ASSESSMENT OF THE KENYAN MARINE FISHERIES FROM SELECTED FISHING AREAS

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ABSTRACT

Lack of information on fish stocks, in addition to inadequate and unreliable data, have been a major concern in the management of marine resources in Kenya. A need to improve methodology in data collection and stock assessment has been recognized. Data collected by the Fisheries Program of the Kenya Marine and Fisheries Research Institute, from Lamu (north coast of Kenya) and Vanga (south coast of Kenya) in 2002 and 2003, was used to demonstrate various analyses. Mapping of catch distributions in the two areas, CPUE calculation, species composition, length distributions and length weight relationships for selected species were performed. Results show that three species: *Lethrinus*, *Lutjanus* and *Siganus* are targeted in Lamu and Vanga. In Vanga, smaller fish (juveniles) are caught compared to Lamu. No conclusions could be made due to the limited data available. However, recommendations are made on improvement of the data to be collected and the type of analyses to be performed in the future when adequate data is available.

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1   INTRODUCTION

The Kenyan coast is about 650 km long and 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. Distinctive along the coastline is the continuous fringing reef, which creates a shallow inshore zone sustaining artisanal fisheries. Mangrove forests occur in many estuaries and deltas, while sea grass beds are distributed between the mangrove and reef areas. The EEZ (what is EEZ?) amounts to about 230 000 km^2.

Kenya's fisheries resources contribute to the national economy through employment creation, foreign exchange earnings and food security support. It has been calculated that the fisheries sector makes up almost 5% of the GDP (agriculture and tourism contribute the most). It is estimated that a total of 40,000 people depend directly on marine fish production. An average of 6300 tons of marine fish, crustaceans and molluscs valued at 348 million Kenya shillings are landed annually. This amount is harvested mostly by artisanal fishermen who restrict their operations to the continental shelf, as they are not sufficiently equipped to venture into the deep sea (Wakwabi *et al*. 2003) However, there are several commercial fishermen who currently operate four modern fishing vessels that trawl prawns along the Kenyan coast. There are about 8,000 licensed fishermen and 2,600 fishing vessels. The Fisheries Department (FD) is responsible for the management of fisheries in Kenya, while the Kenya Marine and Fisheries Research Institute (KMFRI) has the mandate to do research in aquatic resources and give appropriate information and advice to the Department.

The true status of Kenya's marine resources is not known and the last resource assessments were done in the 1980s. Therefore, there is a need for updated assessments. Recorded marine landings currently only comprise around 5% of total catches, so it is believed that there may be potential for the development of marine fisheries, in particular offshore fisheries, but assessments are needed to verify this. The capacity for data collection by the FD has declined in recent years with the retrenchment of staff. Catches by artisanal fishers, who exploit the near shore resources on the continental shelf, are believed to have declined in recent years and catch rates have fallen. It is believed that the offshore marine resources are not yet fully exploited due to the lack of ability of artisanal vessels to fish offshore and the limited licensed offshore foreign fishing. However, scientific information to confirm this is lacking.

Under the Fisheries Program of KMFRI, a fisheries data enumeration seed project was established in 2001. The project was motivated by the fact that there is lack of information on fish stocks, inadequate and unreliable data and general statements that inshore fisheries are on the decline and overexploited. In the project, data enumerators were trained by scientists from the Fisheries Program team and were then attached to fisheries officers (from the Fisheries Department of Kenya) working in different stations. Enumerators have been collecting data in the field using forms (see appendix I) designed by the Fisheries Program team. Data entry into electronic format started in early 2004. The project had the following objectives: train data enumerators on data collection, collect and collate data and information on fish along the Kenyan coast, define the status of inshore fisheries in Kenya and set up a fisheries database. This study will therefore assist in improving the methodology of data collection and

develop appropriate stock assessments, aspects that are considered a high priority in fisheries management. More specifically, this study has the following objectives:

- Analyse data available using appropriate methods
- Describe the fishery
- Improve format of data collection forms
- Examine the data collected, identify gaps in information and identify any additional information that can be collected

2 LITERATURE REVIEW

2.1 Marine fishery in Kenya

Approximately 80% of the total marine products come from shallow coastal waters and reefs, while only 20% is from off-shore fishing. Off-shore fishing in Kenyan waters is done by Kenyans and foreign vessels, the latter under licence. However, due to the nature of such activities, supervision of the fishing area is a big problem and it is likely that unlicensed fishing vessels could easily poach in Kenyan territorial waters. It is also difficult to get accurate information about the fish caught by foreign-owned vessels. The main marine products consist of: demersal species 42%; pelagic species 18%; crustaceans 11%; sharks, rays and similar species 18%; molluscs and echinoderms 4%; deep sea and game fish 6% (Wakwabi *et al*. 2003).

From the artisanal fishery, dermersal fish dominate in catches. Some of the common fish in the landings include: rabbit fish (*Siganus sutor*), variegated emperor (*Lethrinus variegatus*), dash-dot goat fish (*Parupeneus barberinus*), parrot fish (*Sergeant majors*), sweetlips, scavenger, red snapper (*Lutjanus argentimaculatus*), rock cod (*Plectropomus aneolatus*), thumbprint emperor (*Lethrinus harak*), yellow goat fish (*Parupeneus barberinus*), peacock rock cod (*Cephalopholis argus*), pick handle barracuda (*Sphyraena jello*), sailfish and black tip kingfish (Wakwabi *et al*. 2003).

McClanahan and Kaunda-Arara (1996) estimated that the arial densities of fishers in Kenyan reefs are between 7-13 fishers/km^2. Rates of resource extraction from Kenya are estimated at approximately 1.3 tons/km^2/yr. Although fishers prefer to catch certain families of fish (e.g. *siganidae*, *lethrinidae* and *serranidae*) fishing is largely indiscriminate and all fish caught by the commonly used gears is taken.

2.2 Environmental conditions

East Africa's coastal waters have distinct seasonality in physical, chemical and biological parameters. Seasonal patterns are influenced by the movement of the Inter-Tropical Convergence Zone (ITCZ), which creates two distinct seasons, the northeast monsoons (NEM) and southeast monsoons (SEM). The SEM, which prevails from March to October, is characterized by high cloud cover, rain, wind, energy and decreased temperatures and light. During the NEM these conditions are reversed. These climatic phenomena ultimately affect the physical, chemical and biological oceanographic processes (McClanahan 1988).

The East African coastal current, which is formed when the southern equatorial currrent encounters the coast at Tanzania, dominates along the Kenyan coast. During the SEM this current continues north and leaves the continent at Somalia. During the NEM the changing winds slow the northerly water movement and eventually reverse the movement, forming the Somali counter current. Due to these currents the major downwelling areas and associated low nutrient waters are along southern Kenya. Upwelling occurs along northern Somalia during the SEM. During the NEM currents leave the coast from northern Kenya and slight upwelling may occur (McClanahan 1988).

The tidal range in Kenya is 4 m. The air temperature varies from 21°C (July-August) to 33°C (February-March). Radiation is highest in March and November (about 500 langleys) and is lowest in May-July (300 langleys). The surface water temperature ranges from 24°C (August) to 30°C (February) (McClanahan1988).

The chemical parameters also reflect seasonal changes. In the downwelling area in southern Kenya, the main sources of mineral elements (e.g. phosphorous) are water column mixing, discharge and runoff occuring during the rainy seasons. In northern Kenya, water coulmn mixing and river discharge are likely to be important nutrient sources and slight upwelling from the Somali current. Local runoff is greatest during the SEM. The Sabaki and Tana river discharges occur in northern Kenya which further enhances the productivity in this area. Lowest salinities (34.0-34.8) occur at the onset of the SEM when discharge, cloud cover and rainfall are high. Following the rainy season salinity can drop drastically to 26 (McClanahan 1988).

The richest flora and biomass occur towards the end of the SEM. Distinct seasonal changes in finfish catches in Kenya have been observed. Mbuga (1984) divided the Kenya marine weather regime into four distinct annual seasons which form the fishing calendar:
Northeast Monsoon (*Kasikazi*): November - February
Calm Sea (*Matilai*): March - April
Southeast Monsoon (*Kusi*): May - August
Calm Sea (*Matilai*): September - October

Each of the four seasons has a distinct effect on the fishing pattern.The NEM creates a lavish fishing ground along the north coast. The NEM is succeeded by calm weather, which allows lucrative fishing all over the coast. Pelagic fishery is more effectively exploited during this period when non-powered boats can venture into the open waters. During the SEM, when the long rains come, starting in May and lasting until August, the sea becomes more turbulent than during the NEM and the majority of fishermen lay down their tools. Large schools of migratory pelagic stocks abound in the offshore waters of Kenya during the SEM period. Such large shoals include tuna, skipjack, travelly, sardinella, mackerels, marlins, sailfish and swordfish (Mbuga 1984).

Observations have shown catch to be low during the SEM and high during the NEM with a peak in March at the end of the NEM. Factors affecting observed seasonality include: reduced effort by fishermen during the SEM due to rough sea conditions, fish migrations and decreased density and activity due to a deeper thermocline and cooler waters in the SEM (McClanahan 1988).

Studies show that reproduction is highest during the NEM in Kenya for both pelagic and demersal fish (Okera 1974, Kaunda-Arara and Ntiba 1997, Kulmiye *et al*. 2002). Some species are not seasonal breeders while others breed during intermonsoon times (Nzioka 1979). However, the life-histories of the species also come into play.

2.3   Management measures

In Kenya, different management measures have been considered for exploiting the marine resources. As with other artisanal fisheries, effort controls were not considered to be a realistic option. Whilst MPAs were considered appropriate, it was also thought that the number and extent of protected areas in Kenya had reached saturation point. There is resistance from fishers to the introduction of more protected areas and it has also been considered that the science supporting further expansion of MPAs is not yet proven. McClanahan and Arthur (2001) have indicated that the ecological status within parks and reserves is healthier than in open access areas. However, the benefits from reserves are not as great as expected due to the incidence and level of fishing within them. Individual park or reserve managers also have a significant influence on their degree of success (measured in ecological terms). Some existing socio-economic studies of protected areas have addressed the impacts on fishermen through loss of access (Ngugi 2002) and have shown that the fishermen's incomes have been negatively affected by change in access to fishing areas.

Marine protected areas (Figure 1) are long established in Kenya and cover both marine parks and reserves, the former being no-take-zones and the latter allowing fishing using traditional methods. A high proportion of coastal waters are now under MPAs. There are five MPAs, which cover an area of 1010 km^2 and combined occupy about 25% of the coastline (Weru 2000). This has resulted in reduced access to resources by fishers. In addition, the non-involvement of communities in the designation process has led to much resistance to MPAs. Parks and reserves were originally gazetted for conservation and tourism purposes with lack of any reference to existing resource users (Beddington 2002 and Ngugi 2002).

