Coral Reef Ecology and Biodiversity in Watamu Marine National Park, Kenya

A Rocha Kenya

Conservation & Science Report

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Abstract

Watamu Marine National Park is a 10 km^2 marine protected area located on the central coast of Kenya. The biodiversity and abundance of fish and corals was studied in order to assess IUCN Red List species presence in the park and gain an understanding of distribution among several of the main coral reef sites. Ten species of fish and one species of coral were found that are assessed as Vulnerable or Threatened and four species that are Data Deficient. The highest coral cover was seen at Uyombo with 31% and the lowest at Turtle Reef (15%) . In terms of coral community composition, Coral Gardens and Bennett's Reef were dominated by massive *Porites* colonies, whereas Uyombo and Turtle Reef had a more balanced coral composition with notably more *Acropora* and *Pocillopora*. Both Bennett's Reef/Coral Gardens and Uyombo reefs had a similar size class distribution of fish, the mode falling in the 10-20cm size class. Both reefs were also dominated by surgeonfish, wrasse and parrotfish. We recommend a focus for future research on elasmobranchs (sharks, rays, guitarfish) and other IUCN Red Listed species. This includes expanding coral research into unstudied habitats and a focused study on *Anomastraea irregularis*. Ongoing coral reef resilience research will provide a more thorough understanding of the resilience of these reefs to climate change.

1. Introduction

Watamu Marine National Park (WMNP) is one of the oldest Marine Protected Areas (MPAs) in Africa being gazetted in 1968. It consists of 10km² of shallow lagoon containing coral, seagrass, sand and mangrove habitat 100km north of Mombasa in Kenya. All extraction of resources, including fishing, is prohibited. It is one of two no-take zones nested within the larger Watamu-Malindi Marine National Reserve, which is 245km², within which traditional and sustainable fishing and extraction activities are permitted. The park is managed by Kenya Wildlife Service (KWS) with the goals of biodiversity protection, providing sustainable livelihoods, managing tourism, education and training and reducing conflicts between stakeholders of the area (Muthiga 2009).

Watamu is near the northern edge of a 200km long fringing reef which stretches along the entire Southern Kenyan coast from Shimoni to nearby Malindi. Malindi also marks the northern extent of the Western Indian Ocean (WIO) coral reef region, which stretches south to Kwa-Zulu Natal, South Africa and east to the Chagos Archipelago, UK Indian Ocean Territory (Obura 2012). This region is part of the wider Indo-Pacific marine biogeographic zone stretching from the Red Sea to Hawaii and the Pitcairn Islands in the Central Pacific. Surprisingly this means that Watamu and the East African coast has largely similar ecology and even shares some species with Hawaii, on the opposite side of the globe, and other Indo-Pacific reefs, such as the Great Barrier Reef, Australia, but is distinct from coral areas such as the Caribbean.

Modern scientific studies of WMNP began in the 1960s with the Watamu Research Expedition conducted by Bangor University, Wales. Howver, it wasn't until the early 1990s when consistent research and

monitoring began. To date Wildlife Conservation Society (WCS) and KWS have carried out annual monitoring of coral areas of the park and Coral Reef Degradation in the Indian Ocean (CORDIO) and Kenya Marine Research and Fisheries Institute (KMFRI) have conducted various studies of the coral reef and associated habitats. Indeed the 20+ year monitoring data from WCS (McClanahan et al 2001) and CORDIO's status reports (Obura 1999) have provided invaluable insights into how the park and the entire WIO region are changing, especially concerning a catastrophic disturbance during the 1998 ENSO event. During this El Nino period, sea surface temperature rose and caused mass coral bleaching in March 1998 and resulted in 60-90% of coral on Kenyan reefs to die. Since then, much coral reef conservation effort has been focussed on understanding and preventing such mass-mortalities, with research from Kenya providing important information for global efforts.

Besides this periodic basic monitoring, there has been little intensive research undertaken in WMNP. Most attention has focused on just two patch reefs known as Coral Gardens and Bennett's Reef, leaving the other patch reefs and habitats in the park unstudied. However these are critical to the integrity of the WMNP and are therefore the focus of A Rocha Kenya's Marine Conservation and Research Programme. This programme builds on past work, expanding it into all coral areas and other habitats in the park with a wider range of monitoring and research techniques than have been used before. The goal is to document biodiversity and conservation threats at a high resolution in order to understand key processes and threats influencing the park and hence support the objectives of KWS. We report here some initial results from this programme.

