Improving bycatch mitigation measures for marine megafauna in Zanzibar, Tanzania

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Abstract

This study was conducted to explore the governance processes and socio-economic factors relevant to the potential implementation of bycatch mitigation for various vulnerable marine megafauna (rays, sharks, marine mammals and turtles) in Zanzibar, Tanzania. Questionnaire-based interviews were conducted between February and April 2017 with fishers (n= 240) at eight landing sites. One focus group discussion was held in each site and eleven key informant interviews were carried out. The study showed that current measures to manage bycatch rates are not explicit; no rules govern ray and shark bycatch; and rules regarding marine mammal and sea turtle bycatch are poorly enforced. Binary logistic regression was used to determine the effects of five selected socio-economic factors (education, age, proportional fishing income, fishing experience, and the number of adults who bring income into the household) on the willingness of fishers to participate in potential future bycatch mitigation measures for marine megafauna. The results indicate that only one factor (the number of adults who bring income into the household) had any significant effect (p=0.016). These findings could benefit the future governance and management of marine megafauna in Zanzibar through a better understanding of what mitigation measures are more likely to be supported.

Keywords: fisheries, conservation, marine mammals, elasmobranchs, turtles

Introduction

Marine megafauna play major roles in ecosystem structure and function (Bowen, 1997). Their status as apex and meso-predators and as mega-grazers mean they directly influence community structure, community dynamics and nutrient cycling (Preen, 1995; Aragones, *et al.,* 2006; Heithaus, *et al*., 2008). Therefore, threats to the survival of these species have potentially wide-ranging consequences for marine ecosystems and those who rely upon them. In the past, loss of their natural habitats contributed to considerable mortality (Pusineri and Quillard, 2008). However, currently, fisheries are the greatest anthropogenic threat to these taxa at the global level (Lewison, *et al.,* 2004; Kiszka *et al*., 2009; Riskas, *et al*., 2016), where they may present as both targeted catch and bycatch. Persistent growth in human activities has increased interactions with megafauna, contributing to injuries, damage and finally death (Capietto *et al.*, 2014). Thus, in order to preserve these species, the ecosystems they affect, and the people who rely upon the marine environment, fisheries bycatch requires immediate action (Reeves *et al*., 2013).

Bycatch in small-scale fisheries receives limited attention from either local or global fisheries authorities (Moore *et al.,* 2010). Although small-scale fishers generally use simplistic and smaller gears compared to their industrial counterparts, their gears and fishing strategies are generally less selective and their volume means they pose a serious bycatch threat to marine

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megafauna (Adimey *et al.,* 2014). Indeed, a growing number of researchers believe that marine megafauna bycatch in small-scale fisheries might be as extensive or even greater than in industrial fisheries (Alfaro-Shigueto *et al*., 2011; López-Barrera *et al.*, 2012; Mancini *et al*., 2012). In the South Western Indian Ocean, where small-scale fisheries employ at least 495,000 people, bycatch is widely reported (Temple *et al.,* 2017). Kiszka (2012) found that 31 species of marine megafauna were caught by small-scale fishers in Zanzibar; five species of sea turtles, five species of marine mammals, and 21 species of elasmobranchs.

Although many studies have focused on the by-catch problem in large-scale or industrial fisheries (Komoroske and Lewison, 2015), the bycatch problem in artisanal fisheries remains largely ignored (Curtis *et al.,* 2015). Attempts to manage and, where required, mitigate bycatch in small-scale fisheries are limited firstly by insufficient information on the scale and composition of the bycatch itself (Temple *et al.,* 2017). Moreover, implementation of mitigation strategies must consider the complex interactions between cultural, economic, social and environmental issues in order to achieve their goals (Read, 2008). This complexity is reflected in the growing recognition of the role of social and economic research approaches in facilitating the implementation of mitigation plans (Komoroske and Lewison, 2015). Social and economic factors can influence the effectiveness of bycatch mitigation measures, because fishers dependence on a fishery will influence how likely they will follow laws which may impact their social and economic well-being (Peterson and Stead, 2011; Teh *et al*., 2015). Knowledge of socio-economic factors such as the numbers of people in certain areas, their beliefs, and their age can contribute to an understanding of how fishers can impact the sustainability of the megafauna populations (Stead *et al*., 2006; Brewer *et al*., 2012). Adequate understanding of social and economic features of fisher's communities are also essential requirements for good governance (Kittinger, 2013; Turner *et al*., 2014).

