

Marine Research and Conservation at A Rocha Kenya: 2010-2014

A Rocha Kenya

Science & Conservation Report

by

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Introduction

A Rocha Kenya's Marine research began in 2010 and has since achieved several research objectives and grown in capacity. The mission of the programme has always been to be an extension of Kenya Wildlife Services (KWS) research team based permanently in Watamu. We are collecting data on relevant ecological and conservation issues facing Watamu Marine National Park (WMNP) and the surrounding area and doing so in a way that honours God and A Rocha's core commitments to five C's (Christian, Conservation, Community, Cooperation, Cross-Cultural).

We are grateful to the A.G. Leventis Foundation for a small grant to help us start our work and to the financial support of A Rocha International and A Rocha USA.

Our research initially focussed on the coral reef areas of WMNP, though increasingly we are trying to understand the other four main habitats including, the rocky intertidal areas, beaches, sea-grass beds and rocky/sandy sub-tidal areas. In addition we are beginning research into the human dimension looking at stakeholders and resource users and the ways in which they interact with natural resources in the area.

The marine portion of A Rocha Kenya's Science and Conservation Programme has grown, inviting local and foreign scientists to contribute and collect information relevant to KWS and A Rocha objectives. This has vastly increased our ability to understand the status of the park and aid KWS in their management of this crucial protected area.

The first marine protected areas (MPAs) established in Kenya were in Malindi and Watamu in 1968. The purpose of creating marine parks and reserves was to protect biodiversity, manage resources in a sustainable way to protect the livelihoods of coastal communities and manage tourism. The work conducted by A Rocha Kenya intends to provide relevant information to these goals through research, capacity building within the local community, partnerships and practical conservation action where necessary.

Overview of Marine Conservation and Research

There are three main areas in which we focus our research currently:

- Biodiversity
- Climate Change
- Fisheries/Poverty Alleviation

These three themes will focus our work into the future.

To date we have mainly been trying to understand the system in which we are working. This has led us to mostly focus on research. This year we come to the end of one phase of that work. We will be collating and publishing all the information we have collected to date and conducting a gap analysis on areas which we might focus in coming years. Additionally, we

will look especially at IUCN Red Listed species to determine appropriate research activities to focus on these species.

To date much of our active conservation has focused on education, beach clean ups, and partnering with local marine conservation organisations in their work.

An additional outcome of the gap analysis will be examining and proposing a Marine Community Conservation Programme, based upon an assessment of historical and our own research, threats to the systems, and our understanding of other successful models.

Biodiversity

We are working with the matrix below which indicates the five main habitats and major taxonomic groups which we are attempting to study. In the matrix, numbers link to reports, articles, presentations and posters listed in the appendix and available online and 'X' indicates that we have collected data for that taxonomic group in a particular habitat, but have not yet finished reporting. There remains much to do in order to have a complete understanding of the biodiversity of WMNP. The matrix below gives the groups of organisms that we are likely to be able to study in the coming years, not including groups such as polychaetes, sponges, and many others where taxonomic expertise and museum facilities are necessary for correct identification.

	Coral Reef	Seagrass	Subtidal rubble and sand	Rocky intertidal	Sandy Beach
Fish	1, 2, 3, 4, 6, 7, 11, 15, 20	X	X	4, 18, 21, 22	-
Echinoderms	14			13, 21, 22	-
Molluscs				X	
Crustaceans					8
Corals	1, 3, 4, 6, 7, 11, 15, 19, 20			17, 21, 22	-
Seagrass		X			-
Algae		X			-

Climate change

This project is the subject of Benjamin Cowburn's Ph.D. thesis at Oxford University, which is currently in process. This will provide a large amount of information on the health, vulnerability and resilience of the coral reef habitat.

Fisheries/Poverty Alleviation

Recently research on the relation between livelihood practices and the resources from WMNP and Mida Creek was completed. The study focussed on the livelihood practises of the villagers, the relation between these livelihood practises and the utilization of the natural resources in the reserves surrounding them as well as their attitude and awareness to the reserves.

Our current work is examining and proposing the feasibility of a Marine Community Conservation Programme based upon an assessment of threats to the ecosystems, successful conservation models implemented elsewhere and existing community livelihood practices in the area.

Another study completed last year examined the use of mosquito nets for fishing in Mida Creek.

Research reporting

Research results are published as A Rocha Kenya Occasional Research Reports as listed in the Appendix and found on A Rocha Kenya's website at <http://www.arocha.org/ken/work/research/marine/research.html>. Some of these reports are then put into a format suitable for publication in a peer-reviewed science journal.

The Occasional Research Reports would have more detailed and complete information, whereas the journal publications focus on aspects of the projects that are of interest to a wider audience. Additionally, a number of interns and researchers pursued projects as part of university requirements to produce a dissertation. These have also been made available on the website and are usually much more detailed and contain literature reviews that may be of wide interest. Below we summarize projects to show what was done and some of the main conclusions. However, for details one should go to the referenced reports.