2. Methods

There were four components to the research reported here; generic richness of corals, species richness of fish, benthic cover of coral areas and population structure of fish. Species lists for corals and fish were compiled from *ad hoc* observations throughout the course of all activities within the park. Coral cover and fish population structure were assessed using quantitative sampling at four patch reefs Coral Garden, Bennetts Reef, Uyombo Reef and Turtle Reef (Figure 1). Coral Gardens and Bennett's Reef are in close proximity to one another, and are sections of the same linear stretch of shallow coral reef. Coral Gardens reef is subject to high numbers of tourists on a daily basis.

- Coral generic richness: High resolution photographs were taken of corals, in order to show details of individual corallites. Each coral was identified to genus and then where possible to species using Veron (2000). Identifications were checked and expert advice was provided by D. Obura (CORDIO).
- Fish species richness: Fish were recorded in all areas of the park including all habitat types. Identifications were made using Lieske and Myers (2001) among other sources and confirmed with Fishbase (www.fishbase.org).
- Benthic Cover: The length of any benthic component encountered along 10m long line intercept transects was measured and assigned to one of the following categories: Hard Coral, Soft Coral, Macroalgae, Turf Algae, Corraline Algae, Seagrass, Sponge or Sand (McClanahan and Obura 1997).
- Fish population structure: 100m long and 5m wide (500m²) belt transects were used to quantify abundance of fish from ten common families which were enumerated within size classes of 0-10cm, 11-20, 21-30, 31-40 and 40+. The selected families were *Acanthuridae* (Surgeonfish), *Scaridae* (Parrotfish), *Labridae* (Wrasse), *Balistidae* (Triggerfish), *Pomacanthidae* (Angelfish), *Chaetodontidae* (Butterflyfish), *Haemulidae* (Sweetlips), *Mullidae* (Goatfish), *Lethrinidae* (Emperor) and *Lutjanidae* (Snapper) (McClanahan 1994). Coral Gardens and Bennett's Reef were combined for this survey due to their small size and proximity and Turtle Reef was omitted due to sampling issues at the time. Three transects were conducted in each site. This method was chosen in order to collect comparable data as that monitored in the park by Wildlife Conservation Society and Kenya Wildlife Service and encompasses the majority of fish families that are primarily found on coral reefs.

3. Results

3.1 Biodiversity

The recorded fish species richness for the entire park as of November 2013 was 354 species from 56 families. The bulk of these (60%) were not evaluated by IUCN for Red List status. Ten species were classified as Vulnerable (VU) or near threatened (NT) all of which were elasmobranchs (sharks, rays and guitarfish) or *Serranidae* (groupers) (Table 1). A further two elasmobranchs and two grouper were considered data deficient (DD), which means that, there are insufficient data to assess their status but there are reasonable grounds to suspect that they might be threatened.

For corals, 32 genera were recorded from 14 families. There were some regional endemics recorded, such as *Acropora branchii* and *Anomastrea irregularis*. The *Anomastrea* is a monospecific genus of high conservation importance being identified as an EDGE (Evolutionary Distinct, Globally Endangered) species by the Zoological Society of London.

3.2 Ecology

In total, 50 line-intercept transects were used to assess benthic cover divided between the 4 reefs which were all small linear or horseshoe-shaped patch reefs within the back lagoon of the fringing reef system. The highest coral cover was found at Uyombo with 31% and the lowest in Turtle Reef at 15% (Fig 2a). Coral Gardens was dominated by short (<10mm) coralline and turf algae (51%), whereas Turtle Reef and Bennett's Reef had more luxuriant growth of macro-algae (45% and 41% respectively). Turtle Reef was the only reef with significant soft coral growth (5%). In terms of coral community composition Coral Gardens and Bennett's Reef were dominated by massive *Porites* colonies (54% and 58% respectively), whereas Uyombo and Turtle Reef had a more balanced coral composition with notably more *Acropora* and *Pocillopora* (Fig 2b).

