What's the Catch?

Mosquito Net Fishing in Coastal East Africa

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September 2013

"A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science and the Diploma of Imperial College London"

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List of Acronyms

BMU, Beach Management Unit

ITN, Insecticide Treated Net

LLIN, Long Lasting Insecticide Treated Net

MN, Mosquito Net

MNF, Mosquito Net Fishing

MSL, Material Styles of Life

NGO, Non-Governmental Organisation

PC, Principle Component

PCA, Principal Components Analysis

RBM, Roll Back Malaria Partnership

WHO, World Health Organisation

CORDIO, Coastal Oceans Research and Development Indian Ocean

Abstract

Mosquito nets have been used as seine nets or as the cod end of larger nets by fishing communities worldwide and listed as an artisanal fishing gear in their own right in recent descriptions of east African fisheries. Mosquito net fishing concerns health practitioners if it diverts MNs from their intended use as malaria protection, and the natural resource management sector because of the small mesh size of the net and the possibility of recruiting more fishers into an overburdened fishery. I sought to begin to understand the extent, frequency and character of MNF and to form a baseline for further study. My approach was first to involve experts and key informants through semi-structured interviews in an extensive survey of the East African coast with a particular focus on Kenya, and second, to conduct an intensive survey of homesteads at a particular site, Mida Creek, Kenya. Over half of the homesteads interviewed at Mida Creek admitted involvement in mosquito net fishing. I found the activity to have no effect on the level of malaria protection in a homestead as fishers generally used old nets. Those involved in mosquito net fishing were mostly adult men and children and their homesteads showed no difference to others in the community in terms of wealth, education or occupation diversity. The weight of expert witness and experience portrayed mosquito net fishing as a common but varied activity throughout Kenya and the east African coast region. Further research will be necessary to understand its implication for stock sustainability and role in the economy of fishing communities.

Word count = 14982

Acknowledgements

For making this study financially possible I am very grateful to the Tropical Agriculture Association and the ICCS bursary. I would like to thank Nick Hill and E.J. Milner-Gulland for their clear supervision and support, to Kirao for his brilliant research assistance and translation, to the team at A Rocha Kenya, to Melita Samoilys, David Obura and the rest of the CORDIO staff for their kind welcome to Kenya, and lastly to Dawn Goebbels who's kind hospitality made all this possible. I am also grateful to all those at Mida creek who welcome me into their homes and fed me too much ugali.

1. Introduction

1.1 Problem Statement

In 2011, world fishery production was estimated at 154 million tonnes, half of which came from marine capture fisheries and was estimated to support the livelihoods of 10 – 12% of the world population (FAO 2012). However it is fair to say that global fisheries are in crisis, in 2006 the FAO considered 52% global stocks as fully exploited and 28% as overexploited, depleted or recovering (FAO 2010).

The east African continental coast is dominated by fringing coral reefs that are rarely further than 2km from shore, enclosing mangrove forests, eroded rocky platforms, mudflats and seagrass beds (Muthiga et al. 2008). A complex issue for the region is the unsustainable exploitation of reef fisheries which suffer from high densities of fishers, by-catch, and destructive fishing practises. Fishing and tourism are the main livelihood occupations in the region, however both are difficult to manage and fishery legislation is old and/or weak with poor enforcement (Obura 2004; Muthiga et al. 2008). East African reefs are considered to be at a critical stage, the main threat being the increasing pressure from human population (Wilkinson, 2008). There has been a call for more socio-economic monitoring to increase support for livelihood interventions in this region (Muthiga et al. 2008).

Mosquito nets (MNs) have been adapted for use as seine nets or as the cod end of larger nets by fishing communities worldwide (observations from Mozambique, Kenya, Madagascar and the Philippines, pers. com. 2013) and have been listed as an artisanal fishing gear in their own right in CORDIO's recent book documenting the practices of Kenyan coastal fishing communities (Samoilys et al. 2011) . Artisanal fishing takes place within 12 nautical miles of the shoreline and encompasses methods and gears that are centuries old to the modern and manufactured (Samoilys et al. 2011). Artisanal fishing enterprises are usually small-scale, traditional, and reliant on small amounts of capital. Despite the frequent mention of mosquito net fishing (MNF), very little is known other than that it is illegal in most countries due to minimum requirements for mesh size. It is not known at what scale the fishing

activity is happening, who uses MNs in this way or the impact on sustainability of fish stocks.

MNs are abundant in the tropics as a result of international health policy since the late 1990s. The World Health Organisation's (WHO) Global Malaria Program toward malaria prevention has orchestrated the delivery of 100s of millions of nets in sub-Saharan Africa (WHO 2012). As an abundant resource, recipients of MNs have found alternative uses for the nets alongside or instead of malaria protection such as fishing, keeping chickens and protecting plants. Eisele et al. (2011) argued against reports that MNs have been generally misused by recipients and aimed to discredit them as anecdotes arising from unreplicated studies. The authors emphasised that it is important to consider the status of nets being used for purposes other than as bed nets. For example, a new net used for fishing rather than as a bed net would detract from malaria protection for the recipient, whereas surplus nets or old nets would not automatically detract from malaria protection if the user already sleeps under a net. A review of studies following up MN distributions highlighted social factors and personal preferences as the main reasons for MN owners not using their nets to sleep under rather than alternative uses (Pulford et al. 2011).

MNF is of concern to both health and conservation practitioners alike. Clearly MNF is of concern to the health community if it diverts MNs from their intended use as malaria protection. Equally MNF is of concern to the natural resource management community because of the small mesh size of the net and the possibility of recruiting more fishers into an overburdened fishery. The small mesh size means that the a large proportion of the catch is juveniles, possibly reducing recruitment to the stock spawning biomass, and thus raising concern for the sustainability of this practice. The wide availability and low or zero cost of the net could aid people to enter the fishing community because the requirement for capital to invest in nets has been removed.

1.2 Aims and objectives

My aim was to conduct a replicated study bringing together observations and experience from experts and local communities to ascertain the extent, frequency

and character of MNF and to form a baseline for further study. I sought to do this using social survey techniques; first involving experts and key informants through semi-structured interviews in an extensive survey of the East African coast, with a particular focus on Kenya, to establish the extent of MNF and its interaction with MN distributions. Second, I conducted an intensive survey of homesteads at a particular site, Mida Creek, to act as a case study to begin to understand the source of MNs being used for fishing, and the demographic and motivations of MN fishers.

My objectives were as follows:

I. To describe the extent of MNF in coastal Kenya within the context of coastal East Africa
    a. Is the practise of using MNF widespread amongst coastal communities?
    b. What fisher demographic and techniques have experts witnessed?
II. To calculate the frequency of MNF within a particular fishing community (Mida Creek) as a case study.
III. To ascertain the source of MNs used for fishing within the case study
    a. Are fishers using new, surplus or old nets for MNF?
    b. Where were MNs for MNF nets sourced from?
    c. Does MNF detract from malaria protection?
IV. To characterise, within a livelihood framework, the demographic of MN fishers within the case study.
    a. How do gender, age, wealth, education, occupation diversity and involvement in fishing affect a homestead's likelihood to be involved in MNF?
V. To understand the reasons and motivations for MNF at the case study site.
    a. Why are fishers using MNs? What are they catching and what do they do with the catch?
    b. What did MN fishers use before MNs were available?
VI. To place MNF in the context of the state of the fishery in recent years at the case study site.

a. Does the community perceive any chance in abundance and size of fish over living memory?
b. How are small mesh nets such as MNs implicated in this?

2. Background

MNs have been listed as an artisanal fishing gear in reports of coastal east African fishing practises (Samoilys et al. 2011; Gough et al. 2009; Jiddawi & Ohman 2002). The local names of the gear, descriptions of their typical deployment and the target species listed in these reports are detailed below (Table 2-1).

Table 2-1: Descriptions of MNs as artisanal fishing gears in coastal East Africa

Country	Name	Deployment	Target species	Legality
Kenya (Samoilys et al. 2011)	*Uduvi* *Tandilo*	Actively dragged in waist deep waters by at least two and often more fishers, usually women.	Sardines (*Clupeidae*), Anchovies (*Engraulidae*) and Juvenile reef fishes.	Illegal
Tanzania (Jiddawi & Ohman 2002)	*Utazi wa juu* / *Utazi wa chini*	Used by women in intertidal areas. Nets are held by several women. Others approach this sheet over a decreasing circle, splashing and making noise to chase fish into the net.	Striped cat fish (*Plotosus lineatus*), Silversides (*Atherion africanus*), Common silver biddy (*Gerres oyena*) and shrimps (*Acetes spp*).	Not mentioned.
Madagascar (Gough et al. 2009)	*Makara-kara*	Pulled with the fishermen as they walk, very slowly, down the channel in the mangroves. The base of the net is attached to the fishers' foot and the top of the net is held onto by the fisherman.	Smallest fish and shrimps.	Illegal outside of sardine season.
Madagascar (Gough et al. 2009)	*Jahoto*	Small mesh gill net with a MN pocket at centre. Used when seining so that fish are herded into the net and trapped in central pocket section. Operated on foot (Tarikake) or by boat (Mananjake).	Small shoaling fish (sardines) close to shore.	Illegal outside of sardine season.

MNs are generally deployed in shallow water dragged by two or more fishers, both men and women, and used to catch pelagic-neritic, reef associated and estuarine fish and crustaceans. Some species, such as sardines, shrimps and cat-fish, appear to be

targeted as adults, whereas others, such as reef fish, are caught indiscriminately as juveniles.

MNs have a mesh size of ~3mm and are made available in East Africa through private sale, subsidised sale and free distribution from government and aid organisations. The intention of MN distribution has been to lower malaria transmission, firstly through reducing the number of mosquito bites, and secondly, when the netting is impregnated with insectide to lower the number of mosquitos. Insectide-treated net (ITN) usage resurged in the 1980s after first use in the Second World War. Since 1998 they have been an integral part of the World Health Organisation's (WHO) Global Malaria Program (Anonymous 2013).

2.1 MNs as an artisanal fishing gear in the literature

There are a number of anecdotal references to MNF; a brief internet search using the term "mosquito net fishing" returned many informal observations and comments concerning the practise. For example a blog post from the African Wildlife Foundation (AWF) documented the use of MNs in the Zambezi river (Walter 2011), an IRIN news article reported on MNF at Lake Tanganyika (IRIN Africa 2009), a news article quoted the District Commissioner of Zambia calling MNF a "total misuse of the mosquito nets" (Anonymous 2008) and a blog article from Malaria World entitled "Of fish and mosquitos" examined the issue (Sampao 2010).

Despite this recognition there is little published in the peer-reviewed literature. A handful of studies from both the medical and fisheries journals mention MNF (Hamerlynck et al. 2011; Abbott & Campbell 2009; Banek et al. 2010; Srivastava et al. 2002), however, there is just one paper that has reported directly on and quantified MNF. Minakawa et al. (2008) studied the use of MNs for catching and drying small fish, locally called omena (*Rastrineobola argentea*), in seven fishing villages along the shore of Lake Victoria, Kenya. They described the motivations behind MN use by fishers which included the availability and low-cost of the gear and the speed and quality with which the fish dry. Long lasting insectide-treated nets (LLINs) were reported as preferentially used over other nets, alongside those provided free or subsidised through health centres and NGOs. The authors showed that the

distribution of nets from one single NGO in 2006-2007 coincided with the advent of MNF in these villages and its subsequent rise in popularity.

When searching the grey literature (NGO and governmental reports) I found two case studies concerning MNF. Manase *et al.* (2002) of the Malawi Fisheries Research Unit published a report analysing the catch and effort data for the south-east arm of Lake Malawi. MNs, whilst not the most popular gear (gillnets numbered in the thousands), showed a marked increase in ownership over the period of the study compared to other seine nets with over 200 nets in use in the late 1990s.

Lopes and Gervasio (2003) reported on the co-management of artisanal fisheries at Kwirikwidge Fishing Centre, Mozambique, where 700 people were employed in fishing. They reported that of the 90 beach seines observed, 73 were fitted with mosquito cod-ends which were cast from small boats and caught small fish and spawns. Consumer preference for small fish was thought to have encouraged the use of MNs, in particular to target anchovies. Respondents to the survey thought that over-use of MNs had caused poor catches and increased conflict between artisanal fishers. In response to this the local committee initiated programs to remove MNs from seine nets and to limit the number of permits for migrant workers. The community showed a developed understanding of fishing resource management and cooperated with government schemes to introduce a minimum mesh size and facilitate gear replacement.

MNF has sparked the interest of two academic communities whose spheres of concern normally operate independently; the natural resource management sector and the health sector. As we have seen the relevant literature from each is sparse and fairly isolated from the other. An important contribution of this project has been to pull together the knowledge and concerns of each. In the following sections I describe both communities in detail before constructing a framework to outline their interactions over this issue and how this dictates our understanding of MNF itself.

2.2 Natural resource management

MNF may interact with fisheries in two distinct ways; the small mesh size (~3mm) of a MN means that even the smallest fish and invertebrates including juveniles can be caught, whilst the wide availability of MNs could facilitate more people to enter the fishing community, potentially contributing to overfishing.

2.2.1 MN mesh size and selectivity

In general, exploited fisheries show reductions in abundance, size and trophic structure of fish (Jennings & Blanchard 2004). All major studied coral reef systems have shown evidence of decline upon human interaction (Pandolfi et al. 2003).