Good governance and appropriate management are acutely relevant to the bycatch problem. Government intervention is needed to assist widespread bycatch reduction, whether through coercion or incentives, and so understanding fishers' perceptions of current governance processes and their effects on fisher behaviour is vital (Eriksson *et al.,* 2015; Turner *et al*., 2017). The term 'governance' is a more comprehensive term than 'management', and it goes further than imposing controls or creating opportunities (Chuenpagdee and Sumaila, 2010). Good governance entails having accountability, participation, predictability, transparency, the rule of law and strong institutions (Lockwood *et al*., 2010; Turner *et al*., 2014). In order to reduce bycatch problems in the South Western Indian Ocean region all of these characteristics of good governance are required in the fisheries sector. Good governance can also help sustainable natural resource management by securing the availability of food, strengthening the rural economy, safeguarding the marine sustainable ecology, and promoting alternative livelihoods (Finkbeiner and Basurto, 2015).

The aim of this study is to identify governance processes within a socio-economic context that may hinder, or contribute to, the introduction and widespread use of bycatch mitigation methods. The outputs of the research are intended to include recommendations about how to mitigate bycatch through a better understanding of the human dimension of the fisheries.

Materials and methods

The Zanzibar archipelago is part of the United Republic of Tanzania, consisting of many small islands and two large ones, Unguja and Pemba. Like many other African nations, Zanzibar is considered as (part of) a developing state. It has a GDP of $ 675 million (Murphy *et al.*, 2016) and a total population of 1,303,569 (Population and Housing Census, 2013). This study was conducted in Unguja Island which is located at 6° 13'S and 39°13' E, situated approximately 40 miles off the coast of mainland Tanzania. Nearly 70% of Zanzibar's population is found on Unguja Island. In this study, data were collected from eight fisheries landing sites (See Fig. 1). These sites were chosen on the basis of geographic spread, fishing gear composition (with a bias toward sites with high numbers of long-lines, drift and bottom-set gillnets) and logistical constraints. Data collection took place between February and April 2017. A mixed-methods approach was used to obtain qualitative and quantitative information from different stakeholders. This approach was taken so as to reduce the weakness of mono-method research (Place and Kelle, 2008), and allow for triangulation of information (reinforcement of findings).

Face-to-face structured questionnaires were administered in a survey of 240 fishers (30 individual from each study site) to collect data on: (i) socio-economic factors comprising education (years spent in school), age, proportion of income from fishing to household,

number of adults who bring income to the house, and fishing experience with gears; (ii) willingness of fishers to participate in potential future bycatch mitigation; (iii) perceptions of current management in relation to principles of good governance; and (iv) appropriate persons/organisations to involve when making decisions on marine megafauna bycatch management. Simple random sampling was used to select fishers, and survey questionnaires were administered at landing sites when fishers returned from fishing trips, repaired their fishing gears, relaxed at landing sites, or at their homes. Interviews were conducted face-to-face. Fishers were asked for their consent before the interview was conducted, anonymity was assured, fishers were free to choose not to answer any questions that they did not feel comfortable with, and could end the interview at any time.

One focus group discussion (FGD) was conducted in each study site where the moderator led different stakeholders such as leaders of the villages, fishers and members of Shehia fisheries committees. Each group contained six participants who were selected on the basis of their expert knowledge, their fisheries experience and the length of time they had lived in the area, thus taking account of historical context. Information obtained from the fishers included fishers' perceptions of catching marine megafauna, current laws regarding marine megafauna, their enforcement, and ways to conserve marine megafauna. The discussions were tape-recorded with the permission of the participants. Charlesworth and Rodwell (1997) suggested that FGDs should be comparatively small in size; not less than five and not more than eight participants, to give them more