Both Bennett's Reef/Coral Gardens and Uyombo reefs had a similar size class distribution of fish, the mode falling in the 10-20cm size class; and similar abundance of fish with 254 per 500m² in Uyombo and 262 per 500m² in Bennett's Reef/Coral Gardens (Fig. 3). Both reefs were also dominated by surgeonfish, wrasse and parrotfish (in descending order), but in Uyombo surgeonfish were more dominant with 78 per 500m².

4. Discussion

4.1 Biodiversity

New fish and coral records continue to be made. Lemmens et al. (1993) found 113 species of coral from 45 genera in WMNP. We have added three new genera (*Anomastrea*, *Symphillia* and *Plesiastrea*) and one new family (*Euphyllidae* - *Pleogyra*) to their list. Certain groups of fish are highly likely to have declined, such as *Chaetodontidae* (butterflyfish), of which many are obligate corallivores (Lieske and Myers 2001) and so are closely linked to coral health and diversity.

East Africa is in a medium fish and coral diversity area of the Indo-Pacific region with an estimated 297 species of coral in 55 genera (Obura 2012) and 2000 species of shallow water fish (Richmond 2001), 10,000 km west of the Indo-Pacific centre of diversity, known as the "Coral Triangle." However, when

comparing to regional richness, it is important to note that WMNP only includes the reef crest and back reef lagoon and none of the seaward fore-reef zone which can often be the most diverse area of a reef.

In contrast to findings in terrestrial habitats where endemicity is found in centres of diversity, peripheral coral regions are thought to contain most endemics (Hughes et al 2002) and hence the Western Indian Ocean (WIO), being on the edge of the Indo-Pacific, does contain a moderate number of endemics, with an estimated 15% across all taxa (Richmond 2001). Endemicity is possibly even higher in Watamu at the northern edge of the WIO region, 1000km north of the regional centre of diversity in Northern Mozambique and at the interface with the even more peripheral and unique Red Sea/Gulf of Aden fauna (Obura 2012). However the area is poorly studied and species ranges, conservation statuses and even species definitions are uncertain (Richmond 2001). Indeed two of the four IUCN Data Deficient fish species are thought to be regional endemics.

4.2 Ecology

The 1998 bleaching event had the most severe impact on the ecology of WMNP, and that of coral reefs around the world, that has been recorded. Prior to 1998, the coral cover in the no-take parks of Kenya was 35-45%, and dropped to just 10% following the bleaching (Muthiga 2009). Reefs in Kenya have recovered, but in some areas, including in Watamu, this has been slow. Coral cover at Coral Gardens is still only 18% even 15 years after the event. However, other patch reefs in the lagoon had a much higher coral cover of around 30% (Uyombo and Bennett's Reef), highlighting the variable nature of reef recovery even on this small scale and hence the need for high resolution studies to uncover the processes behind these patterns.

Coral cover is a useful and widely used metric of reef health, but it is also rather crude and gives no indication of the community or population structure of the reef corals. It has been shown that certain corals are much more susceptible to bleaching than others and hence post-bleaching reef communities can be quite different to before the disturbance. In particular the once common "complex branching" guild of corals including *Acropora, Pocillopora,* branching *Porites* and *Stylophora* are particularly susceptible and were entirely lost from shallow lagoon reefs in Kenya immediately after 1998 (McClanahan et al. 2001). When examining coral composition on different patch reefs in WMNP we noted that there is high variability in the presence of these genera on different patch reefs with much lower *Acropora* and *Pocillopora* levels at Coral Gardens and Bennett's reef. This means that the seemingly healthy Bennett's reef, with 30% coral cover, is actually a relatively depauperate coral community dominated by massive *Porites* colonies and few branching corals. Uyombo is much closer to a pre-bleaching condition with high coral cover and an abundance of

Acropora and *Pocillopora*. However, throughout the entire park, branching *Porites* was only found in small patches and not a single *Stylophora* colony was found.

In contrast to corals, it seems that fish abundance and community structure has remained relatively stable since before the 1998 bleaching. McClanahan (1994) reported 400-500 individuals per 500m² in no-take areas in Kenya, which is higher than the 260 we reported, but this is likely to be a result of that study also including *Pomacentridae* (damselfish), of which he found on average 174 per 500m². Community structure is also similar between 1994 and 2012 with approximately equivalent levels of each family. Despite the decline in corals, the protection offered by the no-take policy of the marine parks seems to have maintained fish levels.