Alternative management mechanisms have been considered to be appropriate and necessary, including further gear controls. In 2000, the use of beach seines and spear guns was prohibited. However, these are not widely enforced at present and lack of capacity for enforcement of any management measures is a significant constraint. A commonly stated view was the need to consider fisheries in the wider land-water interface context. Land-based impacts of human activities cannot be detached from fisheries management issues, which need to be addressed in an integrated manner (Beddington 2002).
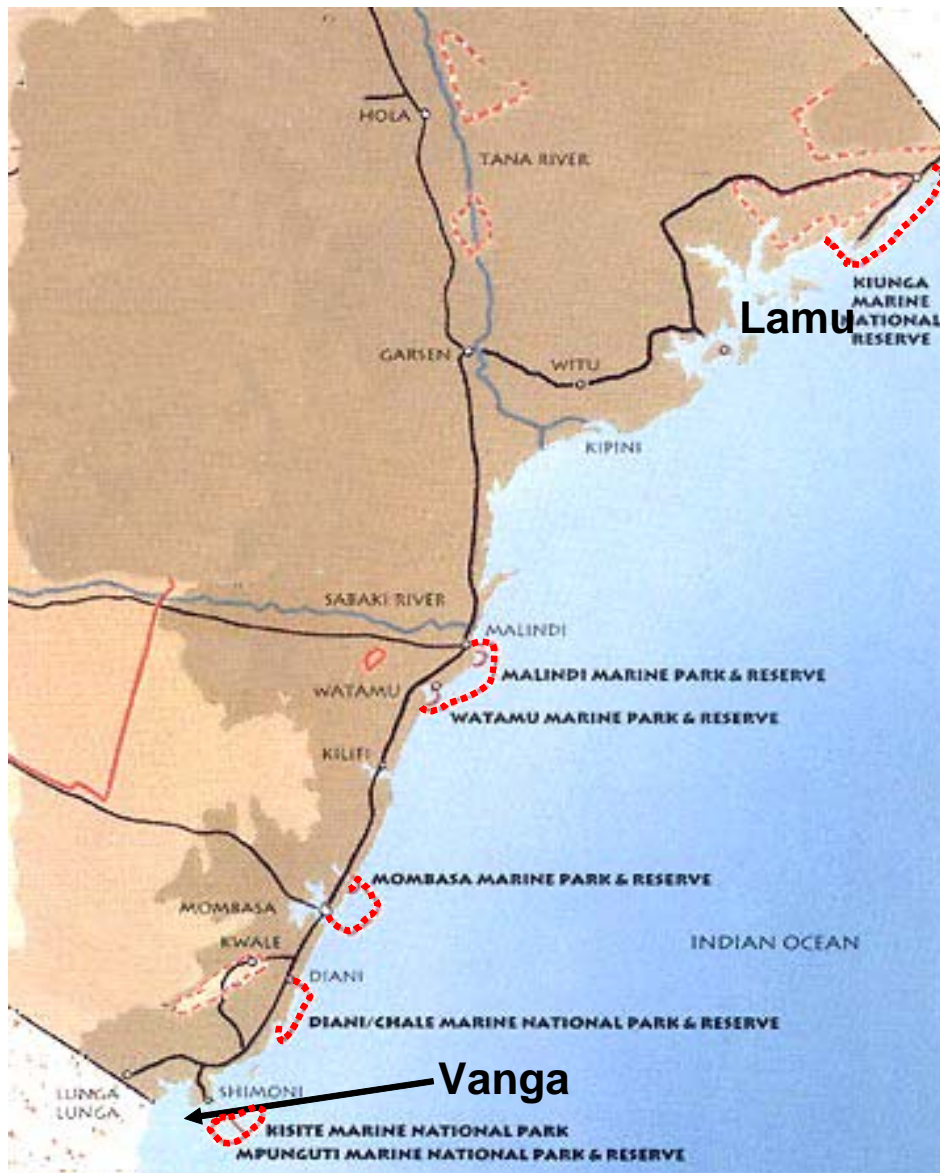
Figure 1: Map of Kenyan coast showing MPAs and selected study areas Lamu and Vanga (adapted from Kenya Wildlife Service 2005).

2.4 Fishing areas, fleet and gears

The major fishing areas reported along the Kenyan coast are the Kiunga coastline and Lamu islands in the North, Tana River mouth, Ngwana Bay and Malindi area including the offshore North Kenya Bank and Shimoni, Vanga, Funzi Island and coral reef areas on the Southern border (Oduor 1984) There are about 80 landing sites along the whole coastline. In addition to the tides, types of boats, gears and the monsoon weather pattern, social and economic factors affect fish landings. Over the years demersal fish species have predominated over pelagic species in the catches and the status still remains the same to date (Oduor 1984, Wakwabi *et al*. 2003).

Different types of vessels are used by the artisanal fishermen to suit the various fisheries and weather vagaries. The following fishing vessels are used in the Kenyan

marine waters: *Dhow* (sailboat), *Ngalawa* (outrigger canoe), *Mashuwa* (open fishing boat), canoes and motorised boats. Table 1 shows the estimated number of common gears and boats recorded in different areas during the survey on the status of fish catch and landings in Kenya (Oduor 1984).

Table 1: Estimated number of big gears and boats in 1984.

Administrative district	Beach seine	Barricades	Other gears	Canoes	Dhows (sail boat)	Motor boats
Lamu	14	8	3	303	225	99
Malindi	20	38	3	321	85	10
Mombasa	13	95	8	538	77	35
Kwale	16	125	8	674	107	54
Total	90	266	22	1836	494	198

Sailboats and outrigger canoes are made to suit rough weather and open offshore fishing expeditions. They are mainly equipped with shark net, drift net, other set gillnets and line gears. Canoes are mainly deployed in the operation of active gears such as beach seine and cast nets, drift long lines and inshore passive gears such as set gillnets, fish pot and barricade trap (Mbuga1984). In many fishing villages people fish by swimming and reef walking. Women and children also collect molluscs and crabs during the low tides in many areas.

The following fishing gear types are used by the artisanal fishermen: basket traps (*lema*), barricades (*uzio*), weir (*tata*), gillnets (of various sizes 2" to 4 ½ "), shark nets (*jarife*), seine nets, cast nets, long lines, hand lines, spear guns and spears (Fisheries Department - Mombasa pers. comm.)

2.5   Biological information

Biological information on the different fishes in Kenya is lacking. Few studies on some species have been conducted. Kulmiye *et al*. (2002) studied some aspects of the reproductive biology of the thumbprint emperor (*Lethrinus harak)* from the South coast of Kenya in Gazi and Msambweni areas. Percentage length frequencies of up to 25% for the length frequency distributions were recorded, with peaks at 21-24.9 cm for males, and 25-26.9 cm for females. The species has a prolonged spawning season extending from October to April with peaks in October and February during the NEM period when the water temperature is high, cloud cover is minimal and the sea is relatively calm.

No comprehensive biological overview of fishes is available for Kenyan waters. However, studies on targeting few species such as blue marbled parrot fish, snappers and some reef fishes, are available. Mwatha and Ntiba (1999) studied the population dynamics of the blue marbled parrot fish (*Leptoscarus vaigiensis*) in Kenyan inshore waters with data collected from artisanal fish catches off the South coast of Kenya. The length weight relationship equation was $Log_{10}W=2.86Log_{10}L - 1.595$. The growth constant was estimated to be 1.5 yr^{-1}. The exploitation rate was also estimated to be 0.33 per year. The fish were recruited into the fishery at 11.7 cm and attained sexual maturity at 16.8 cm, indicating that growth over fishing takes place in this area.

Studies on the reproductive biology of the dory snapper (*Lutjanus fulviflemma*), have shown a prolonged spawning season which begins from November-December and lasts until April-May. The fecundity of the species was found to approach a cubic relationship with the body length: F=27.69L $^{2.64}$ (Kaunda-Arara and Ntiba 1997)

In Kaunda-Arara and Rose (2004) studies on tagged fishes from MPAs to fisheries in the Kenyan coast, showed that only three species, the commercially important white spotted rabbit fish (*Siganus sutor*), the sky emperor (SEM) (*Lethrinus mahsena)* and the trumpet emperor (*L. miniatus)*, exhibited consistent movements from the parks. These movements are spill over from the MPAs to the adjacent areas.

Observations on the spawning seasons of reef fishes belonging to 21 families and 73 species along the East African coast done by Nzioka (1979) showed that spawning occurred throughout the year with two peaks in January to March and September to November. The highest peak of breeding was in October, corresponding to the time of the SEM.

2.6   Needs and importance of fisheries data collection in Kenya

Any resource can be managed if sufficient good data and information are available.

Management strategies for fisheries require stock estimates, environmental, economic, sociological and political considerations. A monitoring programme is necessary in order to collect data, including catch and fishing effort information, and assess the effectiveness of management strategies (King 1995) .

Information and data about a fishery are collected to support the objectives and programmes of fishery management. There are various objectives for management, which are not always shared by all stakeholders in the fishery. Collection of fisheries data usually has more than one objective. Fisheries biologists, economists, sociologists, managers, politicians, industrialists, etc. may all require different information. Some basic fisheries data, however, will be of interest to all groups (FAO 2003).

The most common objective of fisheries data collection is the regular publication of a yearbook or Annual Fisheries Statistics by the government, which in Kenya, is done by the Department of Fisheries. The Department has the responsibility of registering fishing vessels. Basic catch data comprising of weight and value of landings by administrative units (districts) are also recorded.

Different types of data are usually required to assess the fisheries. These include data on species composition, distribution and abundance data, biological data, environmental data and economic information. Catch and fishing effort information are the basic data requirements but may be supplemented by the regular collection of length-frequency data. Basically, all biological aspects of the stock are of scientific interest. Length-frequency and catch per unit effort are the most commonly used data in the estimation of biological parameters. In monitoring fishing effort, inventories of boats, fishing gear and fishing methods used in the fishery must be maintained and continually updated (King 1995).

Considering that the recorded marine landings currently only comprise around 5% of total catches, improved data collection and resource assessments are considered a priority (Beddington 2002). Baseline studies of the ecology and population dynamics of important commercial species, stock assessment of offshore and inshore resources (to inform management of appropriate fishing levels) for key species in different habitat types need to be done. This requires efficient information and data collection and therefore calls for design of improved data collection systems within the existing capacity.

Collection of data and information is expensive in that it requires people, transport and communication systems to be effective. Furthermore, it requires trained individuals that may not always be available. Because of the cost and the demands on often scarce trained personnel, it is important that any programme for the collection of fishery information be efficient (Sparre 2000). In Kenya, the Department of Fisheries lacks the necessary staff due to retrenchments and therefore new strategies of data collection need to be put in place.

3   MATERIALS AND METHODS

3.1   Description of data forms

Data collected from various fish landing sites was recorded by data enumerators in two types of forms (A and B see appendix I). The data for form A has been entered into Excel spreadsheets.

