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SHARK BYCATCH - SMALL SCALE TUNA FISHERY INTERACTIONS ALONG THE KENYAN COAST

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Abstract

In Kenya and to a great extent most parts of the WIO region, shark catches majorly occur as by-catch in artisanal tuna fisheries and prawn trawls, including sport fishing activities. However, the extent to which these various fisheries catch sharks is not known but may be significant. The species structure, distribution, catch rates and levels of fisheries-shark interactions are not well documented. This information is, however, necessary to assess exploitation levels of shark species and for setting regulatory, conservation and management frameworks. This study therefore aimed at filling this information gap. Data was collected from fisher landings at various sites along the Kenya coast and by observers on commercial and scientific trawl surveys. Landings at 5 beaches were inspected for 15 days per month for 12 months (August 2012 to July 2013). Specimens were identified to species and, sex, length and weight recorded for each shark landed or trawled as by-catch. Results indicate that the artisanal and the prawn trawl shark bycatch is dominated by Hammerhead sharks (*Sphyrna lewini, 53.7%*), Blacktip Reef shark (*Carcharhinus melanopterus,* 33.7%), and Grey Reef shark (*Carcharhinus amblyrhynchos,* 5.5%*)*. Other species present in the catches in lower quantities (~7.1%) include *Carcharhinus falciformis, Carcharhinus longimanus, Carcharhinus brevipinna, Sphyrna zygaena, Stegostoma fasciatum.* Catch rates of species show spatial and seasonal variation in abundance with higher catches in Kenya's north coast. Morphometrics of the dominant species are included, and size-frequency distributions show mostly juveniles in the catches. There is need to continuously monitor the distribution and abundance of sharks, including shark-fishery interactions in the WIO region for purposes of conservation.

Key words: By-catch, Conservation, Tuna, Sharks, Red list, Fisheries-interactions

INTRODUCTION

Worldwide, sharks are fished for their fins, liver oil and cartilage and are often caught as by-catch in tuna and tuna- like fisheries. Direct and indirect shark fishing has caused serious declines in shark populations in many areas of the world (Baum *et al*., 2003; Burgess *et al*., 2005) and in the Western Indian Ocean (WIO) countries, including Kenya. Sharks are top apex predators with low fecundity, slow growth rate and late maturity, hence are vulnerable to both growth and recruitment overfishing (Stevens *et.al*., 2000) resulting into cascading effects associated with top predator removals (e.g. fishing down the food web; *sensu* Pauly, 1998). The loss of these top predators has effects on trophic interactions associated with resultant increases in lower-level predators, such as rays, skates and smaller sharks. The prevailing view is that it is important to control directed shark fisheries and shark by-catch (Baum *et al*., 2003). The IUCN red list indicates a number of shark species as being threatened. Despite this scenario, few countries manage their shark fisheries and there are no national or trans-boundary management systems in place for chondrichthyan populations in the Kenya, or even the WIO region countries. However, some initiatives are now underway to conserve shark populations (e.g. IPOA-sharks; FAO, 2000).

In Kenya most of the shark landings occur as by-catch in artisanal tuna fisheries and in prawn trawls. A comparatively substantial amount of sharks is landed from the artisanal fishery especially in Kipini and Ziwayuu Islands in Tana River County (Fisheries Department Annual Report, 2011). Further, the extent to which inshore prawn trawlers, offshore commercial long liners and purse seiners catch sharks is not known but may be significant. While most of the carcass is consumed locally both fresh and dried, the fins are exported to Far East countries like Hong Kong and China.

The tuna stock in the Kenyan EEZ is estimated at 155,000 M tons/ year. The Artisanal fishermen land about 8,000 M tons/ year (this is a very low harvest relative to the actual potential). The biggest challenge is data collection from artisanal tuna catch data.

Other sharks are caught as bycatch from artisanal fisheries. Good records of data exist on sport fishing in Kenya extending as far back as the 1960's.

According to the Kenya Marine Frame Survey 2012, there are 149 fishers targeting tuna and 490 fishers targeting sharks. However, Kenya's artisanal fishery does not have a strictly shark directed fishery with fishers landing whatever catch is caught in their gillnets and longline hooks.

Despite this level of exploitation and the economic importance of the fishery both for food and income to the local communities, the species structure and distribution, standardized catch rates and levels of fisheries-shark interactions are not known. This information is necessary to assess exploitation levels of species and for setting regulatory conservation and management frameworks. This research has endeavored to fill that knowledge gap.

There is an obvious lack of information on shark populations and other top predators and their effects on ecosystem functions (Rudy van der Elst *et al*. 2003; www.swiofp.net). This information gap needs to be addressed through focused research.

The monitoring of morphometric parameters of sharks in the Indian Ocean (Kenya) fishery is the first important step towards the provision of basic information on the state of the shark bycatch and shark stocks in addition to any other information that may be gained from catch-effort data. The length frequency and length-weight data gives information on the size structure of the species and the well being of the stocks available in the fishery. From the same data, information garnered on size at maturity (from the biological studies of the most abundant shark species) is needed to give the first glimpse on mesh-size regulation standards in the fishery.

All the above information is a basic requirement for proper management of the shark fishery and is as such of great use to fisheries managers and policy makers. It will aid in making holistic decisions that incorporate especially the Ecosystem Approach to Fisheries principle and in the drafting of the National Plan of Action (NPOA) for Sharks, or any other management and conservation instruments that may be required from time to time.