Research Phase 1: December 2010 – August 2012

Tourist impacts on Coral Gardens

This project was commissioned by KWS and examined the ecological impact of tourism on the reef and also the potential damage to visitor satisfaction caused by over-crowding and environmental damage.

Tourism is an important aspect of the Marine Park. Not only does it help to educate an international audience on marine biology within Kenya, but it generates revenue for marine conservation and KWS. Unfortunately, many tourists unknowingly damage the reef through

physical contact while they are enjoying the scenery. Whether accidentally or out of curiosity, many visitors touch coral and pick it up and occasionally even decide to take their own souvenir home and remove articles from the Marine Park.

During the study (October 2011 to February 2012) An average of 11 boats visited the reef each day carrying on average 14 passengers meaning that, if these numbers are representative, an estimated 154 people visit the reef daily. Interestingly only 3 out of 4 people on boats got in the water, meaning that the actual number of snorkeling is estimated to be 117 per day. Boats stayed at the Coral Gardens for on average 40 minutes, but their guests only stayed in the water for the relatively short time of 19 minutes.

A total of 47 people were followed in the water and their interaction with the reef was monitored. Twenty one (45%) of those people made physical contact with coral in some manner and one person interacted negatively with the reef on 8 separate occasions by scraping it four times, trampling on it once, holding onto it once, and stirring up the sediment twice. Sadly some people chose to sit on the reef to sunbathe and many people stood or sat on the reef to fix their fins or masks.

These results show us that a high number of boats and people visit the reef every day and a worryingly high number of these people make potentially damaging contact with the reef.

The results from this study are available on A Rocha Kenya's website in reports #24 entitled "Impact of Watamu Marine National Park on marine biodiversity & habitats" and #26 "The impact of snorkeling on marine habitats of Watamu Marine National Park." Additionally, a portion of this study was published in the Western Indian Ocean Journal of Marine Science as "Tourism, Reef Condition and Visitor Satisfaction in Watamu Marine National Park, Kenya."

Coral and Fish Biodiversity

This project expanded the scope of previously published work completed by other researchers by collecting data in previously un-surveyed coral reef areas of the park and using a range of methods to investigate diverse indicators from coral cover to fish biomass.

Research was conducted at three main coral reef sites representing different ecological locations. The sites included: Coral Gardens – *Richard Bennett*, a site with high tourism pressure located in the inner lagoon north of Mida Creek, Uyombo, a site with low tourism pressure located south of Mida Creek and Turtle Reef a gap along the reef crest. This site experiences intermediate tourism pressure and is often visited by divers in deeper water.

Abundance surveys at the Coral Gardens – *Richard Bennett* and Uyombo sites show similar trends. For example, surgeonfish are the overall most abundant fish followed by wrasse and then parrotfish. Most fish tend to be small with the most frequent size range being from 10-20 cm. The majority of the surgeonfish were found in the 10-20 cm range with more surgeonfish found in Uyombo compared to Coral Gardens. Wrasse were mostly observed in the smallest size classes, <10 cm and 10-20 cm. Also, even though some of the fish families

have the capacity of growing to large sizes, for example surgeonfish, snapper and sweetlips, very few in larger size classes were observed and in the case of snapper and sweetlips there were relatively few individuals in any size class.

In terms of fish diversity, 99 species of fish were identified for Coral Gardens – *Richard Bennett* and 88 species were identified for Uyombo. In addition to these surveys a list of all fish identified for all areas of the park over the entire fieldwork period was compiled and a total of 180 species were identified from 44 families at that time.

Line Intercept Transects compared the dominant coverage on the seafloor for the different study sites. The benthic coverage for Coral Gardens, Turtle Reef, and Uyombo was overall dominated by a combination of turf and macro-algae. Hard coral cover was highest in Uyombo at 31% cover and this is also where the highest diversity of coral was seen.

The results from this study are available on A Rocha Kenya's website in reports #24 entitled "Impact of Watamu Marine National Park on marine biodiversity & habitats and #27 "Coral reef ecology and biodiversity in Watamu Marine National Park."

Research Phase 2: Sep 2012 – March 2014

Coral Reefs

Bleaching Survey: This project monitored the changes to the benthic communities of reefs in WMNP during a small bleaching event in March 2013. Data were collected before the event in February and continued until August 2013 noting the prevalence of bleached, dead and recovered coral. Despite the high prevalence of bleaching during the event (over 50% of corals) the majority seemed to recover and mortality was low. A paper is in the process of being prepared for publication by Benjamin Cowburn detailing this project. Preliminary results were presented as a poster (available on the ARK website) at the Reef Conservation in the UK meeting (UK scientists focused on coral reef conservation) held at the Zoological Society of London.

Resilience Indicators: Benjamin Cowburn is focusing his Ph.D. dissertation on applying methods laid out by CORDIO for evaluating coral reef resilience on the various patch reefs of WMNP. The ability to predict future trends in coral reef recover or decline due to climate change and mass bleaching is of considerable importance. This project is both gathering data to understand the trajectory of coral in WMNP and feeding into a wider debate about global coral reef decline. Data has been collected and is expected to be available in report form by the end of 2015.

