Successes and disappointments of MPAs in the Western Indian Ocean: the case of Mombasa Marine Park and Reserve

Stephen MANGI

Plymouth Marine Laboratory, Prospect Place, The Hoe, Plymouth PL1 3DH, United Kingdom
E-mail: stcma@pml.ac.uk

Abstract
Concerns about the effectiveness of marine protected areas (MPA) as conservation and fisheries management tools have led to a growing interest in conducting evaluations. Protection from fishing leads to increases in biomass, abundance and average size of exploited species and to increased diversity. Such effects are of great interest to fisheries managers because rebuilding exploited populations in marine parks offers prospects of fisheries enhancement. This paper reviews the conservation and fisheries management issues surrounding the Mombasa Marine Park and Reserve. Since effective protection, the park has seen increases in live coral cover while sea urchin populations have gradually decreased. Both fish biomass and density have dramatically increased over time and there is evidence that this has enhanced the adjacent fisheries. Gear restrictions in the surrounding reserve would have been more effective if the regulations were well enforced. For instance, beach seines are banned but seining still continues despite growing evidence that this gear is greatly impacting coral reef biodiversity. The management issues surrounding the park therefore include the enforcement of MPA regulations and mechanisms for raising education and awareness of conservation among stakeholders. Nevertheless, the park's establishment has helped restore coral reef habitats and enhance adjacent fisheries yields. The lessons learned concerning the process of the MPA establishment should form the basis for solutions regarding compliance of regulations.

Introduction

As governments and organizations around the Western Indian Ocean promote the establishment of protected areas to preserve marine biodiversity and prevent environmental degradation, recognition of the successes and disappointments of the current marine protected areas (MPAs) in the region has increased. As a result, many methods have been developed to analyse the success of MPAs including the IUCN's "How is Your MPA doing?" workbook (Pomeroy *et al.* 2004), the United Nations Foundation's "World Heritage Management Effectiveness Workbook" (Hockings *et al.* 2004), and the IUCN Eastern African Regional Programme's Workbook for the Western Indian Ocean (Mangubhai 2003).

How MPAs perform in terms of protecting fish stocks has been the focus of many studies. A common conclusion is that there is an increase in fish numbers in the MPA compared to adjacent areas and/or compared to the situation before the MPA was established (e.g. Watson and Ormond 1994, McClanahan and Obura 1995, McClanahan *et al.* 1999, Halpern 2003). Evidence that MPAs enhance fisheries in the adjacent fished areas is also accumulating (e.g. Russ and Alcala 1996, McClanahan and Mangi 2000, Roberts *et al.* 2001). Most such studies have used direct methods such as fish tagging experiments (e.g. Munro 2000, Zeller and Russ 2000, Kaunda-Arara and Rose 2004) and indirect methods such as fish trapping studies (e.g. Ratikin and Kramer 1996, McClanahan and Mangi 2000) to study migrations of fish from parks to adjacent fished areas.

The purpose of this paper was to review the potential of the Mombasa Marine Park and Reserve to support fisheries development in Kenya. This was achieved through a number of studies looking at the dispersal of exploitable fishes from the park to the adjacent fished area, changes in fish catches in the adjacent areas over time and the effects of gear restrictions on habitats around the park. The management issues and lessons learned are discussed.

Background

MPA approaches in Kenya

Kenya's MPA system is based on the protection of core areas as no take zones with the surrounding buffer areas designated as limited use zones. Thus, the marine parks are encompassed within larger marine reserves where fishing gear types are restricted. Kenya has four marine parks (no-take areas) located in Malindi, Watamu, Mombasa and Kisite, with corresponding marine reserves (gear restricted areas) surrounding each park. The fisheries resources of Kenya are managed by the Fisheries Department under the Fisheries Act, and, where designated as

Protected Areas, by the Kenya Wildlife Service (KWS) under the Wildlife and Conservation Act.