This study therefore aims to fill the identified information gap by providing data on the status of shark populations in Kenya, with special emphasis on historical landings data, spatial distributions and seasonal composition, and catch rates of the various shark species.

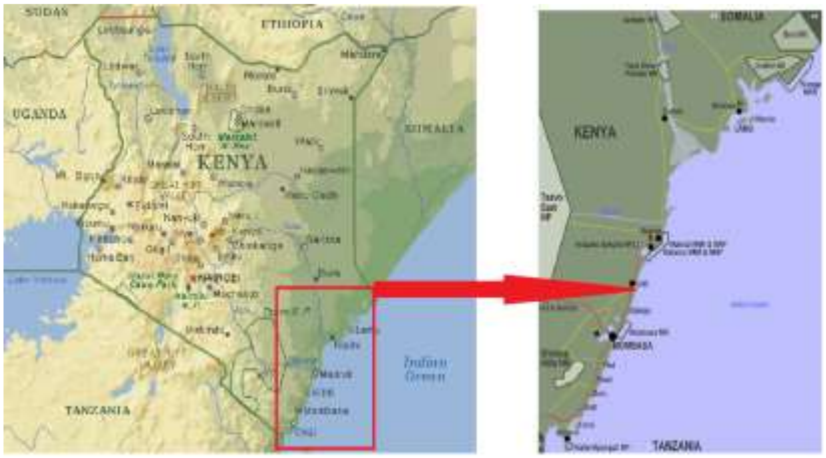
MATERIALS AND METHODS

STUDY AREA

The study was done between July 2012 and July 2013. It was carried out at carefully selected tuna landing sites along the 650km long Kenyan coastline, and in trawl and commercial fishing and research vessels in Kenya's territorial waters and the EEZ.

The Kenyan coast is bordered by Somalia to the north and Tanzania to the south. About 2.5 million people (8% of the population) live in the coastal zone (Fondo and Sigurðsson, 2004). The coastline is fringed by coral reef, which creates a shallow inshore zone sustaining artisanal fisheries.

Map. 1: Map of Kenya showing the Kenya waters of the Indian Ocean (the study area)



SAMPLING DESIGN

The study was carried out within selected sites along the Kenyan coast. More specifically, samples were collected from the south coast tuna fish landing sites sites of Shimoni and Msambweni, (all in the South Coast); Ngomeni, Kipini and Ziwayuu Island (in the Middle Coast/ Ungwana Bay), and Kiwayuu Island in Lamu (in the North Coast). The study was limited to these landing sites considering catch amounts based on data from the Fisheries Department (Fisheries Department Annual Report, 2011) and to some extent, logistical reasons. More data was collected from the semi-industrial prawn fishery in Malindi and Formosa bays (the larger Uungwana Bay).

Data was collected from all shark species landed or caught, and this included both the oceanic species (e.g. Oceanic whitetip shark (*Carcharhinus longimanus)*), and the coastal sharks (e.g. Hammerheads, *Sphyna* sp.). Sampling period lasted for one year and was spread to cover the northeast and southeast monsoon seasons.

DATA SOURCES

Data was also obtained from the following sources:

i) Research observer survey data from semi-industrial/ commercial prawn bottom trawl vessels and demersal research survey trawls.

ii) Fisheries historical landing statistics as recorded by the Department of Fisheries and;

iii) Catches recorded at selected landing sites along the coastlines.

SAMPLE MEASUREMENTS AND DATA ANALYSIS

i) Historical Data

A time-series of total tuna and shark landings was constructed for the years running from 1990 to 2010 and 1984 to 2011 respectively. Lowess smoothing techniques was used to show main trends in landings and depict the exploitation status of sharks in Kenya. Data on historical landings was obtained from Fisheries Department of Kenya.

ii) Observer and shark landings data

Artisanal shark landings data were examined to define the number of vessels reporting shark landings, the magnitude and geographic extent of shark catches and the gross weight of shark catch landed. These landings were from various fishing gear including gillnets, long line hooks and monofilaments. Shark landings were examined and the weights of shark species landed were recorded through time. Frequency-distributions for the species were used to map spatial distributions. Length-weight and, body weight-fin weight relationships were also determined.

Data from the prawn trawl observers was also used to determine the catch characteristics of the sharks taken by the fishery (species composition, catch per unit effort- CPUE) and examine the number of sharks captured per location per month during the trawling season. CPUE data of species between the artisanal and prawn fishery were compared using analysis of variance (ANOVA) of $\log(x + 1)$ transformed data from all areas fished. The CPUE of sharks was also compared among seasons using the ANOVA to find out if there are significant seasonal differences in landings among priority species.

Data from the landings were seasonally aggregated and graphical presentation used to correlate variables like length, weight and maturity.

Data from landing sites was further aggregated into seasonal means and used to examine seasonal changes in numbers and weights of species landed. The location of capture for species was used to map spatial distribution of species in Kenya. The frequency of gear-based shark landings as by-catch was also used to determine levels of fisheries-shark interactions.

iii) Total Length-Total Weight

Immediately after being landed, sharks were identified, sexed, and measured (both total length – TL and Pre-caudal length – PCL) to the nearest mm. The weight was taken to the nearest 0.001 kg using an automatic self loading balance for smaller sharks, and a spring balance for larger sharks of more than 5 kilograms.