Coral recruitment: Surveys of permanent quadrats for coral recruitment was completed by Benjamin Cowburn over 18 months (November 2012 to April 2014) in order to assess the growth and mortality of juvenile corals in permanent quadrats in the park. This will help understanding the recruitment of the coral in the park.

Damselfish territoriality impacts on coral recruitment: Tim Gordon, an A Rocha intern from Cambridge University, investigated the territorial damselfish *Plectroglyphidodon lacrymatus* or Jewel Damsel on various patch reefs in WMNP. This fish is known to defend a territory in which it “cultivates” an algal patch, and will in fact “weed” out any unwanted organisms, which settle in its patch. He looked at whether juvenile corals were affected by this process, and reported that damsel territories had fewer juvenile corals. This demonstrates how the abundance of one species can impact the whole ecosystem, as these fish influence coral recruitment and growth. This study was published in the premier peer-reviewed journal Coral Reefs. Preliminary results were presented as a presentation and poster (available on the ARK website) at the Reef Conservation in the UK meeting (RCUK - UK scientists focused on coral reef conservation) held at the Zoological Society of London.

Fish of branching corals: Peter Musembi, A Rocha Kenya’s resident marine biologist, conducted a study of coral obligate fish species. These fish are dependent on branching corals for food and/or shelter and are hence highly threatened should these corals be lost. Linked with our resilience work this study demonstrates the ecological importance of specific corals and also the importance of detailed monitoring of habitats to understand how they may change in the future.

Sea urchin diversity and abundance: Sarah Tyrrell, an A Rocha Kenya intern from Exeter University in the UK, surveyed sea urchin diversity and abundance on coral reefs within and outside WMNP. It was noted that in Coral Gardens, Bennets and Lambis, *Echinometra Mathaei* was the dominant urchin recorded on these transects. These species test size are extremely small and they inhabit burrows in the reefs which provide them protection from predation. Also in these three reefs we had a number of transects where no urchins were noted on the reef.

However we did find during a pilot night survey at coral gardens a significant increase in Sea urchins along the transects. We recorded 37 individuals compared to 11 during the day. This night visit also showed the presence of eight *E. Diadema* and two *D. Savignyi* sea urchins compared to the one *E. Diadema* noted during the day. A night survey of these reefs may provide a more accurate representation of the distribution and diversity, because of the nocturnal nature of the Sea Urchins.

In Kanani and Uyombo we found much larger test sizes, and a more dominant presence of the Diadema species (*D. savingyi*, *D. setosum*, *Echinothrix diadema*). This echinoderm family are characterized by longer spines and are much larger test sizes than the burrowing *Echinomtrema mathaei* and *Echinostrephus molaris*. *Diadema Savigni* and *Diadema setosuma* are widely considered to be more present on disturbed reef ecosystems. The environment at Kanani with numerous sea grass beds surrounding the reef may have contributed to the high number of *Trinopenutis gratillias* found as they often prefer to inhabit sea grass areas.

The full report is available on A Rocha Kenya’s website as Sarah’s university dissertation entitled “The Distribution and impact of Sea urchins on Coral reefs in Watamu, Kenya.”

Hawkfish biodiversity and habitat use: A preliminary survey on hawkfish has shown that there are four hawkfish species in the park: freckled (*Paracirrhites forsteri*), arc-eye (*Paracirrhites arcatus*), twospot (*Amblycirrhitus bimacula*) and pixy (*Cirrhitichthys ocycephalus*) with a fifth species found on the reef crest, the stocky hawkfish (*Cirrhitus pinnalatus*). These species are of interest to the IUCN for providing information from Watamu to contribute to their Red-List of global taxa. Studies were completed in the autumn of 2013 by marine intern Hannah Hereward and will be written up as part of her university studies to be finished in the Spring of 2015.

Follow up study on Coral Damage by tourists at Coral Gardens: In the month of February 2014 A Rocha in collaboration with CORDIO East Africa conducted a survey on coral damage by tourists. This was carried out at Coral Gardens as the impacted site and two other sites not usually visited by tourists. The study was a follow up of what was conducted in 2011 and 2012 as noted above. The present study recorded more coral genera at Coral Gardens than in the other sites surveyed. The study also reported substantial coral damage at Coral Gardens compared to the other sites that are not visited by tourists. This study was completed in collaboration with CORDIO who published the report as part of the COAST project.

Seagrass

Research by marine researcher Dorothea Kohlmeier, a Ph.D. student at University of Bremen in Germany, on the biodiversity and distribution of seagrass found that 11 of the 12 species of seagrass species known to occur in the region are present in the park. This includes *Zostera capensis*, a species that is listed on the IUCN red list as a vulnerable species. These species occurred in various habitats such as intertidal rock pools, sandy areas near the beach and in some subtidal areas near the reef. This research also has shown that there are many species of macroalgae, invertebrates and fish that use the seagrass as habitats. Turtles, and in other areas of Kenya dugongs, are known to graze directly on seagrass further emphasizing the importance of seagrass habitats.

