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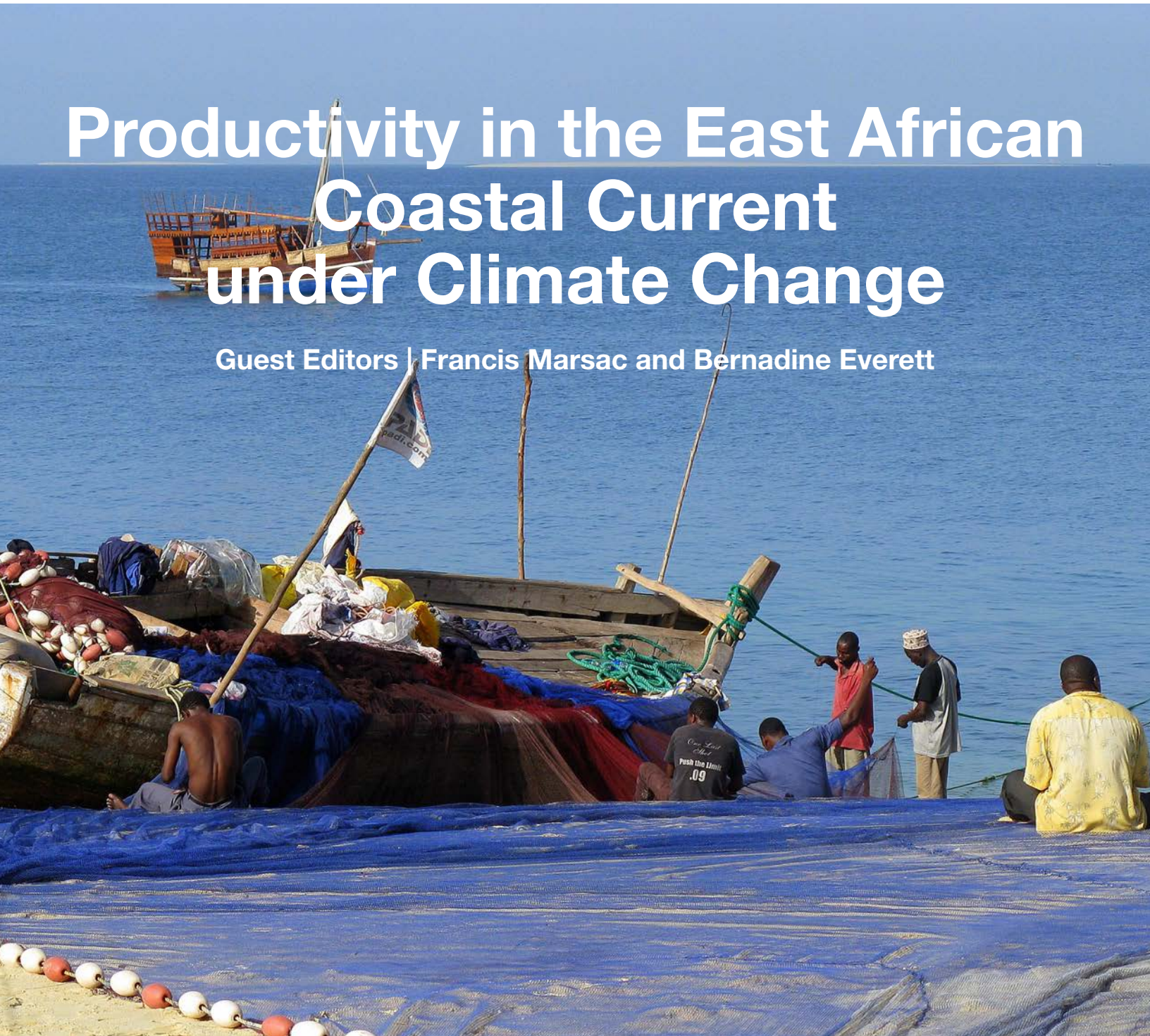
Productivity in the East African Coastal Current under Climate Change

Guest Editors | Francis Marsac and Bernadine Everett



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Livelihood impacts and adaptation in fishing practices as a response to recent climatic changes in the upwelling region of the East African Coastal Current

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Abstract

A socio-economic assessment was carried out at Amu and Shela in Lamu County and Ngomeni in Kilifi County on the coast of Kenya. The aim was to establish fisher perspectives on the livelihood impacts of changes in upwelling associated with the East African Coastal Current, and adaptations in fishing practices to determine the vulnerability, resilience and adaptation options for fisheries dependent communities in this upwelling region. Primary data and information were collected through direct observation, semi-structured interviews, key informant interviews and oral histories. Descriptive and non-parametric analysis was conducted for quantitative data and content analysis for qualitative data. The study covered 92 respondents out of which 90 were male. About 82.5 percent of the respondents had attained different levels of primary school education and below, and were therefore highly vulnerable to climate change impacts. Furthermore, 80.4 percent of the respondents were aged between 20 years and 49 years with a mean age of 40 years, thus falling into the economically active age category. In terms of livelihoods, fishing and fishing-related activities formed the primary livelihoods at the three study sites with fishing being the main occupation for 93 percent of the respondents. Fishing effort was higher during the north-east monsoon season. Fifty two percent of the respondents targeted small pelagic species. The main changes observed included increased fishing effort and a decline in the quantity of fish caught per fisher, and changes in the composition of fish species. Changes in the composition of fish species have further been compounded by a decline in rainfall over time, sea level rise, irregular wind patterns and increased temperatures. The decline in fish catch further led to a general decline in income and welfare. The climatic changes increased vulnerability of the fishing communities.

Keywords: Livelihood, Coastal communities, Small pelagic fish, Upwelling, Modern technologies, Descriptive statistics

Introduction

Coastal upwelling is closely related to human welfare since it supports some of the most productive fisheries in the world. Upwelling is driven by alongshore wind stress through Ekman transport divergence at the coast, and by the nearshore wind stress curl through Ekman pumping (Miranda *et al*., 2013). The flow turns to the right in the northern hemisphere and to the left in the southern hemisphere because of the Coriolis force. If that happens to be in an offshore direction, surface water moves offshore and is replaced by cold, nutrient-rich deeper water (Wang *et al*., 2015) fueling phytoplankton blooms that feed higher trophic levels. Upwelling is associated with massive populations of small pelagic fishes such as sardines, anchovies, mackerels, threadfins and herrings (Bakun *et al*., 1998; Bakun *et al*., 2010). Coastal communities in the East African region have relied on the sea for livelihood and culture and have gained extensive experience on the conditions of their marine environment. They depend on the biological productivity which is induced by coastal upwelling and have learnt to adapt to a combination of the north-east monsoon (NEM) and south-east monsoon (SEM) winds, precipitation

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and tidal variation, which influences marine and land-based activities (Tobisson *et al*., 1998; Tobisson, 2014).