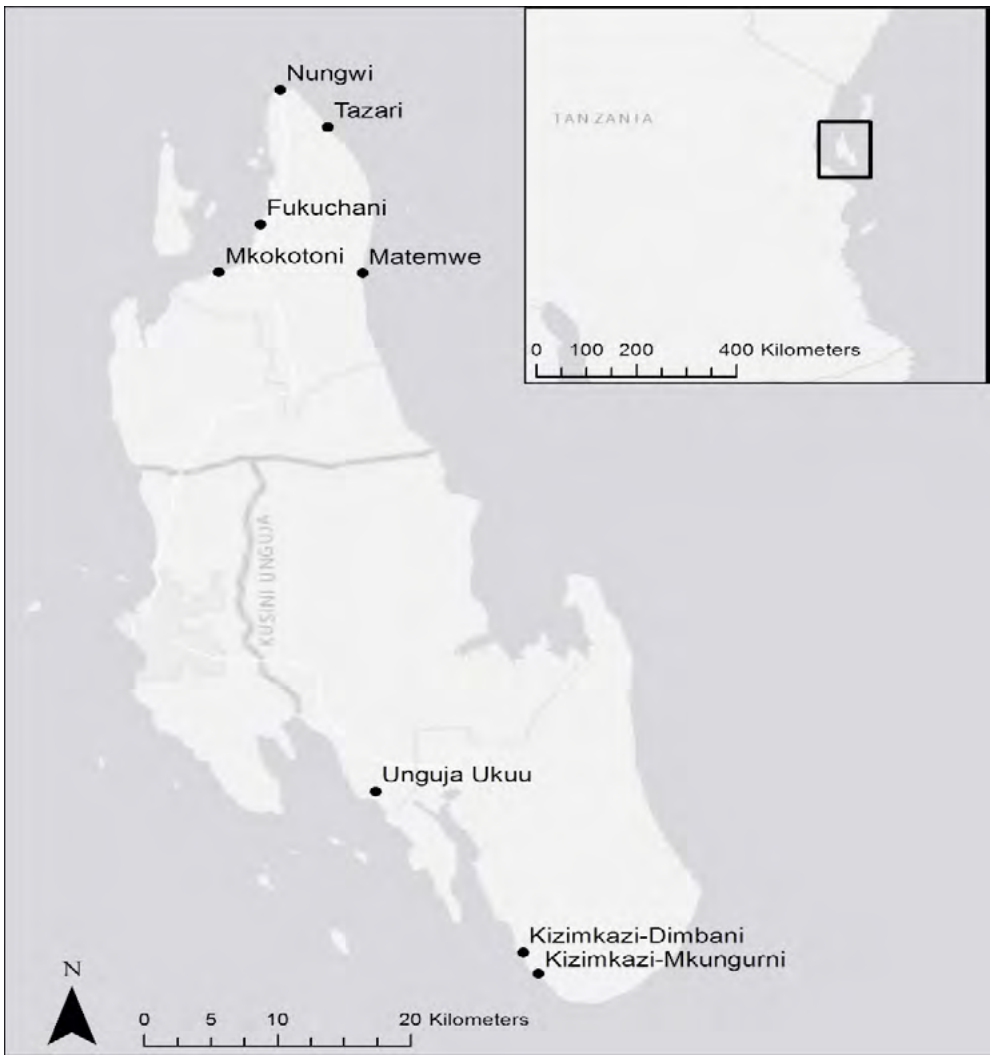

Figure 1. Map of Unguja Island highlighting the study areas.

time to discuss their views, experiences, and enable moderators to manage active discussions better than with larger groups.

Eleven key informant (KI) interviews were carried out, comprising one stakeholder from each study site and three from the fisheries department (a lawyer, a fisheries officer, and the Manager of Menai Bay conservation area). These participants were selected for their knowledge, role in the setting, and willingness and ability to provide useful information on the topic. These KI interviews were conducted to obtain a more synoptic perspective on the marine megafauna bycatch problem. The interviews were tape-recorded with the consent of the participants.

Quantitative data from the survey questionnaire returns were analysed by using statistical software SPSS version 20 wherein binary logistic regression was employed to assess the effect of socio-economic factors on the willingness of fishers to implement bycatch mitigation measures for marine megafauna. The socio-economic factors of the level of education, age, proportion of income from fishing to household, number of adults who bring income to the house, and fishing experience with the gears were taken as independent variables. A significance level (α) of 0.05 was used. Evidence of collinearity between variables used in the analysis and resultant variance inflation factors (VIF) on the binomial model was assessed. In the event of significant collinearity and high VIF (VIF >10) only one of the independent variable was submitted to the final model. Content analysis was employed to analyse qualitative data from focus group discussions and key informant interviews, where opinions recorded were listened to carefully, coded and interpreted to provide meaningful data which are presented below in the form of tables.

