Artisanal Fishing in the Comoros



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Abstract Whilst the impacts of industrial fishing are widely recognised, artisanal fishing pressures on coral reef ecosystems in developing countries are generally considered more benign. The Comoros is a country with extremely high marine biodiversity, however increasing fishing intensity from a population largely dependent on subsistence fishing poses a threat to the benthic communities, invertebrates and fish compositions of coral reefs. To determine the impact of artisanal fishing methods on reefs in the Comoros, this study, performed in conjunction with Community Centred Conservation (C3), sought to assess the effects of artisanal fishing impacts on the status of reefs in two villages on Grande Comore. Transects and underwater visual censuses were performed to document substrate structure, invertebrate densities, and fish family compositions, whilst data on fisher numbers was collected through key informant interviews. Potential impacts linked to fishing pressure were observed in elevated levels of recently killed coral, increased sea urchin densities and shifts in size compositions of targeted fish species. This small scale study also intended to serve as a pilot for C3 to implement a broader monitoring scheme for coastal villages in the Comoros. Challenges arisen from the pilot survey indicate issues such as the budget required, data collection methods, and safety of personnel need to be considered before designing a broader scale monitoring program.

Tant que les impacts de la pêche industrielle sont bien connu, il y a moins de recherches sur les effets de la pêche artisanale sur les écosystèmes des récifs coralliens. Les Comores sont un pays avec beaucoup de biodiversité marine, d'ailleurs il existe un grand nombre de pêcheurs de subsistance qui constitute une menace aux communautés des poissons et les invertébrés des récifs coralliens. Pour enquêter ces impactes dans les Comores, cette etude, en collaboration avec Community Centred Conservation (C3) a analysé les effets de la pêche artisanale dans deux villages sur Grande Comore. En utilisant des transects et des recensements sous-marines, nous avons documenté les compositions des poissons, des coraux et des invertébrés. Le nombre de pêcheurs dans chaques villages a été etabli par des entrevues avec les principaux informateurs dans chaques village. Les impacts négatifs sur les coraux ont été découverts dans les niveau élevées des coraux recemments tués, les numeros des oursins, et les tailles des poissons ciblées par des pecheurs. En outre, cette enquête a été réalisée pour servir comme une étude pilote pour C3 pour mettre en œuvre un programme de surveillance pour plusieurs villages aux Comores.

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1. Artisanal Fishing in the Comoros: An Introduction

There is increasing evidence to suggest that artisanal fishing methods pose a threat to the benthic communities, fish composition and invertebrate densities of coral reefs in developing countries (Hawkins and Roberts 2004, Jones and Gray 2009, Russ 2002). The Comoros is an island nation in the Mozambique Channel (see Appendix A), and although its has been identified as a country with extremely high marine biodiversity and one of the largest areas of coral reefs in the Western Indian Ocean (Ahamada et al 2008), large portions of the growing population depend on artisanal fishing for subsistence (Stobbs and Bruton 1991) placing increasing pressure on coral reefs. In addition, the reefs of the Comoros are being threatened by anthropogenic impacts from destructive fishing practices, coral extraction, and pollution (UNEP 2000). Management of these reefs has been severely limited as the Comoros strives to tackle more than thirty years of political unrest, rendering international conservation efforts extremely difficult due to a lack of infrastructure (UNEP 2002). To date, very little research has been conducted on the state of the coral in the Comoros and monitoring schemes performed on the islands identifying the impacts of anthropogenic pressure including artisanal fishing techniques on coral reefs have been minimal (Post 2007).

This study, conducted in conjunction with Community Centred Conservation (C3), an NGO aiding conservation of marine biodiversity in the Western Indian Ocean, was conducted with the aim of identifying potential impacts of artisanal fishing techniques on the state of coral reefs near coastal villages in the Comoros. C3 intends to implement a reef monitoring program in which villagers can assess the condition of their reefs and will be capable of conducting community based management to minimise impacts on the reef. There were therefore two research questions that I intended this project to answer:

RQ1: *Are artisanal fishing practices having an impact on the state of the coral reefs in coastal villages on Grande Comore?*

RQ2: *What are the main challenges involved in implementing a long term monitoring program for coastal villages in the Comoros?*

In order to assess the 'state' of the reefs, this study analysed the current substrate conditions, invertebrate densities and fish family compositions on two fringing reefs adjacent to human settlements on Grande Comore (See Appendix A). Artisanal fishing impacts on the state of the reefs were assessed by collecting socio-economic data including intensities of each type of fishing method employed in coastal villages, and the techniques used by village associations to implement community based management of their reefs. The aims of this study were to thus devise and conduct a small scale pilot project that would survey the levels of fishing pressure and the status of two reefs on the Grande Comore, and in doing so evaluate the plausibility of developing a long term monitoring program for coastal villages in the Comoros.

2. A Review of the Literature

2.1 ***Socio-Economic Conditions in the Comoros***

The Comoros is composed of three volcanic islands (Grande Comore, Moheli and Anjouan), but in contrast to its vast ecological wealth, it is one of the poorest nations in the world that has been politically unstable since its independence from France in 1975. The culmination of more than 20 successful or attempted coup d'états on the three islands have resulted in a country suffering from a lack of infrastructure, uncontrolled demographic growth, and corruption (UNEP 2002). The average national level of unemployment is estimated at 14.3% (Union des Comores 2007), instigating high levels of poverty, as Grande Comore experiences a household poverty rate of 34%, whilst Anjouan and Moheli have considerably higher rates of 61% and 56% respectively (Union des Comores 2005a).

An annual population expansion of 2.1% (Djoumoi 2007) is regarded as a key factor causing environmental degradation in the Comoros as severe deforestation, over-fishing, and sedimentation run off are all consequences of increasing demands from human pressure on the islands (Duraiappah 1996). Deforestation is most extensive in Anjouan, the island with the highest population density, with only 13% of natural forest remaining (UNEP 2002). There is also a distinct lack of waste management, with very few urban areas having any kind of sewage treatment or waste. As a result, waste is often discarded directly into the sea, contaminating ground water and the marine environment (UNEP 2002).

2.2 ***Impacts of Artisanal Fishing on Coral Reefs***

Whilst the effects of commercial fishing are widely documented, threats to marine ecosystems from artisanal fishing techniques in developing countries are generally less considered (Hawkins and Roberts 2004, Jones and Gray 2009). Collapse of exploited species' stocks and severe degradation of benthic communities from methods such as trawling and dredging (Collie et al 1997, Watling and Norse 1998) are among the examples of the destructive impacts of industrial fishing, yet in comparison, artisanal fishing (small-scale, largely traditional techniques) are frequently deemed less harmful. To support this view, Dalzell (1998) concludes that archaeological records from several coral reefs sites in the Pacific have revealed little or no impact from artisanal fishing over the last thousand years. Whilst many marine parks across the world allow local fishers to continue artisanal fishing, (including the Parc Marin de Moheli in the Comoros) there is increasing apprehension that subsistence fishing poses a severe threat to coral reefs in developing countries (Russ 2002). Destructive fishing techniques such as purse seine nets have been known to harm substrate composition and target juvenile fish (Mangi and Roberts 2006), leading to changes in trophic dynamics on reefs (McClanahan and Mangi 2004). Indirect effects of fishing have also been observed on coral reefs, as McClanahan and Shafir (1990) suggest that depletion of triggerfish (*Balistidae)* populations have resulted in increased sea urchin abundance, which has instigated bioerosion and reduced coral cover due to the change in grazing pressure on Kenyan coral reefs.

Artisanal fishing is an extremely import source of subsistence for large portions of the Comorian population (Stobbs and Bruton 1991) which has resulted in high human pressure on coral reefs (UNEP 2002). Similar studies on artisanal fishing in developing countries (Hawkins and Roberts 2004, Ruttenberg 2001) have revealed that from human pressure on reefs might can be deduced from the status of benthic communites, invertebrate densities and fish assemblages on reefs adjacent to human settlements.