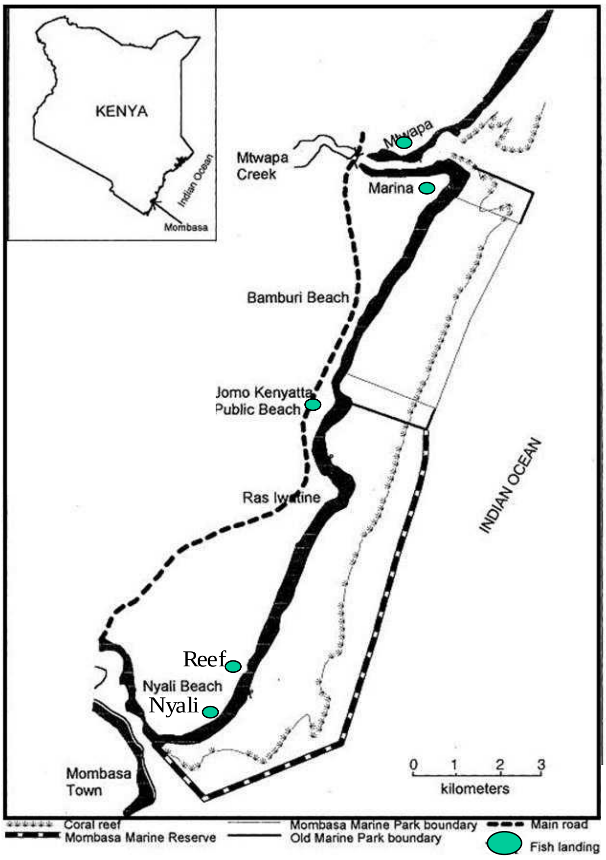

Fig. 1. Map of the Mombasa Marine Park and Reserve showing the different management areas, border changes and landing sites.

Mombasa Marine Park and Reserve

The Mombasa Marine Park was declared a protected area excluding fishing in 1987, but total exclusion of fishers did not occur until 1991 (McClanahan and Kaunda-Arara 1996). As is the case in other MPAs in Kenya, Mombasa Marine Park was established after a great deal of pressure on the Government by the tourism sector. Most stakeholders were therefore not adequately consulted prior to the legal gazettement by the government. The information that was used to justify the creation of the park came mainly from coral reef studies although other marine habitats such as seagrass beds occur in the Park as well (McClanahan *et al.* 2005a).

After creation, management of the park changed following recommendations by a coastal zone management study completed in 1994 -1995 (Coast Development Authority 1996). Originally the park excluded fishers from an 8.2 km^2 area (shore to reef), which was eventually reduced to a 6.2 km^2 area in October 1995. The southern side of the park was established as a reserve (traditional gears only) and therefore, beach seines were eliminated from this part of the reserve (Kenyatta fishing ground, Fig. 1) in April 1995. In 1996, trap fishers were allowed to fish a narrow band on the northern side of the park (Marina). Fishing in this small area requires a license. The local fishers' association decides who will fish in this area and passes their names to the Kenya Wildlife Service (KWS) who issue them with licenses. Beach seining continued in the northern end of the park edge (Mtwapa).

Evidence for recovery of the reef

The area surrounding the park was heavily fished before protective management. Fish landing data and underwater fish biomass studies suggest that before the park's creation fishes were heavily exploited (McClanahan and Kaunda-Arara 1996). Live coral cover and fish density were low while sea urchin populations were very high (McClanahan and Shafir 1990). After effective protection the park saw dramatic increases in diversity and abundances of both finfish and benthic communities (Fig. 2). Fish biomass increased by a factor of five from 1991 to 2004, while coral cover in the park increased from 21% to 27%. The percentage increase could have been higher had it not been for the 1998 coral bleaching and mortality event. Sea urchin populations have steadily decreased in the park as predation rates on them have increased (McClanahan *et al.* 1999).

