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Size structure and gear selectivity of target species in the multispecies multigear fishery of the Kenyan South Coast

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ABSTRACT

Multispecies fisheries commonly target those species and sizes that provide highest revenues (due to both their high abundances and market values) using multiple gears. Yet most tropical countries still apply single species management approaches, which ignore species - species and species - gear interactions in these complex fisheries. The objective of the here presented study was to evaluate the role and importance of the different fishing gears for the exploitation of the different species and sizes of the artisanal reef fishery catch from the Kenyan South Coast. Like in most tropical multi-species fisheries, the artisanal catch was characterized by a very large number of species (138 species representing 38 families). Of these, 17 species dominated the catch making up 91% of the overall abundance and 70% by weight of the total catch from all gears. Species belonging to the families Siganidae, Scaridae and Lethrinidae dominated the catch of most gears. Species selectivity by gear was determined by a classification analysis (hierarchical agglomerative clustering) based on a similarity matrix from transformed abundance data of the fish species by gear. At a similarity of 50%, five groups were differentiated by the cluster dendrogram. Considerable species and size overlap was observed between gears with the basket trap and beach seine showing very similar selectivity with the composition of their catches to a large extent being complementary. Overall the beach seine landed the smallest individuals in the catch with the key species captured being smaller than the size at first maturity but only contributed 10% of the total biomass landed compared to the basket traps which also targeted similar size ranges but at higher relative abundance and biomass. The hook and line method and the ring net targeted the largest individuals in the catch but the hook and line contributed more in terms of the total biomass landed (31%). Our findings indicate that the current fishing practices exploit fish species of small sizes but also small to medium sized specimens relative to the species potential maximum size. Therefore, fishers by diversifying their gears and strategies, have been able to target a significant part of the entire fish assemblage (species and sizes) with each gear imposing different fishing mortalities on the target species. This fishery strategy is a major challenge to decision-makers, and it is evident that the current regulations focusing on gear restrictions are not adequate to manage this complex and highly effective fishery. Thus, our proposal is that in addition to the current measures, an attempt should be made towards an integrated approach that incorporates the fishing dynamics and distribution of effort across different gears while complementing these with market based regulatory measures. Therefore, an important next step in the analysis of the fishery of Kenya's coast should be the determination of the present exploitation rate of the target species along the resource size spectrum both temporally and spatially to provide a proper assessment of the fisheries and provide a more succinct management advice towards reallocation of fishing effort among alternative target species in this multispecies fisheries.

1. Introduction

Artisanal fishing is one of the most important exploitative activities on coral reefs sustaining many coastal communities in the tropics (Russ and Alcala, 1989; Sadovy, 2005). Estimated to account

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for up to 25% of the world's catch, these artisanal reef fisheries are among the most important direct contributors of fish for human consumption and yet they are still greatly neglected and overlooked (Allison and Ellis, 2001).

While the impacts of industrial fishing are widely recognized, marine ecosystems are considered less threatened by artisanal fisheries (Hawkins and Roberts, 2004; Shester and Micheli, 2011). This view is rooted in the fact that artisanal fisheries are small-scale and multispecies and use small quantities of different gears that are often passive and selective and considered to have changed little over the years (Mathew, 2003).

Nevertheless, over the past decades, coral reef fish stocks have come under increased pressure in many places, mainly due to growing fishing effort and the use of destructive gears causing moderate to severe declines in valuable tropical marine species (Hawkins and Roberts, 2004; Sadovy, 2005).

Studies on the fishery impacts on tropical reef ecosystems have shown that a decrease in abundance and biomass of target species are the most obvious consequence (Hawkins and Roberts, 2004; Jennings and Kaiser, 1998; Ruttenberg, 2001). The fishery-induced reduction in size and yield of target species concomitant with a decrease in their recruitment success may eventually lead to a total species collapse and a gradual shift in fish community structure (Koslow et al., 1994).

These declines may be attributed to some interacting factors including increased fishing intensity (Hawkins et al., 1999; Koslow et al., 1994), selective removal of top predators and the use of destructive fishing methods (McManus et al., 1997; Pauly et al., 1989). This has been exacerbated by the limited control over fishing effort and a lack of regular monitoring, which is characteristic of most artisanal fisheries, and which often leads to a rapid growth in artisanal fisheries under open access regimes (Mathew, 2003; Tanner et al., 2014).

At the Kenyan coast, the importance of artisanal fisheries cannot be overemphasized. Historically, they play a vital role in livelihoods and are crucial for nutrition in Kenya. These resources are especially vulnerable to damage caused by overfishing, a growing human population and the frequent and unregulated use of destructive fishing techniques (McClanahan et al., 2005).