The character of change in exploited fisheries is related to the fishing intensity and the types of fishing gear used as they are selective by size and species dependent on mesh size and technique (McClanahan & Mangi 2004; Mangi & Roberts 2006a). One major concern about MNF is the suspected high percentage of juvenile fish caught due to the mesh size and deployment in nursery habitats. Seine nets of <3cm (including MNs) catch both reef and pelagic species during migration and total fishing catches have been shown to be lower in fishing grounds with high frequency seine-net use where the gear competes with other gears instead of exploiting a unique resource (McClanahan & Mangi 2004; Mcclanahan & Mangi 2001). Beach seines of 1 – 3cm are responsible for catches with highest quantity of juvenile fish compared to other fishing gears in artisanal Kenyan fisheries (Mangi & Roberts 2006b). Juvenile reef fish are found disproportionately in mangrove and creek habitats compared to neighbouring mudflats and seagrass beds, due to the protection from predation and increased food availability that the habitat offers (Laegdsgaard & Johnson 2001). Indeed mangroves serve as an intermediary nursery habitat that can increase survival of juvenile fish and therefore increase biomass of adult population of fish stocks (Mumby et al. 2006).

According to Marshall et al. (2003) one of the basic goals of fisheries management is to "conserve sufficient reproductive potential of a stock to allow sustainable exploitation." Much fisheries management has been dedicated to off-shore single species commercial fisheries where efforts are dedicated to finding an optimal mesh

size to maximise reproductive potential of the stock. However in a tropical, artisanal, multi-species fishery which is being exploited using a diversity of gears, management is notoriously difficult and gear use is often dictated by tradition and resource availability (McClanahan & Mangi 2004). According to McClanahan et al. (2004) "a well-managed fishery should utilise a range of gears to select most species at sizes least detrimental to their population sustainability". Growth overfishing, the disproportionate take of immature individuals before they have spawned, is traditionally thought to have negative impacts on stock sustainability (Vasilakopoulos et al. 2011) . Therefore using gears that catch the largest individuals and have low overlap in gear selectivity is thought to improve the sustainability of a fishery (McClanahan & Mangi 2004).

However support has been growing for balanced fishing which would operate "across a range of species, stocks, and sizes and could mitigate adverse effects and address food security better than increased selectivity" (Garcia et al. 2012). Spawning stock biomass (SSB) and fishing mortality are often used as reference points for harvest control. There is a general trend for recruitment to be related to SSB, however in practise adult females are highly variable in fecundity and eggs do not have equal probability of survival. Downward shifts in the size structure of a stock can affect reproductive potential because fecundity, egg quality and favourable spawning behaviours increase with size/age and size shifts can skew the sex ratio towards males, violating assumptions of linear recruitment from stock size (Marshall et al. 2003). Because of this, some fisheries scientists argue for greater emphasis on maintaining large fecund individuals to aid recruitment to the stock and to balance fishing mortality across larger range of species, stocks and sizes in proportion to natural productivity (Garcia et al. 2012). Thus the exploitation of juvenile fish as part of a balanced fishing effort may be acceptable for stock sustainability (Law et al. 2012).

2.2.2 MN availability

The cost of fishing nets are substantial compared to daily incomes; fishing gears and boats are often owned by elites who hire them out or employ others to work using them (Carter 2012; Lopes & Gervasio 2003). A socio-economic assessment of Mnazi

Bay, Tanzania showed that small mesh nets were more likely to be fully owned by the user, than part-owned or hired (Malleret 2004). The free or subsidised availability of MNs in coastal East Africa may have removed the requirement for capital to invest in fishing nets before one can enter the fishing community.

When these two pathways of interaction- small mesh size and availability - are combined, the stock may be made vulnerable to decreases in abundance and juvenile recruitment where MNF is being practised (Figure 2-1).

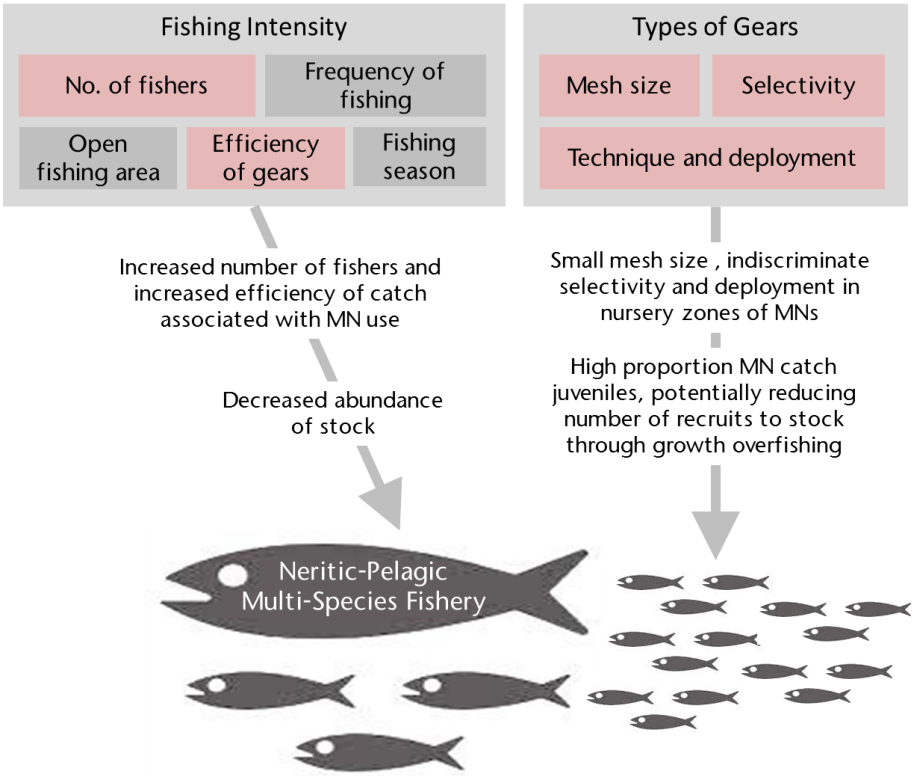

Figure 2-1: Conceptual role of MNF in stock sustainability of the neritic-pelagic multi-species fishery associated with tropical East Africa. According to McClanahan & Mangi (2004) the character of change in an exploited fishery is related to the fishing intensity and the types of fishing gear used. This figure details the ways in which fishing intensity and types of gear can vary, those highlighted in pink are affected by MNF

2.2.3 Legislation

As a result of the above concerns, most countries on the east African coast have made MNF illegal. The details of this are listed below (Table 2-2).

Table 2-2: Fisheries legislation relevant to MNF from Kenya and Tanzania

Country	Details relevant to MNF	Law
Kenya (Government of Kenya 2012)	46. (1) No person shall use, permit to be used or attempt to use or carry on board a vessel: (i) a seine net the mesh of which is less than forty-five millimetres in stretched diagonal length; (j) a beach seine net for the purpose of fishing; 43 (2) A seining net whose mesh sizes are less than 50mm when diagonally stretched shall be prohibited fishing gear except for fishing for *Rastrineobola* sp. (omena).	Fisheries Act Chap 378 Revised [2012] 1991
Tanzania (Government of Tanzania 2005; Government of Tanzania 2003)	42 (3)No person shall use a beach seine net or trawl net in an area which is 500 meters on each side of an estuary and extending seawards to a distance of 1000 meters measured from the lowest tidal level equidistant from the main channel and when regressed to 500 meter outwards 42 (5) No person shall fish in marine waters using beach seine net with mesh sizes below 3 inches at the wings and 1.5 inches at the cod end.	Fisheries Act , 2003 (No. 22) Fisheries Regulations, 2005 (GN No. 314 of 14th 10/2005)

2.3 Health

The Roll Back Malaria Partnership (RBM) - a "global framework to implement coordinated action against malaria" - estimates that 1 million people die of malaria each year, and that malarial illness and mortality cost the African economy USD 12 billion per year (RBM 2013). MNs fall under the category of vector control in malaria prevention and are described by the WHO as the most powerful and broadly applied intervention alongside indoor residual spraying (WHO 2012). Most MNs procured today are Long Lasting Insecticide Nets (LLINs) which cost around USD 5 each, can last up to five years and have replaced ITNs which need re-impregnating with insecticide every six months for maximum effectiveness (Palmer 2007; WHO n.d.).

Current recommendations from the WHO (WHO 2012) include:

- LLINs must be universally accessible; one LLIN to be distributed to every two people.
- Cost should not be a barrier to availability; LLINs should be distributed free of charge or highly subsidized.

- Need for a combination of delivery systems; "Catch up" through mass distributions and "Keep up" through availability at maternal clinics.
- LLINs must be used effectively; distributions accompanied by education.
- LLINs need to be safe; only LLINs recommended by the WHO Pesticides Evaluation Scheme to be procured.
- Recognition that the lifespan of LLINs are variable; LLINs must be monitored in situ and programmes altered accordingly.

As a result of this international strategy, ITN delivery has increased rapidly in the last decade, with over 150 million nets delivered in 2010, almost half of which went to just five countries; Democratic Republic of Congo, Ethiopia, Kenya, Nigeria and Tanzania (Figure 2-2). Due to this availability, over 50% of households in this region now own at least one ITN and over 30% of the population sleep under an ITN (Figure 2-3).

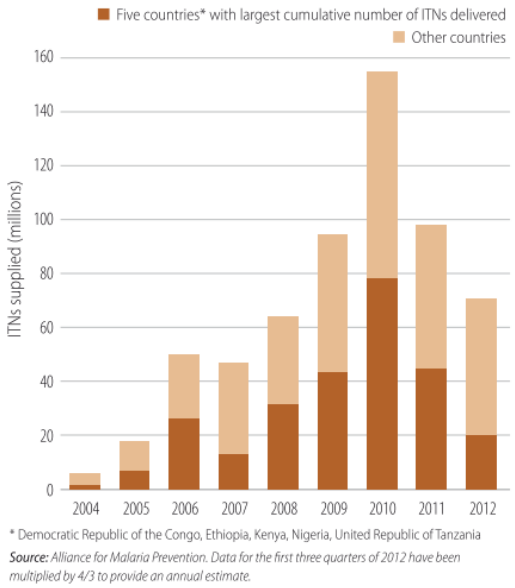

Figure 2-2: Number of ITNs delivered by manufacturers to countries in sub-Saharan Africa 2004 - 2012. Taken from (WHO 2012).

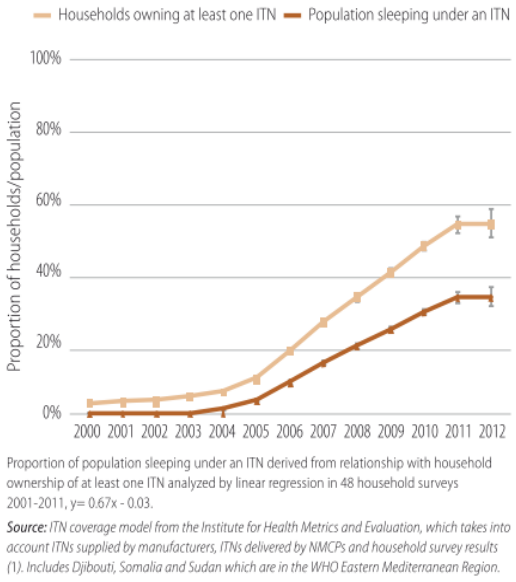

Figure 2-3: Estimated trend in proportion of households with at least one ITN and proportion sleeping under an ITN in sub-Saharan Africa, 2000 - 2012. Taken from (WHO 2012).

With so much at risk in terms of health and financial investment in this intervention, health professionals are keen to ensure that MNs are used properly. This is important for the individual using the MN as well as the wider community

because malaria transmission is reduced even for those not sleeping under a net when an area achieves a certain coverage of MNs (Howard et al. 2000).

Pulford et al. (2011) reviewed the literature to understand the reported reasons why net owners do not use nets. Discomfort due to heat, perceived low mosquito density, social factors (e.g. sleeping elsewhere) and technical problems were the most commonly cited reasons. In 2011, Eisele et al. published an essay in which the authors countered media accusations of widespread MN "misuse". They derided anecdotal reports of MNs used for fishing and bridal gowns, using the lack of replicated studies in the peer-reviewed literature as evidence against wide-spread alternative-use, yet provided no further evidence to bolster their argument. However, Eisele et al. (2011) rightly point out that we should not assume that the alternative use of MNs is reducing the number of MNs being used as bed nets. While communities may indeed be substituting bed nets (and therefore reducing malarial protection) they may equally be using old nets or surplus nets that are otherwise unused.

The health community is most concerned about alternative net use where it impacts malarial protection i.e. nets being substituted for other purposes. But how much responsibility should distributors hold for the disposal of and alternative use of old and extra MNs? This is a pertinent question in countries distributing millions of nets, with a life span of just five years. A recent newspaper report from Kenya described the situation as a "headache" for authorities; Although MNs are recyclable, there is no such recycling facility in Kenya and pilot programs have found net owners to be unwilling to give up decommissioned nets without a fee (Mutisya 2013). An USAID report on the subject raised three main concerns about decommissioned MNs remaining in the community: 1. Insecticide in old nets used for other purposes (e.g. fishing, plant cover) may cause harm to environment and health, 2. Mosquito exposure to old MNs may have an impact on insecticide resistance, 3. Keeping old LLINs in use may decrease uptake of new LLINs (Nelson et al. 2011). However there is no mention of concern about environmental impacts related to alternative uses such as fishing and the risk of increased litter pollution. However many of the ways in which MNs are being used by recipients are beneficial

to them and have no perceivable impact on the environment. See Figure 2-4 for examples of alternative MN use in Mida Creek, Kenya.

Figure 2-4: A-E Photographic evidence of alternative MN use in Mida Creek, Kenya. Photos by E.R. Bush 2013

A pilot project run by USAID to assess the feasibility of recycling MNs in Madagascar encountered many challenges including social and cultural aspects, such as reticence among people to bring dirty MNs into the open to exchange them, but did at least show that such a mechanism is logistically possible (Nelson et al. 2011; Ramanantsoa et al. 2012). A recent investigation into the possibilities for MN recall demonstrated that manufacturers were positive about and, in some cases, actively exploring MN pull-back for recycling, however none of the companies interviewed actively provided guidance for MN disposal (Koehrn & Meyer 2009).