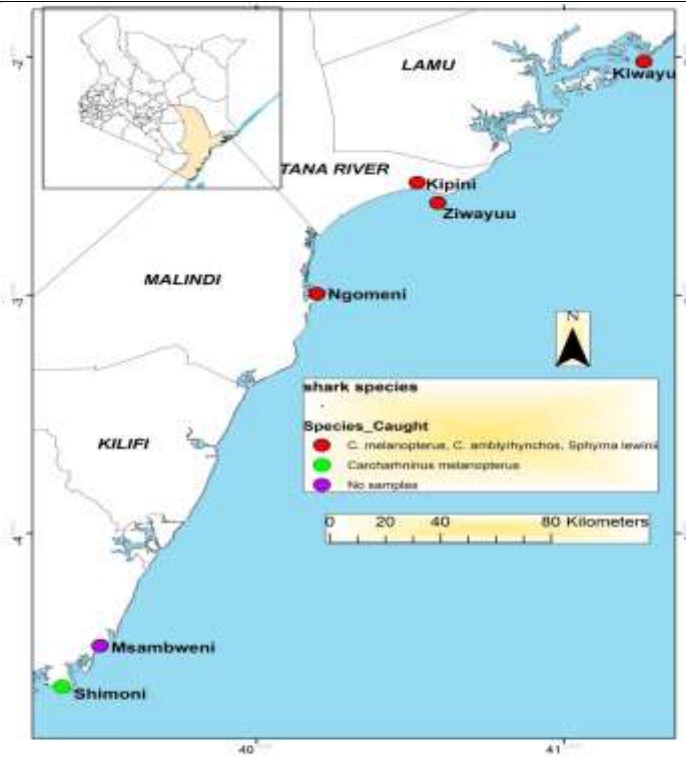
RESULTS

i) GENERAL CATCH DATA, COMPOSITION AND SPATIAL DISTRIBUTION OF SHARKS BYCATCH IN KENYA

Even though most shark species exhibited a universal distribution along the fishery, major concentrations were observed in the middle coast, comprising the larger Sabaki River mouth-Tana Delta marine ecosystem complex (Malindi- Ungwana Bay). Species of *Sphyrna lewini*, *Carcharhinus melanopterus* and *Carcharhinus amblyrhynchos* showed a near-coast wide range (Map 2). The research results indicated that over 98% of the shark sample biomass landed from Kenyan fishery waters was from this Malindi- Uungwana Bay ecosystem complex (Table 1). Statistics from Kenya’s State Department of Fisheries indicate that the actual contribution of the shark biomass landed in Kenya from the Ungwana Bay complex is over 52%. This points out to the ecological importance of the fishery complex especially its contribution to elasmobranch landings.

From Shimoni fish landing site in the South Coast, 5 specimens (composed of only *Carcharhinus melanopterus*) were caught in July and August, while the greatest shark landings were experienced in Kipini (919 specimens of *Sphyrna lewini*, n=518; *Carcharhinus melanopterus*, n=58; *Carcharhinus amblyrhynchos*, n=26; *Carcharhinus leucas*, n=3; and *Carcharhinus limbatus*, n=325).

Generally the *Sphyrna* spp. (*S. lewini* and *S. zygaena*) were relatively more abundant than the rest. The analysis of catches from the small scale and semi-industrial prawn fishery indicated the *S. lewini* had an abundance of about 28%, and then followed by *S. zygaena* at about 24%



Map 2: Map showing the main sampling points of the study, and the distribution of the four main shark species caught from the Kenyan waters of the Indian Ocean.

The small scale elasmobranch fishery landing in Kenya has steadily been decreasing from the early 1980s (Fig. 1). Even though a high of 3,000 Metric tons was observed in the early 1990s, the lowest ebb was immediately reached around the year 2000, and the trend has continued to be alarmingly downward. On average, Kwale County contributes 14.2% of the total shark biomass landed in Kenya, Mombasa 24.5%, Kilifi 27.6%, Tana River 34.3% and Lamu 9.4%. Therefore the Ungwana Bay fishery in which much of this study concentrated on average contributes 62% (it is hosted by both Kilifi and Tana River counties) (Fisheries Department, 2011). The catches of *S. lewini* seem to be peaking during the period of the North East trade monsoon winds and are low during the South East monsoon trade winds season.

Most of the landings of *S. lewini* occurred in the months during the closed season for prawn trawl fishing (November to April), with a peak during January. The other minor peak is during the month of September just immediately before the onset of the North East Trade Monsoon winds in October (the commencement of active small scale fishing). During the months of April to August (corresponding to the South East Trade monsoon winds season), the catches are low probably because the fishing gears of the fishers are rudimentary to enable optimum fishing during this season. The same trend informs for the other shark species, along with all the other fisheries along the Kenyan coast's small scale fishery (Fig 2).