2.3 ***Threats to Coral Reefs in the Comoros***

Coral reefs sustain extremely high levels of biodiversity, and because they only exist within thresholds of certain physical factors such as temperature and salinity, they are extremely vulnerable to disturbances (Hutchings 1986, Cornell and Karlson 1996, Hawkins and Roberts 2004). The complex compositions of the reef ecosystems and the interaction between coral and marine organisms dictate that removal of one species can have disastrous consequences for other organisms within the ecology of the reef (Jennings and Polunin 1996, McClanahan and Shafir 1990).

There are 430km^2 of coral reef across the three islands, with the majority being fringing reefs situated close to human settlements (Ahamada et al 2008). The reefs are at threat to natural as well as human disturbances, demonstrated by the extensive damage caused by the 1997-98 El Niño events, instigating severe coral bleaching in the region as sea temperatures rose (Ahamada et al 2005). Dynamite fishing has been documented on the island of Moheli, where entire reef flats have been known to be reduced to coral rubble (Ahamada 2003). Trampling by fishers that hunt octopus or lay traps for small fish during low tide has also caused widespread damage to coral (Hauzer et al 2008). In addition, domestic waste in most villages is discharged directly into the sea, causing potential proliferation of algae and eutrophication (UNEP 2000).

2.4 *Coral Reef Research and Conservation Efforts in the Comoros*

There is very little baseline data available on the state of reefs in the Comoros. Moreover, conservation has been hampered by a lack of environmental awareness and an inability for local communities to implement changes (Union des Comores 2005b). The absence of previous scientific research may be due to the logistical challenges that conducting projects in the Comoros involves, however recent studies have been carried out by international organisations such as Association d'Intervention pour le Développement et l'Environnement (AIDE), which conducts monitoring on several sites across the three islands once a year (Post 2007). A monitoring program conducted by AIDE from 1998-2003 evaluated the status of the coral after the El Niño events at 3 sites on Grande Comore (Ahamada 2008), observing that there had been sharp declines in live coral cover since 1998 due to coral bleaching, however there are signs that coral has made a slow but strong recovery in most sites (Ahamada et al 2008). C3 are currently producing a report on the socio-economic conditions across the 3 islands that include surveys on income, fishing methods and household demographics that will hopefully lead to a greater understanding of the root causes of degradation to the marine environment in the Comoros and will assist community based management schemes. By working with C3, I intended to help explore the possibilities and challenges involved in implementing a low budget, effective monitoring program by which coral reefs could be monitored by villagers in order to limit their impact on the coral and the species compositions of the reefs.

3. Methodology

In order to design a study that would assess the impact of fishing on the state of the coral reefs adjacent to villages in the Comoros, data was collected on ecological features of the reefs, whilst socio-economic information on fishing practices was also documented. Aspects of reef health including benthic communites, invertebrate densities and fish compositions were recorded using two underwater survey techniques (transects and underwater visual censuses), whilst data on fishing practices was documented through site descriptions and key informant interviews held at both sites (see Table 1). Due to my limited time and resources dispensable at the C3 research centre, this survey aimed to produce a thorough analysis of the effects of artisanal fishing techniques on only two villages on the West coast of Grande Comore, and in doing so serve as a pilot study for any future monitoring program for coastal villages in the Comoros.

Methods selected for this project were done with in the knowledge that a broad scale monitoring program might be eventually implemented by C3 in the Comoros, and thus the success of methods employed in my research would serve as an indication of the feasibility of installing a program in several coastal villages. Therefore, several limiting factors had to be considered to produce a cost and time efficient project that might be replicated by a future C3 project. Firstly, the majority of resources used would have to be easily accessible on the island because of the difficulties involved in importing equipment to the islands. In addition, all materials used in the survey would have to be assembled at as low a financial cost as possible in order for the assessment to be carried out on a broad scale and at a low budget. Any training done prior to the survey to identify marine species underwater would be done with materials readily available for replication for local Comorians. The number of personnel used whilst carrying out the survey would also have to be kept to a minimum due to the number of researchers available at the research centre, without sacrificing safety requirements and the accuracy of the data. Thus all methods applied in this survey were chosen to assess the practicalities of conducting a larger scale monitoring program for coastal villages in the Comoros.

Table 1. Summary of the aims of each method employed in this project, and dates in which they were conducted

Aim	**Method**	**Dates**
General description of human activity	Site Description	Jul 20-23
Fishing numbers, methods used	Key Informant Interview	Jul 25-30
Substrate Conditions	Manta Tow	Aug 1-3
Substrate composition	4x20m transect for substrate composition	Aug 5-20
Densities of indicator fish and invertebrates	4x 200m^2 transect for indicator species	Aug 11-Sep 5
Fish families composition	10x 30 min Underwater Visual Survey	Aug 15-Sep 7

3.1 ***Site Selection***

An analysis of the impacts of artisanal fishing practices on the reefs at two villages required the two sites chosen to be similar in terms of type of reef, distance from shore and population sizes of human settlements. Additionally, due to limitations to our access to transport on the island, both sites had to be fairly close to the C3 research centre at Iconi, as all surveying equipment had to be transported from the research centre to the sites. Consequently, the two sites selected would be located within 15km of the research centre. In order to assess the impacts of anthropogenic pressure on the reefs as the main variable, both coral reefs would have to be similar in physical qualities such as size, depth contours, distance from shore and water quality, yet have a significant disparity in fishing intensity. Accordingly, the two locations encompassed fringing reef within 200m of human settlements, whilst the population sizes at both sites were comparable. The reefs would also have to be easily accessible from the shore using *pirogues* (local fishing canoes) in order to perform underwater surveys at a low cost.

3.2 ***Site Description***

Once the sites were chose, a brief site description was conducted at both locations to assess basic socio-economic conditions at the two villages, and the level of human impact on the marine environment. The approach used was based on a site description technique used in Hodgson et al (2004) for coral reef monitoring which categorises impacts from factors such as fishing, pollution and tourism into low, medium and high levels, with the intention of providing a broad perspective of the human interaction with the reef and its general condition. In addition, qualitative descriptions of the site were taken from general observations of the area, in order to provide descriptive information on human activities that might be damaging to the reef. This was conducted according to the Global Coral Reef Monitoring Network (GCRMN) observations protocol and involved conversations with local people about human activities that might affect the local environment (Bunce et al 2000).

3.3 ***Key Informant Interviews***

In order to obtain more information in greater detail about the anthropogenic pressure on the reefs from the human populations at both sites, key informant interviews were held in both villages. These are modified semi-structured interviews (Bunce et al 2000) which involve consulting with a selected group of informants (6-8 individuals per site) who share a common background or knowledge, in this case local fishers. This technique was adapted to gather data on the type and number of fishers at each village, and on the mechanisms used by the local community to manage their fishing vicinity. Simple, direct questions on fishing practices were posed with the aid of a translator and involved concise answers in order to minimise the length of time of the interviews. Careful planning had to be taken whilst arranging the key informant interviews so as not to disturb religious activities in the village such as prayer times and the holy month of Ramadan which was ongoing at the time of research.

At both sites key informant data were recorded on:

- The number of pirogue fishers/spear fishers active in the village
- Methods used by each type of fishing activity

- Any self regulating management schemes on fishing that the village imposes on destructive activities such as dynamite or purse seine net fishing

3.4 ***Manta tow***

In order to assess the state of the reefs at both locations, underwater surveys were conducted to document substrate levels, invertebrate densities and fish compositions. To analyse substrate composition, a manta tow survey was performed to identify the areas of reef with the highest levels of hard coral cover. The manta tow technique performed was adapted from English et al (1997) in which a diver is towed by a boat (see Figure 1) to record cover levels of hard and soft coral along the reef crest utilising categories designed by Dahl (1981) (see Figure 2).

The manta tow method covers large areas of in a relatively short amount of time (Hill and Wilkinson 2004), however because of the limited resources available the English et al (1997**)** method had to be modified so that a pirogue and snorkel equipment were used instead of an outboard motor and diving equipment. Using snorkel equipment and a life vest, the diver was towed behind the pirogue, using laminated Dahl (1981) categories on an underwater slate to note percentage cover of hard coral and soft coral along 2 minute time intervals. The manta tow survey was also used to document numbers of *Acanthaster planci* (Crown of Thorns Starfish, COTS) to identify potential outbreaks of this species that can be destructive to coral reefs (Hill and Wilkinson 2004).