2.4 The fisheries narrative

An environmental narrative, as emphasised by Abbot and Campbell (2009), combines the discourse, data and actors surrounding an environmental problem.

The old paradigm of fisheries and poverty incorporates a few established and permeating ideas that are now being challenged. Firstly we have, what Abbott and Campbell (2009) refer to as the "overfishing narrative" and Béné (2003) refers to as "they are poor because they are fishermen"; that overexploitation of a fishery - due to common access and low opportunity incomes in fishing communities - causes decreases in catch per unit effort and fish size and thus to poverty. Another related narrative is "they are fishermen because they are poor" (Béné 2003); that fishing is the last resort of the poor, a "safety net" to which the poor can turn when other income opportunities fail. Both lead to the conclusion that fisheries equal poverty (Figure 2-5).

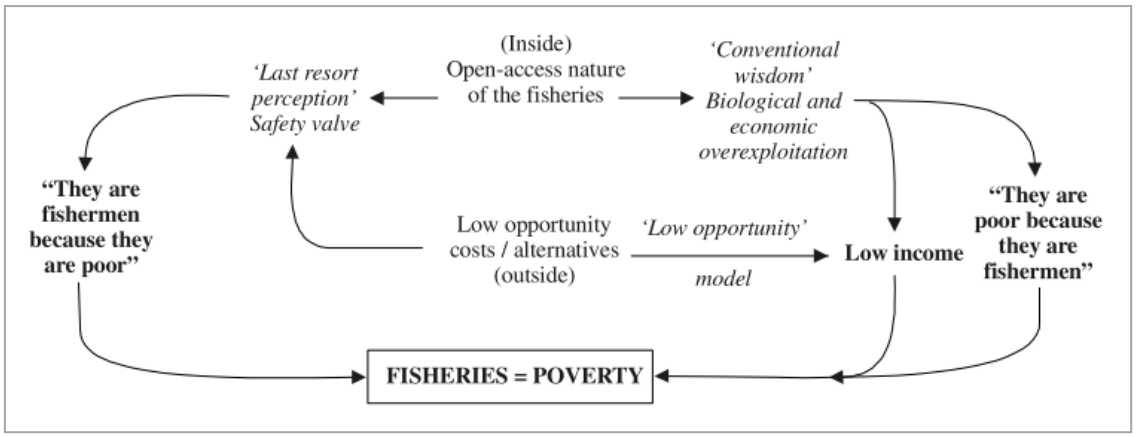

Figure 2-5: The two pillars ("they are fishermen because they are poor" and "they are poor because they are fishermen") forming the circular logic of the old paradigm and leading to the 'self-contained' equation "fisheries=poverty". Taken from (Béné 2003)

The common responses to this paradigm are to conserve fish stocks and the marine environment from overfishing and to address poverty by making fisheries more efficient. In practise this means limiting fishing effort and access to fisheries, e.g. by prohibiting gears (Abbott & Campbell 2009) and through incentive based schemes to encourage fishers to exit the fishery (Allison & Ellis 2001).

The new paradigm encompasses a livelihoods approach, where fishers are viewed in the context of their whole livelihood, not just the fishing activity of interest (Béné 2003). According to Ellis (2000), a livelihood comprises "the assets (natural, physical, human, financial and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by the

individual or household." Individuals choose certain fishing behaviours within a balance of the costs and benefits of other occupations available to them (Abbott & Campbell 2009). This paradigm allows us to acknowledge that rural people from developing countries often engage in multiple occupations and to factor costs that lie outside the realm of economics and the environment, such as gender, age, ethnicity, religious and cultural associations and politics. As Béné (2003) expresses it "there is no simple linear relationship between population, production, resource availability and poverty". The response to this would naturally demand more nuanced management from a variety of actors including participation of the target community itself.

How does MNF sit within these narratives? There are three communities involved with MNF; The local community including the fishers, the health community and the natural resource management sector. The health community supplies MNs directly to the local community through distributors. Other actors such as the funders, health professionals and international health initiatives all influence this process as described previously. The response thus far from the natural resource management sector had been to enact legislation to ban MNF and to enforce this through fisheries management. However, the new paradigm of the livelihood acknowledges that an individual's choice to engage in MNF is a result of a balance of costs and benefits of and access to other occupations, and their cultural, social and political context. Moreover the response from the natural resource management sector should not be channelled through just one pathway, such as increased legislation, but should also target diverse aspects of the problem. This could include the individual's decision to engage in MNF, their suite of livelihood choices and the roll of MNF in the community, or factoring individuals who do not directly engage in MNF but benefit through the supply of income and protein or who may be put at a disadvantage through decreased abundance of stock (Figure 2-6).

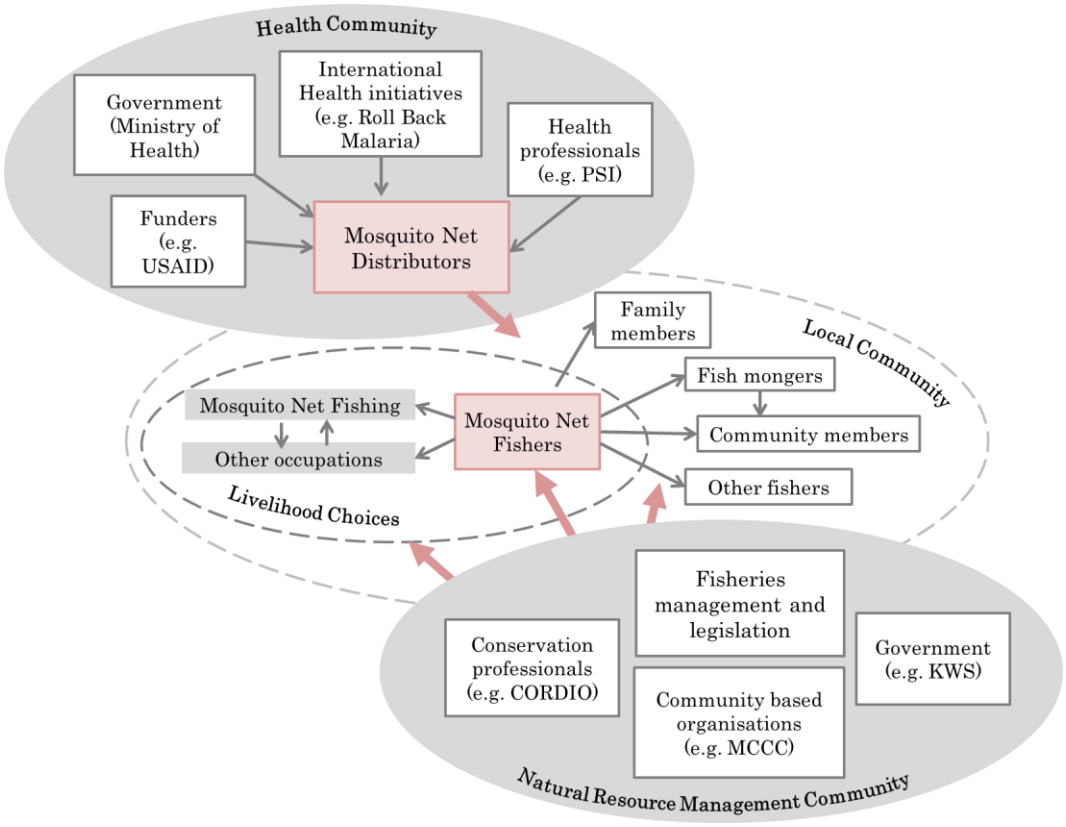

Figure 2-6: How the relevant communities interact with MNF. MN distributors supply MNs to the local community. Some of the local community choose to engage in MNF as a balance of costs and benefits of their other occupations as part of their livelihood choices. MNF supplies income and affordable protein to the local community and may negatively impact other fishers if MNF affects sustainability of the fish stocks. The natural resource management community engages with MNF through legislation and through incentives to leave the fishery amongst other means.

Beyond simply establishing the extent of MNF, we will use this framework to look at MN fishers in the context of their livelihoods as well as external actors from the health and natural resource management sectors.

2.5 Background to study sites

2.5.1 Kenyan coast

Malaria is endemic in Kenya with 36% of the population inhabiting areas of high malaria transmission (WHO 2012). The WHO (2012) estimated that in 2011 over 60% of the Kenyan population at high risk of malaria were protected with an ITN due to widespread distribution. However there has been some variability in uptake of MNs in Kenya, Macintyre et al. (2002) showed that wealth and education positively correlated with MN use and number of mosquito protective measures undertaken.

They emphasised that this does not mean the poorest in society are not trying to protect themselves from mosquitos, but that the richest are doing more.

The coastal population is rapidly increasing (at above 3% annually) and currently constitutes 8% of the total population (Government of Kenya 2009). It is estimated that 10,000 fishermen engage directly in artisanal fishing, and their activities constitute 95% of the marine catch for the country (Government of Kenya 2009). Kenyan reef fisheries have demonstrated signs of over-fishing with declining yields from reef-lagoons in recent years (Mcclanahan & Mangi 2001).

The ethnicity of the Coast population is predominantly Swahili and Mijikenda. Swahili civilisation arose when Arab traders settled along the coast and intermarried with African coastal peoples. Swahili people are generally Islamic and speak Kiswahili, a Bantu language with Arabic influence. The Mijikenda are a Bantu tribe of agriculturalists who are associated with the inland kayas (forests) of the Coast province and subdivide into nine groups each speaking a distinct dialect, the largest group is the Giriama (Carter 2012). The Coastal province has been subject to Portuguese, Omani, German and British jurisdiction through the colonial period and as a result of the decisions made during these times, the Mijikenda have been left largely landless whilst the Swahili system of land tenure was recognised. The Swahili were the traditional fishers in this area and are famed for their seafaring dhows. However since the 1960s, the Mijikenda who have moved to the coastal strip have also entered the fishing community in large numbers (Hoorweg et al. 2008). The Swahili fishers are known to guard their knowledge regarding boat making and fishing and only share it with those within the Muslim community leaving the Mijikenda somewhat behind in their fishing practice (Carter 2012).

In 2007 the Beach Management Unit (BMU) regulation was enacted in Kenya, to engage the local community with the management of fisheries resources (State Department of Fisheries 2013). BMUs are involved with law enforcement, beach development, collection of fisheries data and conflict resolution. They are made up of local fishers and community members with a chairman, secretary and treasurer voted for by the members.

2.5.2 Case study site description

Mida Creek is a body of water covering 32km² bordered by three tidal flats and surrounded by mangroves. The bed of the creek is covered with eleven different species of seagrass and it is an important habitat for migratory birds and breeding ground for fish and turtles (Carter 2012). It was designated as a marine reserve in 1968 alongside the neighbouring Watamu Marine Park. Fishing is allowed in the reserve and Kenya Wildlife Service is responsible for enforcing fishing regulations. There are 11 villages with landing sites bordering the creek, with an estimated population of over 9000 in 2011. The people living near the creek are mostly Giriama (a subdivision of the Mijikenda) and until the 1950s rarely engaged with fishing (Carter 2012). Early fishing attempts included using traps and were mainly for subsistence purposes. By the 1960s and 70s modern nets and fishing lines became available as well as small mesh nets as the market for fish began to expand, shifting fishing from a subsistence to a commercial activity. During the 1980s and 90s, fishers reported that there was an increase in the use of small mesh nets and also a decline in catches (Carter 2012). Recent estimates have put the number of fishers in the creek between 400 and 800, most of whom use dug-out canoes or fish on foot using lines, gill-nets, seine-nets, small mesh nets, spears and spear guns, poison and fish traps (Carter 2012).

There are various community and conservation organisations based in the villages around the creek which have come to together to form the Mida Creek Conservation Community (MCCC) group, the objectives of which are to encourage conservation action within the community and to be a torchbearer for environmental conservation. The group is reported to have developed in response to the declining number of fish in the creek and degradation of the mangrove habitat (pers. com. Benjamin, MCCC chairman). Whilst there are recognised landing sites at Mida creek, there is as of yet no formal BMU.

In the most recent census the government estimated there were a total of 1,960,574 people identifying as Mijikenda, and 110,614 as Swahili in the coastal province. In addition four times as many respondents self-identified as Giriama than Swahili or Bajuni (an ethnic group related to Swahili) in a socio-economic assessment of fishing

communities along the Kenyan northern coast (Cinner & McClanahan 2006)Although the Swahili dominate the beyond-reef artisanal fishing, the Mijikenda are entering the fishing community rapidly to satisfy subsistence and this case study will therefore have clear relevance for many sites along the Kenyan coast.

Carter (2012) conducted an intensive anthropological study at this site to understand the relationship between tourism, conservation and development. She defined the unit of study for her conventional household monitoring survey as the locally relevant "homestead". That is, one S*hamba* (Kiswahili for farm or family land) where an extended family - all answering to the same head - live together in a cluster of houses, generally facing inwards to a central point where people cook and eat. This was a locally relevant definition of a household and readily understandable for survey participants and assistants. The head of a Giriama household, from which the family gets their name, is usually the oldest man. If he has passed away then headship passes to his first wife (and then subsequent wives) and after that his oldest son (Carter 2012). The location of study villages in relation to the creek are shown on (Figure 2-7).