Fig.1: Catch trends of Elasmobranchs in Kenya

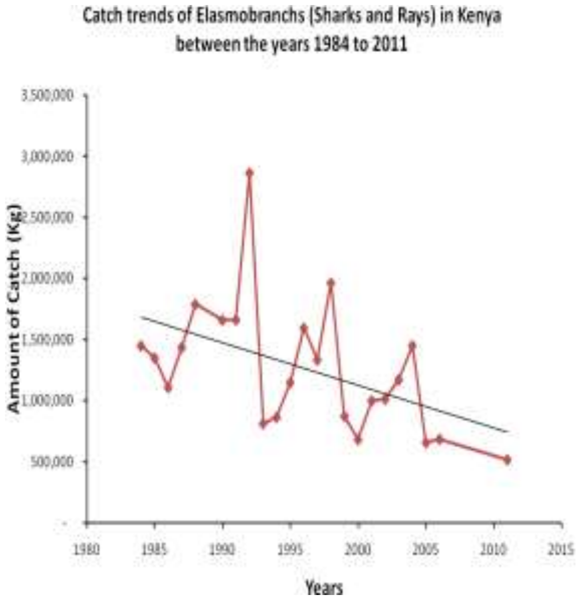
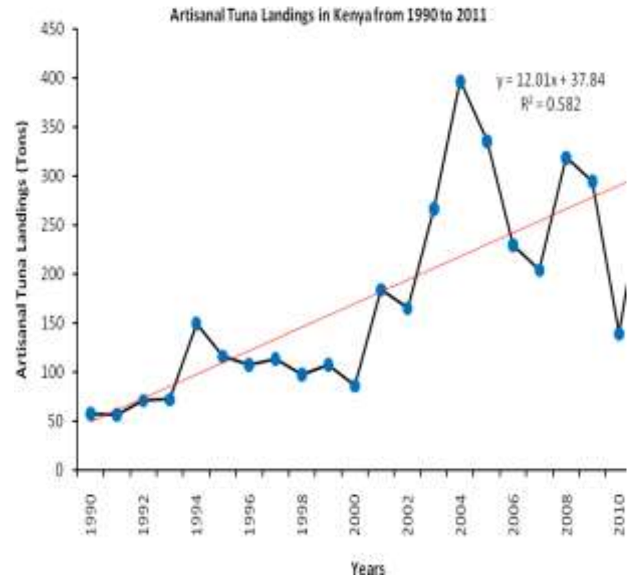


Fig. 2: Catch trends of Tuna in Kenya



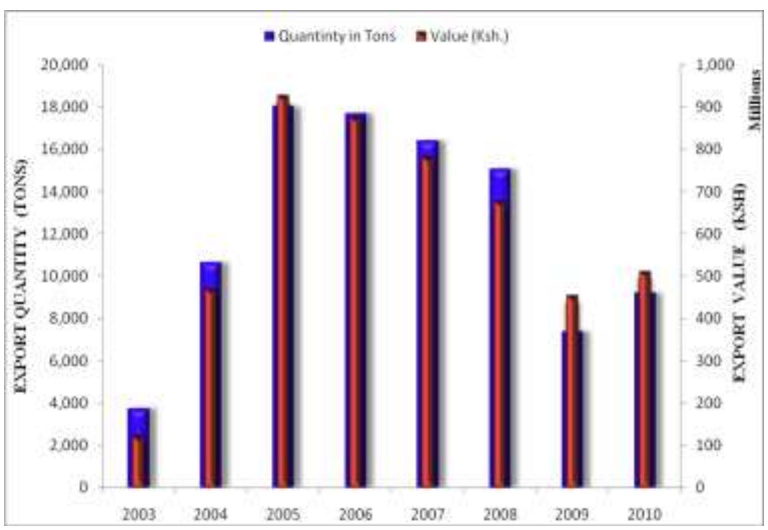


Fig. 3: Tuna fish products export and value from Wananchi Marine Products from 2003 to 2010

Table 1: Tuna catches from the Recreational fisheries in 2009 and 2010

a. Tropical tuna	**2009**	**2010**
Species	**Kgs**	**Kgs**
Yellowfin Tuna	18,144	10,400
Bigeye Tuna	29	4
Skipjack Tuna	769	718
Longtail Tuna	3,329	16
b. Neritic Tuna		
Kawa kawa		830
Frigates		215
c. Billfishes		
Sailfish		28,502
Blue marlin		17,645
Black Marlin		948
Striped marlin		1,401

Table 2: Tuna catches from Industrial Longliners between 2007 and 2010

Catches in tons	**2007**	**2008**	**2009**	**2010**
Swordfish	210	277	288	73
Bigeye tuna	17	23	9	26
Yellowfin tuna	11	22	17	28
Sharks	205	71	44	10
Others	2	18	1	0.08
Total	**445**	**411**	**359**	**137.08**

The composition of sharks from research trawl surveys and catch rates were quite different from those of fishery dependent sources. Their catches were dominated by African Angelshark (*Squatina africana)* with catch rates of about 25.5kg/hr, followed by Shortnose spurdog (*Squalus megalops)* with catch rates of about 22.6 kg/hr. These were then followed by *S. zygaena* at 2.25kg/hr (Table 5 and 6). As a corollary, the catch rates and the Catch per unit of effort (CPuE) differed from month to month, and for the small scale it fishery ranged from 0.2 kg/fisher/hr to 1.4 kg/fisher/hr in some months (Fig. 2). Evidently, these were higher in the months when the fishery is closed from prawn trawling and during the North East trade monsoon winds when the sea is slightly calm for the small scale fisherman. Overall, the observed differences in composition, distribution, catch rates and abundance of various shark species could have been due to depths of fishing, with research trawls conducting their surveys deeper in to the ocean than the small scale fishers and inshore prawn trawlers.