Figure 1. Manta tow technique (English et al 1997) using a diver and outboard motor boat to survey large areas of reef to record substrate conditions

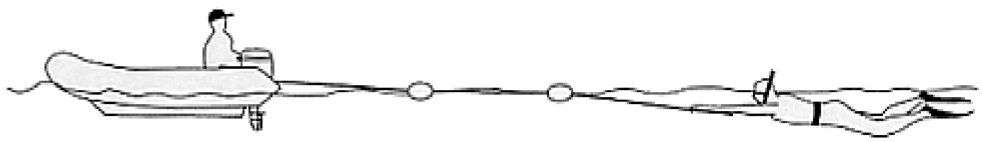
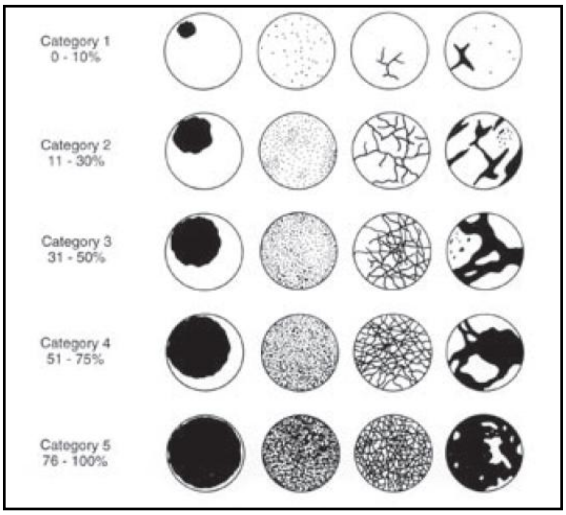


Figure 2. Visual estimation categories for percent coral cover of hard and soft coral (Dahl 1981).



Maintaining a constant speed, GPS locations were taken every 2 minutes for 20 minutes along the reef crest to measure the length of the reef. The tow was performed within 2 hours of low tide at each site and within a 3-6m depth contour at both sites. Additional physical data was also recorded at both reefs during the manta tow which included water pH levels, temperature, dissolved oxygen and turbidity at each site.

3.5 ***Underwater Transects***

The area of highest hard coral cover was selected using data collected from the manta tow (see Table 6). Within this area, indicators of reef health such as substrate cover and and invertebrate densities were surveyed by deploying a 100m underwater transect, based on Hodgson et al (2004). 3 researchers using snorkelling equipment laid a 100m tape measure within the area of highest hard coral cover, parallel to the reef fringe using buoys attached to each end of the tape measure and weights to keep the transect in place. Maintenance was needed to keep the transect line straight, as the current would usually move the tape measure slightly once it was laid, or it could get caught in between the coral. The transect was then divided into four 20 metre zones with a five metre gap between each zone. 10 minutes were allowed for fish activity to resume after transects were laid (English et al 1997), after which substrate composition and indicator invertebrates densities were recorded. Transects were laid within a depth contour of 3-6m, and all surveys were carried out within 2 hours of low tide, and before 11:00am to record optimum fish activity (Hill and Wilkinson 2004). Adequate training for all researchers was needed to be able to identify species underwater, using field guides (Lieske and Myers 2001, Vilcinskas 2002, Terashima 2001) and laminated identification cards for indicator species (Hodgson et al 2004) were also taken out to the reef.

3.5.1*Substrate line Transect*

The substrate line transect was designed to identify benthic composition along intervals and divide them into several categories. Substrate type was recorded by one researcher at 0.5m intervals along the tape measure in each 20m zone, using substrate categories (see Table 2) from Hodgson et al (2004). A plumb line was used to locate each sampling point, in which a small weight was attached to a string and dropped at each interval. This eliminates potential bias due to the sway of the tape measure in the case of strong underwater currents (Hill and Wilkinson 2004).

Table 2**.** Characteristics of substrate categories (Hodgson et al 2004)

Substrate Type	Description
Hard coral (HC)	Reef building corals, includes fire coral (*Millepora*), blue coral (*Heliopora*) and organ pipe coral (*Tubipora*) because these are reef builders.
Soft coral (SC)	Includes zoanthids, but not sea anemones.
Recently killed coral (RKC)	Coral that has died within the past year, and may be broken, standing, white with corralite structures still recognizable etc.
Sponge (SP):	All sponges are included, indicator of sponge blooms as a response to disturbances
Rubble (RB)	Includes rocks between 0.5 and 15 cm diameter. If it is larger than 15 cm it is rock, smaller than 0.5 cm and it is sand.
Sand (SD)	In the water, sand falls quickly to the bottom after being dropped
Other (OT)	Any other sessile organism including sea anemones, tunicates, gorgonians or non-living substrate.

3.5.2 *Invertebrate Belt Transect*

Indicator invertebrate densities were recorded along the same transect intervals. The diver swam along the transect and recorded indicator invertebrates (see Table 2) if they were situated within 5m of either side of the transect.

Table 3**.** Indo Pacific invertebrates documented and what they indicate on a reef (Hodgson et al 2004)

Invertebrate	**Common Name**	**Indicator of**
Tridacna spp.	Giant clams	Overharvesting
Thelenota anana, *Stichopus chloronotus*	Prickly redfish cucumber, Greenfish cucumber	Bêche de Mer fishing
Acanthaster planci	Crown of thorns starfish	Crown of Thorns population outbreaks
Diadema	Sea urchin	Absence or low numbers may indicate urchin disease; high numbers are an indicator of overfishing of urchin predators

3.6 ***Underwater Visual Census (UVC)***

The UVC surveys are designed to identify larger, more mobile species in the reef that might not appear on the transect surveys due to its narrow width (Hill and Wilkinson 2004). The technique used was adapted from English et al (1997) whereby the diver swims at a constant rate of 6m per minute for 30 mins along the crest of the reef. Three of the most commonly fished families (*Serranidae, Balistidae* and *Scaridae*) were divided into size categories to analyse size composition on the reef. Individuals were recorded as they passed within 10m of each side of the diver, and all surveys were performed within 2h of low tide. UVC surveys were repeated 10 times at each site. The UVC indicator species recorded are described in Table 4:

Table 4. Indicator fish families and respective size categories used for the UVC

Family	Common name	Size categories documented (cm)
Serranidae	Groupers	0-10, 10-20, 20-30
Balistidae	Triggerfish	0-10, 10-20, 20-30, 40-50,50cm+
Scaridae	Parrotfish	0-10cm, 10-20cm, 20-30
Scorpaenidae	Lionfish	N/A
Muraenidae	Moray Eels	N/A
Dasyatidae	Rays	N/A
Sphyraenidae	Barracuda	N/A

4.1 A Presentation of the Results and Analysis

4.1 ***Site Descriptions***

The village of Iconi was selected as the first site because it enclosed a fringing reefs located within 100m of the shore, and was accessible from the research centre by foot (see Figure 3). The site chosen for underwater research was located on the north beach of the village, after initial underwater research revealed high levels of hard coral. The other site chosen was at the village of Hantsambou, 9.5 km to the north of Iconi, and was accessible by road from the research centre. Hantsambou and Iconi had similar shaped fringing reefs, and were of a similar population size. The reef chosen at Hantsambou was located 190m from the shore, accessible from a fishing beach in the centre of the village (see Figure 4).

Figure 3. Main features of Iconi village site, including area of highest hard coral cover for transect research and point from which this coral could be accessed (images courtesy of Google Earth 2009).