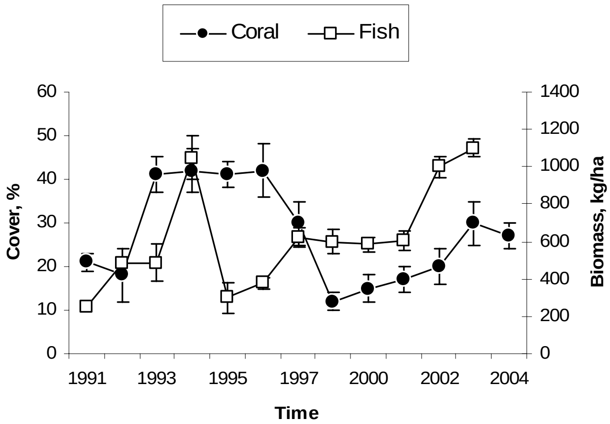

Fig. 2. Live coral cover (%) and estimated fish biomass (kg.ha^{-1}) in the Mombasa Marine Park (source: McClanahan *et al.* 2005a).

Evidence for fish spillover to adjacent fished areas

Evidence that the Mombasa Marine Park is beneficial to the adjacent fisheries comes from a series of trapping studies by McClanahan and Mangi (2000). They placed baited traps on both sides of the park to measure fish spillover from the park. Their results showed that the total wet weight of catches per trap, average size of trapped fish, and the number of species caught per trap declined as a function of distance from the park edge on both the southern (gear restricted) and northern (unprotected) sides (Fig. 3). Spillover was greatest for the dominant fisheries species most of which were moderately vagile such as rabbitfish, emperors and surgeonfish.

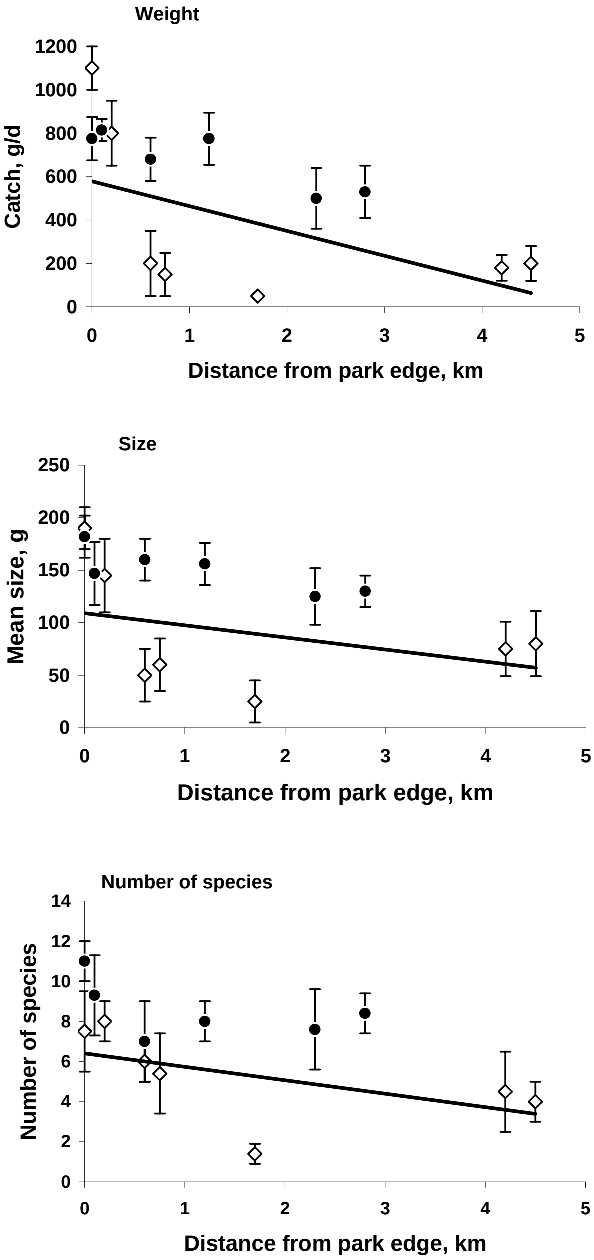

Fig. 3. The total fish catch by weight (g.d^{-1}), mean size of fish (g) and number of fish species over a 14 day sampling period as a function of distance away from the park border for the southern (black circles) and northern (white diamonds) sides of the park (Source: McClanahan and Mangi 2000)