The catch rates and the catch per unit of effort (CPuE) for all sharks from the artisanal fishery was higher during the North East Monsoon season than the South East monsoon season, reaching a peak during the month of November and a slightly lower peak in February (Table 2). The catch rates and CPuE from the artisanal fishery were relatively higher from November to May (and these are also the same months within which the Ungwana Bay fishery is closed for semi-industrial prawn trawling) (Table 3).

Table 3: Catch rates of shark species from the artisanal fishery along the Kenyan coast during various months of the year

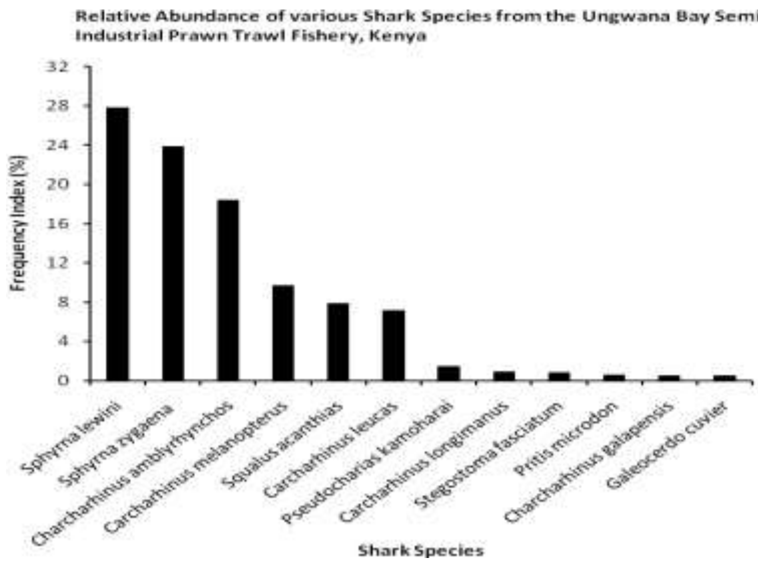
Month	Total Number of days fished	Number of fishermen	Total Landings (Kg)	Catch rate (Kg/fisher /day)	n
July	10	46	30	0.07	53
August	28	118	80.769	0.02	134
September	17	74	61.345	0.05	86
October	11	45	48.01	0.10	46
November	3	16	15.86	0.33	26
December	9	20	17.82	0.10	21
January	23	46	125.46	0.12	120
February	15	44	50.9	0.08	62
March	5	16	11.8	0.15	8
April	3	13	11.14	0.29	6
May	2	10	9.24	0.46	9
June					
July					
TOTALS	**126**	**448**	**462.344**	**0.01**	**571**

Table 4: Catch rates of shark species caught in the semi-industrial trawlers and demersal research trawlers

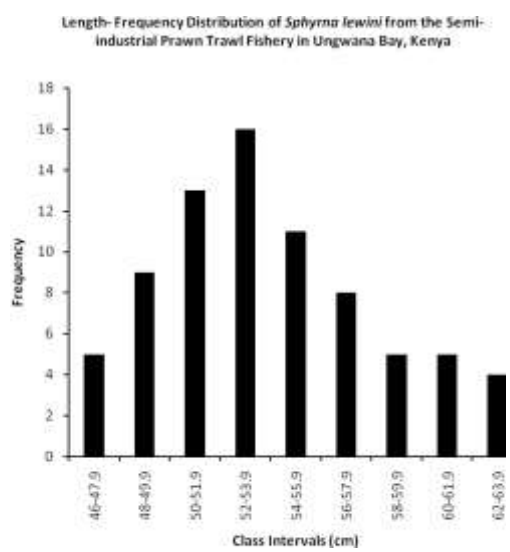
Type of Fishery	Species Caught	Number of Individuals, n	Total Weight (Kg)	Total Fishing Hours	Catch Rates (Kg/ hr)
Semi-Industrial Prawn Trawl	Hammer head, *Sphyrna lewini*	78	77.1	39	2.0
	Grey Reef Shark, *Charcharhinus amblyrhynchos*	83	50.911	53	0.961
	Blacktip Reef Shark, *Carcharhinus melanopterus*	2	27	6	4.5
	Bull Shark, *Carcharhinus leucas*	1	20	3	6.7
	Smooth Hammerhead Shark, *Sphyrna zygaena*	69	66.2	33	2.0
	Zebra Shark, *Stegostoma fasciatum*	3	2.5	9	0.3
	Galapagos shark, *Charcharhinus galapensis*	2	1.47	3	0.5
	Saw fish, *Pritis microdon*	2	1.8	3	0.6
	Tiger Shark, *Galeocerdo cuvier*	1	1.45	3	0.5
	Spiny Shark, *Squalus acanthias*	7	21.8	3	7.3
	Crocodile Shark, *Pseudocharias kamoharai*	3	4.2	3	1.4
	Oceanic White tip, *Carcharhinus longimanus*	1	2.6	3	0.9
Demersal Research Trawl	Grey Reef Shark, *Charcharhinus amblyrhynchos*	2	2	1	2
	Smallfin gulper shark, *Centrophorous moluscensis*	1	2	1	2
	Blackspot Shark, *Charcharinus sealei*	1	0.7	1	0.7
	African Spotted Catshark, *Holohalaelurus punctatus*	13	1.4	1	1.4
	Yellowspotted catshark, *Scyliorhinus capensis*	1	0.4	1	0.4
	Smooth Hammerhead Shark, *Sphyrna zygaena*	1	1.5	0.7	2.25
	Shortnose spurdog, *Squalus megalops*	9	15.8	0.7	22.6
	African angelshark, *Squatina africana*	4	25.5	1	25.5