In the course of this project the issue of sea urchin, *Tripneustes gratilla* arose. There were reports of *T. gratilla* explosion on the northern side of the park. Our researchers however, observed only small number of the species on the Northern parts of the park. Instead they observed high numbers of *T. gratilla* at the Uyombo side of the park (>50 sea urchins per m²). A species list is provided below and full reports will be completed in the near future.

Seagrass species

Cymodocea rotundata

Cymodocea serrulata

Enhalus acoroides

Halophila minor

Halophila ovalis

Halophila stipulaceae

Halodule uninervis

Syringodium isoetifolium

Thalassodendron ciliatum

Thalassia hemprichii

Zostera capensis (*Nanozostera capensis*)

Sandy Beach

Testing human disturbance on beach front: This project recorded two crab species (*Ocypode ryderi* and *O. cordimanus*) within the park with another species (*O. ceratophthalmus*) identified at Mida creek. Previous research on these ghost crabs suggests that they may be indicators of human disturbance on beaches. This project sought to test this hypothesis on Watamu Beach. It was found that the density of the crabs was lower in front of the hotels than in residential and shrub beaches. This could be attributed to increased human activities in front of hotels and thus the density of ghost crabs may be a useful indicator for monitoring impact on the beach. The full report can be found on the ARK website as A Rocha Kenya Occasional Research Report #29 entitled “Testing ghost crab density as a useful indicator of human impacts on exposed sandy beaches.”

Rocky Intertidal

A number of studies have been completed in the rocky intertidal zone of Watamu Marine National Park. This is a habitat that has studied very little throughout East Africa. General reporting on our projects were summarized for a poster presented at the 2013 Reef Conservation in the UK meeting at the London Zoological Society which can be found on the A Rocha Kenya website.

Juvenile fish biodiversity: Marine intern Victoria Sindorf, a Ph.D. student at University of Hawaii, investigated fish diversity and abundance in rocky pools at low tide along Watamu Beach. She identified over 50 species of fish in this habitat, and using species accumulation analysis predicted a maximum diversity of nearly 100 species. Her work added several new species to the fish inventory for the park to date and showed the importance of these rocky areas in the wider context of WMNP as nursery grounds. A paper was submitted for publication by Victoria Sindorf, Benjamin Cowburn, and Robert Sluka detailing this project and was recently accepted with major revisions in the journal *Environmental Biology of Fishes*. Preliminary results were presented as a poster (available on the ARK website) at the 2014 Ocean Sciences Meeting held in Honolulu, Hawaii, USA.

Echinoderm biodiversity: Chloe Naylor conducted a study into the rocky intertidal areas of the park looking at the biodiversity and abundance of Echinoderms, the phylum comprised

of Sea Stars, Urchins, Sea Cucumbers, Sea Lillies and Brittle Stars. She found a large variation in abundance of starfish, with the rocky areas near hotels having very low numbers. This may suggest an impact of tourism on starfish populations and will require more research in order to understand this pattern. This project was written up as part of a dissertation for the University of Southampton entitled “Investigation into echinoderm species richness and abundance within the rockpool habitats of the Watamu Marine National Park, Kenya” and is available on A Rocha Kenya’s website.

Corals of the Intertidal Rockpools: An important discovery during our rocky intertidal research was the relatively large population of an IUCN Red Listed Vulnerable coral species. We thus began a project to understand the ecology and distribution of this coral species *Anomastrea irregularis* in the park. This is a rare coral species of the Western Indian Ocean region and found along the Eastern African Coast and oceanic islands. The research collected data on colony size and abundance as well as documenting record of other species found in conjunction with *Anomastrea*. This research also compiles a list of all the coral species found in the rock pools in the park. Analysis and write up continues, but preliminary work was reported in a poster (available on the A Rocha Kenya’s website) presented by Cassie Raker, Benjamin Cowburn, Victoria Sindorf, Peter Musembi, Benjamin Vanbaelenberghe, and Robert D. Sluka in 2014 at The 43rd Annual Benthic Ecology Meeting in Jacksonville, Florida, USA.

Fisheries

Mosquito net fishing: Emma Bush, then of Imperial College London, conducted surveys around Mida Creek with fishing families to assess their reliance on fishing, their views about how resources are managed and how their fishery is changing. In particular she looked at how mosquito nets, distributed freely within these communities, are being used in fishing. Her dissertation is available for download on the A Rocha Kenya website.

Research Phase 3: April 2014 to present

Rock pool Tourism: Surveys were conducted to describe tourists’ activities in the rock pool areas of WMNP and the form and level of interactions of tourists and guides in this habitat. Tourists’ activities observed include: feeding moray eels, observing of rock pools creatures and watching reef sharks that occasionally came to feed on the shallows sea grass beds more specifically at plot 34 rock pools.