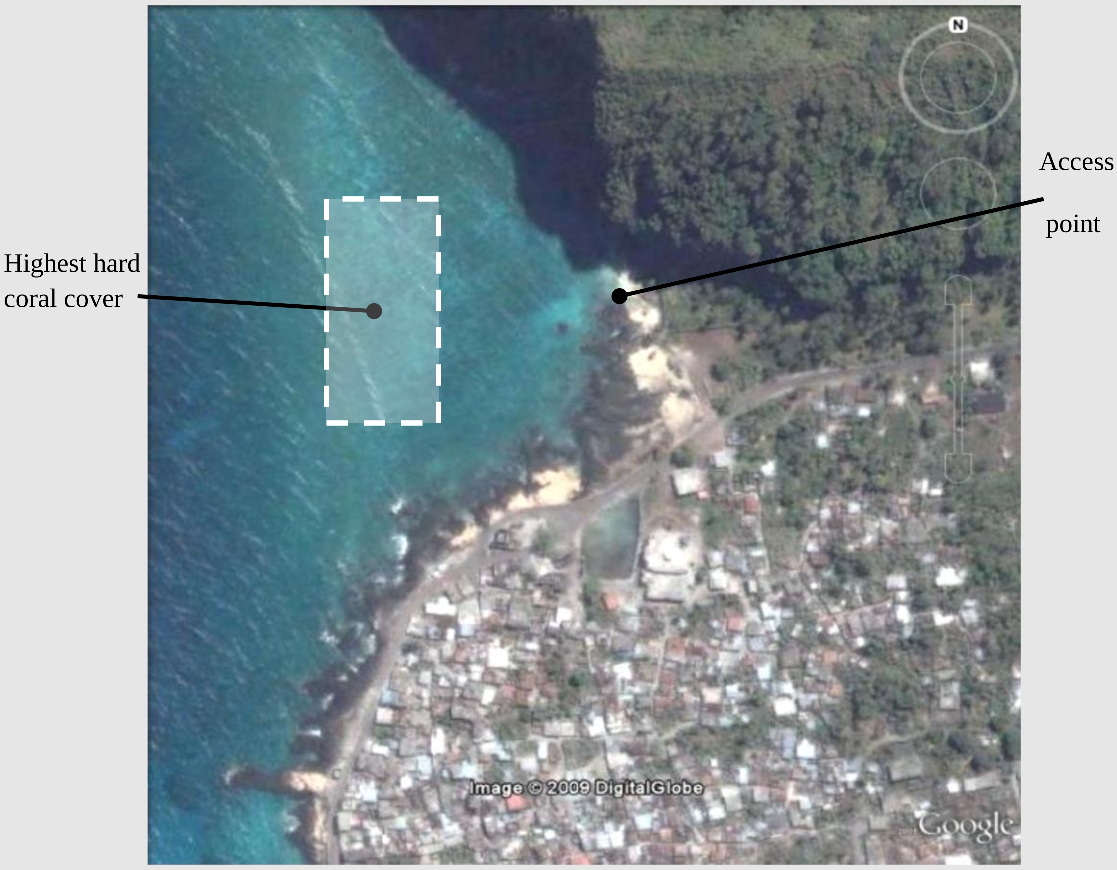


Figure 4. Main features of Iconi village site, including area of highest hard coral cover for transect research and point from which this coral could be accessed (images courtesy of Google Earth 2009).

The site description surveys performed at both sites showed similar levels of human pressure on the marine environment at both sites. Both areas had high levels of pollution from human waste which was also clearly visible at the two sites, as all sewage and litter was directly discarded into the sea or stacked in piles on the beach (see Appendix B). At both sites, fishing was a highly important source of subsistence for many households, with large numbers of pirogue fishers actively observed, and also fishing occuring from the shore documented. There was effectively no tourist activity at either village, and therefore no potential damage caused from recreational snorkelling or fishing.

4.2 ***Key Informant interviews***:

Key informant interviews held at both sites revealed no difference in the way the reefs were managed by the communities, yet quite a substantial variation in fishing method numbers (see Table 5). At both sites, key informants maintained that the destructive fishing practices of dynamite fishing and purse seine net fishing were banned for pirogue fishers within their village waters.

Table 5. Fishing intensity information gathered from key informant interviews. Figures in brackets are the calculated mean number of fishers per metre of reef crest (see Table 6)

	Iconi	**Hantsambou**
N° active pirogue fishers	35 (0.084)	160 (0.275)
Primary Methods	Hand lines	Hand lines
Spear fishers	1 (0.002)	4 (0.006)
Primary Methods	Rods, spear guns	Rods, spear guns
Restrictions on fishing	No dynamite fishing, gill nets, poison fishing	No dynamite fishing, gill nets, poison fishing
Sea cucumbers harvested	Not eaten, sold in large quantities for trade in Asia	Not eaten, sold to merchants for trade in Asia

The key informants revealed no differences between techniques used by fishers, or local management of the reefs. Major differentiation in fishing pressure existed in the number of each type of fishers, as Hantsambou had a significantly higher number of pirogue fishers per metre of reef crest (0.275), compared to 0.084 at Iconi. At both sites pirogue fishers used hand lines to target families such as *Serranidae* and *Scaridae.* Regarding spear fishers, there were differences in numbers and methods used at both sites as at Iconi there was only one full time spear fisherman, whilst key informants at Hantsambou revealed that there were 4 active fishers. Spear fishers at both sites used combinations of iron rods and modern spear guns (propelled) to target fish, whilst also hunting cryptic species such as octopi and lobster. When asked about sea cucumbers, informants at both sites cited ‘Chinese merchants’ who had previously come to the village to buy them for the bêche de mer trade in Asia.

4.3 ***Manta Tow***

The Manta Tow surveys were conducted to identify substrate cover levels of hard and soft coral at each site. No significant difference between hard and soft coral cover was found at the two locations (see Table 6), however reef crest length was larger at Hantsambou, insinuating a larger overall reef area.

Table 6. Manta Tow results demonstrating hard and soft coral cover categories, COTS sightings, water qualities, and reef crest length

Iconi

GPS point	Hard Coral	Soft Coral	COTS
1	3	1	0
2	4	2	0
3	4	1	0
4	3	1	0
5	2	1	0
6	1	0	0
7	2	0	0
8	3	1	0
9	4	2	0
10	4	3	0

Water Quality		Reef Crest Length
PH	7	0.418km
Temp	28	
dO	0	
Turbidity	0JTU	

Hantsambou

GPS point	Hard Coral	Soft Coral	COTS
1	2	0	0
2	4	1	0
3	3	1	0
4	2	0	0
5	2	0	0
6	2	1	0
7	3	0	0
8	3	1	0
9	2	1	0
10	1	0	0

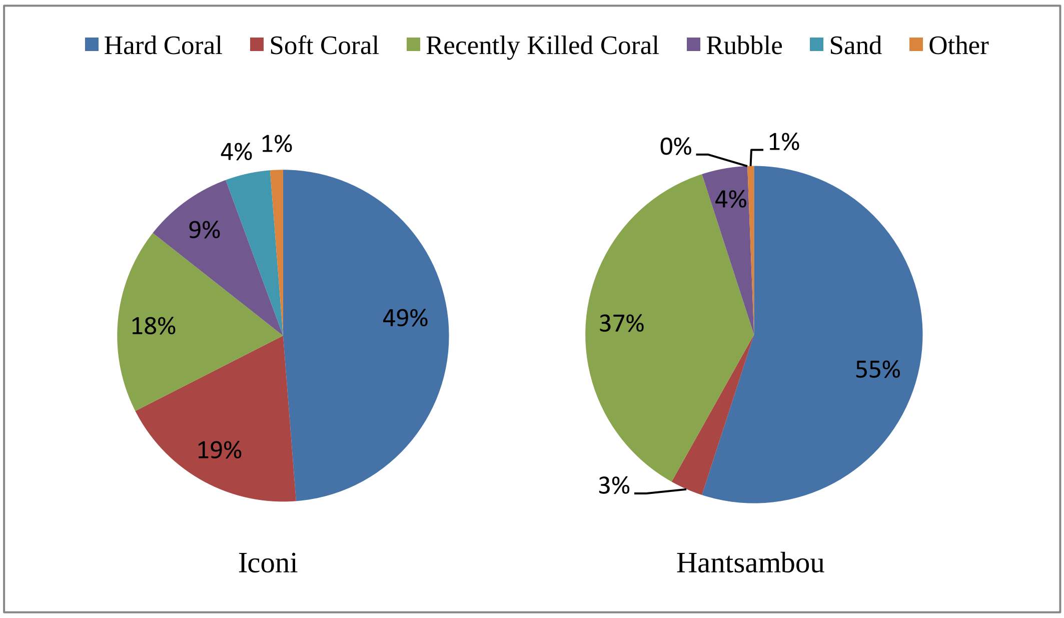
Water Quality		Reef Crest Length
PH	7	0.582km
Temp	26	
dO	0	
Turbidity	0JTU	

No recorded sightings of *Acanthaster planci* were made at either site, whilst Table 6 also reveals no significant differences in pH, salinity, or dissolved oxygen of the water taken at both sites.