Results

Governance of marine megafauna bycatch

Perceptions of fishers about governance principles:

From the survey questionnaire returns, the results showed that trust is the most important governance principle for effective decision-making on bycatch and fisheries issues since it was ranked number one by 29.1% of the 240 fishers surveyed, compared to 19.4% for accountability and 16.4% for effectiveness as shown in Fig. 2.

Perceptions of fishers about appropriate persons/ organisations for making decisions on marine megafauna bycatch management:

In the survey, 38% of respondents perceived that Shehia fisheries committees are the most suitable organisations for making decisions on management of marine megafauna bycatch in Zanzibar, followed by the fisheries department and leaders of the

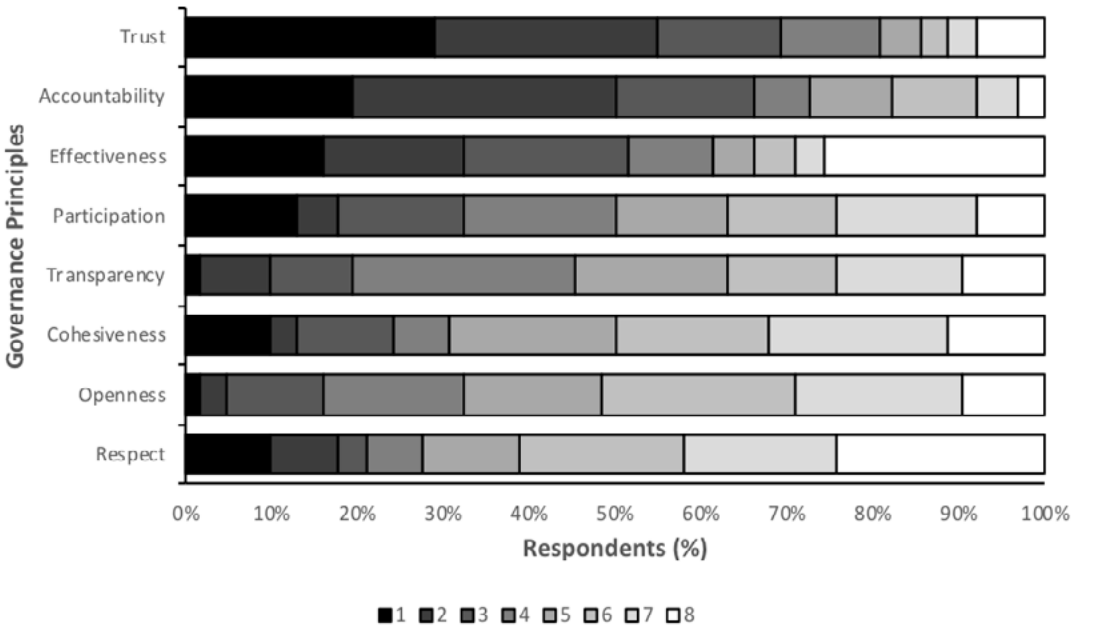

Figure 2. Governance principles ranked by stakeholders according to their perception of the importance of effective decision-making on bycatch issues, where number 1 (presented in black) is the most important principle, while number 8 (presented in white0 is least important.

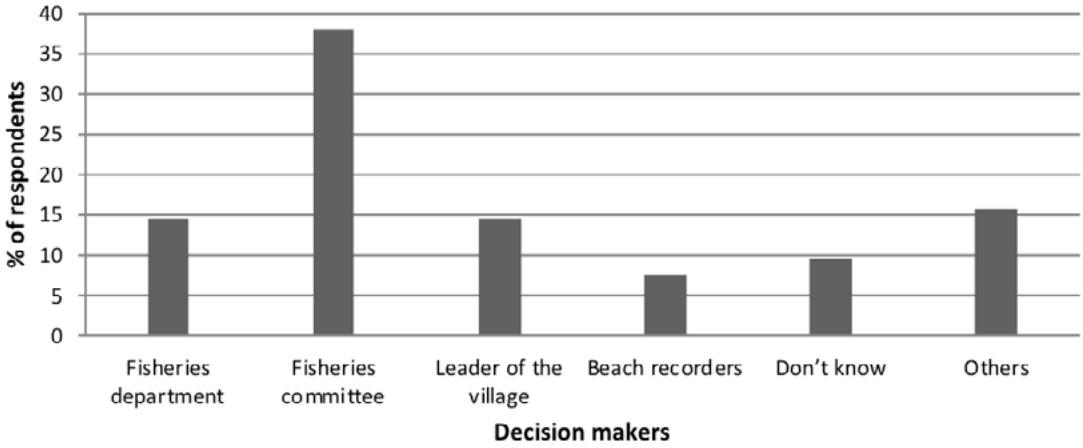

Figure 3. Perceptions of fishers about appropriate persons/organisations for making decisions on management of marine megafauna bycatch.