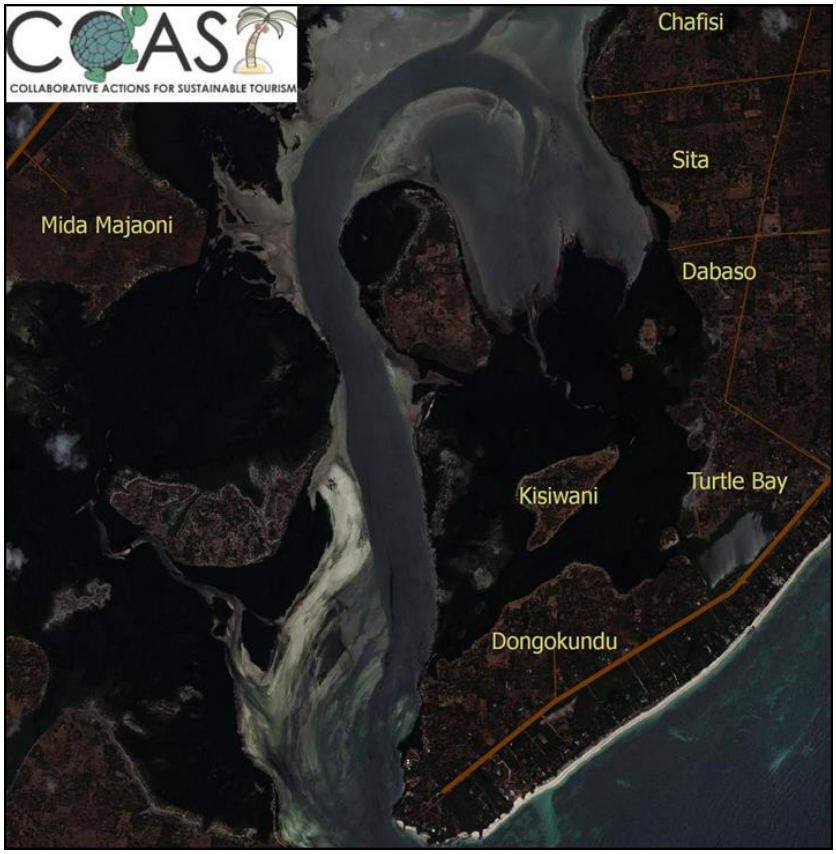

Figure 2-7: Satellite image of Mida Creek showing study villages and main roads. Kindly provided by the UNIDO COAST project.

3. Methods

3.1 Extensive expert and key informant survey

3.1.1 Expert opinion across coastal East Africa

Using a contact list compiled with the research network CORDIO, I contacted conservation and development practitioners along the east African coast by email to gather expert opinion on the practice of MNF. I received information from nine experts, was offered photographic evidence and searched for publications mentioning MNF with regard to a specific locality. Thus I collected evidence for 25 sites from 16 different sources (Table 3-1). I queried the sources as to the extent of MNF at their respective sites and their observations of the demographic of the fishers involved.

Table 3-1: Sites and sources of expert witness regarding MNF in coastal east Africa

Country	No. Sites	No. Sources	Organisations
Kenya	3	3	A Rocha Kenya, Imperial College London, University of Oxford
Tanzania	12	7	Care International, Frontier TZ, IMS Zanzibar, IUCN, MRI Zanzibar, SeaSense, WWF TZ
Moçambique	7	4	Maritime Authority, Universidade Lúrio (UniLúrio), ZSL
Madagascar	3	2	Frontier, C3

3.1.2 Key Informant Interviews from Coastal Kenya

Between May and June 2013 I conducted twelve semi-structured interviews by email, phone and in person at various sites along the Kenyan coast between Mida Creek and Kibuyuni. Informants were chosen from BMUs, conservation organisations and tourism operations. I collected data concerning the position and experience of the informant with regard to their locality, their understanding of how MNs have been distributed and opinion on MNF; whether it occurs, what demographic of people are involved, what they catch and why (see appendix I).

Seven of the informants were fishers, two were conservation practitioners, one was an environmental science student and another was a community health worker. All

informants were male and lived within 6km of their fishing site. All informants had been associated with the site since birth or at least over two years apart from one conservation practitioner at Kuruwitu who had been at his post just nine months and could not complete all questions in the interview.

After seeking permission from the Provincial Malaria Focal Person, I interviewed the District Malaria Control Coordinators (DMCCs) for four coastal counties to triangulate information regarding MN availability and to ascertain their understanding of alternative net uses.

3.2 Intensive household survey

I conducted a household survey with senior representatives of homesteads (as described previously) from seven villages bordering Mida Creek in the Gede/Watamu administrative zone of the Kenyan Coast Province between 6/6/13 and 28/6/13.

3.2.1 Selection of homesteads for interview

In the absence of a census list I worked with the AphiaPLUS Community Health Network to identify the study population. AphiaPlus is an USAID funded health program which recruits active community-minded local leaders as Community Health Workers (CHWs) to lead health initiatives. Each CHW oversees 20 – 30 households neighbouring their own. I was introduced to all of the CHWs whose neighbourhoods bordered the creek by the lead CHW for Dabaso. I met with each to map their neighbourhood identifying homesteads by family name. From initial estimates of population size we planned to interview half all homesteads in each neighbourhood due to time constraints. For each neighbourhood we numbered the homesteads and picked a random sample by blindly picking numbered pieces of paper out of a bag. We were introduced to each homestead by the CHW and interviewed the most senior member available according to the Giriama family structure as described previously.

3.2.2 Data collected from homesteads

The survey consisted of four sections (see appendix II):

(1) "About the Homestead" covered gender, age, education and occupation of every family member, wealth characteristics of the homestead, membership of community organisations and ethnicity.

(2) "About Health" covered the health of the family, their experience of malaria in the last year, the range of malaria protections they currently use including MNs.

(3)"About Fishing" queried their involvement with fishing, what gear they use, the frequency they go fishing, what they catch and the community perceptions of MNF.

(4) A "Timeline" activity to chart perceptions of fish number and size in the creek over the lifetime of the interviewee. We established the first memory of the interviewee, charted significant life events from that point until the present day and then used this personal timeline to interrogate the respondents perceptions of change in the fishery by drawing trend lines.

See Figure 3-1 for photographic record of surveys.

Figure 3-1: Conducting the homestead interviews. (A) Kirao completing a timeline activity. (B) Kirao interviewing a female representative of a homestead. (C) Emma picking a random sample of homesteads with the help of some children.

3.2.3 Data analysis

The interview transcripts were entered into a database and coded appropriately to enable data analysis. Open-ended answers, such as to the question "Give three good reasons for using MNs?" ,were grouped into categories using an iterative process by myself once all data had been collected. All statistical tests were performed in R (R Core Team 2012).

Material Style of Life (MSL). MSL is a method of measuring wealth based on the presence or absence of household possessions or structure (Cinner & McClanahan 2006). We used Principal Components Analysis (PCA) using package gdata in R (Warnes et al. 2013) to create an indicator from the wealth data we collected.

Univariate Analyses. I recorded MNF at the homestead level due to sensitivities attaching an illegal activity to individuals, and therefore demographic variables had to be collated and analysed accordingly. For parametric data we used t-tests and for non-parametric data, Mann-Whitney and Binomial tests, testing for significance at the p=0.05 level. Due to the small sample size we limited the data analyses to univariate contrasts regarding the source of MNs and the MN fisher demographic. To obtain an index of occupation diversity for the homestead I divided the number of occupations listed in a homestead by the number of adults.

Timeline: The data collected from the timeline activity included the direction and speed of change in both fish abundance and size in the creek for each year since the first memory of the interviewee. The categories included rapid decrease, steady decrease, constant and steady increase in fish abundance and size. The percentage of respondents for each year listing one of these categories was calculated and displayed in graphic form to show the strength of agreement in community perception of change. This was used alongside the qualitative explanations given to understand the reasons behind these perceived changes.

3.2.4 Translation and assistance

Interviews were conducted in person in the local dialect Kigiriama by Kirao L. Kithi, a locally born environmental science student at Pwani University, fluent in

Kigiriama and English who was employed as research assistant for the project. The survey was prepared by myself and modified with Kirao after an initial pilot. We practised interview techniques through role play before starting data collection and Kirao showed a quick and thorough grasp of the project aims and methods. I was present for over half of the interviews and we processed all interview transcripts together to identify gaps and clarify answers. We regularly discussed our findings and Kirao's extensive knowledge of the locality and experience fishing in the creek as a child were invaluable in both gaining the trust of survey participants and grounding my interpretations within the local context.

3.2.5 Ethical considerations

We were granted permission for our research from the Chief's office at Gede, the Public Health Officer of Gede Health Clinic and the chairman of the Mida Creek Conservation Community group (MCCC). The homestead interview lasted between 0.5 and 1.25 hours and after consultation with key informants we gave a culturally appropriate gift of 1kg maize flour and 250g sugar to each participating homestead to thank them for their time and knowledge. This proved to be conducive to the research, particularly for the CHW who felt that their time given voluntarily was rewarded, through the bringing of gifts to their neighbourhood. At each homestead we introduced ourselves in the traditional manner and explained the scope and aims of our survey to each interviewee before asking their consent to continue. We were never refused and participants appeared keen and interested to take part. At the end of the research period we presented preliminary findings to a small group of local leaders representing the community health network and conservation organisations. We invited their comments and corrections and they confirmed the relevance and interpretation of our results regarding the creek fishing community

4. Extent of MNF in coastal east Africa and Kenya

4.1 Expert opinion from east Africa

From expert sources I formed a picture of widespread MN use for fishing throughout the east African coast (Figure 4-1). When experts reported that, to the best of their knowledge, fishers did not use MNF (e.g. Zanzibar and Mafia Island in Tanzania and the Quirimbas Islands Natrional Park in Mocambique) the observations were associated with comments about the efficacy of authorities in enforcing gear bans in these protected areas. As these results are based on non-uniform observation data we cannot be sure of the absence of MNF where experts have stated.

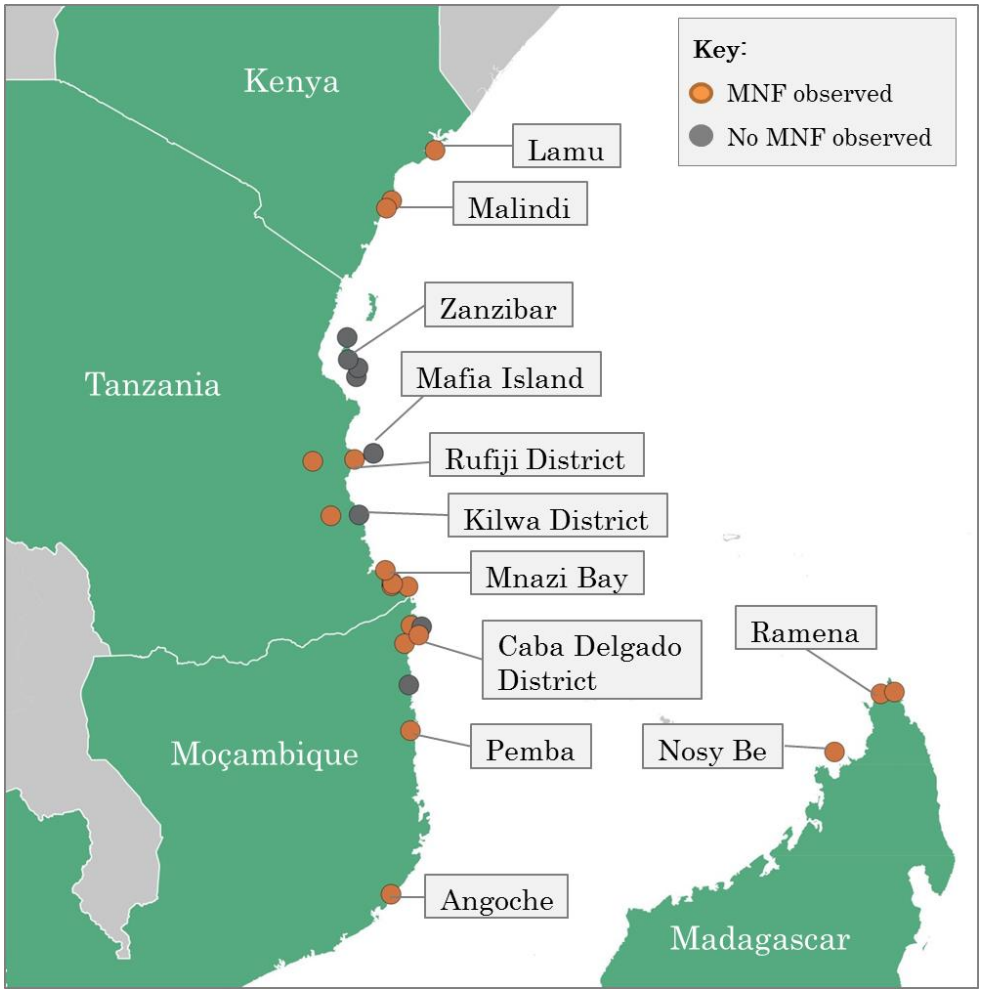

Figure 4-1: Expert witness observations regarding MNF in coastal east Africa.

Otherwise MNF was reported as a common but varied practice at all other sites, involving a wide demographic: adult men and women, teenage boys and girls and young children.

> *"In the whole Rumaki area the technique is called "kutanda". The technique involves a net set by two ladies. One edge of the net is lowered to touch the bottom while the other is raised. The third (and fourth, if any) wades across the shallow water to scare fish into the pre-set net by making waves. Hauling is done when the wading person reaches the net. "*
> ***Hajj Machano, conservation practitioner with WWF Tanzania***

Moreover various habitat types were referred to in the experts' responses, including mangrove creeks, estuaries, seagrass beds and intertidal mud flats and rocky / reef platforms. Most reported observing fishers using MNs as a beach seine type net operated by two or more fishers, without a boat, fishing from shore, the one exception being a report from Mozambique which detailed MNs fitted as the cod-ends of seines operated from boats. There was also a suggestion that MNs are associated with tandilo fishing, a traditional fishing practise using cloths.