McClanahan and Mangi (2000) also studied the behaviour of trap fishermen fishing on the southern side of the park. They surveyed the number and position of their traps with respect to the park edge, and using fish landing data worked out each fisher's catch. Results showed that more traps were placed nearer the park edge than away from the park (Fig. 4). The fishers who fished nearer the park edge caught more than those who fished away from the edge. McClanahan and Mangi (2000) also reported an independent assessment of the fish-border relationship using seagrass blades to tease out the presence of herbivorous fish and sea urchins along a gradient from inside to outside the park borders. At a series of distances from the park edge, they made 3-5 collections of 50 *Thalassia hemprichii* blades and examined them for bite marks. They determined whether the bites on each seagrass blade originated from fish or sea urchin and calculated the frequency of those bite types. The results showed that the frequency of fish bites decreased with distance from the park border and the inverse for sea urchin bites. The results from these three studies suggest that the fishery adjacent the Mombasa Marine Park benefits from adult spillover. Trap fishers are aware of and have adapted to the spillover effect.

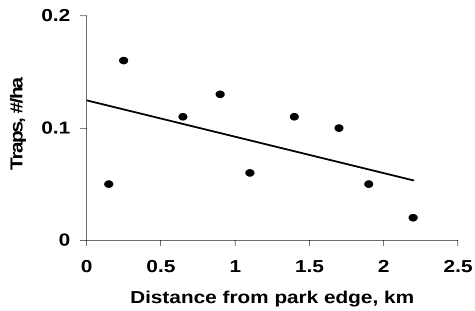

Fig. 4. Density of traps as a function of the distance from the park's southern boundary.

Similar results have been reported from marine reserves in other parts of the world e.g. St. Lucia (Roberts *et al.* 2001), Philippines (Russ *et al.* 2004) and Great Barrier Reef (Zeller and Russ 2000). A network of marine reserves in St. Lucia increased adjacent catches of artisanal fishers by 46–90% within 5 years of creation (Roberts *et al.* 2001). Fish tagging experiments of exploited species in Malindi and Watamu Marine parks found that three species of commercial importance exhibited consistent out-migrations from the parks into adjacent fishing grounds (Kaunda-Arara and Rose 2004).

Changes in fish catch over time

Analysis of fish landing data from the Kenyatta landing site (fish caught in the Mombasa Marine Reserve) and Diani sites (non-reserve) between 1995 and 2000 showed that on an annual basis, total catch declined in all the landing sites (McClanahan and Mangi 2001). The rate of decline in catch was, however lower in the reserve at around 250g per day compared to 380g per day in the non-reserve sites (Fig. 5). On a per area basis, there was a large difference in mean catch between the landing sites. The reserve showed higher yields (5.5 kg.ha^{-1}.mo^{-1}) than the non-reserve sites (4 kg.ha^{-1}.mo^{-1}) despite having the highest number of fishermen (7 ± 2 fishers ha^{-1}.mo^{-1}; Fig. 6). These results confirm the potential of the Mombasa Marine Park to increase catch rates. The reasons why the reserve had the slower decline in catch rate and maintained a higher catch was due to the increase in fish biomass in the park and the dispersal of fish from the park to the adjacent fishery.