Form A

The following information is recorded in this form
Recorder: the name of the enumerator recording the data.
Station: the name of the station (usually the town/village name).
Date: the day, month and year of the recording.
Vessel used: the type of vessel used, i.e. a canoe or motorized boat.
Number of crew: the number of people working on the boat.
Area fished: local name of the fishing area or habitat type where possible.
Gear used: the type of gear used e.g. gill net, trap.
Mesh size: if a net was used the mesh size is recorded, if a line was used the hook size is recorded.
Time in: the time the fisherman came back from fishing.
Time out: the time the fisherman went out to fish.
Total catch: total weight of the fish caught.
Catch ID: the identity number for a sampled boat. It is a code that incorporates the area, the year, day, month and number given to the boat (e.g. MSA03-2-JU-1 is boat number 1 recorded on second day of June 2003 in Msambweni). The fish caught in the boat are sampled and data entered in form B.

Form B

The following information is recorded in this form in addition to "Recorder" and "Station":

Catch ID: as above.
Sub-sample weight: the weight of sub-sample taken from the catch in kilograms.
Number of fish: the number of fish in the sub-sample.
Species: the species in the sub-sample.
Total length: total lengths of all individual fish in the sample.
Weight: weight of individual fish species in the sample.
Sex: where possible the sex of the fish is recorded (in some cases the fish is gutted at sea).

3.2   Fisheries data

Analysis of the data collected in 2002/3 for the two selected areas: Lamu area of the north coast and Vanga area of the south coast (see Figure 1) was done for form A. The data analysed is a subset of the data collected. The data in Excel spreadsheets was transformed into txt format and mapping of common fishing grounds of the catch by gears and seasons was done, with latitude and longitude positions, using the S-plus software. As the actual positions of all the fishing grounds were not recorded, some of the areas were pooled. Therefore, the figures presenting the fishing grounds (the maps) do not reflect all the fishing grounds in the two areas that are dealt with here. Better information on the fishing grounds in terms of positions and depths are required in the future.

From the data the description of the fishery was prepared.

Analysis of catch per unit effort (CPUE) for the areas, seasons and gears was done using a simple CPUE calculation:

C/**N** where **C** is the catch per vessel and **N** is the number of fishermen in the vessel for all the gears.

3.3   Biological data

The data from form B (containing the biological data), had not been entered into electronic format. Therefore, data for April, June and October 2002 and 2003 were converted to electronic format and used for analysis. The data thus posed a limitation and hence the number of individuals for a given species was quite low. However, examples of how the data can be used were demonstrated rather than giving detailed descriptions of the catch composition by gear.

A simple analysis of species composition (% catch) by areas was done.
The length distributions of common species and length-weight relationships of some selected (target) species were done. The length-weight relationship was estimated by using the equation:

$$W = aL^b$$

Where **W** is the weight in grams, **L** is the length in centimetres, **a** is a constant and **b** the allometric growth parameter.

From the above analyses gaps in information were identified and recommendations were made on additional information that can be collected for assessment purposes and improvements in the data collection. The results of the analyses were compared with previous studies (e.g. Oduor 1984 and Mbuga 1984).

4   RESULTS

4.1   Fishery

Along the coast of Kenya there are many fishing grounds, but as described in the previous chapter, only the results for two fishing areas are presented here. For Lamu, the northern area, there are 13 major fishing grounds. These are: beyond the reef, Dodori, Faza, Lagoon, Manda, Matondoni, the outer reef, Pate, Shela, the channel, the coastal lagoon, in the reef and in the reef lagoon. In Vanga, the southern area, there are 3 major fishing grounds: inshore, offshore and in the reef.

Four types of vessels were used, these are: sail boats, motor boats, outrigger boats and canoes (Table 2). Canoes are the least commonly used vessels. The number of fishermen was variable ranging from 1 to over 30 people, depending on the type of boats and gear used.

In the data available for Lamu and Vanga, four different types of vessels were recorded. The most commonly used vessels are sail boats and motor boats. The most employed gears by the motor boats are the ring nets, traps and hooks and lines. In the sail boats, traps are the most commonly used and other important gears are hooks and lines, ring nets, gill nets, shark nets and beach seines. In the outrigger boats hooks and lines and traps are most commonly used. Canoes were less important, with hooks and lines being used. Within each vessel category it is expected that the size of the vessels varies somewhat, although this is not reported in the data collected (form A).

In Lamu and Vanga, there are 10 types of gears used: beach seines, 'chachacha', diving, gill nets, hooks and lines, long lines, ring nets, spearguns, shark nets and traps. All these are gears known globally apart from 'chachacha' which is a traditional gear used in Vanga to catch the half beaks. Six of the gears commonly used are: hooks and lines, gill nets, shark nets, ring nets, traps and beach seines. Table 3 shows the percentage of gears used in the different areas. In Lamu, beach seining is done in Dodori (50%), Pate (41%) and the coastal lagoon (9%). Gill nets are used in all areas in Lamu except in the channel, the coastal lagoon and the reef lagoon. The highest percentage of gill net usage is in Pate (44%), Dodori (24%) and Faza (14%). Hooks and lines are used beyond the reef, in Manda, the coastal lagoon and in the reef lagoon, but was mostly used beyond the reef (94%). Shark nets are used in all areas except in Matondoni, the reef and reef lagoon.

In Vanga, beach seining is used inshore (56%) and in the reef (44%), while 'chachacha' is used in the inshore area only (100%). Diving and hooks and lines are

used only in the reef. Ring nets are used offshore (56%) and in the reef (44%), while a high percentage of traps (95%) are used in the reef.

Table 2: Gears used with the different types of vessels from the data collected in 2002 and 2003 in Lamu and Vanga (combined).

Gear /Boat	Canoe	Motor boat	Outrigger	Sail boat
Beach seine	0	0	1	108
Chachacha	0	1	8	50
Diving	0	0	0	34
Gill net	0	1	0	198
Hook & line	2	145	118	339
Long line	0	0	0	2
Ring net	0	678	1	254
Spear gun	0	2	10	12
Shark net	0	39	2	192
Trap	0	275	79	559

Table 3: Percentage of gears used in the different fishing areas in Lamu and Vanga in 2002 and 2003 (combined).

Station	Area fished	BS	CC	D	GN	HL	RN	SN	T
Lamu	Beyond reef				3	94		10	
	Dodori	50			24			7	
	Faza				14			10	
	Lagoon				6			5	
	Manda				4	2		4	
	Matondoni				3				
	Pate	41			44			10	
	Channel							40	
	Coastal lagoon	9				1		14	
	Reef				2				
	Reef lagoon					3			
Vanga	Inshore	56	100						5
	Offshore						56		
	Reef	44		100		100	44		95

(Key: BS-beach seine, CC-'chachacha', D-diving, GN-gill net, HL-hook & line, RN-ring net, SN-shark net, T-trap).

4.1.1   Description of the fishery by area

The catch data available in electronic format does not reflect actual catches in the two areas. Collection of data from the Vanga area was more extensively done than in the Lamu area, therefore the data from the Vanga area allows for more analysis than for the Lamu area. The total reported catch in 2002 for the two areas was approximately 100 tons with 83 tons reported from Vanga and 17 tons from Lamu (Figure 2). The higher catch in Vanga is indicated by catches of more than 64 kg/nm^2. This amount represents about 4% of the average catch recorded for the two districts in which the two areas fall. In 2003 (Figure 3) the catch for available data was approximately 176 tons with 28 tons from Lamu and 148 tons from Vanga, which is about 7% of the average catch for the two districts in which the two areas fall. Both areas showed

higher catches where catches were more than 64 kg/nm^2 in some areas. Comparing the two years the Vanga area had higher catches than the Lamu area, but as mentioned above, this may not be a true reflection of the actual catches as the sampling effort in these areas was different.
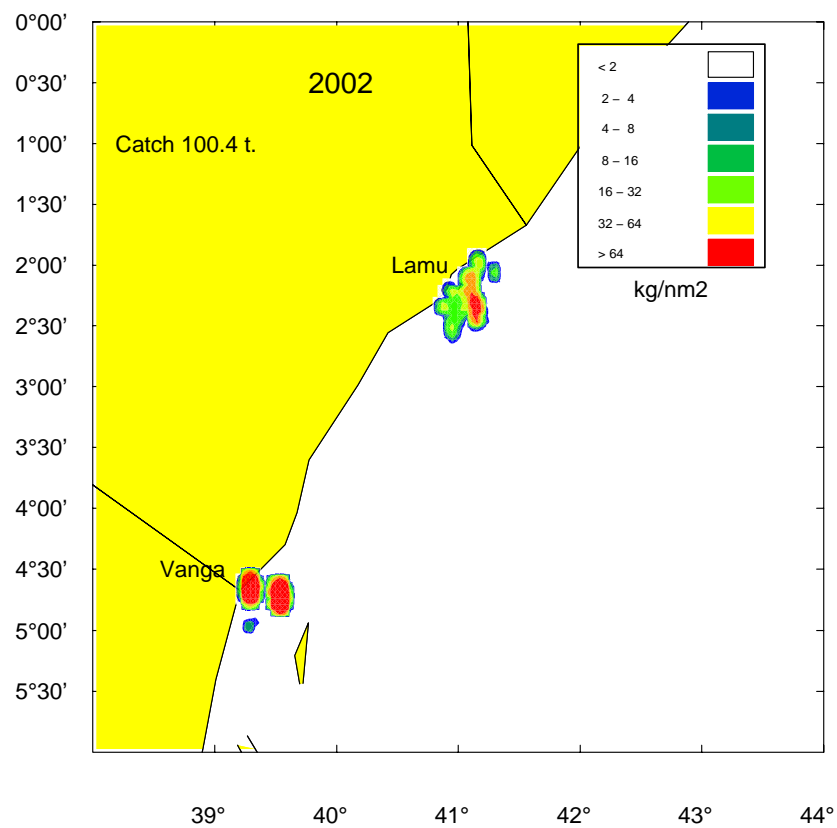
Figure 2: Catch distribution in Lamu and Vanga in 2002.
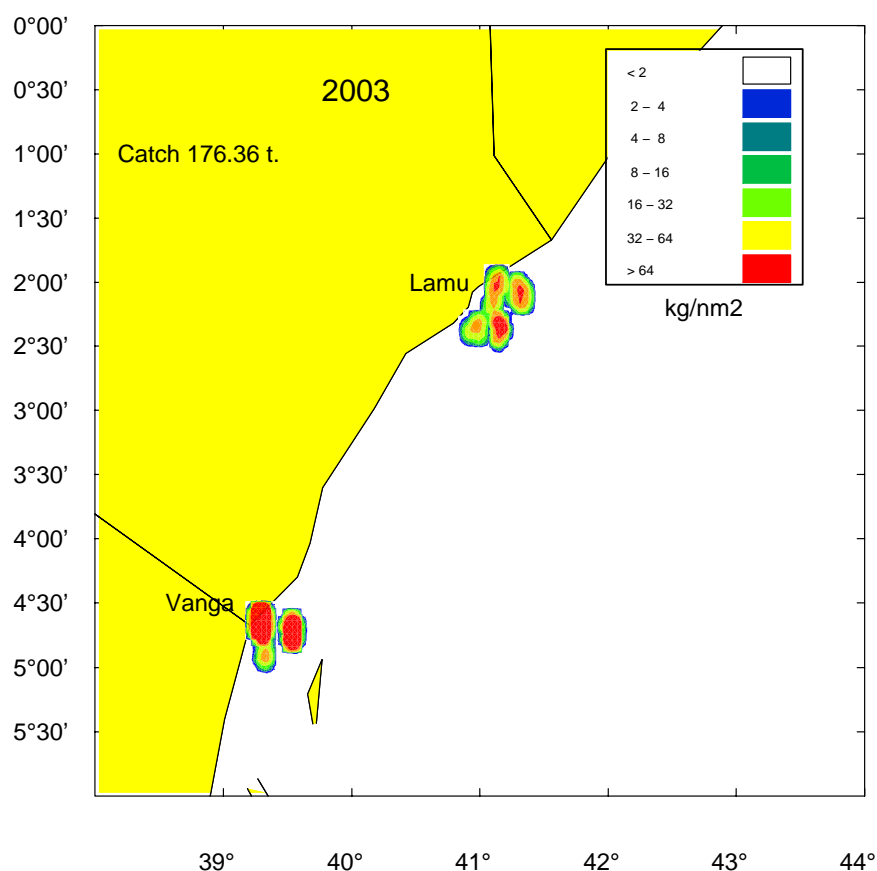
Figure 3: Catch distribution in Lamu and Vanga in 2003.