Coastal communities in Kenya depend on fisheries and other coastal resources for their livelihoods. The importance of fisheries as a livelihood is particularly pronounced in Lamu, Kilifi and Kwale Counties. Ruwa *et al*. (2003) observed that Lamu and Tana River Counties are endowed with a rich marine inshore fishery with the most productive fishing areas being the North Kenya Banks.High productivity in the North Kenya Banks is associated with upwelling. The increasing irregular patterns of wind and sea conditions caused by climate change is however diminishing peoples' ability to 'read nature' because of variable timing of winds and shifting seasons, rendering the people unable to make reliable predictions to time their activities as had been the case in the past (Lyimo *et al*., 2013).

Lack of timely and adequate information and the lack of improved technologies are influencing the quality of people's response options, often compelling them to engage in further biodiversity degradation. There is evidence that low adaptive capacity, which refers to the capacity of humans and institutions to adjust to potential damage to take advantage of opportunities or respond to consequences, is either leading to increased poverty because of low catches and diminishing capabilities to curtail risks (Yanda, 2013), or to competition and resource degradation, as fishers converge on those areas where resources are likely to be found, such as around reefs (Cinner *et al*., 2010).

Enhancing people's adaptive capacity and enabling them to anticipate and respond to changes, to minimize, cope with, and recover from the consequences of change (Cinner *et al*., 2011) is increasing the prospects of fisheries governance in the East African region (Yanda, 2013). Governance practices have also evolved overtime to respond to changing ecological conditions and the impacts of climate change, often for improved biodiversity protection, but also to promote community resilience and adaptive management (Yanda, 2013; Ruwa, 2011). The most recent ecosystem approaches to management as applied within Marine Parks and other biodiversity protection mechanisms are some of these responses. Yet, there is still evidence that management systems are unable to

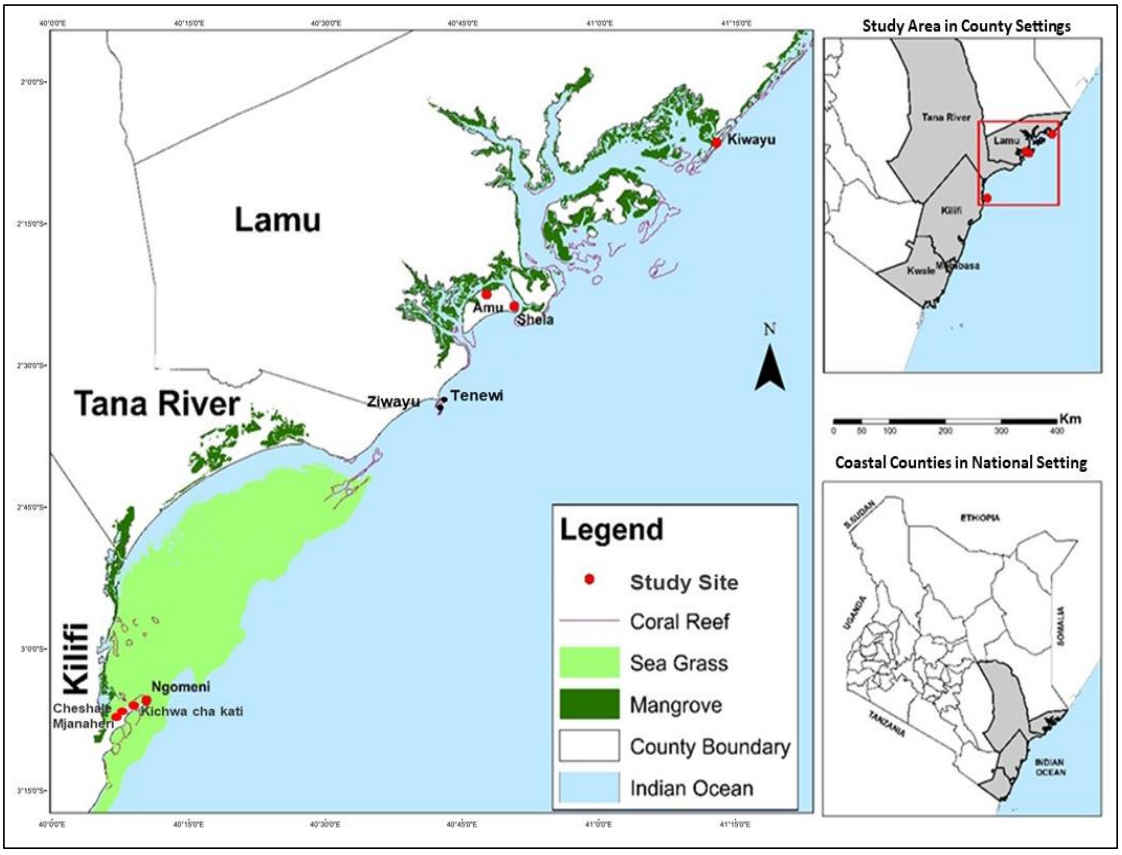

Figure 1. Map showing location of the study sites on the coast of Kenya.

enhance the predictive capacity of fisheries managers and the fishing communities, or respond to oceanic conditions induced by climate change (Ruwa, 2011).

The study sought to establish the social and economic impacts of changes in the upwelling driven by the East African Coastal Current (EACC) on livelihoods and adaptation of fishing practices. The EACC is the dominant surface current influencing East African coastal waters and is characterized by the interaction between the Southern Equatorial Current (SEC) and the African coastline bringing relatively cool water from the south. The EACC is accelerated during the SEM and slower during the NEM. It flows northward throughout the year at 4 knots between latitudes 11°S and 3°S (Newell, 1959; Swallow *et al*., 1991; Nguli, 2006). The specific objective of the study was to evaluate stakeholder perceptions on the impacts of climate change among fishing communities in the EACC upwelling region on the Kenya coast.