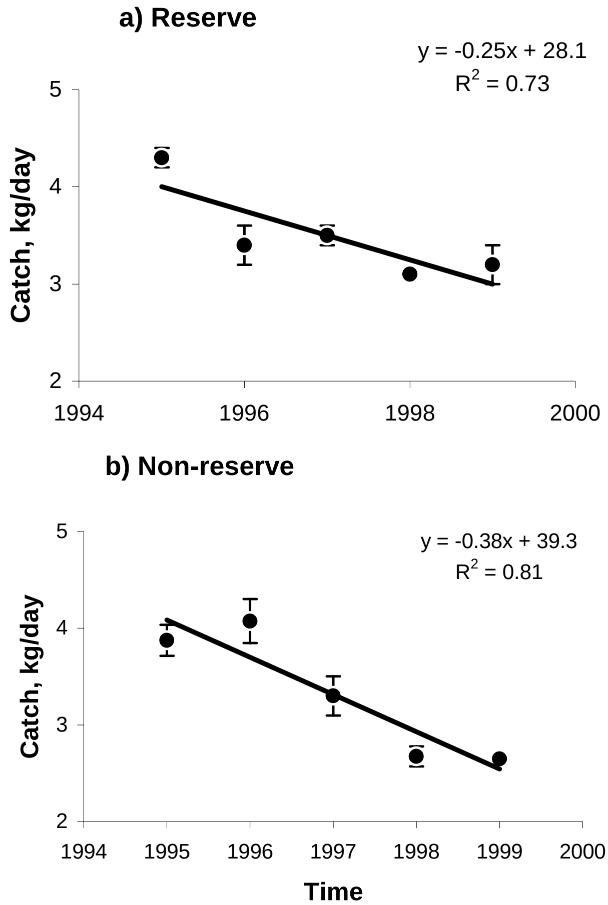

Fig. 5. Annual daily catch per fisherman from 1995 to 1999 comparing the trend in the a) Mombasa Marine Reserve and b) non-reserve sites.

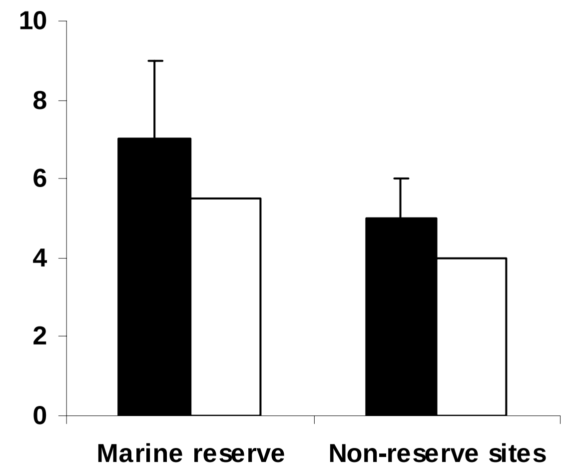

Fig. 6. Comparison of mean catch rates (kg.ha^{-1}.mo^{-1}) in white and density of fishermen (#.ha^{-1}) in black (± SD) in the Mombasa Marine Reserve and non-reserve sites.

Gear restrictions

Environmental impacts

Understanding the impacts of the various gear types used is necessary in order to evaluate the effects of gear restrictions in the Mombasa Marine Reserve. The impacts that have been quantified include the proportion of juvenile fish, by-catch, coral damage per catch and per area (Mangi and Roberts 2006). These impacts have been quantified for the principal gears used in the reserve including large and small traps, gill nets, beach seines, hand lines and spear guns. The results indicate that fishers using beach seines, spears and gill nets cause the most direct physical damage to corals. Spear fishers showed the highest number of contacts to live corals per unit catch followed by fishers using gill nets (12.6 (SD ± 1.8) and 5.9 (SD ± 2.0) coral contacts per kg fish caught per trip respectively (Fig. 7). Fish discarding by six beach seine boats fishing in the reserve showed that 6.5% of the daily catch was discarded into the sea as it was too small (Table 1). Beach seines were also associated with the highest percentage of juvenile fish (68.4 ± 15.7%, Table 2). In general, the size and maturity stage at first capture for 77% of all species caught by all gear types in this fishery was well below the lengths at which they mature. For example, 100% of *Lethrinus xanthochilus*, 99% of *L. nebulosus* and 94% of *L. harak* caught were juveniles. The results of these studies indicate that beach seines have the greatest impact on coral reef biodiversity providing further evidence why they are banned in the reserve. Their continued use however poses questions on the enforcement of gear regulations.

Table 2. Proportion of juvenile fish (%) in catches for the different fishing gear types showing the number of fisher groups examined for each gear.