> *"Mosquito nets are an 'upgrade' from kangas... the cloth skirts they wear... with which they previously used to fish"*
> ***Rhona Barr, researcher with Care International familiar with Mnazi Bay, Tanzania.***

4.2 Key informant surveys from Kenyan coast

4.2.1 Fishing sites

Eight of the twelve key informants reported that MNF occurred in their locality (Figure 4-2). The four that did not were fishers and senior members of the BMUs responsible for enacting fisheries legislation at their landing site. One fisher at Gazi gave evidence that later in the interview he contradicted and an interview with a research scientist at the same site confirmed that MNF did occur there. The remaining three negative answers were accompanied by responses such as "they used to do it before, but not now" and it happens "in other places" referring to neighbouring BMUs. All were however able to describe the practice in detail.

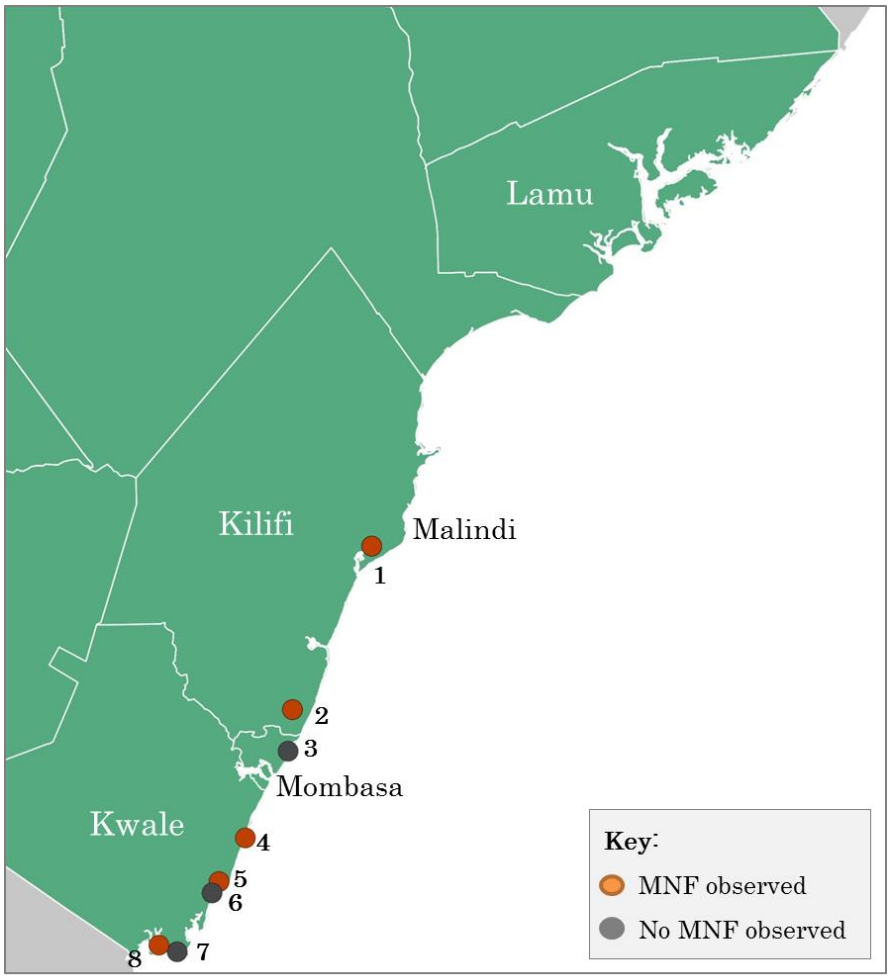

Figure 4-2: Key informants observations along Kenyan coast. 1. Mida Creek: AphiaPLUS, A Rocha Kenya, Mida Creek Conservation Community. 2. Kuruwitu: Beach Management Unit (BMU), Kuruwitu Conservation and Welfare Association. 3. Bamburi, Mombasa: BMU. 4. Diani: BMU. 5. Gazi: BMU, Kenya Marine and Fisheries Research Institute. 6. Mwasambeni: BMU. 7. Wasini: BMU. 8. Kibuyuni: BMU.

Regarding the demographic involved in MNF, six of the informants described young people, four mentioned adult women, four mentioned adult men and two referred to migrant Tanzanian fishers.

> *"Tanzanian migrant fishers come in groups and fish illegally. They tie the MNs with other nets and use with sticks... they use the sticks to break the corals and then scoop the small fish with the net. The Tanzanian migrants don't bother because they can move South Coast to North Coast"*
> ***BMU treasurer at Bamburi Beach, Mombasa***

As to why people participated in MNF the answer given varied by who the informant thought was doing it, a common answer regarding children was that they were "playing" at being fishermen, learning to fish with a gear that wasn't valuable. Others referred to adults using MNs at certain times of the year when a specific catch was abundant.

> *"It is... youth / teenagers, not able to buy gears, fathers might be fishermen and they are training to be fishermen, not taking themselves so seriously"*
> ***Conservation Practitioner at Kuruwitu Welfare and Conservation Association***

> *"Young boys and girls...they go to play especially around the prawn lake. Sometimes they don't have money to buy new fishing nets, this is a hobby and they go there for fun. The owners of the fishing nets don't want children to use them so they take MNs instead"*
> ***Lead Community Health Worker at Mida Creek***

Small fish (referred to locally as *omena, dagaa, taffi, pono, sulli sulli, chaa*) and prawns were reported as target species. Informants described varied habitats in which MNF took place including creeks, shallow water, on the reef, on the beach, where the river enters the sea, tributaries and also in avoidance of fisheries regulators:

> *"[MNF occurs]...not just anywhere, only where harder to see, away from landing site, sometimes at night to avoid patrols".*
> ***BMU secretary at Mwasambeni***

Most informants agreed that MNs had been made available in recent years through mass distributions and maternal distributions to pregnant mothers and children under five, or at clinics for the small sum of KES 50 (USD 0.57) to anyone else. Nets

were distributed by a combination of government and private sector initiatives at times of malaria endemic where households were registered and received nets according to the number of beds. Four informants referred to the mass distribution of 2012 as the most recent. However there is leakage in this system as one informant reported:

> *"If pregnant women go to the clinic they can get more than one. Recently a mother got three and gave one to me."*
> ***Environmental science student, key informant for Mida Creek***

Informants were asked to list up to three good reasons and three bad reasons for doing MNF. The most popular good reason (7/12) was that using a MN brought in a good reliable and fast catch. Three informants insisted there were no good reasons for MNF. Another three referred to the importance of getting something to eat for the family, whilst the rest talked about how MNF was non-technical and could be operated by children and that it provided a form of employment. The most common bad reasons for MNF were jointly (6/12) the illegality of the practice and the habitat degradation caused by the technique. Others were concerned about removal of juvenile fish and the effects on the fishery (4/12), the toxicity of the insectide (3/12), disrupting the food chain (3/12), removal of eggs, child labour and an alternative use of a net designed for malaria protection.

4.2.2 Health districts

The DMCCs from the four coastal districts confirmed there had been mass distributions of nets in the coastal region in the last couple of years. The DMCC for Kilifi stated that in 2011, 262,220 nets were distributed to approximately 0.5 million people in the coastal region. There were three ways nets have been made available; mass distributions, maternity clinics and sold in private shops. The respondents clarified the rules concerning MN distribution via the maternity route:

> *"The Policy is that these nets are to be issued to all pregnant women and children under the age of one year during their visits to the clinic. The rule is one net for one pregnancy and one net for one infant. The nets are free of charge. Health education is given on how to use the net usually by the one issuing the net on one-to-one or health talk in a group."*
> ***District Malaria Control Coordinator for Kwale County***

When asked if they were aware of MNF and other alternative uses of MNs the DMCCs answered "yes" but did not express much concern about the issue. There appeared to be no active program in place to minimise alternative net use and most education centred on proper use of the net to prevent malaria, rather than disposal or against alternative use.

> *"There has been a general talk that mosquito nets are being used for purpose outside the intended purpose. I have not witnessed this and the research shall be able to separate truths from mere rumours!"*
> ***District Malaria Control Coordinator for Kwale County***

> *"Yes I am aware of the mosquito net fishing, it is not very common. Other alternative use... window screening. For torn nets, they are used to protect plants and chicks."*
> ***District Malaria Control Coordinator for Malindi***

In general the DMCCs and the Provincial Malarial Focal Person were keen to participate in the research and positive about the opportunity for collaboration on this issue.

5. MNF at Mida Creek, Kenya

5.1 Description of the community

I surveyed 51 homesteads at Mida Creek covering 1008 people. Average homestead size including children was 19.7 people and six acres. All homestead representatives self-identified their ethnicity as Giriama. 78 of 432 adults were listed as fishers, most of which were male (75 out of 78) and in the age bracket 20 to 40 years (43 out of 78). There was no difference in level of education between fishers and non-fishers (mean rank education: fishers 2.3, non-fishers 2.4).

Regarding the MSL analysis, the first principal component (PC1) emphasised housing material -high values associated with advanced roofing and wall materials - the number of vehicles per adult and the presence of tapped water (Table 5-1). The second principal component (PC2) described the rural/urban divide; those with high scores were associated with larger areas of land and numbers of goats per adult, whereas those with negative scores were more likely to have electricity, vehicles and tapped water. PC1 makes most sense in reference to wealth and I used this to give a numerical wealth score to each homestead for further analysis.

Table 5-1: Summary of results from material style of living PCA. PC = Principal Components.

Factors	PC1	PC 2	PC3
Roof material (1=makuti thatch, 2=iron sheets)	0.61	0.16	-0.02
Wall material (1=mud thatch, 2=coral rock, 3=cement)	0.55	0.15	-0.15
Tapped water	0.38	-0.07	0.61
Vehicles per adult	0.27	-0.20	-0.51
Goats per adult	0.14	0.67	0.10
Electricity	0.12	-0.45	0.52
Land per adult (acres)	-0.27	0.51	0.26
Eigenvalue	2.17	1.45	1.06
Variance explained (%)	31.0	20.1	15.2

Wealth varied considerably by village (Figure 5-1). Turtle Bay with the highest mean wealth score is closest to the town centre and the main road with more expensive housing made from coral rock and iron sheets and greater access to electricity and tapped water. Kisiwani - an island amongst the mangroves - had the lowest mean

wealth score and is the most remote, with no tapped water or electricity available other than solar.

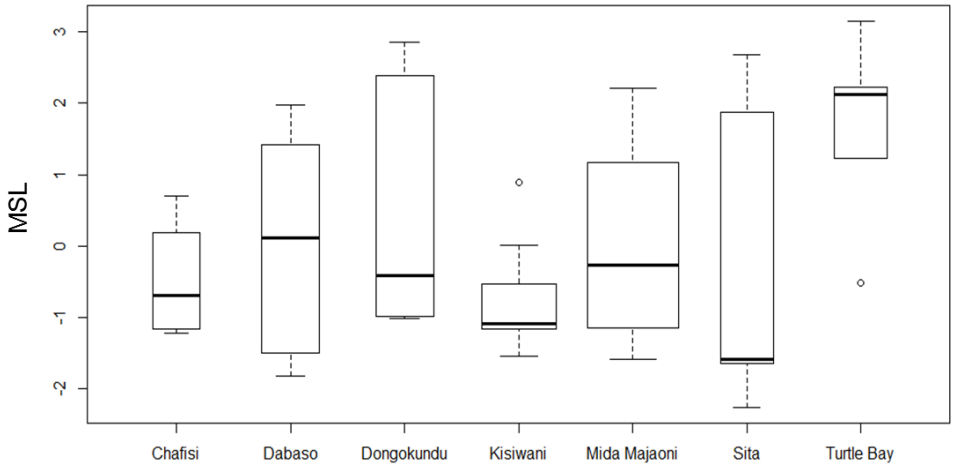

Figure 5-1: Box plot of wealth (MSL index) by village.

5.2 Fishing gears, catch and frequency

The majority of homesteads in our sample (48 of the 51) accessed the creek for fishing and 23 described using a MN amongst their fishing gears. MNs nets were the second most popular gear alongside nets with mesh size over one inch and after fishing line (Figure 5-2A). Fish, crabs and prawns were the most popular catch groups targeted, with some homesteads also reporting catching rays, squids and turtles (Figure 5-2B).

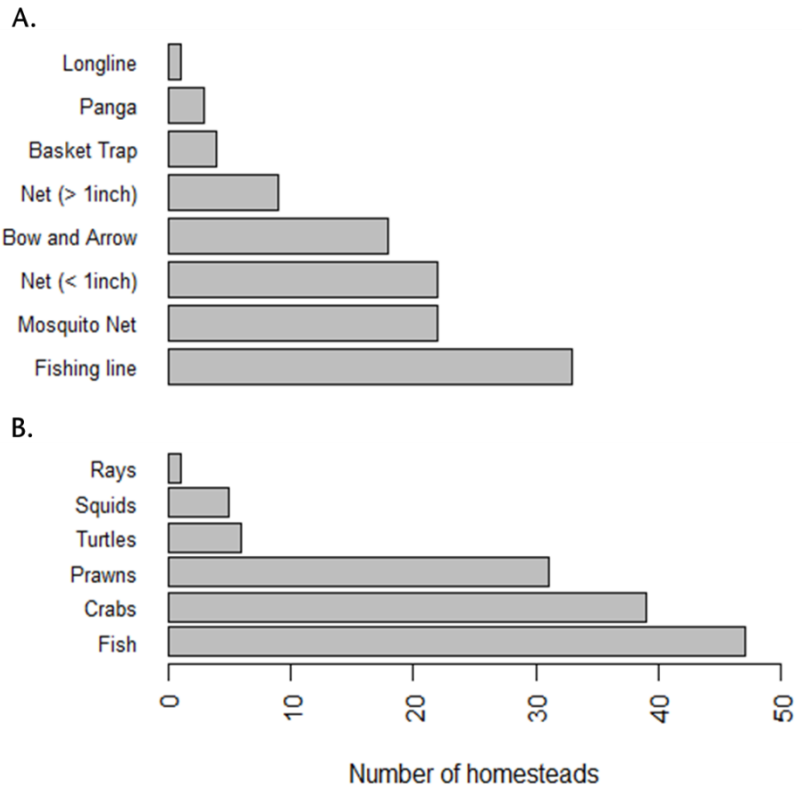

Figure 5-2: A. Gears used by each fishing homestead. B. Catch targeted by each fishing homestead.