Materials and Methods

Study site

The study was carried out at Ngomeni in Kilifi County, and Amu and Shela in Lamu County on the coast of Kenya (Fig. 1). The three sites were selected based on existing knowledge and desktop reviews on communities that depend on the small pelagic fisheries around the area where upwelling occurs. The study covered three sites at Ngomeni namely Ngomeni village, Kichwa cha Kati and Cheshale. Ngomeni is situated approximately 16 kilometres north of Malindi town and is heavily dependent on fisheries as the main source of livelihood. The village has three categories of fishers; namely those who fish in the inshore areas, those who fish at the Malindi Bank and the North Kenya Bank, and migrant fishers who fish at distant fishing grounds such as Ziwayu in the Tana River Delta, and Tenewi and Kiwayu in Lamu County (Fig. 1).Like Ngomeni, Lamu depends on artisanal fishing as the main source of livelihood. Some of the fishers operate in the shallow inshore waters of the Lamu Archipelago while others occasionally fish at the North Kenya Banks which is located 30nautical miles offshore (Morgans, 1959; KMFRI, 2018).

Methodology

Both quantitative and qualitative research approaches were used. The target population covered communities that engaged in fishing and fisheries related activities.Multi-stage sampling was adopted involving different techniques within each stage. Fishers were first stratified with respect to their target fishery which was categorized by fishing gears, and thereafter, samples were drawn purposively from each type of fishery. County Fisheries Directors, Beach Management Unit (BMU) officials and Village heads were also included in the ultimate sample in order to obtain perceptions of those engaged in fisheries governance. For oral histories and key informant interviews the study also targeted experienced artisanal fishers who had been fishing for over 10 years in areas influenced by upwelling.

Primary data and information were collected through direct observation, semi-structured interviews, key informant interviews and oral histories (Bunce *et al*., 2000; De la Torre-Castro *et al*., 2007). Direct observation involved examination of small pelagic fishery landings, the type of gears and boats used, sale transactions and other associated activities at the study sites. Semi-structured interviews were conducted with the fishers and community members that were engaged in fisheries related activities. It involved the use of a defined set of open-ended questions which allowed for the flexibility to probe deeper into issues and pursue new lines of questioning in order to generate information on specific issues of interest (Bunce *et al*., 2000). The questions covered demographic characteristics, information about the small pelagic fisheries, information about upwelling, types of fishing gears and vessels used, duration of fishing and landings, climate change and perceptions on future scenarios. Each interview lasted between 45 minutes and 1 hour. The interviews were conducted in Kiswahili, which is the spoken language that is commonly understood by all respondents. A total of 92 respondents (90 males and 2 females) were interviewed.

Key informant interviews were used to obtain particular information from selected opinion leaders who had unique knowledge about local livelihoods including fisheries and the upwelling conditions associated with the EACC. The selected key informants included the local Beach Management Unit (BMU) chairmen, local leaders such as chiefs and village heads, County Fisheries Officers and officers from the State Department of Fisheries, Aquaculture and Blue Economy (SDFA&BE),who provided insights on many issues that needed further clarification. Oral histories were used to get an in-depth account of personal experiences and reflections from key knowledge-holders, particularly elders, who recounted their historical experiences with respect to changes in climate and oceanographic conditions associated with upwelling,

fishing practices including effort and catch trends, livelihoods and institutions. Information on fishing effort and catch trends were validated using the marine fisheries frame survey report for Kenya that is produced every two years and a national report on the status of Kenya's fisheries (Republic of Kenya, 2016; Kimani *et al*., 2018). The elders were identified through snowball sampling which involved letting the local people identify the elders (De la Torre-Castro *et al*., 2007). This helped to understand people's vulnerabilities and responses to changes over time.

The data analysis involved transcription of the datasheets into an excel worksheet, cleaning for entry errors, coding of variables and proof reading to correct any inconsistent codes. Exploratory analysis was then conducted to verify inconsistencies, anomalies, missing values and outliers using the Statistical Package for Social Sciences (SPSS). Descriptive analysis of the responses was undertaken, where mean, standard deviation, frequencies and percentages were computed. Non-parametric analysis was conducted to establish relationships between variables. Content analysis was conducted on the qualitative data in order to systematically evaluate responses and determine the emerging themes on the status of the small pelagic fishery and upwelling. The analysis involved synthesizing the qualitative data by investigating key concepts, emerging patterns and themes that seemed to dominate the findings.

Results and Discussions

Demographic Characteristics of the Respondents

Of the 92 people who were selected and available for the study, only 2 were female (Table 1).The dominance of male respondents is attributed to the fact that the study targeted people who were involved in fisheries as a livelihood source, most of whom were male. This is consistent with the findings by Ochiewo (2004) that traditionally, fishing is a male occupation and therefore any study that targets fishers is likely to have more male than female respondents. In terms of age, 80.4 percent of the respondents were aged between 20 years and 49 years (Table 1) with the average age being 40 years. This means that most of the fishers fell into the active age category and therefore had the energy required for fishing operations. In addition, about

Table 1. Demographic characteristics of the respondents in the study.

Gender	Number	Percent
Male	90	97.8
Female	2	2.2
Age		
20-29 years	21	22.8
30-39 years	30	32.6
40-49 years	23	25
50-59 years	8	8.7
60-69 years	10	10.9
Education level		
Complete primary	22	23.9
Complete secondary	5	5.4
Higher education	3	3.3
Incomplete primary	30	32.6
Incomplete secondary	8	8.7
Madrassa	12	13.0
No education	12	13.0

41 percent of the respondents were aged between 40 years and 69 years and had therefore been involved in fishing for a long period. These respondents had gained valuable experience and observed changes that occurred in the small-pelagic fisheries as well as local climatic and oceanographic conditions over many years. About 23 percent of the respondents were aged 20 years to 29 years indicating that young people are also being recruited to the small pelagic fishery.

Most respondents had low levels of education with 13 percent having no education at all, 32.6 percent had incomplete primary level of education, 13 percent had basic Islamic education (Madrassa), and 23.9 percent had a primary school certificate (Table 1). This implies that about 82.5 percent of the respondents had attained different levels of primary school education and below and were therefore highly vulnerable to climate change impacts based on vulnerability indicators by Colburn *et al.*(2016). Only 8.7 percent of the respondents had attained secondary and higher education and were therefore more resilient as they could access alternative livelihoods.