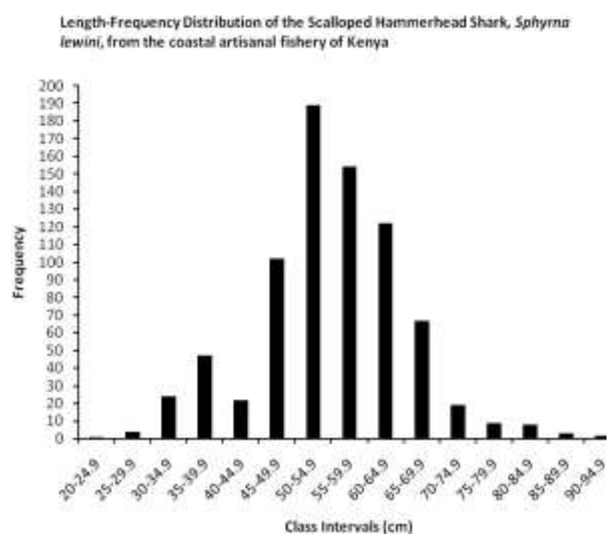
Generally the *Sphyrna* spp. (*S. lewini* and *S. zygaena*) caught in the semi-industrial/ bottom trawl prawn fishery were relatively more abundant than the rest. The analysis of catches from the small scale and semi-industrial prawn fishery indicated the *S. lewini* had an abundance of about 28%, and then followed by *S. zygaena* at about 24% (Fig. 3).

Fig. 3: Relative Abundance of Shark Species in the artisanal and Semi-Industrial Prawn Trawl fisheries in Ungwana Bay, Kenya

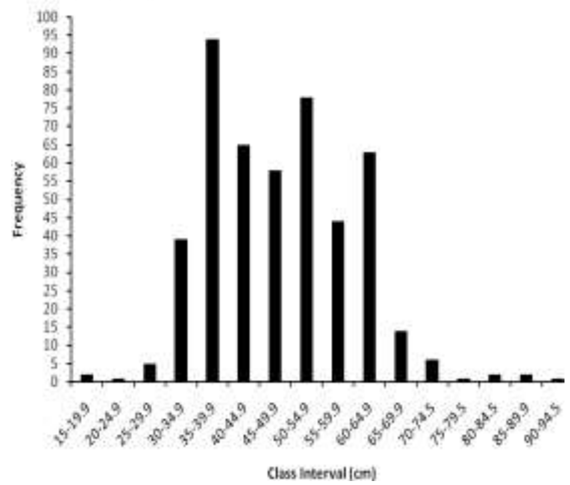


ii) LENGTH- FREQUENCY DISTRIBUTIONS

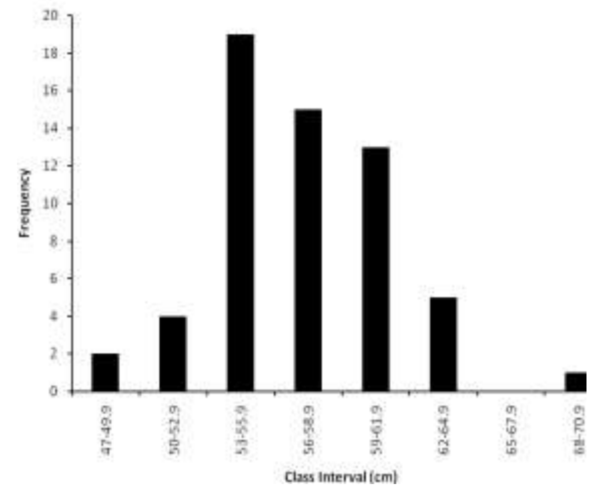




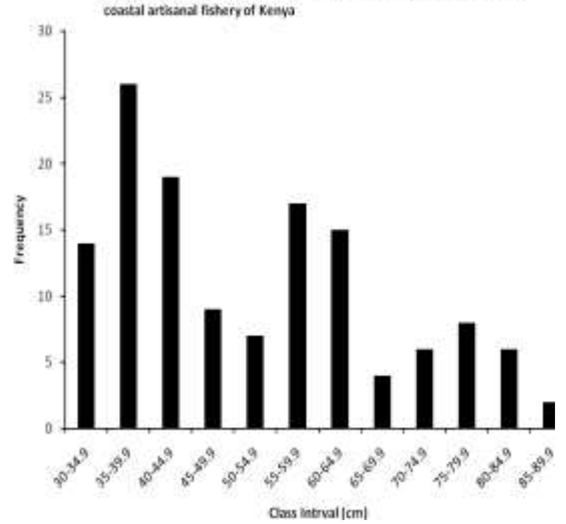
Length-Frequency Distribution of *Charcharhinus limbatus* from the coastal artisanal fishery of Kenya