4.1.2   *Description of the fishery by gear*

A variety of gears were used in the two areas, Figure 4 shows these gears. Four main types of gears were used in Lamu: beach seines, gill nets, hooks and lines and shark nets. Both hooks and lines and gill nets were important in Lamu in 2002 while in 2003 hooks and lines, gill nets and shark nets were important. In both years, the number of records were higher for the SEM than for the NEM. In Vanga, more gears were used: beach seines, 'chachacha', diving, gill nets, hooks and lines and shark nets. In 2002, hooks and lines, traps and ring nets were mostly used while in 2003 traps and ring nets were used. For both years the number of records were higher for the NEM than for the SEM. Generally, there were more records for Vanga than for Lamu. This is as a result of the data collection effort in the areas and may not reflect the actual situation in the areas.
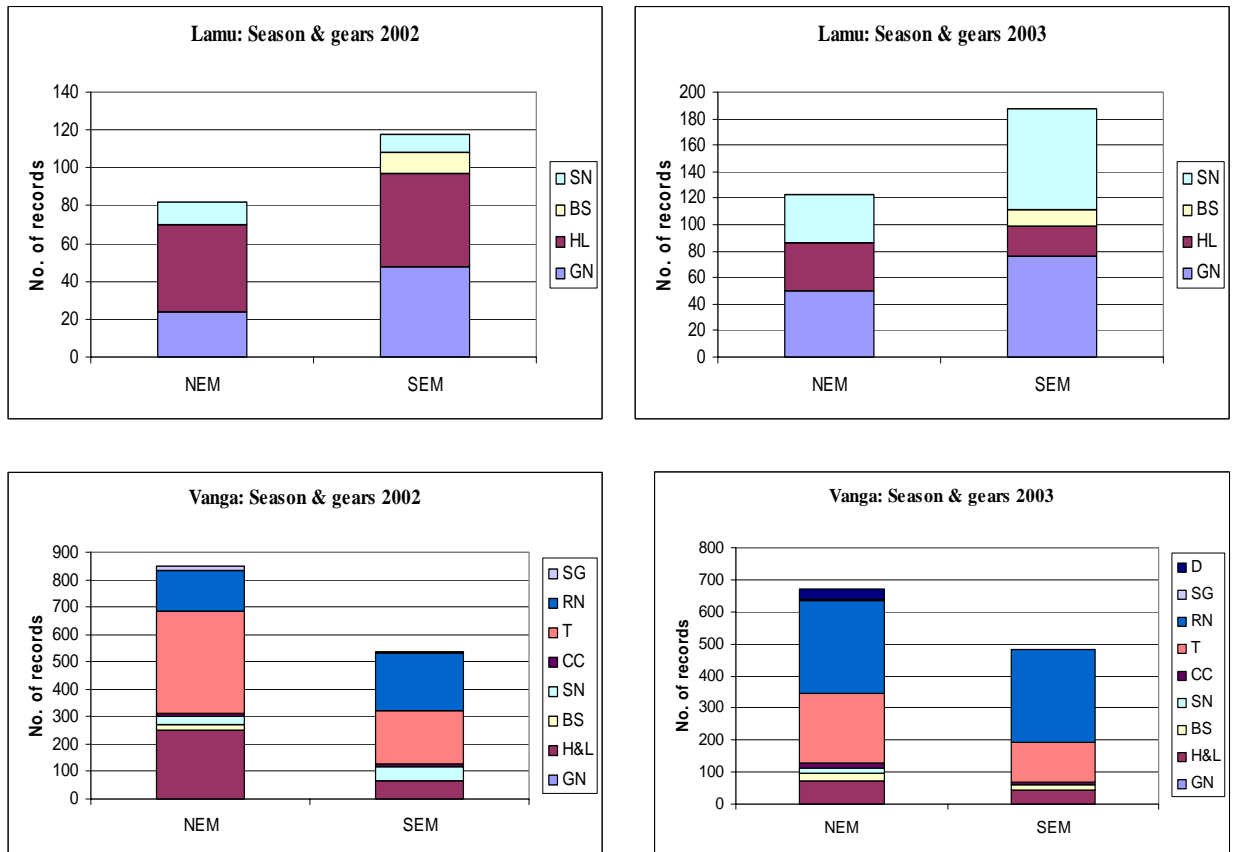
Figure 4: Gears used in the Northeast and Southeast monsoon in the two areas in 2002 and 2003.

Key: BS-beach seine, CC- 'chachacha', D- diving; GN- gill net, HL- hook & line, RN- ring net, SG- speargun, SN- shark net, T- traps.

Figure 5 shows the catch distribution in the two areas by beach seining for both years. There was more catch in the fishing areas in Vanga where there were catches of more than 64 kg/nm^2. In Lamu, the catch was low and is indicated by catches of only 2-4 kg/nm^2. This shows that beach seining is more important in Vanga than in Lamu.

All years, Beach seine

Catch 7.99 t.

Lamu

Vanga

< 2
2 – 4
4 – 8
8 – 16
16 – 32
32 – 64
> 64

kg/nm2
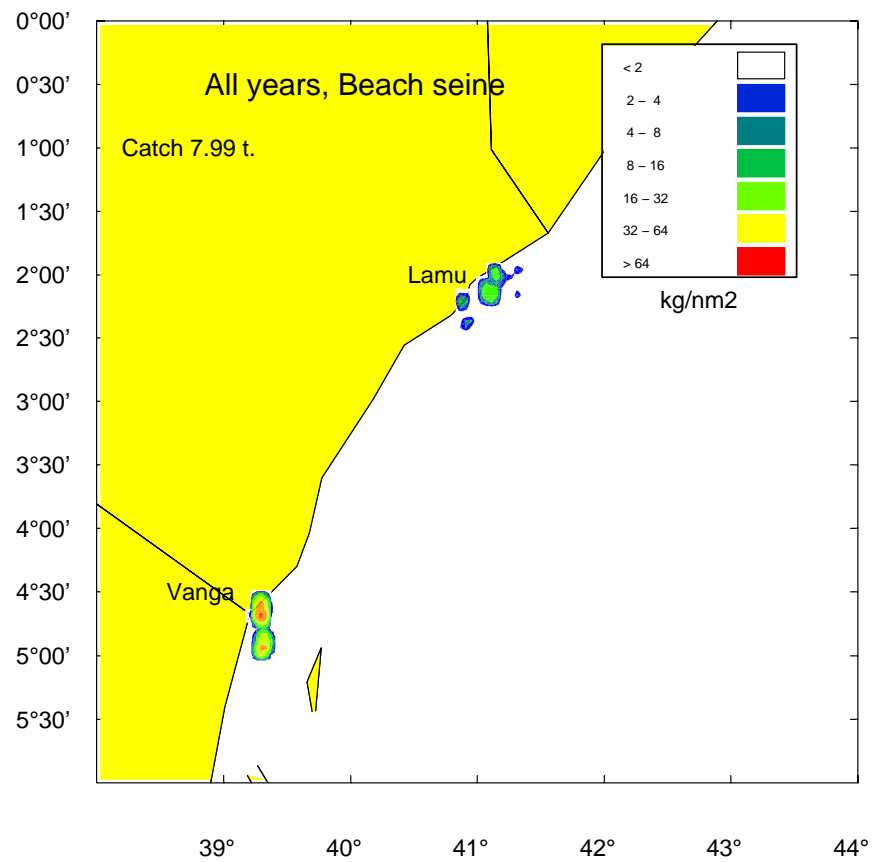
Figure 5: Catch distribution in Lamu and Vanga using beach seines in 2002 and 2003.

For gill nets there was more catch in the fishing areas in Lamu than in Vanga (Figure 6). This map shows that gill nets were widely used and therefore more important in Lamu than in Vanga, even though catches did not exceed 64 kg/nm^2 in any of the areas in Lamu.
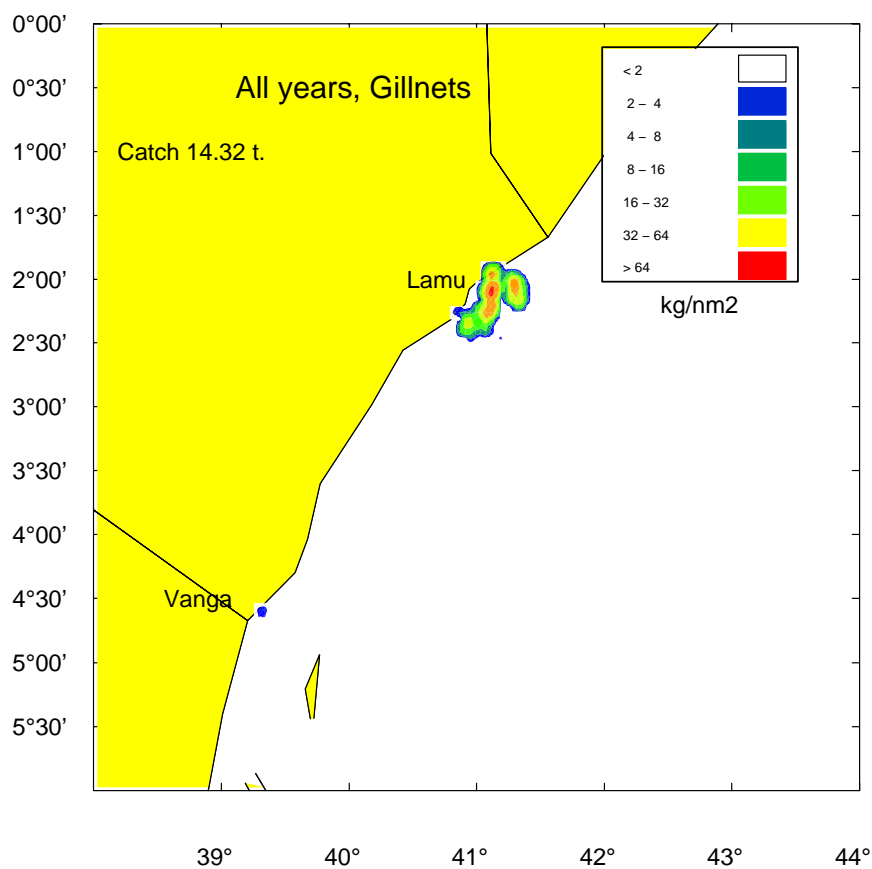
Figure 6: Catch distribution in Lamu and Vanga using gill nets in 2002 and 2003.