Livelihood Sources

Fishing and fishing-related activities including fish trading constituted the primary livelihoods at the three study sites. Fishing was the primary occupation for most (94.6 percent) of the respondents followed by fish trading (5.4 percent). While fishing was traditionally a male occupation (Ochiewo, 2004), a few women particularly at Ngomeni had turned to fishing as their preferred livelihood. Fish trade on the other hand was carried out by both men and women. Men had relatively more capital and therefore operated as fish dealers with deep-freezers and fish shops while women operated on a smaller scale as fishmongers, who bought small quantities of fish from the fish landing sites, processed the fish through deep-frying and sold it in the villages and local market centres. The three study sites, Ngomeni, Amu and Shela are typical fishing villages among several other typical fishing villages spread across Lamu and Kilifi Counties, thus confirming the importance of fisheries as a source of livelihood. The importance of fishing and other fisheries-related activities has also been elaborated by the County Government of Lamu (2018). Secondary

Table 2. Common small pelagic fish landed at Lamu and Ngomeni, based on responses.

Small Pelagic Fish	Scientific name	Family name	Common/English name	Percentage of small pelagic fish catch
Una/oona	*Rastrelliger kanagurta*	Scombridae	Indian mackerel	18.18%
Simu/kerenge	*Sardinella melanura*	Clupeidae	Blacktip sardinella	16.23%
Mkizi	*Mugil cephalus*	Mugilidae	Flathead grey mullet	12.34%
Pangapanga	*Pterogymnus laniarius*	Sparidae	Panga seabream	8.44%
Mtumbuu	*Strongylura leiura*	Belonidae	Banded needlefish	7.14%
Mbinini	*Planiliza alata*	Mugilidae	Diamond mullet	6.49%
Nyimbwi	*Albula vulpes*	Albulidae	Bonefish	3.90%
Mkeke/chuchungi	*Hemiramphus lutkei*	Hemiramphidae	Lutke's halfbeak	3.25%
Peruperu	*Monodactylus falciformis*	Monodactylidae	Full moony	3.25%
Chuchungi/mkeke	*Hemiramphus far*	Hemiramphidae	Black-barred halfbeak	1.30%
Mamba ngumu	*Hypoatherina barnesi*	Atherinidae	Barnes' silverside	0.65%
Others				
Bonito	*Sarda orientalis*	Scombridae	Striped bonito	9.09%
Kisumba	*Sphyraena barracuda*	Sphyraenidae	Great barracuda	4.54%
Sehewa	*Euthynnus affinis*	Scombridae	Kawakawa	1.30%
Sehewa	*Katsuwonus pelamis*	Scombridae	Skipjack tuna	3.90%

livelihood sources included sand harvesting which is widely practiced in the area between Ngomeni and Mjanaheri. The harvested sand was transported by tracks to Malindi and Mombasa where it is used as building material. Small scale businesses also constitute another important livelihood source particularly at Ngomeni where there were several retail shops selling groceries, and temporary kiosks which sell food, fruit and vegetables. Peasant farming was also practiced by the fisher households at Ngomeni as an alternative livelihood. The crops grown by the fisher households were mainly coconut and sesame.

Target species

Based on the responses, the common small pelagic fish landed and traded were Indian mackerel which constituted 18.2 percent of the total catch, sardines that accounted for 16 percent of the total catch, mullets (12.3 percent of the catch), ribbonfish (8.4 percent of the catch), banded needlefish (7.1 percent of the catch), common blue stripe snapper, diamond mullet and mackerels (Table 2).The results are consistent with the findings by Munga *et al.* (2016) and Kimani *et al.* (2018) that the most common small pelagic species landed by ringnets in Kenya include *Stolephorus delicatulus*, *Harengula humeralis*, and *Sardinella gibbosa*; while medium pelagic species include *Hemiramphus far, Rasterlliger kanagurta,* and the barracudas *Sphyraenajello, Sphyraenaflavicauda,* and *Sphyraenaobtusata*. Seventy seven percent of the fishers did not target small pelagic fish, but caught them as by-catch of the demersal fishery.

Fishing effort

Seine nets (both ringnets and reef seines), cast nets, gillnets, harpoons, fence traps, scoop nets, longlines and monofilament nets are the main fishing gears used in the small pelagic fishery. Sardines were targeted by the ringnets, cast nets and reef seines. The ringnets targeted different species based on the time of fishing, the net mesh sizes and the area of deployment. The ring nets deployed during the day target reef and pelagic species while those deployed at night mainly target sardines. While 45 percent of the 38 ringnets in Kenya target sardines (Republic of Kenya, 2016), the three ringnets that were in operation at Ngomeni targeted the small and medium pelagic species.

Cast net were used to target prawns (82 percent), sardines (16 percent) and other species (2 percent). Cast nets were mainly bell-shaped gillnets tied to a rope held by the fisher, and were thrown out over the water to spread out and land on the surface, thereafter sinking to the bottom, entrapping fish when retrieved. The cast nets were only found at Ngomeni in Kilifi County with none observed in Amu and Shela in Lamu County. Reef seines were seine nets operated within the reefs and operated by two crafts. The reef seines targeted sardines (6 percent) alongside non-pelagic fish species such as scavengers (21 percent), rabbit fishes (16 percent), and snappers (10 percent). The study established that a few of the scoop nets targeted sardines (2 percent). However, scoop nets were mainly used as accompanying fishing gears by divers who targeted lobsters (77 percent), aquarium fish (10 percent), and crabs (9 percent).The findings are consistent with the observation by Kimani *et al.* (2018) that small pelagic species typically aggregate and are often caught using surrounding fishing gears such as small-scale purse seines which are commonly referred to at ringnets.

Mullets were targeted by gillnets of single vertical panels of below 3 inches mesh size which were either set or active. Harpoons, fence traps, scoop nets and longlines with some longline hooks that were set at the surface were also used. The harpoons targeted octopus (67 percent) and mullets and scavengers (13 percent). About 42 percent of the fence traps targeted prawns while 10 percent targeted mullets and the remainder targeted grunters (18 percent) and carangids (16 percent). Longlines were defined as a single twine on which a series of short branch lines were attached at intervals. A baited hook is attached at the end of each short branch line which can be of various sizes, and the longline is anchored in the deep waters to fish. In Lamu County the number of hooks increased by 115% from 2,165 in 2014 to 4,659 in 2016 (Republic of Kenya, 2016).