More tourists’ activities were observed at Turtle bay rock pools compared to the other rock pools, followed by rock point. These two sites also recorded high abundance and richness of the target species. In the course of the study, two incidents of poaching were observed at Garoda and Rock point. Rock pools tourism was more pronounced and slightly better organised at Turtle bay rock pools than in any other surveyed sites.

The current study documented various unrestricted human activities including unofficial guide trade that are carried out in the rock pool. If left unrestricted these activities may pose as threats to biodiversity and habitat through trampling, pollution and resource extraction. Together with illegal activities such as poaching, these activities can significantly affect the biotic community structure of these systems, compromise with their ecological functions and affect the ecological integrity of other systems such as sea grass beds and coral reefs. We recommend that KWS consider protection of these habitats both as important interlinks to the near coral reefs and as unique habitats with distinct assemblage. We also recommend a more detailed study of the biodiversity of these rockpools and threats to their ecological integrity.

The full report is available as A Rocha Kenya Science & Conservation Report #33 authored by Peter Musembi, Martine Koemans and Jack Kamire.

Marine conservation and livelihoods project

Based on our findings on fisheries and livelihood research around the park we are looking at setting up a community marine conservation and livelihood project. Locally run marine conservation areas have continually proved to be an important management tool in conservation of marine resources globally. We are looking at using our experience in community participatory management of Watamu Marine Reserve and Mida Creek to set up a community project that will contribute towards conservation of these vital marine resources as well as improve the livelihood of the adjacent communities. This will be an area-based conservation project that will be informed by community livelihood practices and needs, social patterns and existing threats to marine resources.

Mollusc biodiversity

Matthias Horions, a student from Hasselt University Belgium, completed work that had started earlier in the year on mollusc biodiversity and abundance in the intertidal rocky platforms of WMNP. Molluscs are an important group of marine species that are exploited mainly for their shells among other uses. Over 40 species of molluscs from 20 families were recorded in Watamu Marine National Park. In the four sites surveyed, Turtle Bay and Rock Point recorded the highest species richness while *Engima Mendicaria* was the most dominant species.

The study also carried out a survey to look at shell trade around the park and record significant levels of shell trade but could not ascertain where they were extracted. We are planning for a detailed study on shell trade in the area. Other interesting finding from this study was that we observed high number of empty or broken shells at Plot_34 we could not ascertain whether these were washed off from the nearby or the site was previously high abundant in molluscs.

Fisheries project

Following up on fishing practices of the communities, we joined CORDIO East Africa to survey gillnet fisheries in different landing sites around the park and reserve. This project is looking at types, sizes, method and habitat of deployment of gillnets as well as species, sizes and weight of associated catches. These important aspects of artisanal gillnet fisheries will provide information that will inform on the most appropriate gillnets, their method of deployment and habitat in which they are used. This survey was based on the fact that, some gears termed illegal under the Fisheries Act may not have degrading impact when deployed in a certain manner or habitat as well as some legal gears may not be appropriate when deployed in a certain way in certain habitats. This will also further help us understand fishing practices among the surrounding communities.

Research Gaps

We have made a significant amount of progress in understanding the biodiversity of Watamu Marine Park. Yet there remain many marine taxonomic groups for which there is no information: sponges, soft corals, and polychaetes to name a few. These are difficult to identify groups and will need taxonomic expertise beyond A Rocha Kenya's current capacity. Some progress could be made for sponges by focusing on functional groups and for easily identifiable species of these four groups. However, it is suggested that taxonomic experts be encouraged to come to Watamu to focus on these groups. It is also notable that to date little work has been completed in the subtidal rubble and sand habitat.

Additionally, current work has focused exclusively on Watamu Marine National Park. Methodologies and programme areas could be expanded into other areas of Kenya. These studies should focus on topics where partner organisations are not currently working so as to increase overall capacity and understanding rather than duplicate it.

Results to date indicate several lines of research that are likely to prove fruitful. The first is focusing on fish of both conservation and fisheries value. We have identified a number of species which are red listed vulnerable or threatened. Research could focus on the ecology, biology and fisheries of these species, particularly elasmobranchs. Additionally, we have identified the rocky intertidal as a habitat of particular importance due to a rare coral species, high biodiversity, relative lack of study in East Africa, and as a nursery habitat for fisheries important species. These habitats are ideally suited for study from Mwamba in terms of travel time (a short walk down the beach) and lack of cost for transport/equipment to study. It is suggested that volunteers looking for research projects of a marine nature be directed to this habitat first.

Climate change resilience is the focus of Benjamin Cowburn's Ph.D. thesis and he is progressing with data analysis and report/publication writing. It is anticipated that in the next year, our understanding of this topic will increase significantly. It is suggested that unless funded projects present themselves for our involvement, that we not focus on this topic until we have the results from Benjamin's study and recommendations for future work and conservation practice.

Work on fisheries, especially related to poverty alleviation, is only now beginning and is an area that shows great promise for future research. Our good relationship with CORDIO researchers and the link between the marine park as protection of fishery resources and nursery habitat (rocky intertidal) link our research to community wide concerns for livelihoods and nutrition. This is an area we need to build capacity and experience.