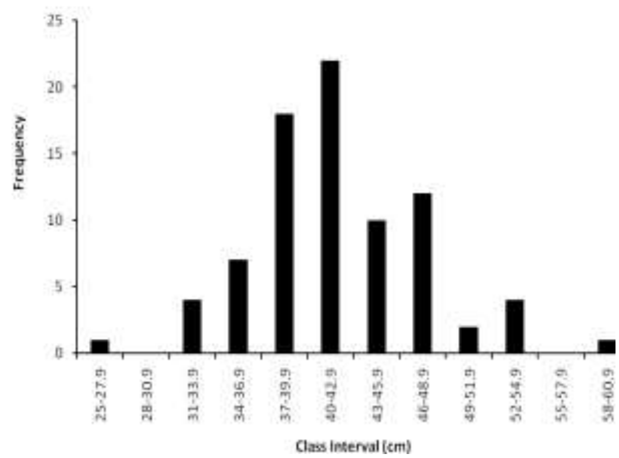
Length- Frequency Distribution of the Smooth Hammerhead Shark, *Sphyrna zygaena*, in the Semi-industrial prawn Trawl Fishery in Ungwana bay, Kenya



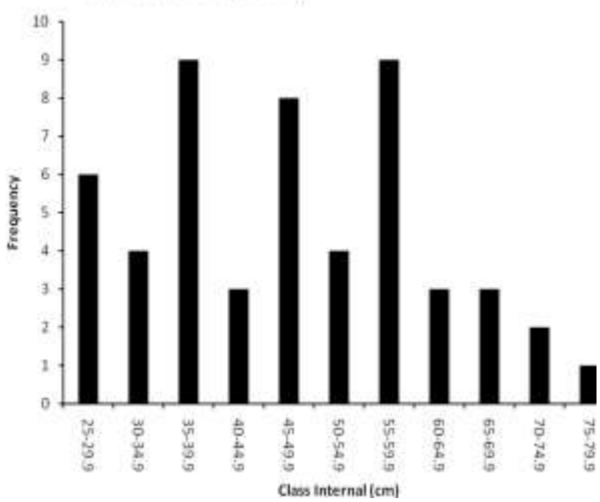
Length- Frequency distribution of *Carcharhinus amblyrhynchos* from the coastal artisanal fishery of Kenya



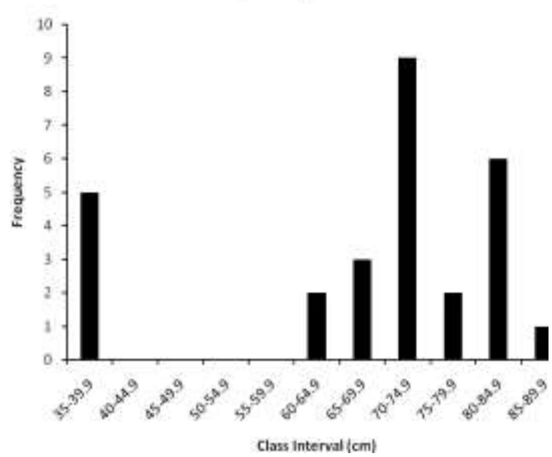
Length-Frequency Distribution of *Charcharhinus amblyrhynchos* in the Ungwana Bay Semi-industrial Prawn Fishery, Kenya



Length- Frequency distribution of *Carcharhinus melanopterus* from the coastal artisanal fishery of Kenya



Length- Frequency distribution of the *Carcharhinus leucas* from the coastal artisanal fishery of Kenya



The sizes of *S. lewini* landings ranged from 15.3 cm TL to 92.5 cm TL. Most samples were juveniles, with some neonate samples having almost fresh umbilical cords. This directly indicated that the fishery ground is both a parturition and nursery ground. This fact held true for most of the other shark species encountered.

The structure of the L-frequency distribution for *S. lewini* caught from the semi-industrial prawn fishery had a prominent modal L class between 52 and 53.9 cm while those from the small scale fishery had between 60- 64.9cm. Both results indicate that the fishery may at any given time be dominated by one cohort consisting of mostly juveniles. Likewise, juveniles dominated the catches from the other species of sharks from the artisanal fishery.

a) Sex Ratio

Although there were some temporal variability between sexes caught during the period examined, the pooled sex ratio of males to females of, for example, *S. lewini* (1: 0.89) was not significantly different from 1: 1 ($X^2 = 3.84$, $p > 0:05$). A similar scenario also obtains in *C. amblyrhynchos*.

DISCUSSIONS

Morphometric analysis, based on body proportions and relationships, is useful for characterizing units of stocks and facilitating the estimation of size compositions based on landed shark carcasses or fins. While some descriptions of such relationships for many shark species, for example *S. lewini* have been published (White *et al.*, 2008) they are restricted to other areas and stocks. Furthermore, Garrick (1982) showed that there could be large variability between different areas, illustrating the need for fishery specific analysis.

In the present study, it was determined that there is a negative isometric relationship between the length and weight of all the sharks investigated. This implies that these shark species become slimmer with increasing length.