Most of the fishing vessels that were sampled at Ngomeni, Amu and Shela where small pelagic species were targeted, were modern motorized fiber boats. These boats were popular with the fishers who target small and medium pelagic fish that require traveling long distances to access their preferred fishing grounds. Less than 50 percent of the fishers in Kenya target small pelagic species because Kenya's coast is endowed with demersal stocks that are exploited by over 50 percent of the fishers, despite being threatened by over-fishing. Most of the fishers who target demersal fish relied heavily on sailboats, wooden planked boats, traditional dug-out canoes and fibre boats. Data from Kenya's marine artisanal fisheries frame survey of 2016 shows that the sail boats (popularly known as *mashua*) were the most dominant fishing vessel in

Lamu County accounting for 48 percent of all fishing vessels. The frame survey data further showed that the traditional dugout canoe was the dominant fishing vessel in Kilifi County accounting for 68 percent of all the fishing vessels. Despite the threat of overfishing on the demersal stocks in the seagrass beds and coral reefs in Kenya, a larger number of artisanal fishers target demersal stocks compared to small pelagic stocks. Consequently, most of the artisanal fishers fish within the coral reef where they do not have to travel long distances. The sailboats were also preferred by a section of the respondents (29.6 percent) because they rely on wind and are therefore cheaper to operate compared to the modern motorized fibre boats that require fuel to be purchased. The sailboats had a carrying capacity of 3 to 4 crew members and most of them were owned by individual entrepreneurs who employed the crew to work for them.

Approximately 49 percent of respondents reported that the small pelagic fish were mainly caught during the NEM season while the rest stated that they were also caught during the SEM season (27.2 percent), both seasons (21.7 percent) and during the inter-monsoon period (2.2 percent).A Chi-square test for independence indicated an association between fishing effort and availability of small pelagic fish across seasons ($X^2_{(9,\ n=92)}$ =0.292, p=0.005, phi=0.506).The p value is less than 0.05 implying that there was a statistical relationship between the variables.

The study sought to establish the time (number of days and hours) fishing is carried out during both the NEM and SEM seasons and these results are presented in Table 3. Time spent fishing was analyzed because it is determined by the target fishery and it is an important measure of fishing effort. In terms of target fishery, the small purse seine (ring net) is used at night to target sardines and anchovies and is used during the day to target both reef and pelagic species. Previous studies such as Ochiewo (2004) also indicated that time is a measure of fishing effort with fishers spending more hours in the sea during the calm NEM season and less hours during the SEM season. The results showed that fishing was conducted for 5.62 days per week during the NEM season. This means that fishers went fishing for 6 days in each week and rested for one day, mainly on Friday which is the main prayer day for Muslims. On average fishing duration has increased over time from 6 hours per day during the NEM season 30 years ago to 8 hours per day in 2018. In the past, artisanal fishers never travelled long distances to fish at the North Kenya Banks or the Malindi Bank that require a 24 hour trip, because they caught enough fish within the inshore areas. During the SEM, fishing is conducted for 5 days per week. The number of hours spent fishing during the SEM season has also increased from 4 hours per day 30 years ago to 6 hours per day during the current study. Overall, the number of hours spent fishing has increased over time. Further, there was less fishing effort during the SEM season compared to the NEM season. The SEM season coincides with strong winds and rough seas. During this time, most fishing activities take place within the sheltered shallow inshore areas which can be accessed using small fishing crafts.

Fish preservation

The results in Table 4 reveal that 48.5 percent of the small pelagic fish was sold fresh to the buyer/consumer, 33.8 percent of the fishers used ice to preserve their catch of small pelagics, while others used other methods of preservation, including salting and drying (16.2 percent), deep freezers and deep frying.

The majority (52.1%) of the respondents targeted small pelagic species which are used as bait as well as for food. The small pelagic species were considered seasonal, were easily caught at night and could be found

Table 3. Descriptive statistics for fishing time during the NEM and SEM seasons.

Season	Fishing time	N	Minimum	Maximum	Mean (±SD)
NEM	Fishing days per week	85	2	7	5.62±1.3
	Fishing hours per day	80	1	24	8.39±5.3
SEM	Fishing days per week	81	1	7	4.91±1.7
	Fishing hours per day	81	2	24	5.81±3.4

Table 4. Frequency distribution of fish preservation methods for small pelagic fish.

Fish preservation method	N	Percent
Preservation in ice	23	33.8
Selling while fresh	33	48.5
Salting and sun-drying	11	16.2
Deep frying	1	1.5
Total	68	100

near shore. The respondents observed that the small pelagic fish provided high income compared to demersal fish because they are caught in large quantities and have a ready market. It was noted that there were some fishers who did not target the small pelagic fish but captured these fish incidentally.

Knowledge and perceptions of the impacts of upwelling

About 52 percent of the respondents did not have a particular term for the upwelling phenomenon and could not confirm that they fished around the upwelling areas. However, 42 percent of the respondents described the phenomenon and explained how they interacted with it through their fishing activities. They described upwelling uniformly elaborating on aspects such as water in the upwelling area being relatively cooler compared to water outside the upwelling area. The level of disparity in knowledge about upwelling could be attributed to the fact that upwelling took place in the distant deeper waters and only those fishers who travelled to the upwelling area could observe it. Further, one needs to be observant in order to recognize the phenomenon and therefore it was only those fishers who were keen to observe the physical characteristics of their fishing grounds were able to recognize it. When asked about the period when upwelling occurs, about 30 percent of the respondents stated that they were not aware. The study also revealed that 40 percent of the respondents did not recognize the importance of upwelling.

Changes in fishing practices and scenarios of change

The study sought to examine both short-term and long-term changes in fishing practices. It was established that long-term changes experienced included increased use of motorised vessels/boats, changes in type of fishing gears used with the introduction of 2 ringnets at Ngomeni, increased crew size from the traditional crew of 2 for gillnets to a crew of 4 for monofilament nets, and a crew of 23 to 31 for ringnets, increased time spent fishing at sea, changing fishing grounds and increased number of fishers. The increased fishing effort caused a decline in the quantity of fish caught per fisher and changes in the composition of fish species, with some species becoming very rare. The decline in fish catch led to a general decline in income, which has translated to a decline in welfare, and the fishers have become worse off today than 30 years ago. To counter these changes, the communities opted to adopt alternative livelihoods.