MNF homesteads fish no more or less frequently than non-MNF homesteads (Fisher's exact test. P=1; Figure 5-3). Most homesteads reported fishing more than once a week but less than every day.

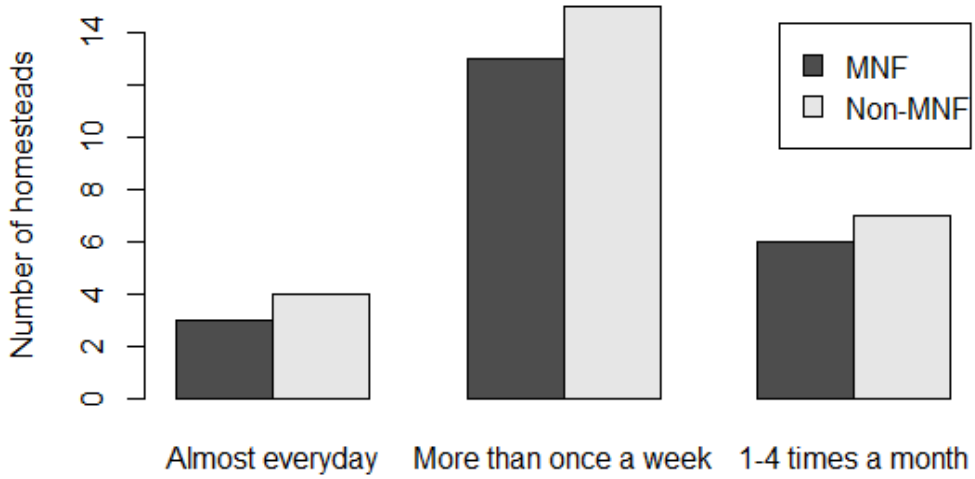

Figure 5-3: Frequency of fishing activity for MNF and non-MNF homesteads

Figure 5-4: A-F Photographic evidence of MNsadapted for fishing at Mida Creek. Photos by E.R. Bush 2013

5.3 Source of MNs used for fishing

Of the 23 homesteads engaged in MNF, just one reported buying the net especially for fishing; another used an unused extra net, whilst the rest fished with old used nets. There was no indication that MNs were more or less available in homesteads that did MNF, with a mean of 0.57 nets per person in MNF homesteads and 0.56 nets per person in non MNF homesteads (T test, n=51, t = 0.2011, df = 46.085, p=0.8415). The mean proportion of people in each homestead who slept under a net was the same for MNF and non-MNF homesteads, 0.91, although MNF homesteads showed a greater spread within the interquartile range than otherwise this difference was not significant (Mann-Whitney test, n=51, W = 174.5, p=0.07; Figure 5-5). MNF at Mida Creek is generally undertaken using old MNs that have already been used as malarial protection and have been replaced by new MNs.

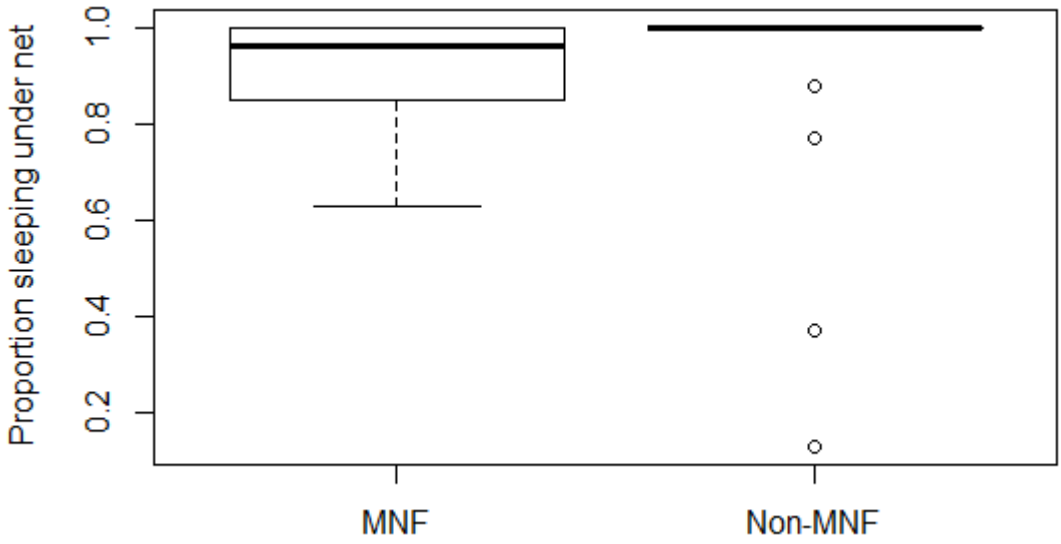

Figure 5-5: Proportion of people in the homestead sleeping under a MN at night compared between MNF and Non-MNF homesteads.

There were three main ways that homesteads obtained MNs; private sale, receiving them from mass distributions or from maternal distributions. Of the 51 homesteads visited, 43 reported having received MNs through mass distributions; followed by 14 having bought them and eight having received through maternal distributions (a homestead could report more than one source). There was no evidence the source of MN had any effect on the likelihood of MNF (Binomial test, X-squared = 0.071, df = 2,

p=0.9651). The use of MNs for fishing does not appear to decrease the number of people using a MN as malaria protection.

5.4 Describing MNF homesteads

Wealth, education and occupation diversity had no effect on the likelihood of a homestead engaging in MNF (Figure 5-6). MNF homesteads were no more or less wealthy than others (T test, n=51, t = 0.3689, df = 44.524, p=0.714). Average level of education (total of education ranks / number of adults) had no effect on likelihood of MNF (T test, n=51, t = -0.773, df = 44.445, p=0.4436). Those homesteads that engaged with MNF were no more or less limited in their options regarding occupations than otherwise with an overall mean of 0.6 occupations listed per adult (T test, n=51, t = 0.4369, df = 48.927, p=0.6641). However we did find that the proportion of adults listed as fishers in each homestead was negatively correlated with MNF it was not significant (W = 237, p=0.09524 Mann-Whitney test, W=237, p=0.95).

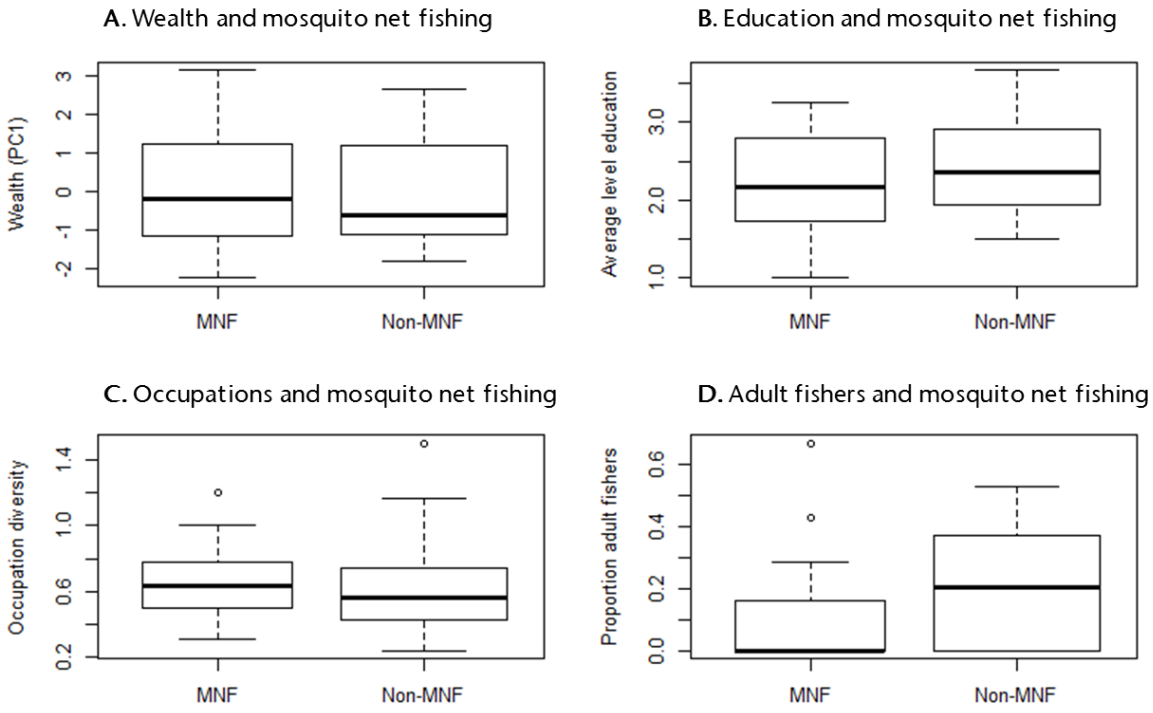

Figure 5-6: Comparisons between the A. Wealth, B. Education, C. Occupation diversity and D. Proportion adult fishers in MNF and non-MNF homesteads.

Most fishers at Mida creek were adult men and children. However there was no clear pattern between age and gender for those involved in MNF and not (Fisher's exact

test, p=0.44; Figure 5-7). Homesteads where only the adult men fished were equally as likely to be engaged in MNF as not, whereas homesteads where only the children fished were less likely to be engaged in MNF. Only one homestead listed female fishers alongside children.

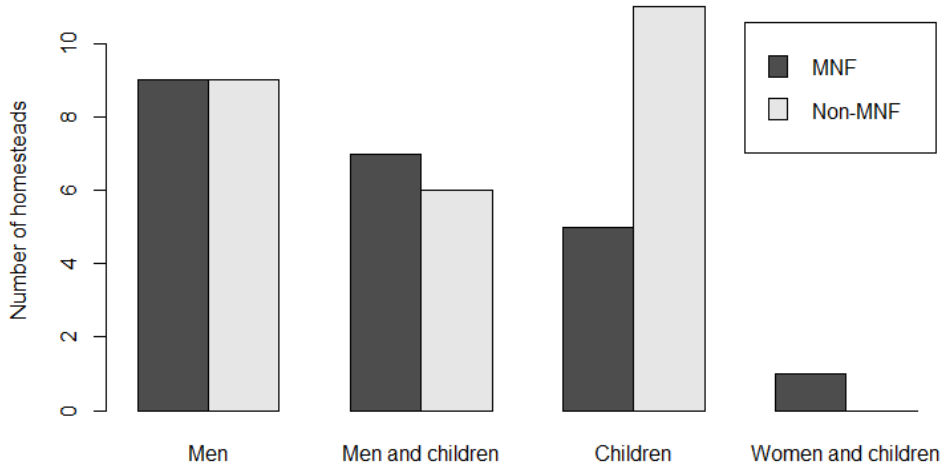

Figure 5-7: Demographic of fishers involved in MNF.

5.5 Reasons for MNF

Over half of the MNF homesteads listed prawns and /or juvenile fish as the main target catch (Figure 5-8). Ngogo, a type of cat fish (*Plotosus lineatus*), was mentioned three times with the explanation that the backward pointing, venomous spines get caught in other larger mesh nets and damage the fish. These fishers claimed to only use MNs when the Ngogo entered the creek once or twice a year. Crabs, rays and squids were also mentioned as target catch.

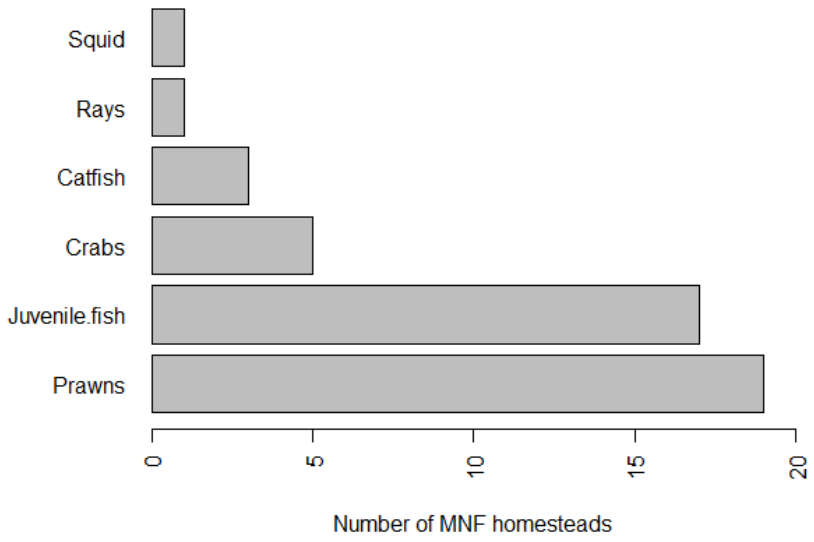

Figure 5-8: Target catch listed by homestead when MNF

Of the 23 homesteads that practised MNF, 20 gave the purpose as finding food for domestic use; twelve also said they sell whatever is surplus to domestic need, and three indicated fishing solely for commercial reasons. Those that sold all or some of their catch also claimed to fish more often on average than those who fished purely for subsistence (Figure 5-9).