4.4 ***Transects***

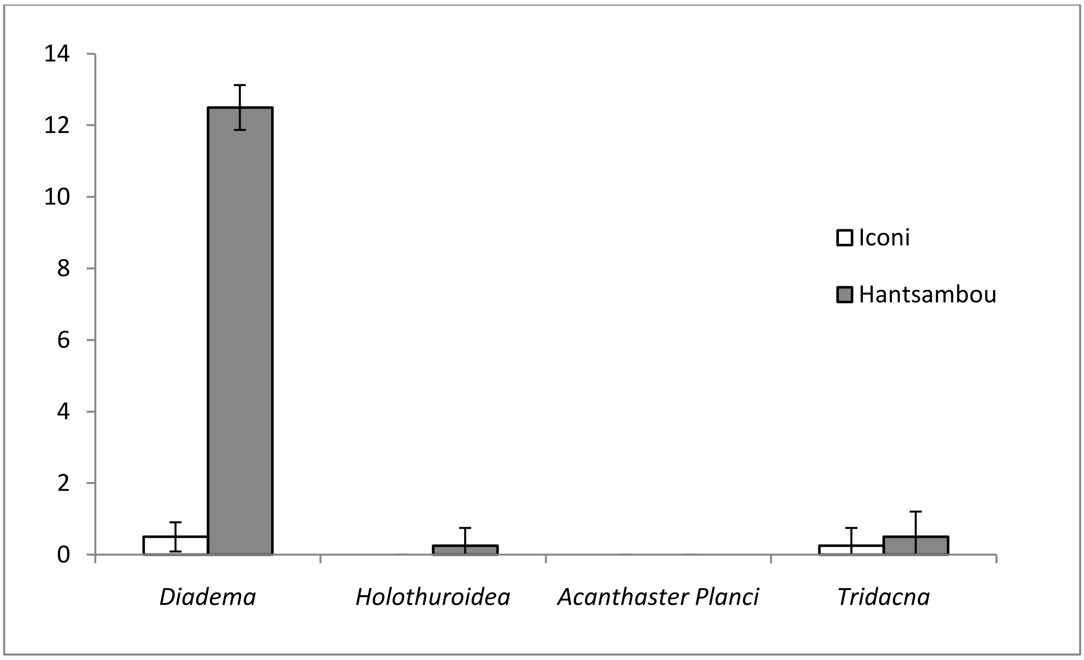
Substrate line transects taken at both sites reveal several statistically significant differences between substrate compositions at both sites (see Figure 5). Both sites had comparatively high levels of hard coral for reefs in the Western Indian Ocean since the 1998 El Niño bleaching event (Ahamada et al 2008). One statistically significant difference was in the amount of recently killed coral documented at both sites, as the Hantsambou reef consisted of 37% recently killed coral percentage, whereas Iconi had only 18%.

Figure 5. Substrate composition of 0.5m intervals along 80m line transects at Iconi and Hantsambou



Belt transects were then performed at 5m either side of the initial transect to document indicator invertebrate densities. Figure 6 represents indicator mean invertebrate densities per 200m^2 section of belt transect, revealing a significantly higher density of urchins at Hantsambou than at Iconi. There were no *Acanthaster planci* recordings from the transects at both reefs, whilst very few sea cucumbers were found compared to other studies done in the region (Ahamada 2005).

Figure 6. Mean indicator invertebrate densities (± standard error) per 200m^2 section of belt transect (*Holothuroidea* are sea cucumbers)



4.6 ***Underwater Visual Survey***

Indicator fish family sightings were analysed after 10 UVC surveys at each site (see Table 7), and a T Test was performed to divulge any significant difference between mean abundances. Given the assumption that reef variables such as physical conditions of the water and depth contours were similar, Table 7 suggests that *Serranidae* figures at the two sites were the only statistically significant disparity in families of indicator fish at both sites. The small sample size of this UVC however, suggests that a more detailed survey documenting individuals to the species level and with more repetitions might be more adequate in producing conclusions on fish compositions.

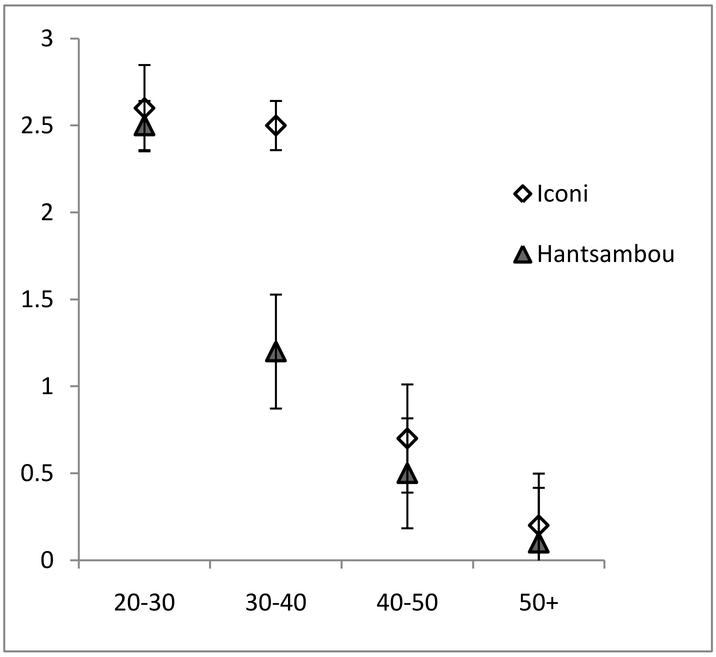
Table 7. Mean number of individuals (x± standard error) of fish families at Iconi and Hantsambou

	Mean Iconi	**Mean Hantsambou**	**T TEST**	**Sig**
Serranidae	5.0±0.18	3.1±0.13	0.00349	*
Balistidae	4.3±0.17	6.0±0.19	0.06061	NS
Scaridae	2.4±0.41	3.6±0.20	0.11421	NS
Muraenidae	2.4±0.32	1.3±0.36	0.09258	NS
Scorpaenidae	1.2±0.23	1.9±0.38	0.09574	NS
Dasyatidae	0.7±0.32	0.1±0.36	0.05568	NS
Sphyraenidae	0.3±0.28	0.3±0.28	0.19382	NS

*P < 0.05

Analysis of size compositions of *Serranidae, Balistidae* and *Scaridae* were examined, having been divided into 10cm size categories based on abundance figures documented during UVC surveys. A significant discrepancy in *Balistidae* abundance for size ranges 30-40cm at Hantsambou was noted (see Figure 7), in addition to a lower mean total of *Balistidae* at Hantsambou (Table 7).

Figure 8. Mean individual numbers of Balistidae (± standard error) at each size range (cm) for Iconi and Hantsambou



Diversity of fish families for both sites were calculated (see Table 8), along with average trophic level derived from FishBase 2005 (see Appendix C). Table 8 reveals no statistically significant differences between Simpson diversity indices at both sites, nor between the average trophic level of the two sites.