Gear	Mean	SD	n
Big trap	48.9	27.4	434
Small trap	39.8	21.6	45
Gill net	49.4	28.4	139
Beach seine	68.4	15.7	63
Hand line	55.6	27.2	241
Spear gun	38.2	25.9	588
Total	50.1	22.7	1510

Comparison of gear based fishing regimes

Based on the type of gears used, the fishing grounds surrounding the Mombasa Marine Park can be grouped into three gear regimes: 1) a trap only ground where only authorised basket traps are allowed; 2) fishing grounds where almost all gear types are used other than beach seines; and 3) fishing grounds that are unrestricted and fishermen use any type of fishing gear, particularly beach seines to catch fish. Studies focusing on fish, sea urchin and substratum characteristics from these grounds indicate

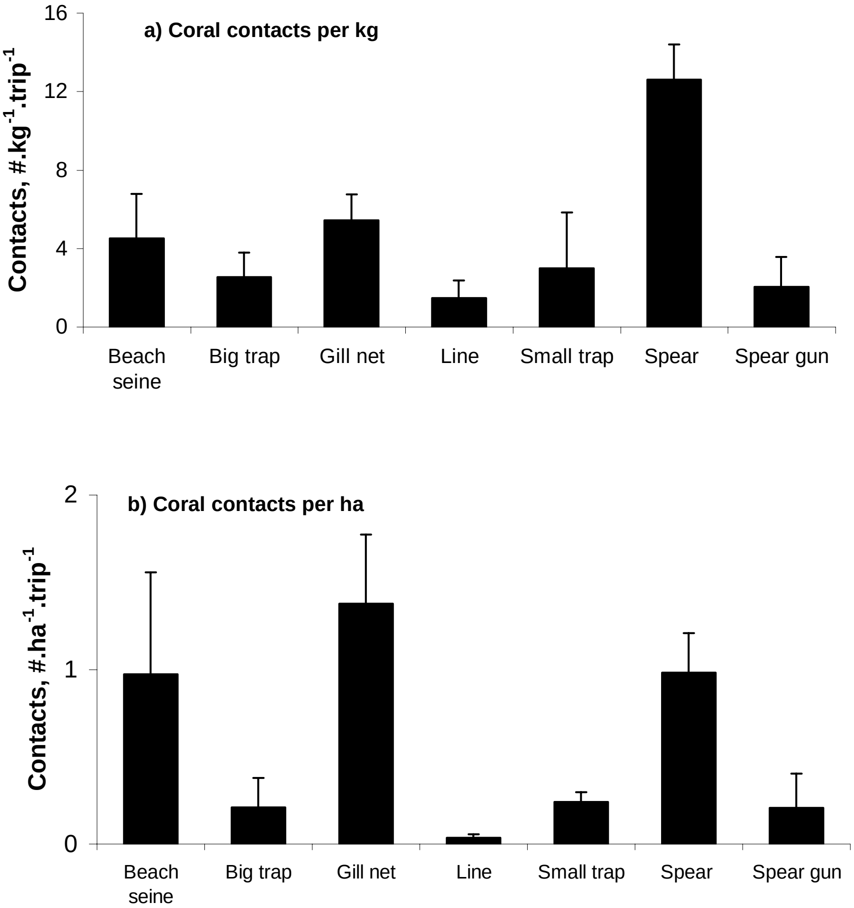

Fig.7. Mean number of contacts (± standard deviation) between fishers and/or their gear and live corals on the basis of the a) fish catch ($kg.trip^{-1}$) and b) area fished ($ha.trip^{-1}$) by each of the gear types.

that sites fished by all gear types, including beach seines, have the lowest fish density, coral cover and topographic complexity (Mangi and Roberts 2006, 2007). Most corals were overgrown by algae and were found hidden in pockets of rubble and surrounded by seagrass. This is probably due to the dragging of nets through the bottom substrate. Net dragging across the seafloor has a number of consequences. It can lead to resuspension of bottom sediment that results in increased turbidity and the smothering of benthic organisms (Jones 1992). It can also lead to the removal or crushing of epibenthic organisms e.g. sponges (Sainsbury *et al.* 1997), coral and epibenthic flora such as seagrass (Northridge 1991) along the path of the net. The considerable length of the beach seine and the pulling and dragging nature of its operation makes it very mobile. Beach seining can therefore be expected to affect the seafloor habitat with an intensity and spatial extent orders of magnitude greater than other disturbances to the same environment (McManus 1997, Watling & Norse 1998, Auster 1998). These findings reveal that destructive gears, such as beach seines are reducing the habitat structure of the reefs, supporting the need for enforcement of gear restrictions in the Mombasa Marine Reserve.