Lastly, a future thrust of research should be to coordinate the capacity of A Rocha, both in Kenya and internationally, with local and international partners to examine the entire watershed. Specifically, focusing on the inter-relationship between Arabuko-Sukoke Forest, Mida Creek, and the Watamu Marine National Park. This would include understanding water flow through the watershed, local oceanography, and livelihoods that might inter-relate through this entire ecosystem. This “Forest to Reefs” project could have important implications for watershed management and linking these systems through research, conservation and education.

Appendix: A Rocha Marine Research and Conservation posters, presentations, and papers

Papers and book chapters

1 - Cowburn, B., R. Sluka, J. Smith, and M.O.S. Mohamed. 2013. Tourism, Reef Condition and Visitor Satisfaction in Watamu Marine National Park, Kenya. *Western Indian Ocean Journal of Marine Science* 12: 57-70.

2 - Gordon, T.A.C., Cowburn, B, and R.D. Sluka. 2014. Defended territories of an aggressive damselfish contain lower juvenile coral density than adjacent non-defended areas on Kenyan lagoon patch reefs. *Coral Reefs* DOI 10.1007/s00338-014-1229-z

3 - Musembi, P. and B. Cobwburn. In Review. Diversity and abundance of coral-associated fish in Acroporid and Pocilloporid corals of Watamu Marine National Park, Kenya. *PLOS ONE*

4 - Sindorf, V, B. Cowburn and R.D. Sluka. In review. Rocky intertidal fish assemblage in the Watamu Marine National Park, Western Indian Ocean. *Environmental Biology of Fishes*

A Rocha Kenya Conservation Research Reports

5 - Robert Sluka, Benjamin Cowburn, and Colin Jackson. 2012. The Impact of Watamu Marine National Park on Marine Biodiversity & Habitats. A Rocha Kenya Occasional Research Report #24. 18pp.

6 - Benjamin Cowburn and Robert D Sluka. 2012. Impact of snorkeling tourism on marine habitats of Watamu Marine National Park. A Rocha Kenya Occasional Research Report #26. 22pp.

7 - Benjamin Cowburn, Robert D Sluka and Joy Smith. 2013. Coral Reef Ecology and Biodiversity in Watamu Marine National Park, Kenya. A Rocha Kenya Conservation & Science Occasional Research Report #27. 14pp.

8 - Hannah F R Hereward and Robert D Sluka. 2014. Testing ghost crab density as a useful indicator of human impacts on exposed sandy beaches. A Rocha Kenya Occasional Research Report #29. 15pp.

9 - Martine Koemans. 2014. Living on the Edge: The relationship between livelihood practises and the national reserves resources. A Rocha Kenya Occasional Research Report #32. 42pp.

10 - Peter Musembi, Martine Koemans and Jack Kamire. 2014. Rockpool Tourism in Watamu Marine National Park. A Rocha Kenya Conservation & Occasional Research Report #33. 8pp.

11 - Peter Musembi and Benjamin Cowburn. 2014. Diversity and abundance of coral-associated fish in Acroporid and Pocilloporid corals of Watamu Marine National Park, Kenya. A Rocha Kenya Conservation & Occasional Research Report #34. 12pp.

University Dissertations and Theses completed using WMNP field data

12 - Emma R. Bush. 2013. What's the Catch? Mosquito Net Fishing in Coastal East Africa. A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science and the Diploma of Imperial College London.

13 - Chloe Naylor. 2014. Investigation into echinoderm species richness and abundance within the rockpool habitats of the Watamu Marine National Park, Kenya. B.Sc. Dissertation University of Southampton.

14 - Sarah Tyrrell. 2014. The Distribution and impact of Sea urchins on Coral reefs in Watamu, Kenya. BSc with Honours in Geography at the University of Exeter.

Presentations

15 - Tim Gordon and Benjamin Cowburn. 2013. Damselfish Territories and Juvenile Coral Density: A Previously Overlooked Association. Reef Conservation UK meeting at Zoological Society of London, 7 Dec 2013, London, UK.¹

Several damselfish species, including the jewel damsel (*Plectroglyphidodon lacrymatus*), aggressively defend small territories on coral reefs, in which they cultivate lawns of edible macroalgae. Previous research on the effects of these territories on corals has been inconclusive and focussed on percentage cover, overlooking effects on juvenile corals. Frequency counts were used to establish paired comparisons of juvenile coral density inside and outside visually conspicuous jewel damselfish territories on lagoon patch reefs in Watamu Marine National Park, Kenya. Over 41 territories, juvenile coral density was similar for all size classes in non-defended areas but reduced by up to 12-fold in the smallest size classes in defended areas. Inhibitory effects of territories were greatest for smaller corals, with decreased effects as coral size increased. The territories of damselfish can occupy a large proportion of a coral reef; territorial behaviour in fish may have greater impacts on reef structure, in particular the resilience and growth-rate of juvenile corals, than previously appreciated.