Table 9. Fish family richness, diversity and average trophic level

	Iconi	**Hantsambou**
Fish Family Richness	13	12
Total Individuals Abundance	249	228
Simpson Diversity Index	0.14588474	0.13184826
Average Trophic Level	3.474533898	3.551141553

5. Discussion

One of the purposes of this study was to determine whether fishing practices were having a detrimental impact on the state of the coral reefs adjacent to both villages. Since no data has been previously recorded on the condition of coral substrate, invertebrate density and indicator fish composition at the two sites surveyed by this project at Iconi and Hantsambou, all inferences on the effects of destructive fishing practices had to be deduced from the current state of the reefs. Consequently, a lack of empirical data on the previous numbers of artisanal fishers at each site necessitates that current data recorded was assumed to be representative of the number of fishers in the past. We can therefore only suggest causes for adverse conditions on the reef from the data gathered on present fishing intensity from the key informant interviews, in order to answer my first research question:

5.1 *(RQ1)**Are artisanal fishing practices having an impact on the state of the coral reefs adjacent to villages on Grande Comore?***

On the basis of the reef conditions at both sites and their varying levels of human pressure from artisanal fishing practices, it is possible to extrapolate that several aspects of the reef might have been influenced by anthropogenic activity. To analyse this, I have divided these impacts into the current state of the reefs at both sites, and in the differences between the two reefs that have likely arisen because of the variation in fishing activity. I have highlighted the key differences as being between the disparity in substrate compositions, indicator invertebrate densities, and to a lesser extent, fish family compositions.

5.1.1 *Iconi*

On the basis of evidence collected on benthic composition, substrate in Iconi can be insinuated to be in a relatively good condition, with high hard coral percentages in comparison with records from other sites in the region (Ahamada 2005, Ahamada et al 2008), whilst soft coral ratios were also relatively high (see Figure 6). In terms of invertebrate densities, a scarcity of sea urchins in comparison with the reef at Hantsambou implies that there is much less bioerosion of coral from urchin grazing (McClanahan and Shafir 1990, Paine 1969, McClanahan 1994) a possibility supported by the lower percentage of recently killed coral. There was no evidence for *Acanthaster planci* outbreaks, and only one documented was recorded from a UVS dive on the reef throughout the surveys. Thus, the possibilities of potentially harmful COTS outbreaks are low (Hill and Wilkinson 2004) at Iconi.

From data gathered at the key informant interview, the reef at Iconi is relatively well protected from the detrimental effects of gill net and dynamite fishing (Table 5). Observations from the reef and analysis of fish species composition seem to authenticate these claims. Damaging anthropogenic pressure on the reef could instead be derived from the intensity of artisanal fishing practices such as pirogue fishing and spear fishers. A distinct absence of sea cucumbers proportionate to other data gathered in the Western Indian Ocean region (Ahamada et al 2008) appears to coincide with assertions from key informants that sea cucumbers were removed by Chinese merchants for the bêche de mer trade at Iconi.

5.1.2 *Hantsambou*

Several aspects of the Hantsambou reef were in a very similar condition to that Iconi. Major discrepancies in substrate composition however stemmed from a statistically significant percentage of recently killed coral and soft coral. Recently killed coral was at a higher level than at Iconi, whilst there was additionally a much lower quantity of soft coral (see figure 5). These traits might be a result of the differences in fishing numbers at the two sites, rather than destructive fishing practices such as dynamite fishing, which was also said to be prohibited by the local community. Regarding invertebrate densities, no COTS outbreaks were recorded at Hantsambou, however sea urchin abundance was documented to be at higher density than at Iconi (Figure 6). There was a deficiency in edible sea cucumber numbers similar to that in Iconi, which again suggests that over harvesting of sea cucumbers for the bêche de mer trade was occurring.

5.1.3 *Substrate structure*

Transects taken along the reef fringes at both sites revealed several significant differences in the substrate composition. Hantsambou had a slightly higher percentage of hard coral, yet comprises a significantly higher portion of recently killed coral (Figure 5). Since physical conditions of the water (temperature, salinity, pH levels) and presumed energy availability at both sites can be deemed to be homogenous (Table 6) due to their proximity in distance, the differences between the two sites might be attributed to differences in the human activity in the two villages.

5.1.3.1 Bioerosion of coral by sea urchins

A possible explanation for the higher levels of recently killed coral at Hantsambou could be due to the higher densities of sea urchins. Erosion of coral reef sub stratum has also been linked with high sea urchin abundance (McClanahan and Shafir 1990), which was identified at Hantsambou (see Figure 6). Sea urchins are major bioeroders of coral reef sub stratum (Ogden & Lobel 1978, Hutchings 1986, Downing and E1-Zahr 1987, Birkeland 1988), and can limit the establishment and growth of coral reefs as they graze (Hutchins 1986). McClanahan and Shafir (1990) found a negative correlation between coral cover and sea urchin density on several Kenyan coral reef sites, and thus the elevated sea urchin densities at Hantsambou could be a contributing factor to the reduction in coral cover of the reef in Hantsambou.

5.1.3.2 Impacts of spear fishing on coral cover

The elevated levels of recently killed coral at Hantsambou might be a result of the differences in fishing method numbers between both sites. The two villages had high numbers of pirogue fishers per length of reef crest (Table 6), however since their main method of fishing is hand lines, contact with coral is minimal and thus does should not have a huge influence on coral compositions (Stobbs and Bruton 1991). A study by Mangi and Roberts (2006) on artisanal fishing impacts on reefs in Kenya observed that fishers using hand lines had the least amount of contact with live coral (1.5 coral contacts/kg/trip) amongst several types of fishing gear. There were however differences in the number of spear fishers, as Hantsambou had an average of 0.275 spear fishers per metre of reef crest, whilst at Iconi that figure was only 0.084. The spear fishing done at both sites involved the use of an iron rod attached to a wooden beam to spear fish, but also was also used to remove cryptic species such as lobster and octopi from the coral. In this respect, spear fishers have a large amount of contact with the coral, and often employ destructive fishing practices when trying to remove target species. Mangi and Roberts (2006) concluded that spears had the highest amount of contact with the coral amongst Kenyan artisanal fishing methods (12.6 contacts/kg/trip). During a dive in Hantsambou, I documented a spearfisherman upturning and killing a table coral in an effort to catch a lobster. Spear fishers also walk out on the coral during low tide whilst searching for octopi, which can lead to coral degradation through trampling (Hawkins and Roberts 1992). A study by Kay & Liddle (1989) demonstrated that human trampling clearly damages coral on reef flats, and can significantly alter the composition of the coral community. Thus, the higher number of spear fishers might be correlated to the elevated percentages of recently killed coral at Hantsambou, due to the increased damage caused by the contact that spear fishers have with live coral.

5.1.4 *Invertebrates densities*

5.1.4.1 Causes of sea urchin abundance

Sea urchin abundance has been linked with removal of predator species (McClanahan 1994), as reductions or elimination of predators may cause shifts in species composition on the reef (Paine 1969, Morrison 1988). McClanahan and Shafir (1990) suggest that removal of sea urchin predators results in population increases of urchins, which can result in a reduction of live coral cover, an increase in substrate bioerosion, and a reduction in topographic complexity. One of these sea urchin predators are found in the Comoros are *Balistidae,* (triggerfish) and have been found to have high predation rates on sea urchins in reefs (Ogden and Lobel 1978). Mclanahan (1994**)** reveals that Balistidae were a major predator of sea urchins on Kenyan coral reefs, and that their density in several sites was negatively correlated with sea urchin density.

In the Comoros *Balistidae* are not extensively fished, as they have a very strong skin and are not easy to eat, yet they are regularly consumed at both village sites. Data collected from the UVC surveys might support with the theory that removal of *Balistidae* can lead to higher urchin abundance, as Iconi had a significantly higher number of triggerfish, and a much lower density of urchins. There was also a significant difference in the size composition of triggerfish at the two sites (see Figure 8), in which individuals of sizes 30-40cm were significantly higher at Iconi than at Hantsambou. Whilst I can only infer from the current number of fishers at both sites, the higher average of spear fishers at Hantsambou per metre of reef crest length (Table 5) might be attributable to this disparity in *Balistidae* size composition. Spear fishers are more effective at species selection (Mangi and Roberts 2004) than pirogue fishers, and therefore a higher number of spear fishers per reef crest length might a possible factor causing the significant difference in the 30-40cm *Balistidae* size range.