Management issues

Enforcement of regulations

The park and its adjacent fisheries are the focus of various government institutions, concerned either with the conservation of the reef resource (Kenya Wildlife Service – KWS), the management of the local fishery (Fisheries Department) or for the development and welfare of local fishing communities (Coast Development Authority). This has created overlap in mandates reducing the effectiveness of management. For instance, despite zoning for fishing and tourism activities, there are ongoing conflicts between fishers and recreational users requiring managers to spend a great deal of time in conflict resolution. The mechanisms and processes to resolve some of the conflicts are, however, either not present or are inadequate leading to conflicts being resolved in an ad hoc manner.

Fisheries management in Kenya has focused on prohibition of illegal gears, which currently covers the beach seines and spear guns. This management policy

Table 1. The volume of catch (cm^3) and percentage of catch discarded for six beach seine boats showing the approximate cut off length for the discarded catch. n = number of days when catch data were recorded for each of the boats. Big catch is the catch that is usually reported in most catch statistics and is comprised of big individuals weighed and sold at the landing site.

Captain	Landing site		Number of fishermen		Discarded catch, cm^3 (< 6 cm)		Landed catch, cm^3 (*Dagaa* 6-8 cm)		Landed catch, cm^3 (big > 9 cm)		Discards as % landed big catch	Discards as % total catch	Commonest genera
		n	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
Ali Shante	Reef	167	13	2	1162.8	522.3	5917.4	2664.3	30557.0	19087.0	3.8	3.1	*Leptoscarus*, *Siganus*,
Faki	Reef	209	11	2	1362.1	813.2	5658.7	2905.9	30974.1	19847.4	4.4	3.6	*Sphyraena*, *Lethrinus*,
Suleiman	Reef	104	13	2	1309.0	648.0	6044.7	3079.5	25938.2	15932.3	5.0	3.9	*Plectorhinchus* and
	Average		13	2	1278.0	661.1	5873.6	2883.2	29156.4	18288.9	4.4	3.5	*Lutjanus*
Shame Ali	Marina	226	20	3	5165.3	2433.5	11834.1	7140.6	42350.8	23715.1	12.2	8.7	
Sheha	Marina	186	19	3	4288.4	1684.9	7770.2	4298.8	31102.8	12676.0	13.8	9.9	
Suleiman Mweusi	Marina	40	15	2	4716.8	2635.1	13970.0	6352.7	45542.4	16789.2	10.4	7.3	
	Average		18	3	4723.5	2251.2	11191.5	5930.7	39665.3	17726.8	11.9	8.5	
Total			93		18004		51195		206465		8.7	6.5	

has received good support from older fishers who mainly use traditional gear, and very little support from young fishers who use modern gear. Nevertheless, gear restrictions and mesh size limits form the main fisheries management tools employed by the fisheries regulatory authority – the Fisheries Department. Despite the existence of such gear restrictions, beach seines and spear guns still account for a very high percentage of reef fish landings from the Mombasa Marine Reserve (Mangi 2006). This must be attributed to the increasing poverty among fishers which hinders their ability to invest in more expensive gears. New entrants to the fishery usually select beach seines or spear guns, as they are the least cost gears to the fishermen (Glaesel 2000, Mangi *et al.* 2007). It could also be due to the lack of political will to enforce regulations. The predominantly small-scale and subsistence nature of the coastal fishery means that the real benefit of the coral reef resource is often overlooked by the government. In Kenya, marine fisheries comprise less than 5% of the national fisheries production (Obura 2001). Further, the Fisheries Department has scarce staff, some of whom are unskilled, and lacks resources for detailed study, monitoring and enforcement of complex multi-species multi-gear fisheries. KWS patrols in the park and reserve to enforce regulations have been fairly effective in the park and less effective in the reserves as KWS concentrates on enforcing regulations in marine parks where most revenue is collected (Muthiga 2001).