16- Robert D Sluka. 2014, The Hidden Things of God in the Ocean. ASA/CIS/CSA Annual Conference, 25-28 July McMaster University, Hamilton Canada.

The rocky intertidal zone exists at the interface of land and sea. Rockpools in this zone filled with a variety of marine biodiversity are often our first introduction to the ocean. A Rocha

¹ This presentation was also made into a poster for this meeting and is also listed under posters.

Kenya has been studying this ecosystem in Watamu Marine National Park resulting in cataloguing high biodiversity, including a rare, endemic coral species. We also found a high contribution to offshore coral reefs as nursery areas for valuable fisheries species. Yet these “hidden things of God” in the ocean are only revealed during a small window of time at low tide. I explore our research and conservation efforts in this ecosystem through the lens of Matthew 5:14-16 regarding the role of research and Revelation 5:9-13.. The role of the marine researcher is to bring to light these hidden things and work with those in marine conservation to protect and bring to fruition new creation in the ocean. Ultimately, the goals for the Christian involved in this endeavor are to glorify the Father and work towards all creation functioning in order that God is praised.

Posters

17 - Cassie Raker, Benjamin Cowburn, Victoria Sindorf, Peter Musembi, Benjamin Vanbaelenberghe, and Robert D Sluka. 2014. *Anomastrea irregularis*, a vulnerable coral of the rocky intertidal zone of Watamu Marine National Park, Kenya. The 43rd Annual Benthic Ecology Meeting, 19-22 March, Jacksonville, Florida, USA.

A rare species of scleractinian coral found in tropical coastal ecosystems is *Anomastrea irregularis*. This coral is classified as Vulnerable by the IUCN and the only species in its genus. Previously there have been no projects focusing solely on *A. irregularis*. Colonies were studied in three main sites of Watamu Marine National Park in Watamu, Kenya with a total of 131 colonies located. Most colonies were found in the northern end in the park (57%), with fewer in the central region (28%), and even fewer near the southern end (15%). *A. irregularis* found in the northern site were generally the largest (13.68 cm²), but colonies found in the southern most site were the most likely to be found with other coral species. In addition to *A. irregularis* specific data, transects were laid parallel to the shore near the seaward edge of each group of rock pools. *A. irregularis* seems to be minimally dependent on conspecifics and able to survive in pools with varying benthic cover. We suggest that further research be completed on the population dynamics of this species and that management of these inshore habitats be included in the ongoing conservation in this national park.

18 - Victoria Sindorf and Benjamin Cowburn. 2014. Indian Ocean Rocky Intertidal Zone – An Important Nursery Habitat for Commercially Valuable Fish Species. 2014 Ocean Sciences Meeting, 23-28 February, Honolulu, Hawaii, USA.

The tropical rocky intertidal is a poorly studied ecosystem, but potentially of great ecological and commercial importance, warranting consideration when planning management strategies. Initial surveys of ichthyofaunal diversity were conducted in the Watamu Marine National Park in Kenya (Western Indian Ocean). Of 56 observed species, 26% were in the

family Gobiidae, 18% in Blenniidae, 16% in Pomacentridae, and 14% in Labridae. A Chao2 asymptotic richness estimate gave an expected asymptotic richness value of 96.36 (s.d.= 6.26), but is likely an underestimate of actual species richness due to limitations of visual census techniques. The majority of species observed (51.8%) were only seen as juveniles, suggesting that these habitats function as a nursery for reef fish, with 35.7% of species having importance to commercial fisheries and 48.2% having a market in the aquarium trade. More research is needed to determine the contribution of juvenile fish found in the rocky intertidal to adjacent reefs and especially to fishing grounds outside of the marine park. This study illustrates the importance of overlooked habitats to the overall biodiversity and ecosystem functioning of tropical coastal areas.

19 - Benjamin Cowburn, Victoria Sindorf, and Paul Simonin. 2013. Do minor bleaching events matter? Ecological observations from a localised event in Kenya, 2013. Reef Conservation UK meeting at Zoological Society of London, 7 Dec 2013, London, UK.

The severe 1998 bleaching event caused approximately 80% coral mortality in Kenyan reefs, with severe long-term ecological impacts. Bleaching is predicted to become more common as climate change progresses. However, the impacts of the bleaching are highly variable with different frequencies of bleaching and then subsequent mortality and recovery. A minor bleaching event, caused by raised water temperature, was observed in Watamu Marine National Park, Kenya starting in March 2013. Data on adult and juvenile corals were collected prior, during and after the event from February until October 2013. Bleaching was observed in 60% of colonies, in most genera of scleractinian corals as well as other zooxanthellate organisms on the reef. This included more resistant corals such as Porites and Favidae, as well as the susceptible genera Acropora and Pocillopora. Recovery to normal colour was fastest in acroporids, while some favids still showed pale colouration in July, four months after the event. Mortality of colonies was low in most genera, except for Pocillopora where 50% of colonies died. Despite a high prevalence of bleaching observed during this event it seems that recovery was high, even among susceptible acroporids. The loss of Pocillopora may have an impact on certain fish and crabs, which are known to be dependant on this genus of coral, but on the whole it could be that this bleaching event had relatively little ecological impact on the reef. Whether the low mortality of reef-forming corals was a result of only a minor excursion in temperature or whether corals are adapting to exposures to high temperature remains open to question.