Hooks and lines were important in both areas with some areas having catch of more than 64 kg/nm^2, with more widespread use in Lamu (Figure 7).
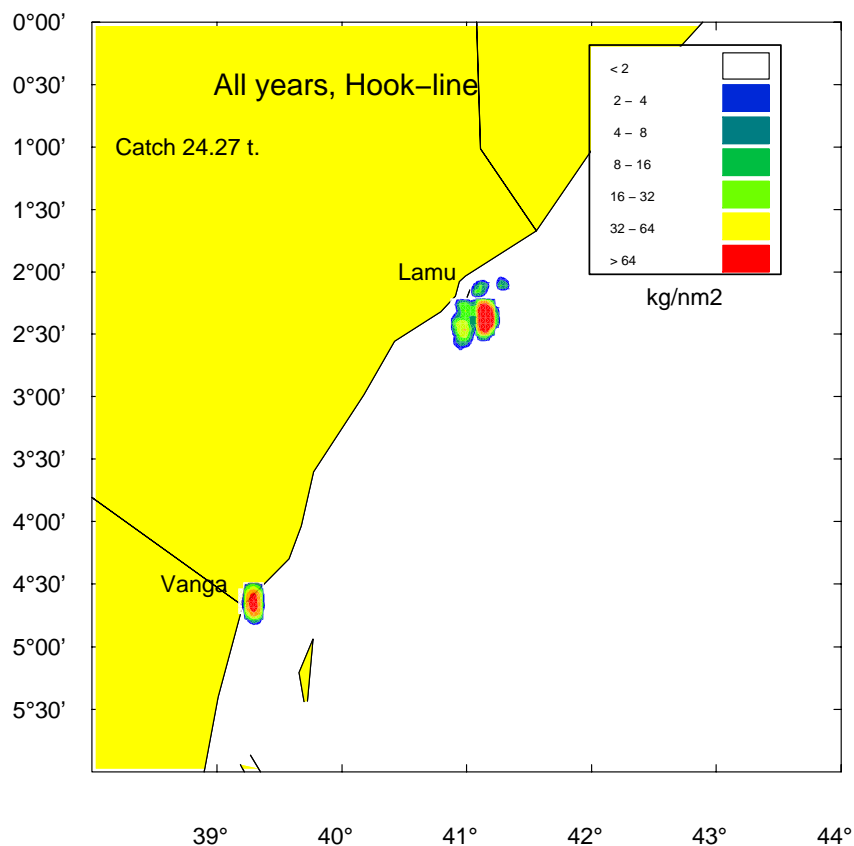
Figure 7: Catch distribution in Lamu and Vanga using hooks and lines in 2002 and 2003.

Vanga fishers were catching more fish than Lamu fishers; using shark nets (Figure 8) although the use of the shark nets was more widespread in Lamu.
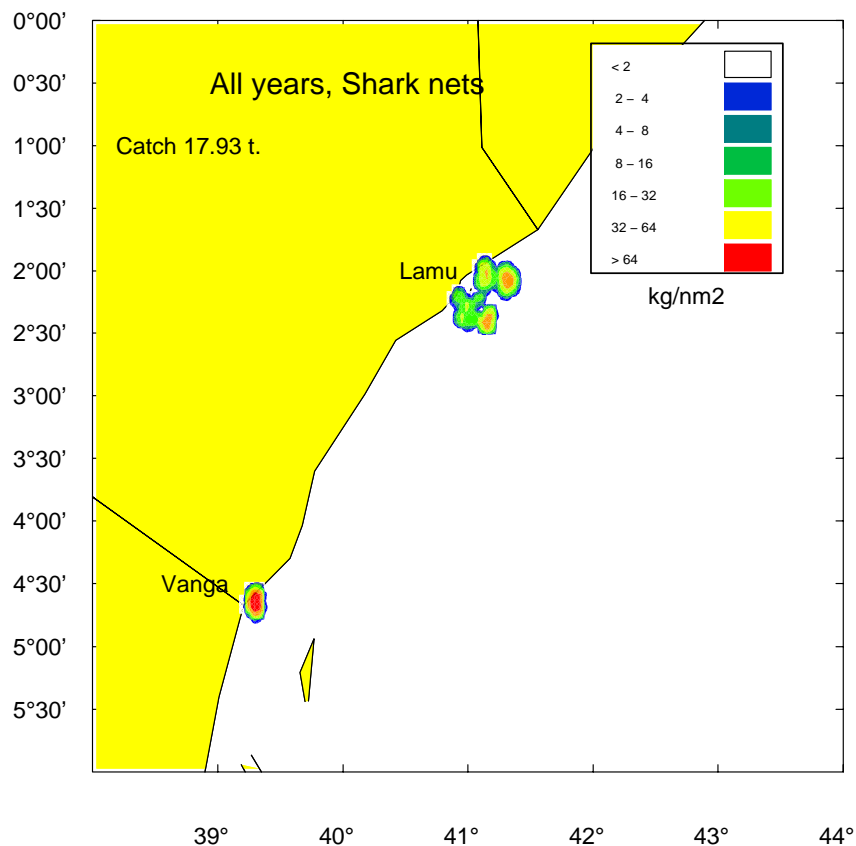
Figure 8: Catch distribution in Lamu and Vanga using shark nets in 2002 and 2003.

Traps are only used in the Vanga area, where the catch was high and is indicated by catches of more than 64 kg/nm^2 in some areas (Figure 9).
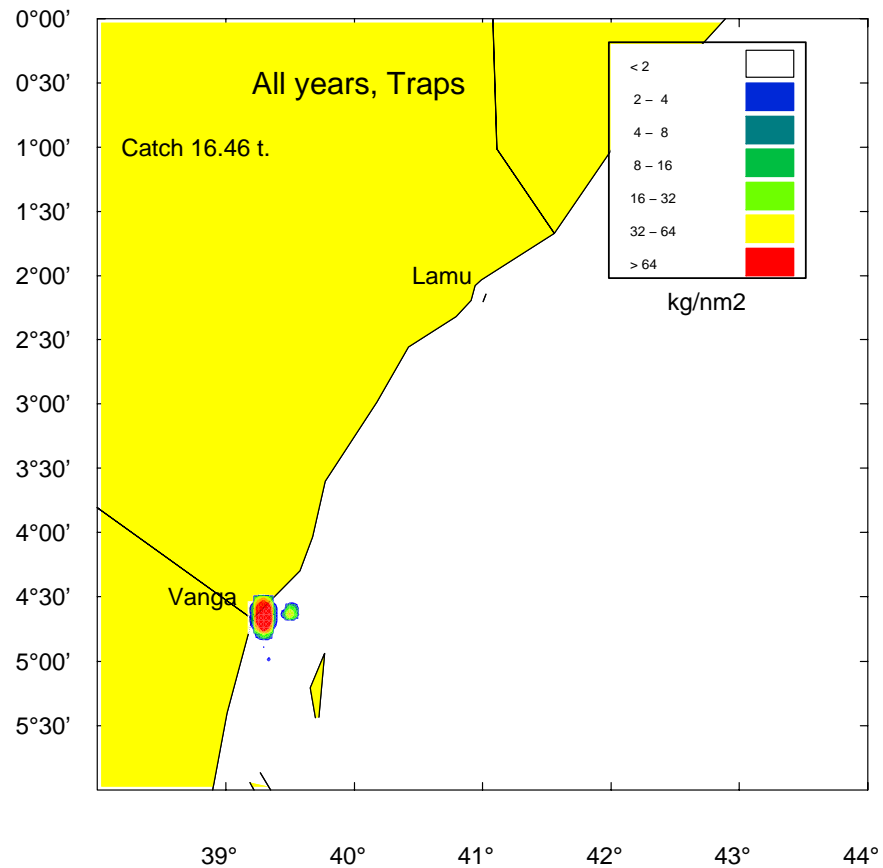
Figure 9: Catch distribution in Lamu and Vanga using traps in 2002 and 2003.

Ring nets are used only in the Vanga area, where the catch was high and is indicated by catches of more than 64 kg/nm^2 in some areas (Figure 10). From all the gears, ring nets had the highest catch for the two years.
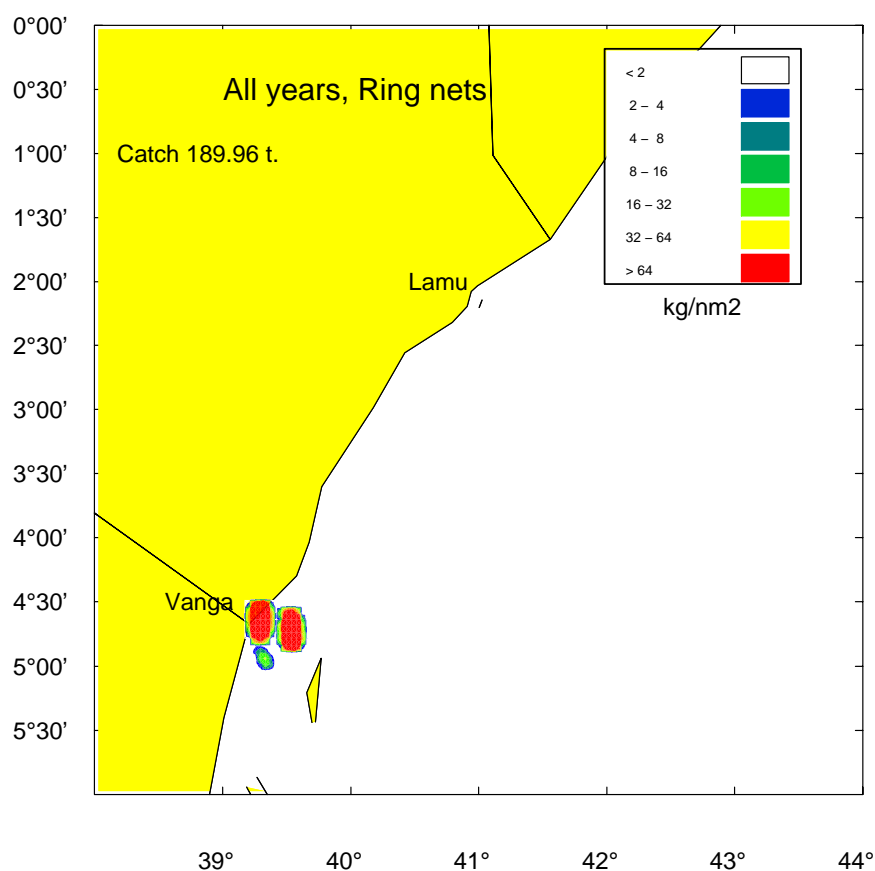
Figure 10: Catch distribution in Lamu and Vanga using ring nets in 2002 and 2003.