The key informants observed that climatic changes such as a decline in rainfall over time, irregular wind patterns and increased temperatures have impacted negatively on small pelagic fish landings. About 60 percent of the respondents did not have any idea of the changes that occur in the upwelling areas and therefore they were not able to describe their effects. When asked about changes that have occurred in the fishing grounds, about 31 percent of the respondents stated that over the past 5-10years a decline in the fish catch had been observed due to bad weather, increased temperatures, increased winds/turbulence, effect of brine from the salt pans, changing weather conditions, dredging of the Lamu port that has polluted the sea, use of destructive fishing gears, influx of fishers, lack of rain and the inability of fishers to venture offshore.

The perceptions on the scenarios of future changes were diverse(Table 5).Approximately 57 percent of the respondents observed that if a shift in the sites where pelagic fish are mostly caught occurred, this will result in reduced catch. Consequently, 38 percent of the fishers said they will respond by venturing into the non-traditional fishing grounds in the offshore waters while 28 percent said they were likely to change their fishing grounds within the inshore areas where they currently operate. In addition, the respondents observed that if a 50 percent reduction in the small pelagic fish stocks

Table 5. Perceptions on the likely effects and responses to future scenarios of climate change.

Scenario of change	Likely effect	Frequency	Percentage	Likely response	Response Frequency	Percentage
A shift in the sites where pelagic fish are mostly caught	Reduced catch	43	56.6%	Increase effort	10	12.2%
	Increased fishing effort/time	17	22.4%	Change fishing ground	23	28.0%
	Increased operational cost	7	9.2%	Change target fishery	2	2.4%
	Loss of income	5	6.6%	Opt for alternative Livelihood	1	1.2%
	None	4	5.3%	Opt for alternative gear, fish,bait	5	6.1%
				Venture offshore	31	37.8%
				None	10	12.2%
	Total	76	100.0%	**Total**	**82**	**100.0%**
A reduction of the small pelagic fish stocks by half (50%)	Reduced catch and income	54	71.1%	Venture offshore	2	2.6%
	Food insecurity	8	10.5%	Change fishing ground	8	10.4%
	Lack of preferred fish type	2	2.6%	Change target fishery	19	24.7%
	Decreased fish population	1	1.3%	Change fishing gear	4	5.2%
	Scarcity of bait	1	1.3%	Increase effort	8	10.4%
	Disruption of the food chain	1	1.3%	Opt for alternative livelihood	17	22.0%
	Reduced trade	1	1.3%	None	19	24.7%
	None	8	10.5%			
	Total	76	100.0%	**Total**	**77**	**100.0%**
A reduction of the small pelagic fish catch by half (50%)	Reduced catch and income	63	84.0%	Change target fishery	8	11.8%
	Reduced trade	4	5.3%	Increase effort	8	17.7%
	Harder to get bait	1	1.3%	Change fishing ground	5	7.4%
	Disruption of the food chain	1	1.3%	Look for alternative bait	2	2.9%
	None	6	8.0%	Government intervention	2	2.9%
				Opt for alternative livelihood	33	48.5%
				None	6	8.8%
	Total	**75**	**100.0%**	**Total**	**68**	**100.0%**

Table 6. Desired changes and the means to achieve them as identified by the respondents.

First priority	Means of achieving the desired changes
1. Adoption of modern technology in fishing	1. Advocate provision of proper gear and advanced vessels to venture offshore
2. Removal of fish landing fees	2. Stakeholders engagement
3. Ban on illegal fishing gears	3. Strengthen co-management between government institution and BMU
4. Strengthening of co-management and inclusive management strategies/approaches	4. Adherence to laws and regulations and promotion of surveillance
5. Conservation of the environment by halting the dredging of Lamu port	5. Identify better markets for fish
6. Controlling pollution that caused the migration of fishers	6. Allocate adequate budget
7. Empowerment of fishers with vessels and equipment (introduction of new fishing technology)to venture into deep sea fishing	7. Develop a compensation mechanism for the construction of port since it has negatively impacted the fishing grounds
8. Frequent surveillance and monitoring of fishing operations	8. Ban beach seine in the channels
9. Limiting fishing effort to allow sustainable use of these fisheries resources	
10.Need to empower the BMU	

occurred, it may lead to reduced catch, decreased income and food insecurity. If the negative impacts are realized, about 25 percent of the respondents said they will change their target fishery, 22 percent will opt for alternative livelihoods, 10 percent will change fishing ground and 10 percent will increase effort over time while 25 percent were not committed to any of the options. Further, the respondents observed that if a reduction of the small pelagic fish catch by half (50 percent) occurred, it may lead to reduced income to fishers. The fishers said they are likely to respond to this change scenario by opting for alternative livelihoods (about 49 percent), changing the target fishery (12 percent), increasing their fishing effort (12 percent), and changing their fishing grounds (7 percent).

The respondents identified the desired changes as well as the means to realize these changes and results(Table 6).The desired changes can be categorized into three themes, namely, modernization of fishing technology and empowerment of fishers to enable them to increase their catches and income by venturing offshore, elimination of illegal fishing gears by strengthening surveillance and monitoring of fishing operations and stakeholder engagement, and strengthening of co-management and conservation of the environment. It is anticipated that the desired changes will lead to increased income of the fishers, sustainable harvesting of small pelagic fisheries, and community participation in the management of pelagic fisheries.

Conclusions

Fishing was the main occupation for 95 percent of the respondents from the 3 typical fishing villages. The importance of fishing as a source of livelihood, income and animal protein has been recognized in the County Integrated Development Plans for both Kilifi and Lamu Counties. Besides the 3 typical fishing villages that were studied, there are several other fishing villages spread across the two counties. Since this study has confirmed the importance of fishing as a main occupation in the two counties, attention should be paid to the sustainable development of fisheries so that fishers can have an assured source of livelihood. Less than 50 percent of the fishers target the small pelagic fishery. The fishing effort is higher in the small pelagic fishery during the NEM season which is associated with upwelling and calm sea conditions than in the SEM season when the sea is rough.

A number of changes have occurred in the climatic and oceanographic conditions that negatively impacted on pelagic fisheries. These changes included changes in rainfall patterns, sea level rise, irregular wind patterns and increased temperatures. The changes compounded the effects of increased fishing pressure and resulted in declining fish catch that further translated into decreased income from the small pelagic fisheries. The fishers have responded by adopting the use of motorised vessels/boats to enable them travel further to access distant fishing grounds such as the

North Kenya Bank, changing the type of fishing gears used including introduction of small-purse seine nets (ringnets), increasing crew size, and increasing time spent fishing at sea.

Supporting interventions that will enable the primary school population to successfully transition to secondary and tertiary levels of education or training will equip the youth with skills to minimize their vulnerability and build resilience to climate change impacts. The skills gained from secondary education and training will enable more people to access alternative livelihoods.