20 - Tim Gordon and Benjamin Cowburn. 2013. Damsel Territories and Juvenile Coral Density: A Previously Overlooked Association. Reef Conservation UK meeting at Zoological Society of London, 7 Dec 2013, London, UK.

Several damselfish species, including the jewel damsel (*Plectroglyphidodon lacrymatus*), aggressively defend small territories on coral reefs, in which they cultivate lawns of edible macroalgae. Previous research on the effects of these territories on corals has been

inconclusive and focussed on percentage cover, overlooking effects on juvenile corals. Frequency counts were used to establish paired comparisons of juvenile coral density inside and outside visually conspicuous jewel damselfish territories on lagoon patch reefs in Watamu Marine National Park, Kenya. Over 41 territories, juvenile coral density was similar for all size classes in non-defended areas but reduced by up to 12-fold in the smallest size classes in defended areas. Inhibitory effects of territories were greatest for smaller corals, with decreased effects as coral size increased. The territories of damselfish can occupy a large proportion of a coral reef; territorial behaviour in fish may have greater impacts on reef structure, in particular the resilience and growth-rate of juvenile corals, than previously appreciated.

21 - Robert D Sluka, Benjamin Cowburn, Benjamin Van Baelenberghe, Chloe Naylor, Victoria Sindorf, and Mohamed O.S. Mohamed. 2013. Rockpools of Watamu Marine National Park: Biodiversity, conservation, and education. Reef Conservation UK meeting at Zoological Society of London, 7 Dec 2013, London, UK.

Watamu Marine National Park, Kenya is renowned for its beautiful beach and nearby coral reefs. In addition, visitors to this national park are often observed exploring rockpools at low tide and an unofficial guide trade has developed around this activity. With the exception of some historical literature, little to no research has been completed in these rockpools and so there has been no assessment of conservation needs. A project was started in December 2012 to study the biodiversity of these rockpools, identify threats, suggest possible conservation interventions, and begin developing education products for use in the local community to raise awareness of these habitats. The initial phase of the project, completed in February 2013, focused on major taxonomic categories of organisms. Biodiversity included all three major algal phyla, lower animal forms such as sponges and corals and higher animal forms such as echinoderms and vertebrates. An educational package was developed and tested with both adult NGO workers and a group of 50 primary school students and their teachers. A guide to these major taxonomic groups was produced as well as presentation resources. Phase 2 of the project focuses on quantifying the abundance and biodiversity of these major taxonomic groups and is currently focusing on corals, algae, fishes (both resident and juvenile reef fish), and echinoderms. Coral studies have identified a population of *Anomastreaa irregularis*, an EDGE coral species. Potential threats to rockpool biodiversity include overuse by tourists, runoff from land-based development, and poaching. Conservation activities include quantifying the full range of biodiversity, monitoring changes spatially and temporally, and continuing education of guides, tourists, and the local community.

22 - Robert D Sluka, Benjamin Cowburn, Benjamin Van Baelenberghe, Chloe Naylor, Victoria Sindorf, and Mohamed O.S. Mohamed. 2013. Rockpools of Watamu Marine National Park:

Biodiversity, conservation, and education. Biodiversity Institute Symposium on Biodiversity Resilience, 2-3 October, University of Oxford, UK.

Watamu Marine National Park, Kenya is renowned for its beautiful beach and nearby coral reefs. In addition, visitors to this national park are often observed exploring rockpools at low tide and an unofficial guide trade has developed around this activity. With the exception of some historical literature, little to no research has been completed in these rockpools and so there has been no assessment of conservation needs. A project was started in December 2012 to study the biodiversity of these rockpools, identify threats, suggest possible conservation interventions, and begin developing education products for use in the local community to raise awareness of these habitats. The initial phase of the project, completed in February 2013, focused on major taxonomic categories of organisms. Biodiversity included all three major algal phyla, lower animal forms such as sponges and corals and higher animal forms such as echinoderms and vertebrates. An educational package was developed and tested with both adult NGO workers and a group of 50 primary school students and their teachers. A guide to these major taxonomic groups was produced as well as presentation resources. Phase 2 of the project focuses on quantifying the abundance and biodiversity of these major taxonomic groups and is currently focusing on corals, algae, fishes (both resident and juvenile reef fish), and echinoderms. Coral studies have identified a population of *Anomastreaa irregularis*, an EDGE coral species. Potential threats to rockpool biodiversity include overuse by tourists, runoff from land-based development, and poaching. Conservation activities include quantifying the full range of biodiversity, monitoring changes spatially and temporally, and continuing education of guides, tourists, and the local community.