4.1.3   CPUE

In 2002 a higher mean CPUE was recorded in Lamu than in Vanga and the reverse was recorded in 2003 (Table 4). The mean CPUE recorded in Lamu was higher (20.48 kg/fisherman) in 2002 than in 2003 (15.57 kg/fisherman). The range in 2003 was higher with a minimum CPUE of 1.25 kg/fisherman and a maximum CPUE of 225 kg/fisherman. In Vanga, CPUE increased from 8.53 kg /fisherman in 2002 to 32.31 kg/fisherman in 2003. The range in 2003 was higher, from 0-900 kg/fisherman. For the seasons, the NEMseason recorded higher CPUE as well as higher ranges. Lamu recorded higher CPUE in the NEM season and the reverse in the SEM season. In Lamu the CPUE during the NEM was 22.13 kg/fisherman with a minimum of 1.25 kg/fisherman and maximum of 225 kg/fisherman. During the SEM the CPUE was 14.43 kg/fisherman with the maximum recorded being 68.2 kg/fisherman. In Vanga, the CPUE during the NEM was 19.06 kg/fisherman with a maximum recorded of 900 kg/fisherman, while during the SEM the CPUE was 17.49 kg/fisherman with a maximum of 873 kg/fisherman. It is important to note that these results are affected by the data collection effort.

Table 4: Mean CPUE (kg/fisherman) by years and seasons in Lamu and Vanga.

(Numbers in brackets are the minimum and the maximum CPUE recorded).

Year	Lamu	Vanga
2002	20.48 (0-150)	8.53 (0.34-160)
2003	15.57 (1.25-225)	32.31 (0-900)
Season		
NEM (both years)	22.13 (1.25-225)	19.06 (0.08-900)
SEM (both years)	14.43 (0-68.2)	17.49 (0-873)

Table 5 shows the mean catch and mean CPUE for the common gears. As the data was only for two years, it did not allow calculations to be made by years. Therefore the mean catch and CPUE were calcuated for each gear for both years combined. For any changes in the status of targerted stocks to be reflected more CPUE data will be required.

Table 5: Mean catch and CPUE (+/- sd) by gears in Lamu and Vanga for two years.

Gear	Average Catch(Kg)	Average CPUE
Ring net	203.79 ± 228.27	37.04 ± 99.31
Shark net	75.70 ± 79.23	18.10 ± 21.75
Beach Seine	75.06 ± 67.00	17.36 ± 42.43
Gill net	71.87 ± 41.92	12.48 ± 8.59
Hook & line	40.97 ± 86.76	12.13 ± 20.22
Trap	18.02 ± 28.10	5.58 ± 4.88

The highest catch (203.79 ± 228.27) was recorded for the ring nets, with high standard deviation. The lowest catch (18.02 ± 28.10) was recorded for traps. The mean CPUE for the gears ranged from 37 – 5 kg/ fisherman. Ring nets recorded the highest CPUE (37.04 ± 99.31) and traps had the lowest CPUE (5.58 ± 4.88).

4.2   Biological data

4.2.1   Species composition by area

More than 50 species of fish were recorded in the two areas for the years 2002 and 2003. Table 6 shows the species compositions for the two areas for species with more than 100 individuals (in both or either area) recorded for the available data.(A complete list of the species recorded is found in appendix II).

Table 6: Number of individuals of the most common species caught in Lamu and Vanga in the two years.

Species	Lamu	Vanga	Total
Lethrinus spp	247	642	916
Lutjanus spp	321	285	606
Siganus spp	141	215	356
Decapterus spp	2	207	209
Scarus spp	1	169	170
Scomberoides spp	20	150	170
'Usigi'	0	163	163
Mugil spp	154	8	162
Caranx spp	124	32	156
Sardinella spp	0	141	141
Half beak	0	136	136
Wolf herring	0	127	127
Nemipterus spp	0	124	124

From the table it is evident that more species were recorded in Vanga than in Lamu. Three species are commonly found in both areas: *Lethrinus spp*, *Lutjanus spp* and *Siganus spp*. Two species that are mostly common to the Lamu area are the *Mugil* and *Caranx* spp. Eleven species are common in the Vanga area but hardly found in the Lamu area. They are: *Decapterus spp*, *Scarus spp*, 'Usigi', *Sardinella spp*, half beak, wolf herring and *Nemipterus spp* and *Scomberoides spp*.

4.2.2   Species composition by gears

Table 7 shows the number of species and the most common species caught by the different gears in Lamu. In 2002 the hooks and lines and gill nets caught the most numbers of species; 31 and 27 species respectively. Beach seine caught *Caranx* (giant trevally of the family Carangidae) a pelagic inhabiting clear lagoons and seaward reefs and feeds on crustaceans and fish (Froese & Pauly 2004). Gill nets caught *Lethrinus* (emperor fish) a demersal fish belonging to the emperor or scavenger family (Lethrinidae). It is a non-migratory reef associated with fish found in shallow sandy, coral rubble, mangroves, lagoons, channels and seagrass areas, feeding on polychaetes, crustaceans and molluscs (Froese and Pauly 2004). Both hooks and lines and gill nets caught *Lutjanus* (Snapper of the family Lutjanidae) a demersal fish , which inhabits coral reefs and feeds on fishes, shrimps and crabs (Froese and Pauly 2004). Both hooks and lines and gill nets recorded high weights (20077 kg and 10685 kg respectively).

Table 7: Number of species, total weight, the most common species and the total weight of the most common species caught by different gears in Lamu and Vanga in 2002 and 2003 recorded in the data available.

(Figures in brackets for the most common species are the percentages of the particular species from the total number of species caught).

Gear	No. of spp	Total weight(kg)	Most common spp	Weight (kg)	Type/habitat
2002					
Beach seine	9	1474	*Caranx* (23.7%)	672	Pelagic/reefs
Gill net	27	10685	*Lethrinus* (16.3%)	1149	Demersal/shallow seagrass & reefs
Hook and line	31	20077	*Lutjanus* (34.1%)	6178	Demersal/reefs
Shark net	10	1849	*Lutjanus* (35.8%)	751	Demersal/reefs
2003					
Beach seine	14	1363	*Siganus* (18.2%)	122	Demersal/reefs
Gill net	19	7595	*Lethrinus* (18.9%)	1131	Demersal/shallow seagrass & reefs
Hook and line	13	7478	*Lutjanus* (32.7%)	2417	Demersal/reefs
Shark net	11	3388	*Lutjanus* (31.3%)	1101	Demersal/reefs

In 2003, gill nets caught the most species (19). Beach seine caught *Siganus* (rabbit fish of the family Siganidae), a demersal fish inhabiting inshore reefs and tolerates low salinities and feeds on benthic algae (Froese and Pauly 2004). For the other gears the same species common in 2002 were caught. Beach seine caught more species in 2003 than in 2002, while the for rest of the gears less species were caught than the previous year. Again the highest weights were recorded for hooks and lines and gill nets (7478 kg and 7595 kg respectively).

In 2002 the ring nets caught the highest number of species (17) in Vanga (Table 8). The hooks and lines caught *Lethrinus* and ring nets caught *Decapterus* (mackerel scad) a pelagic fish which belongs to the Jacks and pompanos family (Carangidae). It is found in clear oceanic water, forms schools along reef edges and feeds on zooplankton (Froese and Pauly 2004). The most common species caught by the traps was *Lethrinus*.

Table 8: Number of species and the most common species caught by different gears in Vanga in 2002 and 2003.

(Figures in brackets for most common species is the percentage of the particular species from the total number of species caught.
There was no data for weights recorded for this area).

Gear	No. of spp	Most common spp	Type/habitat
2002			
Hook and line	6	*Lethrinus* (53.7%)	Demersal/shallow seagrass and reefs
Ring net	17	*Decapterus* (14.1%)	Pelagic/oceanic waters
Traps	9	*Lethrinus* (36.0%)	Demersal/shallow seagrass and reefs
2003			
Beach seine	8	*Lethrinus* (25.4%)	Demersal/shallow seagrass and reefs
Chachacha	4	Half beak (38.1%)	Pelagic
Diving	5	*Lethrinus* (39.0%)	Demersal/shallow seagrass and reefs
Hook and line	11	*Lethrinus* (63.0%)	Demersal/shallow seagrass and reefs
Ring net	18	*Scarus* (17.0%)	Demersal/reefs
Traps	19	*Lethrinus* (11.0%)	Demersal/shallow seagrass and reefs

In 2003, traps and ring nets caught the most species (19 and 18 repsectively). Beach seine caught *Lethrinus*. 'Chachacha' caught half beak a pelagic fish inhabiting shallow waters around mangroves in sheltered bays which are associated to reefs. The early juveniles of this fish are neustonic and float on the surface of estuarine mangroves (Froese and Pauly 2004). *Lethrinus* was caught by diving, hooks lines and traps. *Scarus* (parrotfish), a demersal fish inhabiting lagoons and seaward reefs, was caught by ring nets.

It is clear that more demersal reef associated fish are caught both in Lamu and Vanga. The species composition by gears for the two areas in 2002 and 2003 are in Appendix III.