Three categories of desired changes in fisher empowerment and fisheries governance issues were identified by respondents, namely modernization of fishing technology to enable fishers to increase their catches and income by venturing offshore, elimination of illegal fishing gears by strengthening surveillance and monitoring of fishing operations and stakeholder engagement, and strengthening of co-management and conservation of the environment. The fishers anticipate that the desired changes will lead to improved livelihoods and income, enhanced adaptive capacity to climate change, sustainable harvesting of small pelagic fisheries, and enhanced community participation in the management of pelagic fisheries. Overall, some of the initiatives that have been identified to address climate change impacts include incorporating climate change in planning activities to develop instruments that provide a combination of adaptation and mitigation measures that are effective over time and space, ensuring that mitigation measures are implemented by various players, undertaking capacity building at all levels through training, education and awareness creation, and ensuring rational use and protection of small pelagic fisheries resources by eliminating destructive fishing practices and regulating fishing effort. This may further involve altering catch size, protecting the breeding grounds, and reducing the level of fishing effort to sustain yields.

Recommendations

There is a need to implement both government and traditional rules that target the management of the small pelagic fishery in the area. Issues such as compliance and enforcement of rules and regulations and discouraging the use of destructive fishing gears like monofilament nets need to be addressed. Furthermore, deliberate efforts to introduce alternative livelihoods to assist the fishers are necessary. Both Government and Non-Governmental Organizations should join hands to support education and training to build the capacity of fisher communities and equip them with skills to enable them access alternative livelihoods, minimize their vulnerability and build their resilience to climate change impacts. The support could include protecting the primary and secondary school population against social problems such as child labour, drug abuse and early marriages.

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Appendix – Questionnaire

Masma Project:
Responses of Biological Productivity and Fisheries to Changes in Atmospheric and Oceanographic Conditions in the Upwelling Region Associated With the East African Coastal Current (*EACC*)

Location _____ **Date: ___/____/ 2016**

Part I. Personal Information

1. Name of respondent (optional) _____
2. Residence _____
3. Sex of respondent: Male ( ) Female ( )
4. Age(yrs): _____
5. Education level (Tick where applicable): No education (1), Incomplete primary (2), Complete primary (3), Incomplete secondary (4), Completed Secondary (5), Higher education (6), Madrassa (7), Other (please specify) (8)

   _____
6. Main occupation of respondent: _____

Part II: Understanding of pelagic fisheries productivity and ocean upwelling

To begin, we are interested in your knowledge of a particular type of fishery. There are no right or wrong answers, we'd just like to learn more about your experiences.

Pelagic Fisheries

7. When I talk of fish that live in the middle of the water, not on the bottom and not on the reef, do you know what I mean? Do you have a name for this group of fish? _____

8. We are most interested in those fish that are small even when fully grown. Can you give me the local names for these kinds of fish? **Use fish pictures to prompt here.* _____

9. What do you know about these fish? **Prompt (a-c)*

   a. What time of the year do you find them most? _____

   b. What conditions make for more fish? _____

   c. What factors cause these fish to decline? _____

10. Do you target these fish in your fishing activities? Why / why not? _____

11. Who normally does target this type of fish? _____

Upwelling

12. When you go to sea, how far out in the sea do you go? _____

13. Are there areas in the ocean where sometimes surface water is pulled down into the deep water, or where deep water rises to the surface? Do you have a name for this?**Use upwelling / downwelling pictures to prompt here.*

   a. How do you know / can you see when water from the deep rises to the surface? **Prompt, cold water, turbulence, lots of fish* _____

   b. Where does it occur? _____

   c. When is it strongest? _____

   d. Do you know why / how this occurs? _____

14. Is the ocean upwelling important to you in any way? _____

15. Do you fish in the upwelling area? Why / why not? _____

16. Are there people from your village who fish in the upwelling area? Who? _____

17. Do you know of any connections between climate, upwelling and fisheries? Can you describe the relationship among them? _____

Part III: Fishing / Marine Practices

Fishermen

	NEM* (Nov – Apr)	**SEM (May – Oct)**
18. What type of gear(s) do you use each season? Do you own your gear? *List in order of most used. Indicate ownership in brackets. (Self, Shared, Hired, Employer's)*	E.g., Line (Self)	
	1.	
	2.	
19. What type of vessel do you use each season? Vessel ownership, size (m/ft), propulsion, and crew number? *List in order of most used. Indicate ownership, size, propulsion, crew in brackets*.	E.g., Ngalawa (Employer's, 3m, wind, 2 crew)	
	1.	
	2.	
a. How often do you fish in each season? *Days/wk + hrs/day*	Days/wk _____ hrs/day_____	Days/wk_____ hrs/day_____
20. How much fish do you land by species on average (kgs per day for **top three** target species)?	E.g., Kingfish (5 kgs/day)	
	1.	
	2.	
	3.	
a. How much small pelagic fish do you land by species, if not in top 3 species (kgs per day for **top three** species)?	1.	
	2.	
	3.	
b. At what price do you sell these fish? *Price/kg*	1.	
	2.	
	3.	
21. Where do you fish for small pelagics? *Provide local name of fishing ground and list in order of importance.*	1.	
	2.	
	3.	
a. Why do you choose these areas to fish small pelagics? *Please explain*		

22. How do you process/preserve your small pelagic fish catch? _____

23. How much of these fish do you consume on average (Kg/day)? _____

    a. How much of your small pelagic catch do you keep to consume? _____

    b. How much small pelagic fish do you purchase? _____

24. What do you do with any pelagic catch that you don't eat / sell? _____

Non-fishers

25. What type of fish do you mostly purchase for consumption? _____

    a. How much fish does your household consume on average (Kg/day)? _____

    b. If at all, how much small pelagic fish do you purchase for food? _____

26. What type of fish do you mostly purchase for trade? _____

    a. (b) How much fish do you purchase for trade on average (Kg/day)? _____

    b. (c) If at all, how much small pelagic fish do you purchase for trade on average (Kg/day)? _____

    c. (d) How do you process / preserve this pelagic fish? _____

    d. (e) At what price is this pelagic fish sold? _____

    e. (f) Who do you sell to and where? _____

27. If at all, how often do you go to sea? _____

Part IV: Vulnerability and adaptation of the fisher communities in the EACC upwelling region in relation to climate change