villages, both of which were rated as the most suitable by 14.6% of respondents (See Fig. 3). These Shehia fisheries committees are found in each village.

Rules for catching marine megafauna in Zanzibar: There are rules that forbid catching, landing or using products of some marine megafauna in Zanzibar such as sea turtles, whales and dolphins, and if these marine megafauna are caught accidentally in the gears they must be released. However, there are no such rules for elasmobranch species (rays and sharks) in Zanzibar. Currently, the rules are set by the fisheries department in collaboration with Shehia fisheries committees. Results from FGDs showed that awareness of fishers about these rules is high due to considerable efforts made by the government to educate fishers. However, the level of enforcement is considered very low (See Table 1).

Table 1. Reasons for low enforcement of rules, ways of improving conservation of marine megafauna and techniques used to educate fishers. The items in the columns are listed in order of the number of times they are mentioned by stakeholders, with the most mentioned items at the top.

Reasons for low level of rules enforcement	Ways of improving conservation of marine megafauna	Techniques used to educate fishers about the rules
Inadequate resources for rule enforcement, for example, there are few patrol boats and insufficient fuel for them	More patrols and stricter enforcement of the rules	Outreach programs through fisheries officers to educate fishers in the villages
Corruption between rule enforcers and rule-breakers	Establish marine protected areas to reduce fishing in biodiversity hotspots	Awareness programs through mass media such as television, radio and newspapers
Rule enforcers often come from the same villages and even the same families as the rule-breakers	Accountability of managers and rule enforcers	Members Shehia fisheries committees host meetings with fishers to educate them about rules
There is a poor system for supervising and monitoring the work of the rule enforcers	Improve environmental awareness of the importance of marine megafauna	
Fishers are skilled at concealing their illegal activities by hiding when they catch dolphin and sea turtle.	Require fishers to use more selective fishing gears to avoid unwanted bycatch	
	Suggest fishers move out to deeper water where there is less marine megafauna	
	More cooperation between management and fishers, making better use of fishers' knowledge	

Socio-economics of marine megafauna

Perception of fishers about marine megafauna and their mitigation measures:

Results from FGDs revealed that most fishers believe that catching dolphins, whales and sea turtles is wrong because they are more valuable alive for use in tourism. Moreover, FGDs showed that most fishers consider them as bycatch because targeting them is illegal; however some did not consider them as bycatch and still actively target them for food and bait. Elasmobranchs are not considered as bycatch by most fishers and they believe it is not a bad thing to catch them since they provide marketable products such as fins, teeth, meat and livers for anti-fouling paint on boats, and also it is still legal to catch them.

The majority of fishers surveyed in face-to-face interviews (84%) perceived that implementing mitigation measures would not affect their livelihood and they were willing to implement those mitigation measures, while a small minority (16%) perceived that implementing mitigation measures would affect their livelihood by reducing their catch and therefore they were not willing to comply with them.

Effects of socio-economic factors on the willingness of fishers to implement mitigation measures:

Evidence of collinearity was found between age and experience (0.56, p<0.001) and also between number of adults bringing income to the household and proportion of household income from fishing (-0.43, p<0.001). However, VIFs in the model were small (VIF = 1.516073, 1.510253, 1.443569, 1.365072) suggesting that collinearity had no substantive effect on the outputs of the results, so all independent variables were retained in the model.

Education: From the survey 43.4% of all fishers interviewed had reached ordinary secondary school which is about 10 years of school, but only 0.4% had reached higher education level (university). Statistical results revealed that education levels had no significant effect on fishers' willingness to implement mitigation measures (p>0.05) (Table 2).

Age: 45.5% of all fishers surveyed were aged within the range of 41 to 63 years, while 8.7% were aged above 63 years. The statistical results showed that the age of the fishers had no significant effect on their willingness to implement mitigation measures (p>0.05) (Table 2).