4.2.3   Length distributions by area and gears for selected species

Figures 11, 12 and 13 show the length distributions for three species *Lethrinus*, *Lutjanus* and *Siganus* common to both areas Lamu and Vanga, caught using different gears (for all data available). It is clear that in the Vanga area smaller fish (lengths of 10-20cm) are fished while in Lamu, larger sized fish (>20cm) is caught. In all cases Vanga showed a narrower length distribution while Lamu had a wider length distribution.
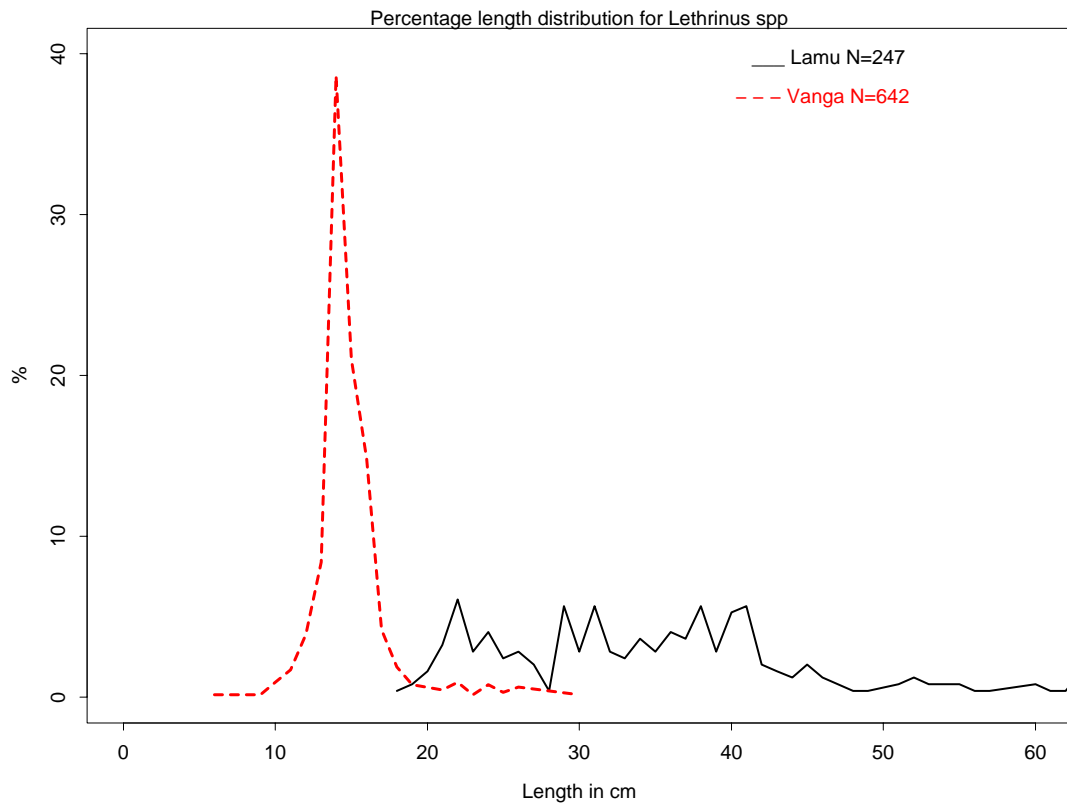
Figure 11: **Percentage length distribution of *Lethrinus spp* from Lamu and Vanga.**
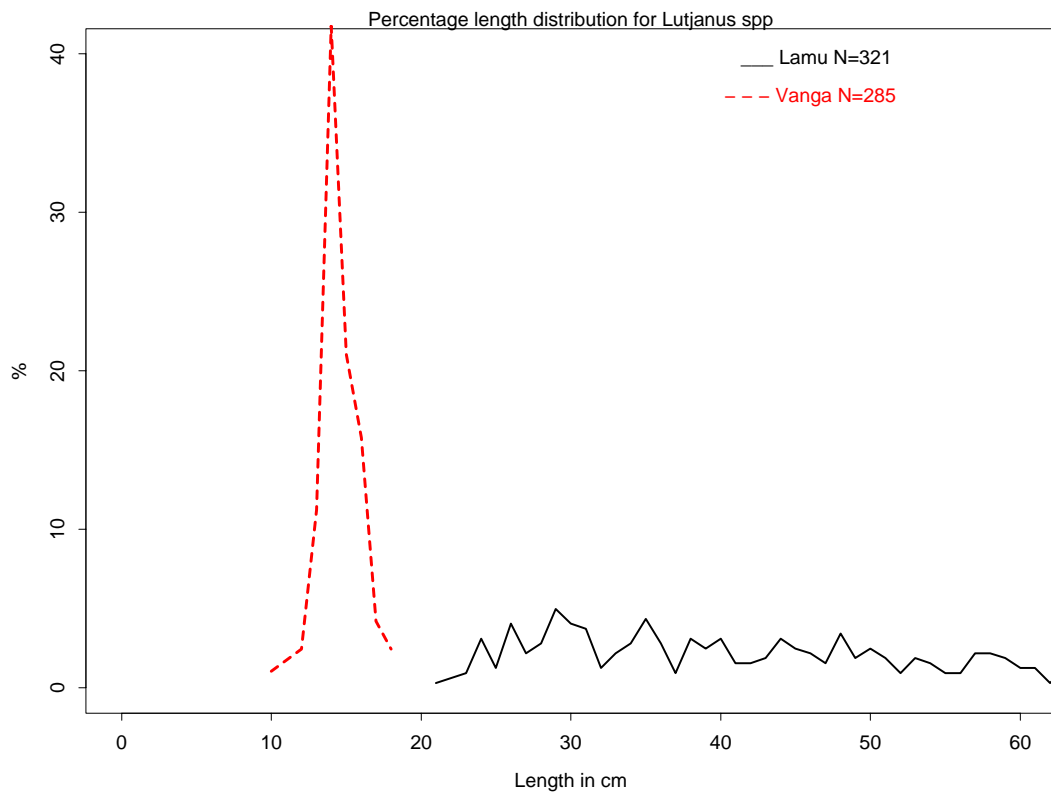
Figure 12: **Percentage length distribution of *Lutjanus spp* from Lamu and Vanga.**
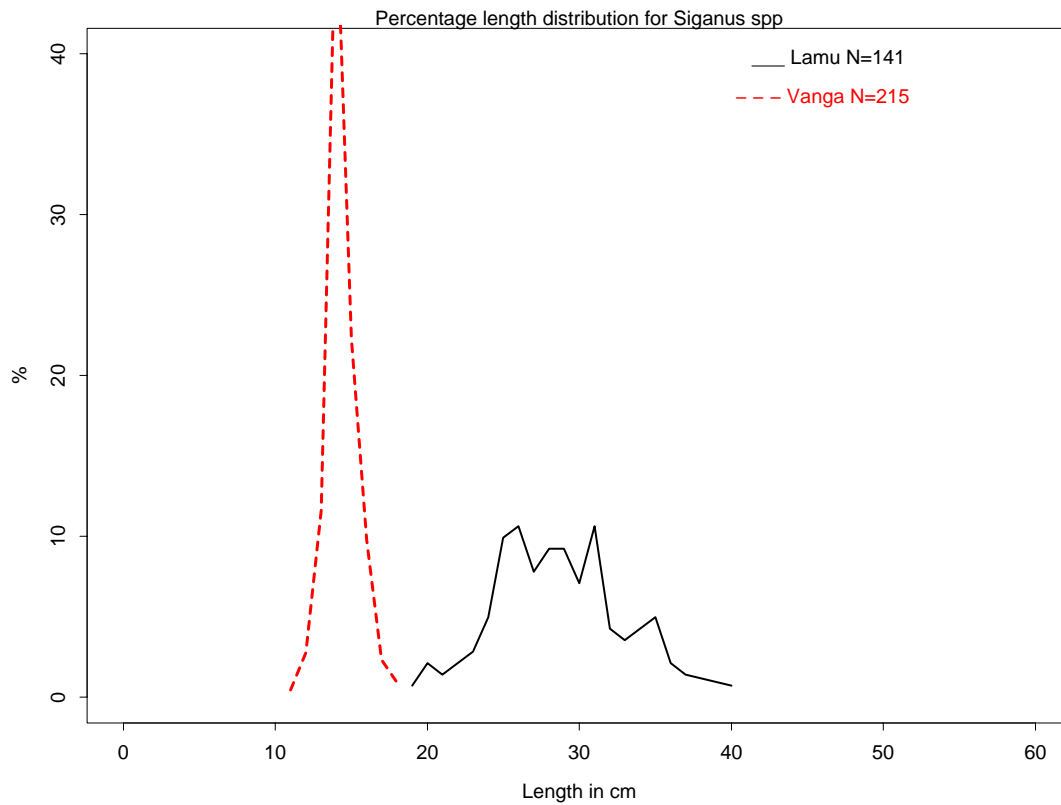
Figure 13: Percentage length distribution for *Siganus spp* from Lamu and Vanga.