Research and monitoring

The reef lagoon in Mombasa has been a magnet for research and scientific interest that has raised the profile of the reefs to global significance. As a result a number of studies focusing on artisanal fishing (e.g. McClanahan & Mangi 2001, McClanahan and Kaunda-Arara 1996), coral reef ecology (e.g. McClanahan and Shafir 1990, McClanahan *et al.* 1996) and social dimensions of fishers (e.g. Glaesel 1997, 2000) have been conducted. A number of government departments e.g. Kenya Marine Fisheries Research Institute (KMFRI) and Kenya Wildlife Service (KWS), non-governmental organizations e.g. Coral Reef Conservation Project (CRCP) and Coral Reef Degradation in the Indian Ocean (CORDIO), and universities e.g. Moi and Nairobi have offered scientific expertise to study the various aspects of the reefs. Many studies have focused on the effect of protective management on fish populations and have made comparisons based on fished and unfished areas. Few detailed studies have been conducted on the response of catches to gear restrictions. Reporting of the results from most studies have targeted publications in peer-reviewed journals, theses or local project reports and have rarely been presented in a simple way for policy makers or resource users.

Management of the fisheries also requires information on the resource. In Kenya, fisheries statistics collected from most landing sites by Government Fisheries Officers are still not reliable and comprehensive enough to provide a complete picture of the status of the resources. While landing data collected by NGOs e.g. CRCP and CORDIO East Africa is fairly good and reliable, it is mainly focused at a few landing sites.

Awareness and education

Education and awareness are major components of any interventions associated with preventing reef decline and are an important part of developing a better understanding of issues amongst user groups as a means of creating a willingness to change attitudes and behaviours. Education is often focused on informing user groups of the negative impact of their actions on the health of the reef and can be used as a means of informing locals of the objectives of an intervention in order to gain their support. Awareness raising programmes and local community involvement in management initiatives therefore needs to be a key part of the management plans early on before the intervention is implemented. Education and awareness on reef conservation and management issues has generally lagged behind in Mombasa. The MPA and fisheries regulations were initiated without adequate consultation and participation of the local communities (Muthiga 2001). This has led to a series of conflicts and slowed down implementation of management plans. However, recently education and awareness campaigns have improved with educational activities such as marine environment day and international coastal clean up taking place annually, involving school students, fishers and boat operators. Research NGOs including the Coral Reef Conservation Project (CRCP) and Coral Reef Degradation in the Indian Ocean (CORDIO) East Africa have also recently initiated annual meetings involving local fishers and Fisheries Officers where monitoring data on fish catch and other environmental data such as live coral cover, fish and sea urchin biomass are presented and discussed.

Lessons learnt

Process of establishing the MPA

The process leading to the establishment of an MPA is critical as it can support or hinder effective management. The Mombasa Marine Park and Reserve was initiated without adequate consultation and participation of the local community. This has led to conflicts and slow implementation of management plans (Muthiga 2001). To win the support of the communities, KWS has had to use dialogue and community projects including assistance with boats and fishing gears. When communities perceive tangible benefits of MPAs they are more likely to comply with regulations.

Restoration of coral reef habitats

The establishment of the park has led to a marked improvement in the coral reef habitats. Coral cover as an indicator of reef health has increased over the years. Fish biomass and sizes have also increased and the sea urchin biomass has also gradually decreased over the years (McClanahan and Kaunda-Arara 1996). Protection has therefore been beneficial to the Mombasa Marine Park.

Supporting adjacent fisheries

The elimination of fishing in the park has led to an increase in fish biomass that is dispersing into the adjacent artisanal fishery hence supporting the fishery. Because the park contains more and large fish, protected populations can potentially produce many times more offspring than can exploited populations. The increase in egg output will supply adjacent fisheries through export of offspring on ocean currents. In addition, as protected stocks build up, parks are predicted to supply local fisheries through density dependent spillover of juveniles and adults in to fishing grounds.

Compliance with MPA regulations

The level of compliance with MPA regulations differs among stakeholder groups.

Stakeholders who depend mostly on tourism show higher levels of compliance mainly because they understand the benefits of a managed system and improved habitats to their businesses. Fishermen groups on the other hand show a lower level of appreciation and compliance to park regulations (McClanahan *et al.* 2005b).

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