4.3 The Future

Since 1998 there has been much attention paid to understanding why coral bleaching occurs, but also how reefs can resist bleaching and recover after bleaching. Such resilience is a complex issue with much unknown, but the wide variation manifest in WMNP provides a valuable laboratory in which to examine how resilience and recovery vary over a small scale and how processes in reef health operate at fine resolution. Expanding the current monitoring into the remaining four patch reefs in the park, and others in the wider reserve, using the same basic metrics which have been used historically, as well as new metrics designed to understand resilience, should provide insights into the response of reefs to bleaching and ultimately climate change.

In common with many MPAs containing coral reefs, the reefs in Watamu have been the focus of most research and monitoring and little work has been done in other habitats. However, the park contains extensive areas of seagrass, rocky substrate, deep sandy substrate and other less common patch habitats, which house threatened species, unique biodiversity and important ecology. For example, many of the elasmobranches, which made up half of the red-listed species recorded in WMNP, are found mainly over sandy areas, which though extensive are very poorly studied. The importance of seagrass beds for carbon sequestration is increasingly recognised (Forqurean et al 2012), which may represent a massive ecosystem service provided by WMNP, as yet unrecognised.

Surveys to date have identified 11 taxa (ten fish and one coral) within the park which are globally threatened and there are expected to be others that have yet to be assessed. Monitoring methods need to be

developed and implemented which will give an understanding of their population sizes and trends to complement work elsewhere within their ranges.

Finally, the key aspect of any conservation project is the interface between people and their environment. Through observations and conversations with locals in Watamu patterns of resource usage relating to WMNP are beginning to unfold. While it does appear that fish populations in the park are robust, poaching has been clearly observed on many occasions. Habitat destruction has also occurred, often arising from tourist activities such as trampling of coral at Coral Gardens by snorkelers (Cowburn et al. in Press) and the destruction of turtle nesting habitat in dune vegetation for sun beds and curio shops near hotels. Research and mitigation strategies for these conservation threats are required to combat degradation and species declines.

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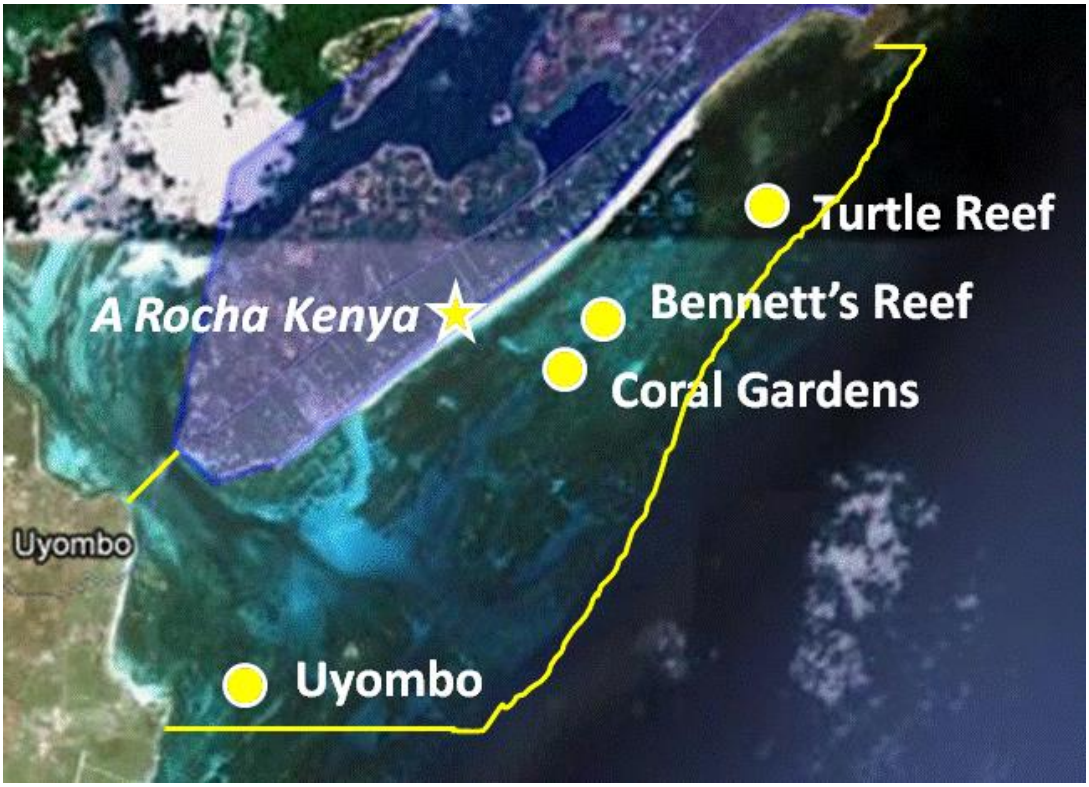
Figure 1. Positions of study reefs in WMNP. Park boundary marked in yellow line.