According to Tuda and Wolff (2015), the number of fishers has increased as has the number of illegal gears, yet overall catch records from landings sites have continued to fluctuate and information on stock status for most of these species is lacking making it difficult to ascertain the impact of fishing on the exploited species. The situation is further complicated by the more fatalistic attitudes held by some fishers, who believe that the amount of fish they catch is what Providence has determined.

The resources on Kenyan coral reefs are considered exploited at sustainable levels or overfished (Kaunda-Arara et al., 2003), with an increasingly high level of fishing pressure (Teh et al., 2013). Despite the fact that overfishing and the use of destructive fishing techniques are the major threats to this fishery (Mangi and Roberts, 2006; McClanahan et al., 2008a), selective fishing of key species and functional groups from the ecosystem has been identified as the root problem (McClanahan and KaundaArara, 1996; Zhou et al., 2015). An implication of this is the inevitable alteration of the composition of a population or community structure and biodiversity (Garcia et al., 2012). Therefore, understanding the dynamics of these fisheries as related to gear selectivity and the impacts on coral reef fish assemblages can help to address the challenges involved in fisheries management (Gobert, 1994; Liang et al., 2014). However, these dynamics are still poorly understood especially in the context of artisanal fisheries. Therefore, this study seeks to assess the size structure of observed catch across a series of fishing gears to evaluate the role and importance of the different fishing gears for the exploitation of the different species and sizes. While this simplified approach should in a follow-up study be enriched by gear selectivity studies, we believe that our results may be qualitatively informative to provide a better assessment of the gear impacts on the resources and may facilitate policy advice.

2. Material and methods

2.1. Study site

The study was conducted at the Kenyan South Coast approximately 50 km south of Mombasa to about 80 km north of the Tanzanian border. Four study sites were selected: Mkunguni (Msambweni area), Gazi, Chale and Mwaepe (Fig. 1). The area of study was chosen based on the proximity of the landing sites to each other and the overlap in fishing sites which make the fishing in all these areas relatively similar and easy to access the catch.

The fishery is coral reef and lagoon based with fishers employing multiple gears across multiple sites and travel to and from their fishing grounds under the influence of the tides (Alidina, 2005; McClanahan and Mangi, 2004). Fishing typically takes place from the shore to the outer reef and fringing reef lagoon in shallow, hard bottom back reef locations between 0.5 and 3 m deep at low tide (Hoorweg et al., 2003; McClanahan and Arthur, 2001). However, the daily fishing patterns are influenced by a range of environmental and weather conditions, which affects the fish migration and the fishers behaviors with regards to the target species (Daw et al., 2011; Mangi et al., 2007).

During the Southeast Monsoon, which is associated with strong winds (May–October), the fishers travel less far and are more

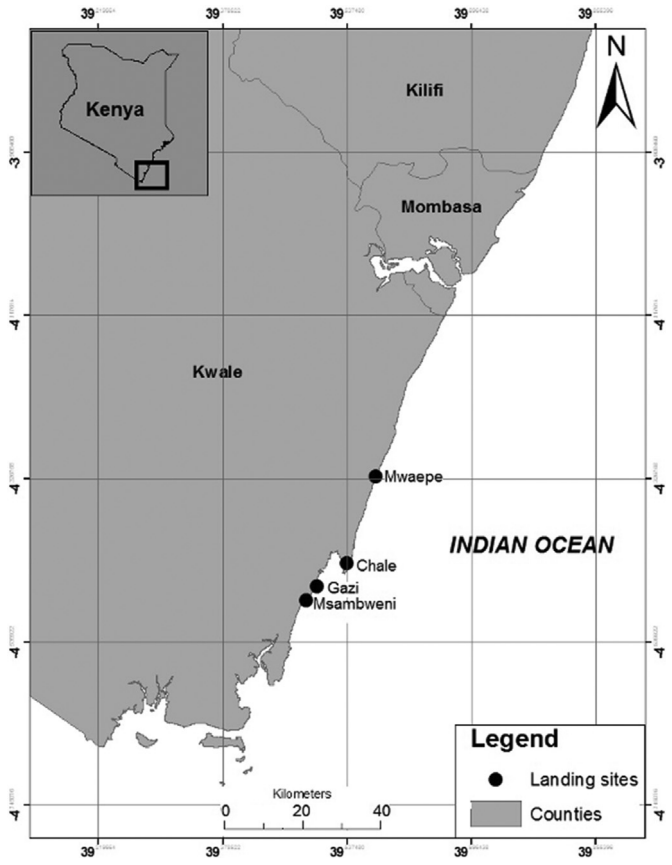

Fig. 1. Map of the study area showing the positions of the sampled fish landing sites.