Proportion of household income from fishing: Fishing activity was the main source of income in most households: 47.5% of all fishers surveyed said that fishing activities contributed 81-100% of household income; 35% of the fishers said fishing activity contributed between 61-80% of the household income; and 17.5% of fishers said fishing activities contributed 40-60% to their household income. Statistical results indicated that the proportion of household income from fishing had no significant effect on the willingness of fishers to implement mitigation measures (p>0.05).

Experience of fishers with main fishing gear: With regard to experience with the main fishing gears, 37.9% of fishers said that they had experience of between 1-10 years, while 0.8% of interviewed fishers said they had experience of greater than 60 years. This factor also had no significant effect on the willingness of fishers to implement mitigation measures (p>0.05).

Table 2. Binary logistic regression analysis on socio-economic factors effecting willingness of fishers to implement mitigation measures.

Socio-economic factors	Coefficient (β)	SE	Exponent of (β)	p-value
Age	0.011	0.014	1.011	0.438
Education	-0.071	0.046	0.931	0.120
Income proportion from fishing	0.017	0.013	1.017	0.215
Adults bring income to the household	0.419	0.174	**1.520**	**0.016**
Experience with fishing gear	0.007	0.016	1.007	0.657

Number of adults who bring income into the household: The average number of adults bringing income into a household was 2, and the survey showed that most households (87.9%) had 1-3 adults who contributed to the income of the household, while 0.5% of respondents said they had more than 6 people who bring income into their households. The numbers of adults bringing income into the household had a positive statistically significant effect on fishers' willingness to implement mitigation measures ($p<0.05$).

Discussion

Governance of marine megafauna bycatch

This study shows that management actions to reduce bycatch of marine megafauna in Zanzibar are ineffective. There are no laws governing either catch or bycatch of elasmobranchs, and while laws do exist for marine mammals and sea turtles, they are poorly enforced. Fishers know about the rules that are in place, a result of substantial efforts by the government to educate fishers, though some still believe catching sea turtles and mammals is legal, and conversely, others believe that catching elasmobranchs is illegal. However, catching sea turtle species appears to be common despite their relatively low market value, reflecting fisher's observations of limited enforcement and thus limited risk of punishment for breaking these rules. On the lack of rules on elasmobranch species, the results found that there are no rules about them in small-scale fisheries, and fishers target them for their meat and fins. However, fishers said that the price they obtained for sharks fins had fallen dramatically since the shark fins trade (including exportation) was prohibited in Zanzibar. These findings support the observation of Temple *et al.* (2017) when they reported that the Government cancelled the shark fins export licence in Zanzibar.

On understanding why there is poor enforcement of the rules governing other marine megafauna, there were three main reasons given by those surveyed. First, there were insufficient resources for enforcing the current laws. Several studies show that lack of human resources, fewer patrol trips and less investment in equipment like boats, trigger rule-breaking events and undermine the effectiveness of conservation law enforcement (Ehler, 2003; Gilman, 2011; Peterson and Stead, 2011 Gilman, *et al.*, 2014). Second, there was a lack of trust in the people who are responsible for governing and managing fisheries activities. For example, respondents claimed rule enforcers like fisheries officers who carried out patrols, took bribes from rule-breakers. This meant that fishers stopped reporting rule-breaking activities, and since when they did report, no action was seen to be taken. Smith and Walpole (2005) indicated that corruption can seriously reduce the efficiency of conservation measures and lead to over-exploitation of vulnerable species. Third, there was no system to make government officers accountable for their actions (or inactions). For example, there were inadequate mechanisms for supervising and monitoring the work of the rule enforcers. Lockwood *et al.* (2010) consider accountability to be the crucial governance principle for effective conservation of natural resources.

Results of the perceptions of fishers about appropriate persons or organisations for decision- making on fisheries management (as presented in Fig. 3) show that 38% of the fishers surveyed perceived that Shehia fisheries committees are the appropriate organisations for decision-making on fisheries issues, including mitigating megafauna bycatch. The reason behind this perception is that Shehia fisheries committees involve local stakeholders, including ten fishers from the village, the leader of the village, and the beach recorder who represents the fisheries department. Carlsson and Berkes (2005) found that the cooperative approach is the best governance approach in decision making of common pool resources since it reduces the marginalization of many stakeholders, empowers them, enables them to share their knowledge, and facilitates their sense of collective strength through unity. As for the 14.6% of fishers who perceived that the fisheries department was the most appropriate organisation to make decisions on fisheries management, their main reason was that the fisheries department is responsible for all fisheries activity in the country and they have resources for implementing their decisions.