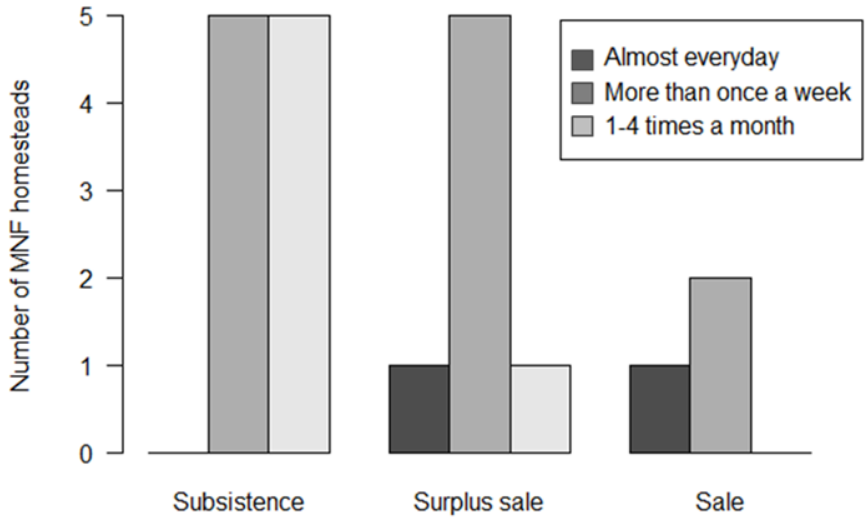

Figure 5-9: Purpose (subsistence vs. sale) and frequency of fishing for MNF homesteads.

When respondents were asked what they used to fish with before MNs, over half (12/23) replied that they didn't target small fish before, so they used bigger nets, whilst others referred to tandilo fishing using cloths or sacks. Still others answered that they didn't fish before or that they didn't know.

The respondents were asked to list up to three good things about MNF and three bad things, including none-MNF homesteads as long as they were aware of it. Many struggled to find three for each. A full description of the answers can be found in Figure 5-10. The most common good answers were to do with "use", that MNF provided food and a livelihood. Many insisted there were no good reasons at all. Others referred to the efficiency of the net for the target catch species. The most common bad answers were to do with the catch, that the net takes juvenile fish and removes fish eggs from the water. Also that it is illegal and that MNs should be used for malaria protection not fishing.

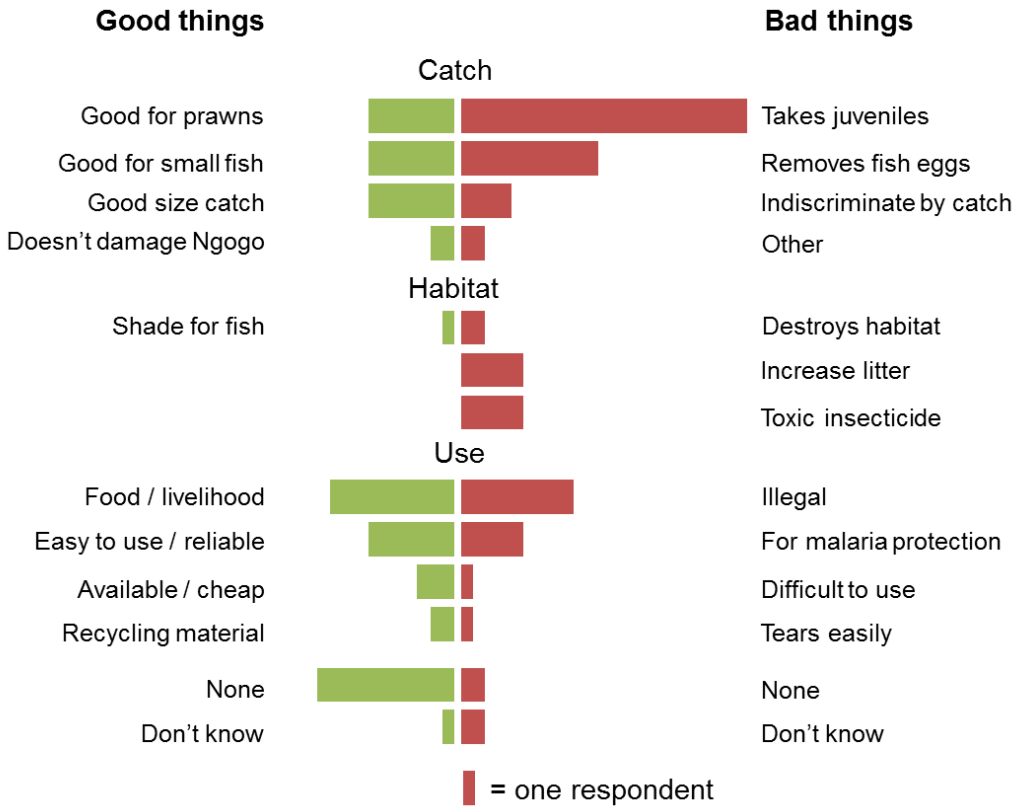

Figure 5-10: Good and bad things about MNF, listed by survey respondents. Each respondent could list up to three good and bad good things.

5.6 MNF strategies

From observations during data collection and discussion with my research assistant I characterised different strategies for MNF. The community referred to three distinct groups involved with fishing at the creek, these were: "Children", referring to a

gender mixed group from the age of walking up to 20 years old; "Young boys", rather confusingly referring to men in their early to late 20s who live at the family homestead, may be married but are still regarded as junior within the family structure; and lastly "Serious fishermen", elders who list fishing as a main occupation and fish more than once a week, often most nights, have some social standing in the community and hold membership to various community conservation and self-help groups.

In conversation, key informants and respondents most commonly described MNF being undertaken by children and young boys, which rather underestimated the community involvement. Children did indeed practise MNF as we have shown, however they were no more likely to be MNF than using other gears to fish such as fishing lines and pangas. And however informal or playful the activity was, it had an important role contributing to domestic food supply.

> *"Fishing [MNF] is good because you can get money. If you cook your food and there is nothing to go with the Ugali, then you can go to the fish pond and get some fish to eat with the food."*
> ***10 – 20 year old male, student, Dongokundu***

The serious fishermen were the most reluctant to talk about MNF, perhaps because of their awareness of its illegality and their standing in the community. The three who referred to fishing Ngogo with the MNF would be classed in this category. They had access to other fishing gears, including canoes and justified using the MNs once or twice a year to target Ngogo, not to indiscriminately sweep for fish and prawns.

Lastly, the young boys or young men as we should call them; some were fishing in between casual labour jobs, whereas others were fishing frequently using MNs alongside other gears. The young men had the most intricately sewn fishing nets from MNs with foot loops, weights and floats. It appeared that they had grown up MNF, developing the activity as their skill and strength had improved. In certain areas of the creek where community conservation activities were weakest, we found these young men to be the most ignorant as to the possible ecological impacts of MNF, or at least the most defiant to its illegality.

5.7 Relationship between MNF and fish stocks

Most interviewees perceived that both fish abundance and size had decreased over the last fifty years (Figure 5-11). The oldest interviewees were able to remember back to 1962, the year before independence in Kenya. The earliest memory of first MN use as malaria protection was in the late 1970s.

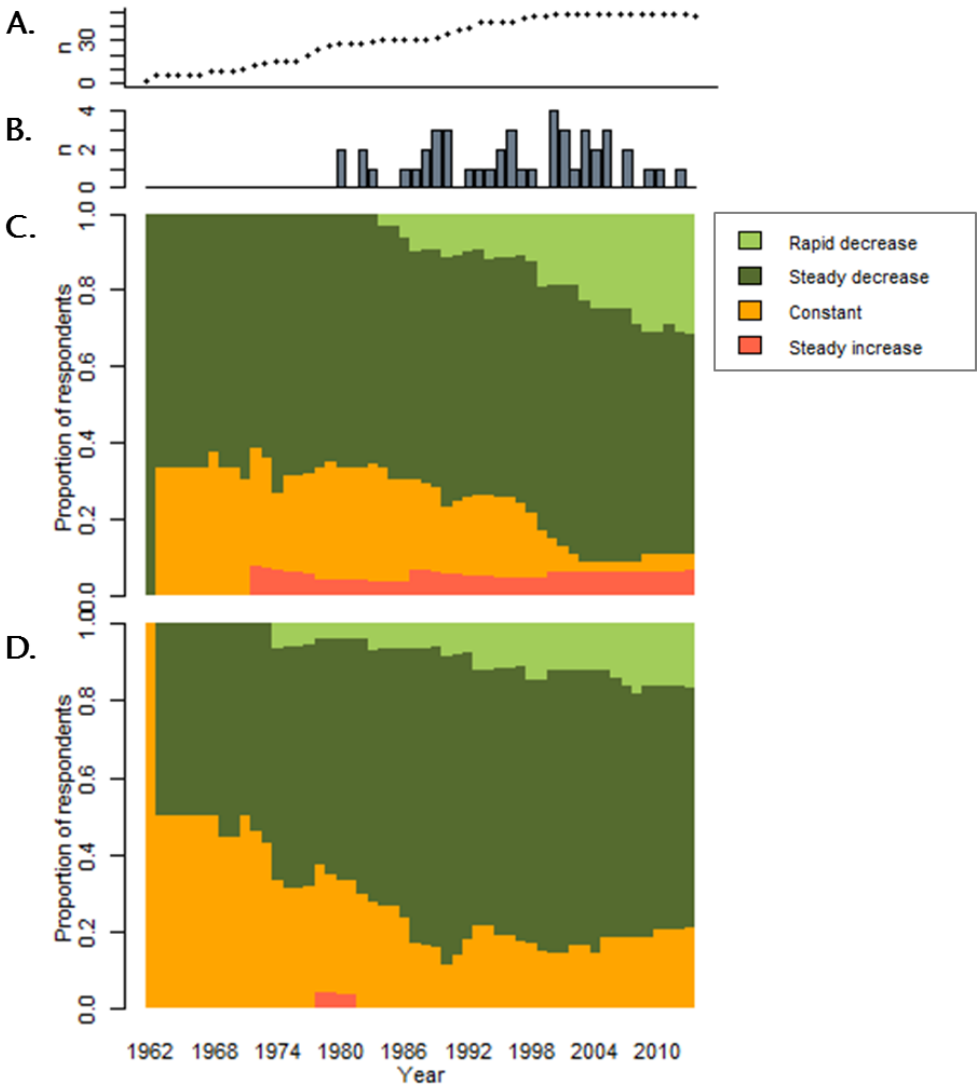

Figure 5-11: Community perception of change in fish stocks at Mida Creek. A. Number of respondents with memory of each year. B. Number of respondents reporting first use of MN as malaria protection in each year. C. Perceived direction of change in fish abundance. D. Perceived direction of change in fish size.

The most common reasons given for a decrease in fish abundance were to do with social change and fishing methods such as population growth and more fishers as well as small mesh gears (Table 5-2).

Table 5-2: Reasons given for perceived direction of change in fish number and size at Mida Creek.

	Reasons for change	Number (n)	Size (n)
Social change	**Decrease (total)**	30	10
	More fishers	25	9
	Population growth	8	1
	Poverty	2	0
	Increase (total)	2	0
	Less fishermen	1	0
	Community management	1	0
	Better management	1	0
Fishing methods	**Decrease (total)**	17	12
	Small mesh nets	8	1
	Fishing gears	7	3
	Poison	4	1
	Illegal fishing	3	0
	Targeting juvenile fish	0	7
Habitat and climate	**Decrease (total)**	9	3
	Climate change	7	0
	Pollution	3	1
	Cutting mangroves	1	0
	Habitat damage	1	3
	Increase (total)	1	0
	Replanting mangroves	1	0
	None / Don't know	9	22

These quotes demonstrate the perception of increased fisher numbers:

> *"Now there are many fishermen and also children fishing, a long time ago this was very rare, now there are not many fish, a long time ago there were a lot."*
> ***20 – 40 year old female, farmer, Mida Majaoni***

> *"There used to be just one or two fishermen at night, now there are many at night. There has been a change, people are becoming more and more and the fish are now decreasing. Long ago there were many fish but no market. Now there is a market but no fish."*
> ***40-60 year old male, farmer, Mida Majaoni***

Two of respondents insisted that fish numbers were increasing. Interestingly these were not fishers, but those that bought fish and reasoned that as they saw more people going to the creek and selling fish now than before there must be more fish.

> *"In the days past we had to go looking for fish down Turtle Bay, now people come to us selling fish everyday"*
> ***40-60 year old female, farmer, Turtle Bay***

Another linked his perception of increased fish abundance in recent years to the improvements in community organisation and mangrove replanting.

> *"[In the 1980s] there was illegal cutting of mangroves and there was nowehere for fish to hide, people were also using poison in the channel. Then people enrolled into groups such as MCCC and self-help groups and started replanting mangroves to create nurseries for fish to hide."*
> ***40 – 60 year old male, fisherman, tour guide and CHW, Sita***

The majority of respondents perceived fish size to have decreased and explained this trend with reference to fishing methods, such as the targeting of juvenile fish, alongside social reasons such as more fishers.

> *"Fish are being caught everyday so they do not live to grow, and some people are using guns to kill big fish which lay the eggs."*
> ***20 – 40 year old female, gardener. Dongokundu***

> *"There is illegal fishing and catching of juveniles, the big fish prey on the juvenile fish, so where there are no juvenile fish, the big fish can also not be found"*
> ***40 – 60 year old male, night watchman, Mida Majaoni***

Few respondents thought fish size was increasing; however a substantial proportion perceived that size had remained constant. Many more respondents answered "don't know" in reference to fish size over abundance and found it difficult to describe and explain this trend

When asked to give the community view of MNF and their recommendations for the future, respondents gave varied answers. Many stated that the community viewed MNF negatively and discouraged it because they were aware of the consequences for the marine ecosystem. However this view wasn't universal as is well described by this respondent:

> *"The community has different views, let your son fish because he is getting some food, while others discourage because destroying the fish. It is very rare to find an old man using MN to catch juveniles. I advocate small net fishing to be stopped but what else can we do? We can't find big fish now. This is just a creek, if we had access to capital we could go further out to deep sea, because no capital, overexploited this area."*
> ***40-60 year old male, farmer, Mida Majaoni***

Others explicitly described the community involvement with and reliance on MNF, whether directly or through purchase of small fish for relish.