5.1.4.2 Sea cucumber scarcity

Transects taken at both sites revealed low levels of edible sea cucumber density, which seems to support information from the key informant interviews suggesting the possibility that over harvesting of sea cucumbers was occuring for the bêche de mer trade in Asia. Sea cucumbers have been fished in the Indo Pacific region for the last 1000 years, due to the strong demand from the Asian market (Uthicke & Benzie 2000). The dried body walls of the animals are considered a delicacy in many Asian countries, and are also used in traditional Chinese medicines (Hamel et al 2001) and can reach prices of $50-100 per kg dry weight. They are an important source of income for fishers in countries like Indonesia, Papua New Guinea and Madagascar as they can be harvested relatively easily (Rasolofornirin and Conand 1998). Over harvesting of holothurians is thought to affect the ecology of coral reefs, as they perform important ecological functions such as bioturbation and recycling of nutrients (Birkeland 1988, Uthicke & Klumpp 1998). Further research is recommended across more sites on Grande Comore to identify harvesting levels of sea cucumbers at different villages, to analyse whether this could have an impact on the marine ecosystems over time.

5.1.5 *Fish family structure*

Compared with substrate conditions and invertebrate densities, there was not much statistically significant data to suggest a correlation between levels of fishing pressure on the reef site and fish family composition. Table 7 reveals that there was only one family of fish, *Serranidae*, whose abundance was significantly higher in Iconi than in Hantsambou. The higher amount of fishing pressure per reef area at Hantsambou than at Iconi might imply that there would be a lower species diversity and trophic level of indicator species, however this was not the case, as there was no significant difference in Simpson diversity indices or average trophic level between the two sites (see Table 5).

The inconclusive results of the fish family composition analyses might therefore indicate that differences in diversity between the two sites might due to natural variables instead of direct anthropogenic impacts. Variation in reef species abundance has been attributed to several factors, including overall area of reef, which increases area suitable for substrate colonisation (Stehli and Wells 1971). The greater reef length at Hantsambou (Table 5) might be a contributing factor to its slightly higher species richness, as a study by Fraser and Currie (1996) demonstrated that reef length per unit area reflects to some extent the “proportion of local substrate suitable for coral growth and, to some extent the total coral biomass per unit area”.

To determine in greater detail whether artisanal fishing impacts were having an impact on species composition on Hantsambou and Iconi, I would like to conduct a study similar to Mangi and Roberts (2004) in which a multi fishing gear analysis evaluated which fishing methods had the greatest impact on coral reef biodiversity. Catch size from each type of fishing gear was analysed to compare maturity stages at first capture. A further recommendation would be to complete a more thorough UVC at both sites, documenting individuals down to species levels for heavily targeted fish species (Ruttenburg 2001), in order to assess the impact of different type of fishing gear at each site on species compositions.

5.2 *(RQ2)**What are the main challenges involved in implementing a long term monitoring program for coastal villages in the Comoros?***

The second aim of this project was to verify if a monitoring program could be implemented by C3 for reefs adjacent to villages in the Comoros by using similar methods and locally available resources, and if so, what would be the major issues to consider. The second part of the project was therefore dedicated to answering the second research question, which I have divided into concerns on budget, data collection and safety based on the experiences of my project.

5.2.1 *Budget*

In order for a large scale monitoring project to be funded by an organisation such as C3, it must be carried out on as efficient a budget as possible without sacrificing the accuracy of the data collected. The adaptation of several survey methods from SCUBA equipment to snorkelling that was performed in my survey would significantly reduce this cost; however the lack of availability of several materials necessary for the project to be successful in the Comoros would require some items to be imported. These include underwater equipment such as snorkelling gear, underwater slates, and underwater tape measures which can be acquired at a relatively low cost outside the Comoros. All other equipment needed to conduct the transects such as buoys and weights can be acquired locally, or fabricated on site. In terms of personnel, all surveys conducted at each site involving transects could be conducted with a minimum of 4 researchers in order to correctly lay tape measures and perform substrate and invertebrate density analyses.

5.2.2 *Data Collection*

To ensure that data was correctly collected and able to be used for management of artisanal fishing, all researchers would have to be adequately trained to maintain the accuracy of the surveys. In order to involve the participation of local Comorians in such a project, (similar to turtle nesting research conducted by C3 in Moheli), training would have to be given for local researchers participating in data collection. Data collection methods would also have to be consistent in order to compare and track changes to reef conditions in different villages.

5.2.2.1Training for researchers

Training needed for researchers to be able to perform aspects of the surveys such as laying underwater transects would however involve substantial challenges as very few Comorians are able to swim confidently. Adequate preparation would have to be made to ensure that researchers would be able to swim correctly, by ensuring all participants pass a mandatory underwater fitness test (see Appendix D). Field guides such as Lieske et al (2001) and Vilcinskas and Vigot (2002) can be used to identify indicator marine species in Comorian waters to the genus level. Underwater identification tags (Hodgson et al 2004) are effective ways of improving accuracy of species classification.

5.2.2.2 Consistency of methods

To compare data collected across several sample sites, methods used in each project would have to be consistent to ensure the accuracy of the data. This implies that all underwater surveys would be undertaken during the same tide thresholds, and during similar visibility conditions. An adequate tide threshold would be within 2 hours of low tide, and during visibility conditions of at least 10m each survey. Monitoring should also occur at the same time of year at each site, in order to reduce discrepancies from seasonal variations in fish movements (Hill and Wilkinson 2004). In addition, cultural limitations to monitoring times over the year would have to be assessed, as most Comorians will not enter the water during the holy month of Ramadan, lest they should drink the water by accident, and thus would not be able to participate in underwater surveying.

5.2.3 *Safety*

The dangerous nature of activities such as snorkelling required to conduct underwater surveys implies that safety of personnel involved in the research would have to be a priority. The project I conducted experienced several days where research was unfeasible due to adverse weather conditions. Specific care would have to be taken to ensure that no underwater activity would be undertaken in situations of high wind or strong underwater currents. The fragility of local fishing vessels means that they can be easily overturned in relatively calm conditions. All research performed should comply with strict regulations and risk assessments to maintain safety standards at each site, such as that used by C3 (Appendix D) to minimise the risk of the effects of hazards such as sunstroke and exhaustion. Potential danger also arises during underwater surveys from marine species such as string rays or lionfish. Sufficient training to be able to identify these harmful species and correct protocol to use in the case of injury would have to be ensured before any surveys took place. Other risks such as heatstroke and exhaustion would have to carefully assessed before each underwater survey.

6. Presentation of the Conclusions

This study sought to determine whether artisanal fishing methods in two villages on the west coast of Grande Comore were having an impact on features of the reef including its substrate composition, indicator invertebrate densities and fish family structure. In conducting this study with C3, results and experiences from methods employed could be utilised in a potential monitoring program with the intention of tracking indicators of reef health for villages in the Comoros. In relation to the influence of local fishing methods on the status of the two reefs surveyed, Iconi and Hantsambou, conclusions were extrapolated from an analysis of current conditions of the coral and its species compositions, whilst socio-economic data gathered from site descriptions and key informant interviews revealed indications of fishing intensity at both sites. Results from ecological surveys such as line transects and underwater visual surveys aimed to distinguish the physical conditions of the reef at each site, and in doing so, an investigation of feasibility of using similar methods conducted in this study to implement a monitoring program for coastal villages in the Comoros was made, based on the major issues raised by use of the techniques operated in this pilot project.