Figure 2. (a) Benthic cover of major categories of sessile organism. (b) Generic composition of corals at each site

Figure 3. Fish size class distributions summarized for all families.


Turtle Reef
A Rocha Kenya
Bennett's Reef
Coral Gardens
Uyombo
Uyombo

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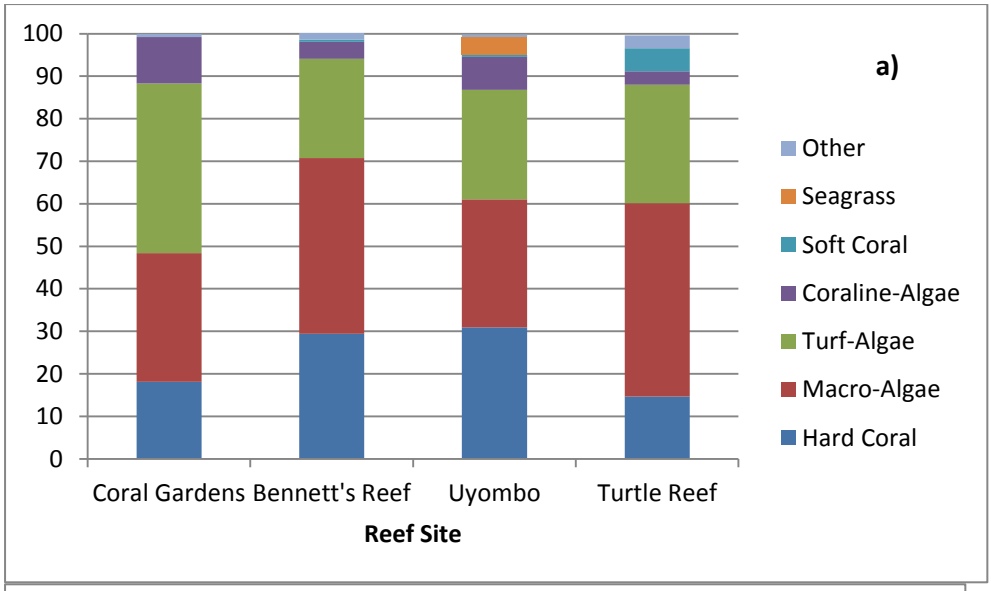
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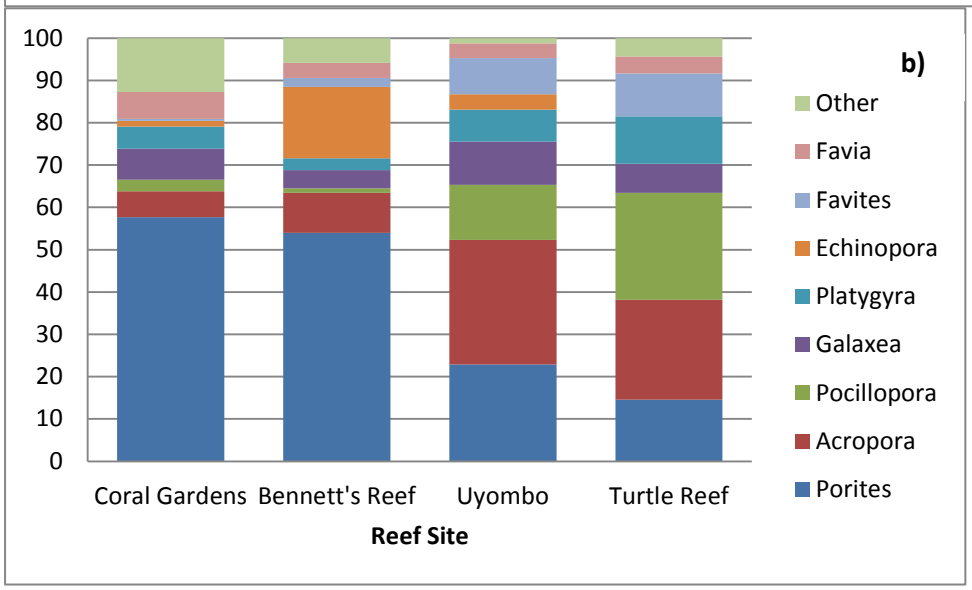
Turf-Algae
Macro-Algae
Hard Coral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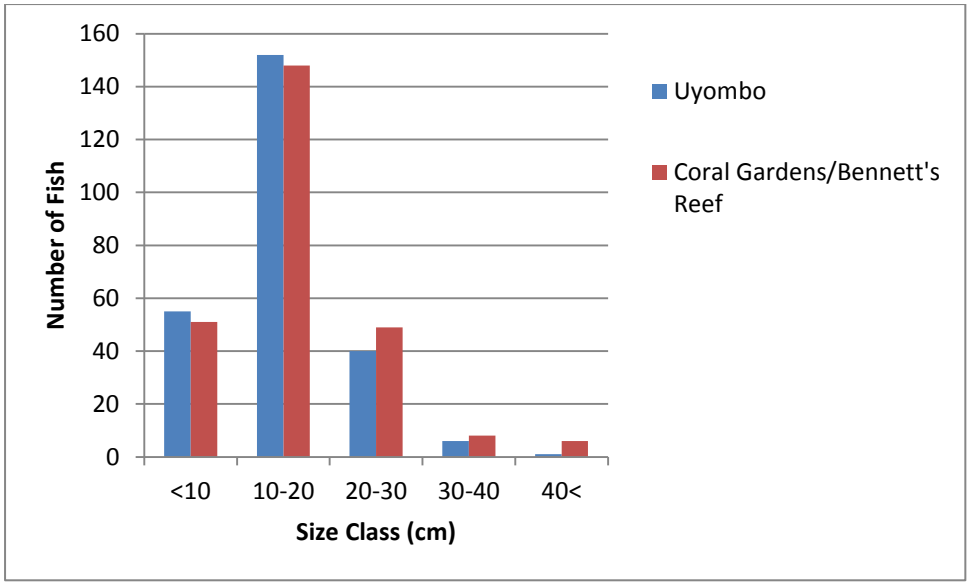
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Size Class (cm)
Uyombo
Coral Gardens/Bennett's Reef

Table 1: IUCN Red List Vulnerable, Threatened and Data Deficient species observed in Watamu Marine National Park.

Vulnerable	Near Threatened	Data Deficient
Whitespotted Whipray *Himantura gerrardi*	Blacktip Reef Shark *Carcharhinus melanopterus*	Bluespotted stingray *Dasyatis kuhlii*[1]
Giant Guitarfish *Rhynchobatus djiddensis*	Whitetip Reef Shark Triaenodon obesus	Marbled electric ray *Torpedo sinucpersici*
Reticulate Whipray *Himantura uarnak*	Blue-spotted stingray *Taeniura lymma*	Greasy Grouper *Epinephelus tauvina*
Giant Grouper *Epinephelus lanceolatus*	Brown-marbled grouper *Epinephelus fuscoguttatus*	Marbled Coral Grouper *Plectropomus punctatus*
Blacksaddled Coral Grouper *Plectropomus laevis*	Malabar Grouper *Epinephelus malabaricus*	

1. From IUCN Red List assessment: "Investigation is vital to resolve the taxonomic issues associated with this species complex and make full assessments of its status. There may be more than five species involved in total."