Experiences of change

	Recent changes (5-10 yrs)	Longer term changes (10+ yrs)
28. Have you observed changes in weather patterns, winds, rains, sea temperatures or sea levels i) over the last 5-10 years ii) over the longer term (10+ yrs)? *Please describe these changes* Do you have a name for these changes?		
a. How have these recent and long termchanges affected you, if at all?		
29. Have you noticed any changes in upwelling (e.g., location, strength, timing)i) over the last 5-10 years ii) over the longer term (10+ yrs)? *Please describe these changes*		
a. (b) How have these recent and long termchanges affected you, if at all?		
b. (c)How do you respond to these recent and long-term changes in weather and oceanographic conditions?		
c. (d)How have your responses improved your life or minimisedany negative impacts on your life, if at all?		
30. Have you observed any changes in your fishing grounds or the oceani) over the last 5-10 years ii) over the longer term (10+ yrs)?*Please describe these changes*		
a. In your opinion, what caused these changes? *List* ***top three*** *causes in order of importance.*	1.	
	2.	
	3.	

	Recent changes (5-10 yrs)	Longer term changes (10+ yrs)
31. Have you observed any major changes in your small pelagic fish catches or what you can purchase (e.g., catch size, composition) i) over the last 5-10 years ii) over the longer term (10+ yrs)? *Please describe these changes*		
a. In your opinion, what caused these changes? *List **top three** causes in order of importance.*	1.	
	2.	
	3.	
b. How have these recent and long term changes affected you, if at all?		
32. Have you changed your fishing/trading practices i) over the last 5-10 years ii) over the longer term (10+ yrs)? *Please describe these changes*		
a. What are your top three reasons for changing your practices? *List **top three**reasons in order of importance.*	1.	
	2.	
	3.	
b. How have thesechanges improved your life or minimisedany negative impacts on your life, if at all?		
33. Have your household changed the way they make a living i) over the last five years ii) over the longer term? *Please describe these changes*		
a. What are your household's top three reasons for doing so? *List **top three**reasons in order of importance*	1.	
	2.	
	3.	
b. How have thesechanges improved your life or minimisedany negative impacts on your life, if at all?		

Scenarios of change

34. In your opinion, **if** you experienced the following changes in future how would they affect you and how would you most likely respond?

    a. A shift in the time when pelagic fish are plentiful.
    Affect _____ Response _____

    b. A shift in the location of where pelagic fish are mostly caught (e.g., further offshore).
    Affect _____ Response _____

    c. A reduction by half (50%) of the number of small pelagic fish in the ocean. **Prompt impacts on large pelagics*
    Affect _____ Response _____

    d. A reduction by half (50%) of your small pelagic catch.
    Affect _____ Response _____

Risk communication and early warnings

35. From who do you receive information on the weather and climate? *List **top three** sources (E.g., community elders, scientists, fisheries department. Be as precise a possible.)*

    1. _____
    2. _____
    3. _____

    a. How do you receive this information? *List **top three** media for knowledge exchange (E.g., meetings, mobile phone, radio, newspaper. Be as precise a possible – ie. Name newspaper)*?

    1. _____
    2 _____
    3. _____

    b. What sort of information do you receive? _____

    c. How useful do you find this information?*Extremely useful (1), very useful (2), 50:50 (3), not very useful (4), not at all useful (5). Please rank.* _____

36. From who do you receive information on pelagic fish? *List **top three** sources (E.g., community elders, scientists, fisheries department.Be as precise a possible.)*

    1 _____
    2. _____
    3. _____

    a. How do you receive this information? *List **top three** media for knowledge exchange (E.g., meetings, mobile phone, radio, newspaper. Be as precise a possible – ie. Name newspaper)*?

    1. _____
    2. _____
    3. _____

    b. What sort of information do you receive? _____

    c. How useful do you find this information? *Extremely useful (1), very useful (2), 50:50 (3), not very useful (4), not at all useful (5). Please rank.* _____

Part V: Governance institutions for small pelagic fisheries

37. Is anyone prevented from catching small pelagic fish? *Please explain why / why not*?

_____

38. What government regulations apply to pelagic fishing or the people who catch pelagic fish? (E.g., gear bans, licenses). *Please list **top three**.*

1. _____
2. _____
3. _____

a. Do you agree or disagree that these government regulations are acceptable to people? *Strongly disagree (1), disagree (2) neutral (3), agree (4), strongly agree (5).*

b. To what extent do fishers comply with these government regulations? *Completely (1), mostly (2), 50:50 (3), slightly (4), not at all (5).*

1. _____ Acceptable _____ Comply _____
2. _____ Acceptable _____ Comply _____
3. _____ Acceptable _____ Comply _____

39. What traditional or local rules apply to pelagic fishing or the people who catch pelagic fish? (E.g., taboos, landing fees, trade tax). *Please list **top three**.*

1. _____
2. _____
3. _____

a. Do you agree or disagree that these local rules are acceptable to people? *Strongly disagree (1), disagree (2) neutral (3), agree (4), strongly agree (5).*

b. To what extent do fishers comply with these local rules? *Completely (1), mostly (2), 50:50 (3), slightly (4), not at all (5).*

1. _____ Acceptable _____ Comply _____
2. _____ Acceptable _____ Comply _____
3. _____ Acceptable _____ Comply _____

40. How do the rules and management of these fish change with the seasons, if at all? *Please explain*

_____

41. How have the rules and management of these fish changed over the years, if at all? *Please explain*
In what ways are you involved in how your community manages these fisheries? *List **top three***

1. _____
2. _____
3. _____

42. In what ways are you involved in how government manages these fisheries? *List **top three***

    1. _____
    2. _____
    3. _____

43. Please rank your agreement or disagreement with the following statements. *Strongly agree (1), agree (2) neutral (3), disagree (4), strongly disagree (5)*

    a. I am able to influence the important decisionsmade about the small pelagic fishery. _____

    b. The organisations managing the small pelagic fishery are accountable to the people that depend on this fishery. _____

    c. The organisations managing the small pelagic fishery are able to respond appropriately to changing circumstances whether environmental, social or political. _____

    d. The small pelagic fisheries are effectively managed? _____

44. Knowing what you know about this fishery what would you change about how it is managed? List in order of priority:

    1. _____
    2. _____
    3. _____

    a. How could these improvements happen? _____

45. Any other comments _____

    _____

The End

Thank you for your time.

Interviewers name: _____

Date _____