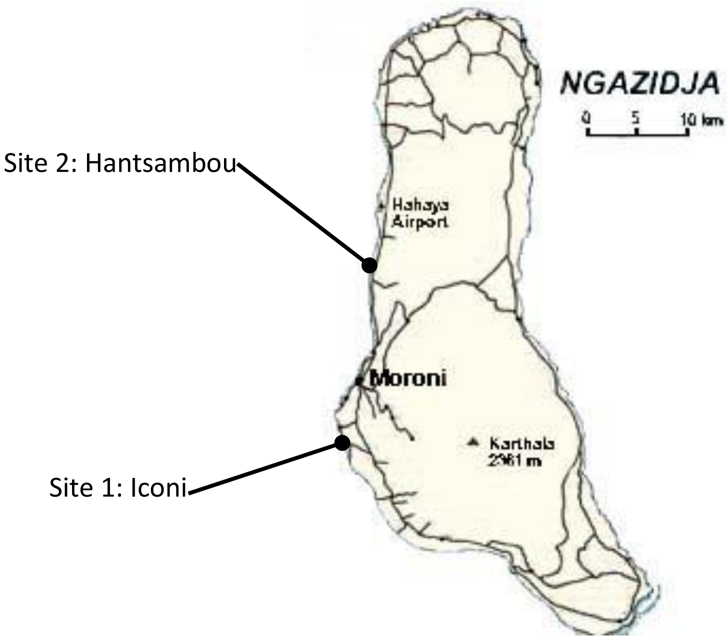
Whilst it is difficult to identify precise impacts of fishing techniques on the state of the reefs using only the current conditions of the coral and the surrounding ecology as evidence, several inferences can be made based on levels of fishing intensity and indicators of reef health at each site. Disparities in substrate structure including recently killed coral percentages at both sites indicate that the greater fishing pressure at Hantsambou might be correlated to its elevated levels of dead coral due to the greater ratio of spear fishers currently active at this site and the frequent contact that this fishing method has with the coral. Regarding the impact of anthropogenic pressure on invertebrate densities, this study revealed the possibility that sea urchin abundance at both sites might be related to removal of one of its key predators, *Balistidae,* by human methods or natural factors. Low numbers of *Balistidae* at Hantsambou might be correlated to the higher densitiy of sea urchin due the reduced predation. There is also a strong likelihood that sea cucumber scarcities at both sites is a result of harvesting for the prolific bêche de mer trade. This could result in potentially damaging indirect effects on the ecology of the reefs in the Comoros. On the subject of artisanal fishing impacts on fish compositions at both sites, results were fairly inconclusive. Further research involving more sample sites and greater detail into the documentation of fish species in comparison with fishing intensity would be more effective in identifying specific threats from each type of fishing gear.

In terms of the prospect of developing a monitoring program for C3 that would be able to influence community based management of the reefs in coastal villages, all techniques included in this survey would be employable. Any such project would have to designed with the knowledge that instigation of a monitoring scheme would be hindered by the restrictions in transport, communications and equipment available on the islands. The completion of this study however indicates that the implementation of small scale underwater surveys collecting basic information on reef ecosystems near villages in the Comoros is viable. Adequate precautions would have to be made to ensure the correct training was provided to ensure the safety of participants and the accuracy of data collected, which could produce data allowing local fishing communities to monitor their impacts on the reef, and manage fishing practices in a sustainable manner.

Appendix A

Map of the Comoros and Research Sites

on Grande Comore (Ngazidja)



Source: UNEP 2002

Appendix B

Site Descriptions at Iconi and Hantsambou

Site name: Iconi

BASIC INFORMATION

Country: Comoros City/town: Iconi

Orientation of transect: N-S

Distance from shore: 95m

Dist. to nearest population center: 0.1 km

IMPACTS:

Major storms:	Yes
Siltation:	Large amounts of runoff from local waste
Dynamite fishing:	None witnessed
Poison Fishing:	Low
Aquarium Fishing:	None
Harvest Invertebrates as curios:	No evidence for this
Tourist Diving/snorkeling:	None
Sewage Pollution:	High, waste discarded directly into the sea
Industrial pollution:	None
Commercial fishing:	High
Artisanal fishing:	High
Other impacts:	Household pollution, plastic bags and bottles abundant

PROTECTION:

Any Protection at this site?	Yes, communities enforce their own protection
Is protection enforced:	Self regulated
Any Banned Activites?:	Dynamite Fishing Gill Nets Poison

Site name: Hantsambou

BASIC INFORMATION

Country: Comoros City/town: Hantsambou

Orientation of transect: N-S

Distance from shore: 95m

Dist. to nearest population center: 0.1 km

IMPACTS:

Major storms:	Yes
Siltation:	Runoff from local waste, human excrement
Dynamite fishing:	No evidence of this
Poison Fishing:	None witnessed
Aquarium Fishing:	None
Harvest Invertebrates as curios:	No evidence for this
Tourist Diving/snorkeling:	Perhaps some from hotel to the north, but wouldn't swim this far down
Sewage Pollution:	High, stacks of pollution on rocks near sea
Industrial pollution:	None
Commercial fishing:	High
Artisanal fishing:	High
Other impacts:	Household pollution, plastic bags and bottles abundant

PROTECTION:

Any Protection at this site?	Yes, communities enforce their own protection
Is protection enforced:	Self regulated
Any Banned Activites?:	Dynamite Fishing Gill Nets Poison

Appendix C

Trophic Levels of Fish Families (FishBase 2005)

Family	Common Name	Sightings Iconi	Sightings Hantsambou	Trophic level
Sphyraenidae	Barracuda	3	3	**4.5**
Muraenidae	Morays	13	24	**3.8**
Dasyatidae	Rays	1	7	**3.8**
Scorpaenidae	Lionfish	19	12	**3.75**
Serranidae	Groupers	31	50	**3.74**
Balistidae	Triggerfish	60	43	**3.5**
Scaridae	Parrotfish	36	24	**3.5**
Teuthida	Squid	0	13	**3.5**
Aulostomidae	Trumpetfish	36	20	**3.5**
Octopoda	Octopus	1	0	**3.5**
Tetraodontidae	Pufferfish	35	23	**2.8**
	Average Trophic Level	**3.474533898**	**3.551141553**	

Appendix D

Risk Assesments for Underwater Surveys used at Iconi

P= Possibility of Risk

S=Severity of Risk

POTENTIAL HAZARD	P	S	CONTROLS IN PLACE	ACTIONS TO BE TAKEN
Exhaustion	1	2	Keep an eye on buddies state of health while underwater No snorkeling whilst in conditions of strong currents or large waves Surface support on beach at all times with mobile phone, contacts sheet and first aid kit	Buddy to be taken out of the water and to lie down and breathe oxygen or brought back to house Appropriate first aid and evacuation to Moroni Hospital if necessary
Sunstroke	2	1	Sunscreen to be applied before getting to the beach As little time spent directly exposed to the sun as possible Water to be taken with buddy pair to the beach Surface support on beach at all times with mobile phone, contacts sheet and first aid kit	Buddy to be taken out of the water and to lie down and breathe oxygen or brought back to house Appropriate first aid and evacuation to Moroni Hospital if necessary
Animal bites	1	2	No animals such as stingrays, moray eels, barracudas to be provoked whilst underwater No shiny jewellery to be worn underwater Nobody to enter the water with any large cuts Surface support on beach at all times with mobile phone, contacts sheet and first aid kit	Buddy to be taken out of the water and first aid applied to wounds Appropriate first aid and evacuation to Moroni Hospital if necessary
Marine life sting	2	1	Project Team fully briefed on dangers of marine life Surface support on beach at all times with mobile phone, contacts sheet and first aid kit	Treatment using vinegar Appropriate first aid and evacuation to Moroni Hospital if necessary
Boat strike	1	5	All surveys will be conducted from a floating surface station (we have a small inflatable boat – as long as sea conditions are good this is prob the easiest way to store your tape, laminated ID sheets etc) or snorkeling buddy pair will tow a market buoy (can be made from an old yellow oil plastic bidon) Surface support on beach at all times with mobile phone, contacts sheet and first aid kit	Appropriate first aid and evacuation to Moroni Hospital if necessary
Drowning	3	5	All survey team members will be tested to ensure that they are able to swim at least 400m unaided and tread water for 3 minutes Duck-diving limited to a maximum depth of 4m or 1min. One of the buddy pair to remain on the surface at all times and ensure the safety of their buddy while duck-diving. The buddy pair should never duck-dive together simultaneously. Hyperventilation before duck-diving must not be conducted under any circumstances No duck-diving to be conducted in areas where there is a risk of entanglement (e.g. fishing nets, lines) Surface support on beach at all times with mobile phone, contacts sheet and first aid kit	Appropriate first aid and evacuation to Moroni Hospital if necessary

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