Socio-economic considerations of marine megafauna bycatch mitigation

In the past, fishers targeted dolphins and used them as bait for sharks. However, nowadays, most fishers perceived that dolphins, whales and turtles are less valuable to them as meat than kept alive as tourism attractions. Although 47.8% of interviewed fishers depend on fishing for 81-100% of their household income, most young fishers in coastal villages like Kizimkazi Mkunguni, Kizimkazi Dimbani and Nungwi are also involved in marine ecotourism which is a lucrative source of income and has led to a reduction in the number of fishers targeting these marine megafauna species in those villages. However, this kind of tourism

activity itself has some negative impacts on marine megafauna because of disturbance from boats and swimmers, so it needs to be well managed as recommended by Stensland and Berggren (2007) and Christiansen *et al.* (2010).

The majority of fishers (84%) perceived that implementing mitigation measures will not affect their income, while only 16% perceived that implementing mitigation measures will have a negative impact on their income. The latter believed that such measures will cause catch reductions not only of marine megafauna species but also of other marine species, hence reducing their income. These results are in line with the findings of Bennett and Dearden (2014), who reported that some communities had negative perceptions about conservation measures since they believed such measures would harm their livelihoods, and therefore did not provide any support for them. Fishers who had a positive perception of mitigation measures on their livelihoods stated that these marine megafauna have less value to them when they catch them compared to other species, so mitigation measures will not reduce their income since they will catch other more valuable species. Fishers from Kizimkazi Dimbani, Kizimkazi Mkunguni and Unguja Ukuu stated that when they did pilot trials with 'pingers' to avoid catching marine mammals, they did not experience any reduction in the catches of their target species, so the results encouraged most fishers to be willing to implement the measures.

Results from binary logistic regression indicated that the willingness of fishers was significantly affected by the number of adults who bring income into the household. Households with a higher number of adults who bring income were more willing to implement mitigation measures. The magnitude of effect of this socio-economic factor was higher than that of other socio-economic factors studied (Table 2). For an additional one adult bringing income in the household, the odds of willingness rose by 1.5. The assumption is that households with more adults who bring in income have a higher income compared to those with fewer adults, and Liobikiene and Juknys (2016) found that income levels have a positive influence on environmental concern. In support of this finding, the 'social class hypothesis' proposed by Liere and Dunlap (1980) argues that the households with higher incomes are more concerned about the environment since they already satisfy their basic needs, unlike households with less income who will do whatever they can to get their basic needs satisfied, even through activities which destroy their environment.

Another finding from this study is that all the socio-economic factors studied had positive coefficients, except education which had a negative coefficient (Table 2); for every additional year fishers spent in school the odds of willingness to implement mitigation measures is lowered. This implies that fishers who had a low level of education were more willing to implement mitigation measures than those with higher education. This finding is contrary to the conclusion of Liobikiene and Juknys (2016) who found that concern for the environment increases with the number of years that people spent in school. In their hypothesis, education has a major contribution in making people understand environmental issues, and therefore increases their awareness and encourages a greater sense of environmental responsibility in them. However, this is not always the case (Kollmuss and Agyeman, 2002). In this study, fishers with low levels of education explained that employment opportunities outside fishing are lower for them compared to those with higher education, thus they are willing to implement mitigation measures to sustain their jobs.

In conclusion, marine megafauna are ecologically, socially and economically important for most coastal communities. However, populations of marine megafauna are at significant risk as a result of bycatch globally. In order to reduce or to eliminate this decline, rules and regulations for catching elasmobranch species should be established and those for other megafauna species should be strictly enforced. Furthermore, fishers must be encouraged to implement bycatch mitigation measures, and to achieve this encouragement there is need to understand socio-economic factors that influence fishers' willingness to collaborate with the authorities in introducing regulations and to then comply with those regulations. The present study can form a basis for understanding these socio-economic factors and the educational processes needed to encourage the willingness of fishers, but further studies are needed to understand the institutional governance of bycatch and to find alternative livelihoods in order to reduce pressure on the marine resources.

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