> *"The community cannot view MNF as bad because they know the person who is using it is just making a living. "*
> ***40-60 year old male, hotel cook, Mida Majaoni***

Many respondents asked for government help to exchange illegal gears and buy costly legal gears. One respondent described the cost of the one inch meshed net, most closely corresponding to a MN, as at least KES 2000 (USD 22.83) .

> *"If we could get an alternative method it would be good. A 1" net costs KES 200 per metre, and you would need 10m for a net so it is very expensive."*
> ***40 - 60 year old male, carpenter, Dongokundu***

6. Discussion

6.1 Results in context of aims

The aim of this project was to collate observations and experience from experts and local communities, using extensive and intensive social survey methods, to begin to describe and explain the extent, frequency and character of MNF and to form the baseline for further study.

6.1.1 Extent MNF

The weight of expert witness portrays MNF as a common activity throughout Kenya and the east African coast making use of an abundant resource made available through health distributions. However there is much heterogeneity amongst MNF behaviours and the demographic of fishers involved. The responses from experts throughout east Africa routinely pointed toward "non-normal" fishers - women, children, migrants and hobby fishers – those marginalised from community management structures such as BMUs. Indeed all BMU representatives involved in the Kenyan key informant survey were Swahili men, representative of beyond-reef fishers bringing catch into landing sites, officially registered and operating within community management frameworks. They showed a great awareness of the illegality of the activity and suggested that MNF occurred outside of this framework, unregulated and unrecorded.

6.1.2 Frequency and character of MNF at Mida Creek

Socio-economically and ethnically our case study is a good representative of Kenyan coastal fishing communities. Mida Creek falls neither at the poorest nor wealthiest ends of the spectrum of fishing communities along the north Kenyan coast (as presented by Cinner & McClanahan 2006), but fluctuates around the mean for all major wealth characteristics; a greater proportion of the community have metal roofs at Mida than on average (37% at Mida compared to 23.5%), although less have cement walls (10% at Mida compared to 29.3%) and electricity than on average for the region (4% at Mida compared to 11%). In all but one of the villages studied by Cinner et al. (2006), Giriama people outnumbered Swahili and Bajuni by as many as four times. Indeed in our sample, all homesteads-heads self-identified as Giriama.

Over half of our sample admitted involvement in MNF, and these were generally frequently fishing homesteads. MNF is common along the Kenyan coast; and it is practised at high frequency within certain communities.

Health initiatives achieved an average of 91% of the population sleeping under a MN at night at Mida. MN fishers were generally using old or surplus MNs, from free distributions, that had been replaced during recent distributions. MNF did not negatively impact malaria protection at Mida Creek and anti-malarial programs were working effectively. Whilst most fishers modified pre-constructed bed nets, I found that MN can also be obtained by the metre as raw sheeting, and at least one fisher was purposively constructing fishing nets from this material.

The study found no difference in wealth, education or occupation diversity between MNF homesteads and the rest of the community. This could be because the homesteads were fairly homogenous as the sample was already delimited to those living in neighbourhoods bordering the creek. Or that as Hoorweg (2008) points out; "the view that fishers are destitute, among the 'poorest of the poor', are trapped in a hopeless situation and are desperate for other opportunities clearly does not apply".

Adult men and children were the main groups engaging in MNF at Mida Creek. This is in contrast to frequent reports of female fishers at many other sites along the Kenyan and east African coast. The most common purpose of MNF was first to supply domestic need for protein and then to sell if there was surplus. MNF rarely featured as a primary occupation but as an activity that complimented other livelihood choices such as employment in other sectors or farming,

6.2 Key steps forward

I have established from the evidence that MNF is a common, frequent and varied fishing activity. But should it be of concern for natural resource management and the anti-malarial programs that delivered the MNs? And what role does it play in the local community? Here I establish key steps forward in the study and the management of MNF.

6.2.1 Natural resource management

There are three ways in which we have found MNF to be impacting natural resource management; access to the fishing sector, the targeting of juvenile fish and the operation of MNF outside of management frameworks.

From discussion amongst the fishing community I have concluded that some of the greatest barriers to becoming a fisher are knowledge, confidence with the marine environment and capital. As the catch from MN seines is indiscriminate, detailed knowledge of fish behaviour or biology are not as important as for gears that need technical use. From preliminary descriptions of MNF at Mida and elsewhere we found that MNF is mostly practised from the shore, in waist-height water, removing the requirement for the fisher to swim or use a boat. MN availability may have lowered the capital required to enter the fishing sector or at least encouraged more fishers to target juvenile fish and prawns using a free resource; Various respondents at Mida stated that before they started MNF they didn't fish, or they didn't target small fish. Because of these circumstances we suspect that many MN users are traditionally inexperienced, unregulated fishers whose entry into the fishing sector may be contributing to the high density of fishers on the East African Coast (Obura 2004; Muthiga et al. 2008).

MN fishers stated that they were actively targeting juvenile fish. While this would need further research to quantify and identify the taxa involved, the result does give an indication of the impacts of the fishing gear. As we explored previously it is currently unclear whether this is an issue for stock sustainability. Is the targeting of juveniles diverting the fishery from optimal selection or balancing the take (Rochet et al. 2011)? A better understanding of this will be an important step in determining the management of MN as a gear. The community is convinced that the Mida Creek fishery is degraded and that both fish abundance and size have decreased over the last 50 years. It is difficult to disaggregate causation and effect between the use of small mesh gears such as MNs and apparent downward shift of the fishery.

MNF is an informal small-scale fishery, practised for mostly subsistence purposes and bypasses official landing sites. Thus the catch of MNF goes unrecorded and

unregulated. If the activity is as widespread as the evidence indicates then this will be problematic for enforcement of existing legislation and for informed management for the East African neritic-pelagic fishery as a whole.

6.2.2 Health community

The WHO's 2012 recommendations for LLIN distribution have been successful on the Kenyan coast. There was more than one net available for every two people at Mida Creek , key informants and respondents reported that distributions had been regular and free through a combination of strategies for delivering nets and they have been provided with information as to their proper usage for malaria protection. Surplus or old MNs are now a readily abundant resource amongst the coastal community and used in various inventive and purposeful ways to aid livelihood activities such as fishing, chicken keeping and plant protection. Walking amongst the Mida Creek homesteads MNs were striking as the only abundant non-natural, non-biodegradable material being utilised. As it does not appear that alternative MN use is deterring from malaria protection, what responsibility should the health community take in directing MN disposal? The health representatives that we were interviewed had already concluded that MNF and other alternative uses were undertaken with old nets and thus did not show much concern. However with anti-malaria targets reliant on the continued distribution and availability of MNs, I expect a build-up of surplus and old nets in the coming years and look with interest to the pilot projects being undertaken by the WHO in MN recycling alongside future distributions.

6.2.3 Local community

Many times experts, key informants and community members themselves referred to children MNF and its role as a hobby or a game that they do in their free time. However at Mida Creek, it is a game with serious positive outcomes for the diet of the family; respondents described how the small fish and prawns supplied were eaten as relish with meals. This is reminiscent of other instances in which child play has serious and positive role in their development and contribution to the household:

"And one day they find that the games they have been playing are not games any longer, but the real thing, for they have become adults."
Colin Turnbull (2012) in reference to Africa's Mbuti Pygmies

At the beginning of this study I was unsure as to the extent of MNF, having been met with similar replies from key informants; that MNF was something children and non-serious fishers do, that they knew of it but were convinced it only happened in a small area. They did not a cohesive picture of widespread MN use. Having heard so many reports, I am convinced that what appears to be informal play is actually repeated on a very wide scale.

MNF supplies cheap protein and income to the fisher and local community and MNs have become a valuable commodity to conventionally poor and resourceful but resource-poor communities. Management intent on limiting the use of the resource should be mindful of this when planning interventions. The conservation sector is becoming increasingly aware the chances of project success are limited when it does not understand or address the socioeconomic needs of stakeholders (Cinner & McClanahan 2006).

6.3 Reflection on the study

A major concern for this study was the tendency for respondents to withhold information regarding illegal activities. However, the number of positive MNF results at Mida was due to the skill and familiarity of my research assistant and translator, Kirao, with the local community. Also I followed a traditional procedure of seeking permission through established hierarchical structures - within local governance; health networks and the conservation community – which produced a high level of trust and positive feeling with local community.

I started from a point where very little was known about MNF and I feel this work sets an important baseline that MNF is happening and at a large scale. I hope this study will provide a weight of evidence for further investigations into the interactions of MNF with stock sustainability and anti-malarial programs.

Due to time and financial limitations most key informant surveys had to be conducted by phone. Although we were able to proceed with interviews, we often

had to explain the purpose of the research many times and that we were not connected to the fisheries regulatory bodies. I was aware that speaking on the phone about sensitive issues without having met in person was not productive for building trust. I would like to see this part of the study repeated at a greater scale using face-to-face semi-structured interviews.

The homestead survey at Mida covered 51 homesteads and 1008 people. However due to sensitivity around an illegal practise, we asked for occurrence of MNF at the homestead level, limiting our sample size for analysis, making it difficult to disaggregate subtleties in the demographic of MN fishers and their choices.

6.4 Implications for policy and future research

At Mida Creek there is a strong community-based conservation network made up of fishers and other community members. They have been working to encourage mangrove planting and other proactive schemes to improve the quality of the habitat, and to discourage illegal practises, including MNF. They are keen to take forward these results to guide them in community self-organisation and management.

Rochet et al. (2011) emphasise that the outcome of gear selection depends on the particular species composition and size structure of the community it is used in and that unambiguous management objectives concerning biodiversity and the fishery are necessary to guide interventions. The next step for those concerned with natural resource management is to commission further research into the species composition and size structure of the marine communities targeted by MNF and how the gear fits with others in this multi-species, multi-gear artisanal fishery.

A seemingly simple way for anti-malarial programs to limit alternative use of MNs when they are surplus or old is to limit the number of MNs distributed to what is necessary and to recycle old MNs when distributing new ones. However pilot schemes have shown this to be far from simple but not impossible. I hope that the evidence collected here will encourage further exploration into this important but previously neglected step in the supply chain of MNs.

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Appendix I: Mosquito net fishing Key Informant Survey

Introduction: Hi, my name is Emma, I am a student from England working with CORDIO and Stephen. Do you have time to speak to us? It might take 10 minutes. We are looking at mosquito net fishing in Kenya. We are not working in regulation or enforcement. We have called you because we know you are involved in the BMU and will be knowledgeable about these things in your area. We want to know your opinions on this type of fishing and why you think people do it. We will keep anything you say confidential. Is it okay if we continue?

Name, Village, Organisation, Occupation, Gender:

1. **The Informant and the village**
    a. How long have you been living in this area?
    b. Do you live locally?
    c. Where are you from?

2. **Malaria Interventions**
    a. Do you know if there have been any mosquito net distributions in this area in the last 5 years?
    b. When was the last distribution?
    c. Who distributed the nets?
    d. Could a household get more than one?
    e. Were there any conditions? E.g. given to pregnant women or under-5s or could anyone get one?
    f. How were the nets distributed? Centrally from a clinic, house by house etc?

3. **Mosquito-net fishing**
    a. To your knowledge does anyone in this area use mosquito nets for fishing?
    If NO, have you heard of this anywhere else*? (And then go to question 3f)*
    b. Could you describe who (demographic) and how often you think these people do Mosquito net fishing?
    c. Why do these people do mosquito net fishing? What do they do with the catch?
    d. Where is the mosquito net fishing taking place?
    e. What do you think about mosquito net fishing? Could you list 3 good things and 3 bad things about mosquito net fishing?
    f. Do you have any other comments on mosquito net fishing in this area?

Appendix II: Mosquito Net Fishing Homestead Survey

1. About the Homestead

a. How many households are there?
b. Who lives here normally? (Household, Gender, Age, Level Education, Occupation)
c. Are any household members part of Community Based Organisations?
d. What ethnicity / tribe are the household members?
e. Wealth indicators: (Land (ha); Tapped water; Electricity; Number of livestock; Number of vehicles).

2. Health History and Interventions

a. Has anyone in the family had malaria in the last year?
b. Has anyone accessed any medical services in the last year? Where?
c. Do you have any malarial protection in your home? (Mosquito nets, Screens, Spray, Coils, Shrub, Medication, Other.)
d. How many mosquito nets?
e. Where did you get them from?
f. When did you get them?
g. What were the conditions?
h. How many family members sleep under them at night?

3. Timeline (on separate sheet of paper)

a. First memory and personally significant events
b. Public events
c. History of mosquito net use

4. Fishing

a. Does anyone in the family fish (including children)?
b. What do you catch?
c. What nets / techniques do you use? Do you use small mesh nets / mosquito nets?
d. How often have you been fishing in the last month? (Everyday / More than once a week / 1 – 4 times a month / Haven't been)

e. Is this typical of the whole year? (Yes / Seasonal)

f. Can you describe if fishing in the creek has changed over your lifetime? (Using timeline sheet created previously, ask about trends in number of fish and size of fish).

If use mosquito nets for fishing then answer following questions, otherwise go to (k)

g. Where did you get mosquito nets from for fishing? Were they new?

h. What do you catch with them?

i. What do you do with the catch?

j. Why do you use a mosquito net? What did you use before?

k. What do you think about mosquito net fishing? Can you give 3 good reasons and 4 bad reasons?

l. What do people around here think about mosquito net fishing?

m. Do you have any final remarks or recommendations to share?