The length frequency results showed that the samples of *S. lewini* from the artisanal fishery were almost similar to those from the prawn trawl fishery, with strong modal classes of both falling between 50-55cm TL. The same was observed for the other Sphyrnid, *S. zygaena*. Most samples of the shark species encountered were juveniles, with some neonate samples having almost fresh umbilical cords. This directly indicated that the fishery ground is both a parturition and nursery ground. This fact held true for most of the other shark species encountered.

A number of different studies on ratios and biometric relationships between the weight of the different fin sets and the bodies of the sharks have been conducted recently to estimate or indirectly verify the catches of different species (Ariz *et al.*, 2006, 2008; Clarke 2008, Clarke *et al.* 2004, Cortés and Neer 2006, Espino *et al*. 2010, Mejuto and García-Cortés 2004, Mejuto *et al.* 2009b, Rose and McLoughlin 2001, Santos and García 2005, 2008). These ratios may sometimes be useful in defining thresholds as a measure to control landings in order to avoid the undesirable practice of finning in the fleets or vessels that are still engaged in this abominable practice. Therefore, in addition to being of unquestionable scientific value, these ratios may also provide legislators with a foundation on which to base the definition of realistic thresholds adapted to the fishery practices of the respective fleets (Lorenzo *et. al*, 2010). The interest to determine the fin to carcass weight relationships and ratios is that these ratios are used in the regulations on finning (= fins cut on board of the fishing vessel and discard of the carcass). The average ratio of 5% often used is controversial (Hareide *et al.*, 2007; Hindmarsh, 2007; IOTC, 2007; Petersen *et al*., 2007; Fowler and Séret, 2010; Biery & Pauli, 2012). These need to be determined for all the shark species found in Kenya and in the Western Indian Ocean (WIO) region.

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Even though the sex ratios of all shark species were not significantly different, female neonates dominated the landings. Although female *S. lewini* have been considered to be associated more with oceanic waters (Clarke, 1971), those caught in Ungwana Bay prawn trawl and artisanal fishery waters were taken mainly in coastal areas and significantly outnumbered the males in the landings of this species (Chen et al., 1988). Klimley (1987) hypothesized that female *S. lewini* move offshore at a smaller size than their males. Thus, depending on whether fisheries are operating in offshore or more inshore waters, the catches of this species are likely to be dominated by one sex or the other (White, *et al.*, 2008).

FISHERIES IMPLICATIONS AND DISCUSSION

All the sharks landed were caught using tuna gillnets and longline hooks, with gillnets contributing over 90% of the catches. Currently 490 fishers target sharks along the Kenyan Coastline (Frame Survey, 2012). But it is not quite clear that there exists a strictly artisanal shark directed fishery in Kenya, indicating that most of the shark landings could be bycatch from the small and medium pelagic fisheries.

All the sharks harvested were juveniles compared to the lengths at maturity recorded in existing literature. Thus, on average, almost all the individuals of both sexes examined at the landing sites had been caught before they had had the chance to breed.

The fisheries managers responsible for Kenya's Indian Ocean fisheries will need to consider the fact that all the sharks harvested are bycatch from other fisheries, are juveniles, especially in view of the substantial numbers of *S. lewini* taken in Ungwana Bay waters and the large proportion that are below the size at maturity. Besides, it should be borne in mind that the removal of large numbers of this apex predator, whether mature or juvenile, will deplete the fishery and in the end have an impact on the trophic structure in Kenya's fishery waters (Bonfil, 1994; Kitchell *et al*., 2002).

From the study results, it can be concluded that Ungwana Bay is a pupping ground for the scalloped hammerhead shark, *Sphyrna lewini*. The pups are seemingly most abundant between April and October. This period also coincides with the onset of the South West monsoon winds, and the short rain season. While in the bay, the pups seem to stay in the most turbid areas by day and move out at night to reef areas where they feed on reef fishes and crustaceans. Most fishers interviewed ad hoc during the study said that the preference for turbid areas during the day by the pups (where they are caught using gillnets especially monofilament gillnets) is to avoid cannibalization by their parents and predation by other larger sharks roaming the bay. This line of thinking may need further investigation. Additionally, further investigation that will involve tagging experiments is required to ascertain the food and feeding habits, and the annual movements of the pups and adults.

Considering that this research has shown that the small scale and semi-industrial harvesting of sharks in Ungwana Bay and other parts of the Kenyan shark fishery involves juveniles, and that the elasmobranchs have a life history strategy marked by traits that may render them vulnerable to overexploitation, future research needs to include more detailed examination of the current level of exploitation and the development of appropriate but simple models to determine sustainable effort and catch levels.

Given the evidence presented in this research showing that it is feasible to relate weight of fins against total weight, regular samples need to be collected to monitor the relationships of all the other shark species available in the fishery. This will ease the development and implementation of management measures and their enforcement, including the FAO National Plan of Action for Sharks (NPOA- Sharks) and other bycatch management frameworks in tuna fisheries.

Future research should focus on shark movements and possible occurrence of spawning aggregations in the estuarine waters, the effects of tidal currents and environmental variables therein, and the study area should also be expanded to include all contiguous habitats.

It is also recommend in this study that an effective management plan be developed for the whole Tana Delta estuary complex, establishing resource-user community agreements on effort control and well coordinated Monitoring, Control and Surveillance (MCS) actions to ensure compliance.

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