galaxea
197	547670	9083135	547765	9082836		tr	reef	sl45,bgining of slope	45			4												0	
198	547670	9083157	547765	9082858	9	tr	seem	9m,hc60-70,dc10,sc*,rc-rest bottom edge of reef,dom-acropora,pic26@8m				4	65	10	*	*							25	90	acropora