Figures 14 to 18 show the length distributions for the most common species in Lamu. These species are *Lethrinus*, *Lutjanus*, *Mugil*, *Siganus* and *Caranx*. For most of the species, the length distribution is wide, ranging from 20- 50 cm, with variable peaks and minimum variations between the years. The length distributions do not show distinct shift of length peaks between the years that would indicate growth. However, for *Siganus spp* there is a peak shift from 25-30 cm to 32-37 cm from one year to the next and for *Caranx spp*, there is a peak shift from 45-52 cm to 52 to 60 cm from one year to the next.
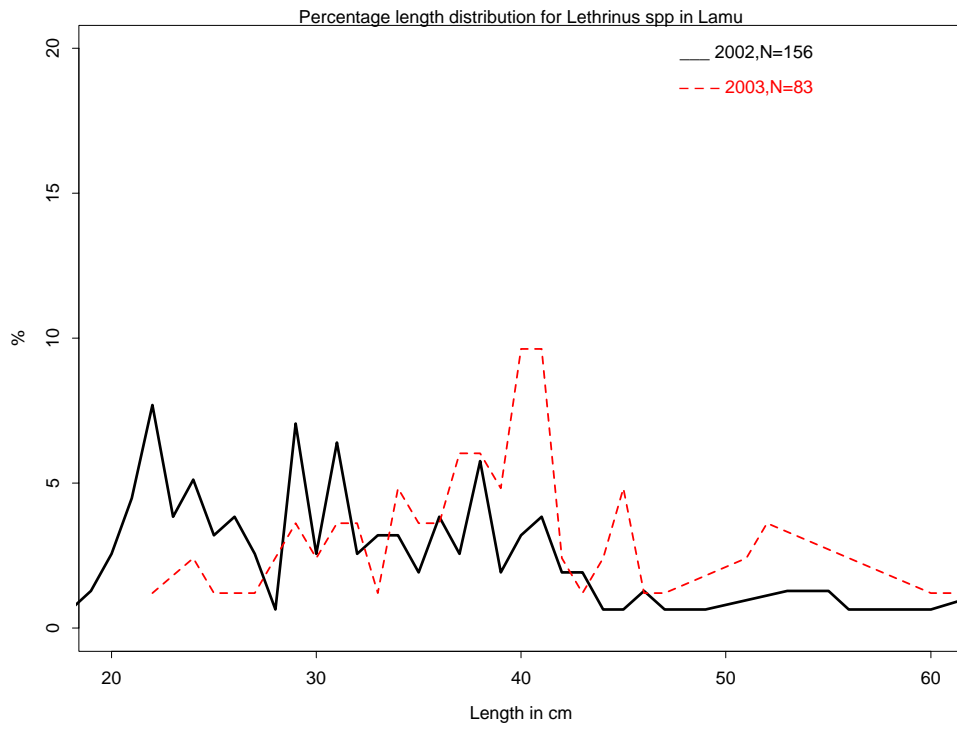
Figure 14: Percentage length distribution of Lethrinus spp from Lamu in 2002 and 2003.
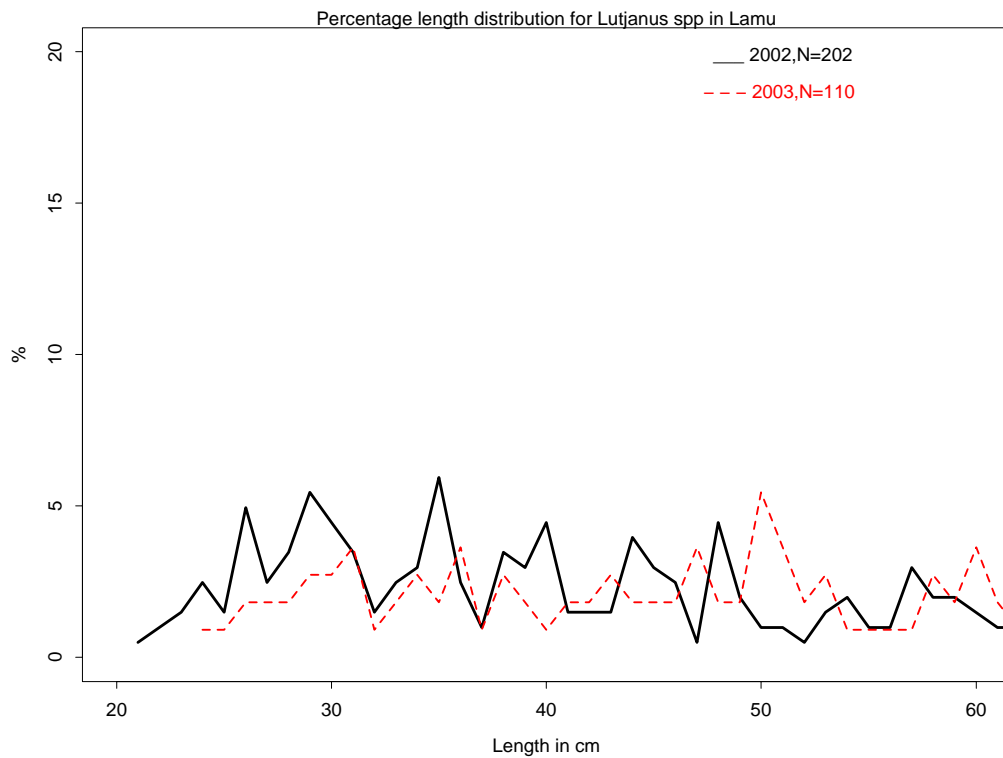
Figure 15: Percentage length distribution for *Lutjanus spp* from Lamu in 2002 and 2003.
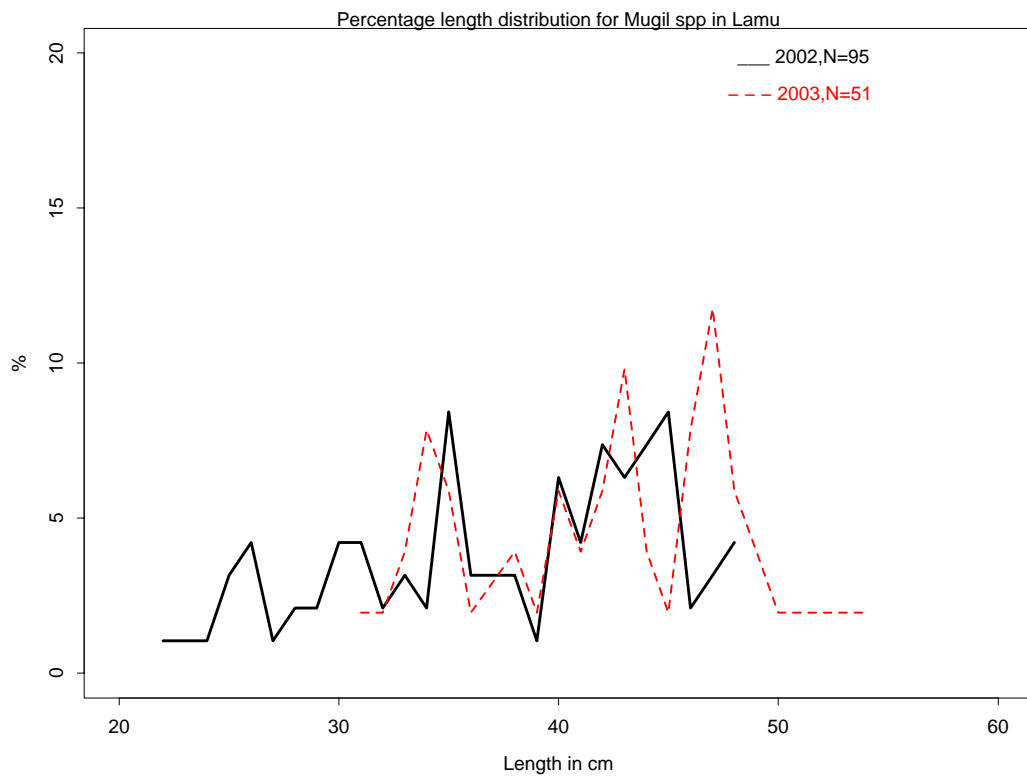
Figure 16: Percentage length distribution for *Mugil spp* from Lamu in 2002 and 2003.
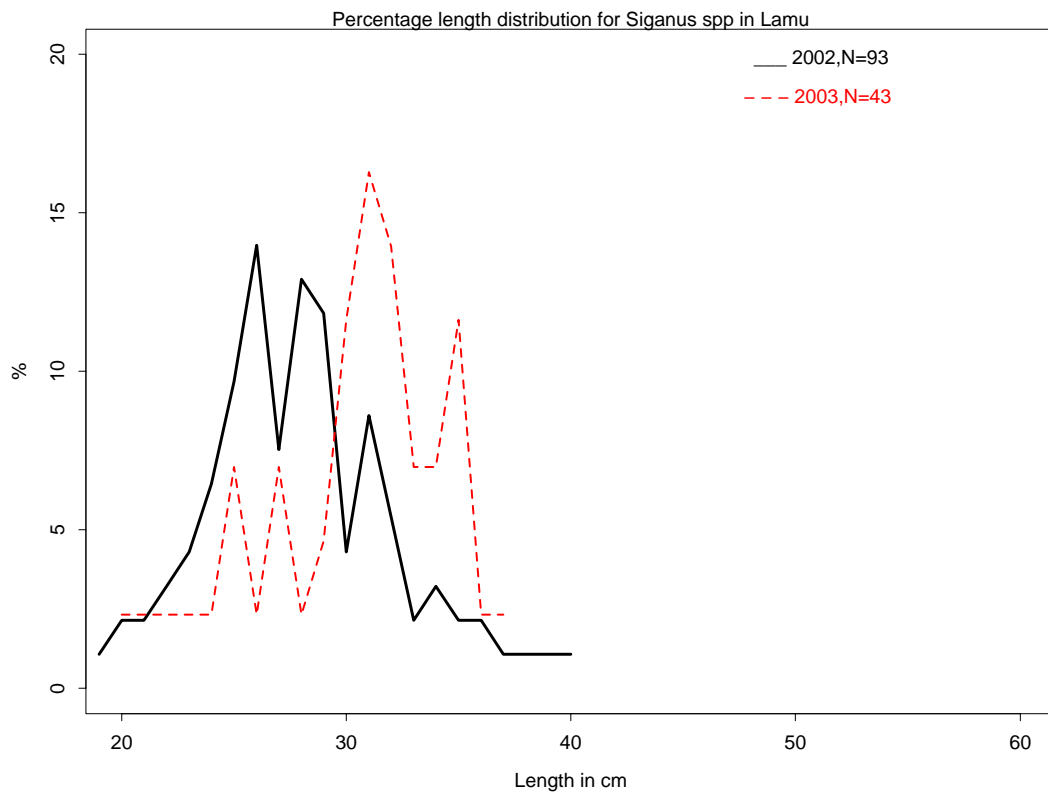
Figure 17: Percentage length distribution for *Siganus spp* from Lamu in 2002 and 2003.
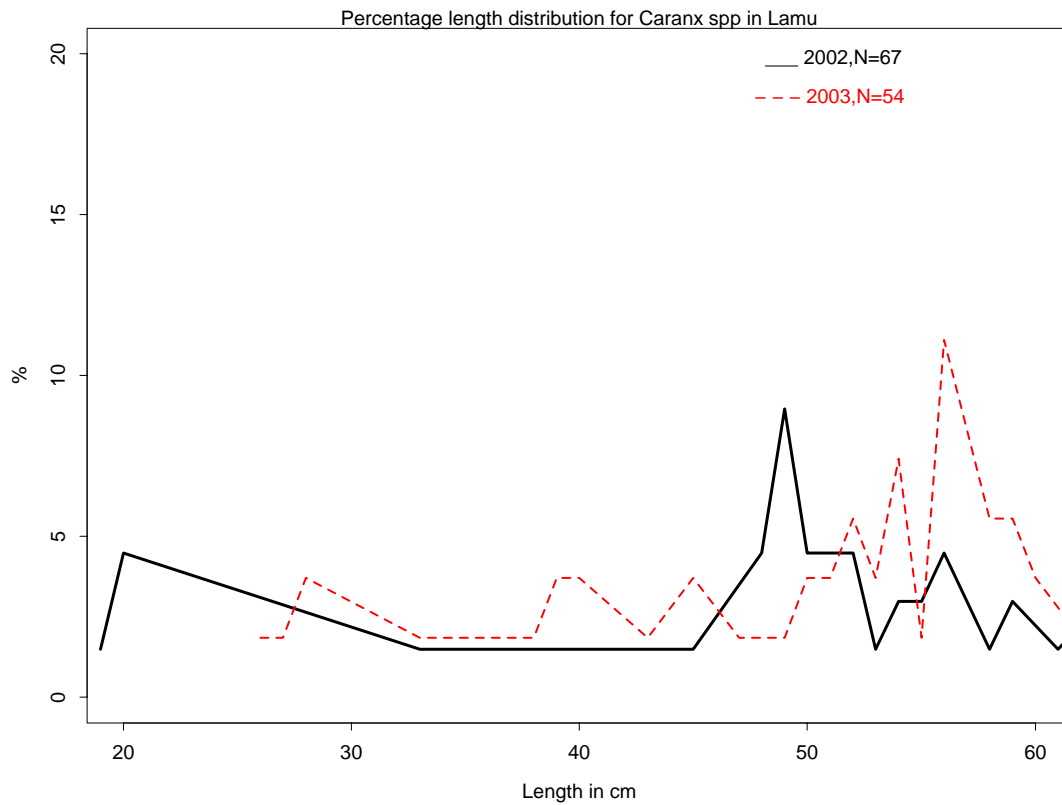
Figure 18: Percentage length distribution for *Caranx spp* from Lamu in 2002 and 2003.

Figures 19 to 22 show the length distributions for species common in Vanga in 2002 and 2003. These species are *Lethrinus*, *Lutjanus*, *Mugil*, *Siganus* and *Decapterus*. The distribution was narrow compared to ones seen in Lamu (Figures 14-18), with peaks at around 15 cm, no distinct shift in the length distribution is displayed for any of the species, apart from *Decapterus spp* where there is a slight shift of the peak in the length from 15 cm in 2002 to 18 cm in 2003.

Percentage length distribution for Lethrinus spp in Vanga
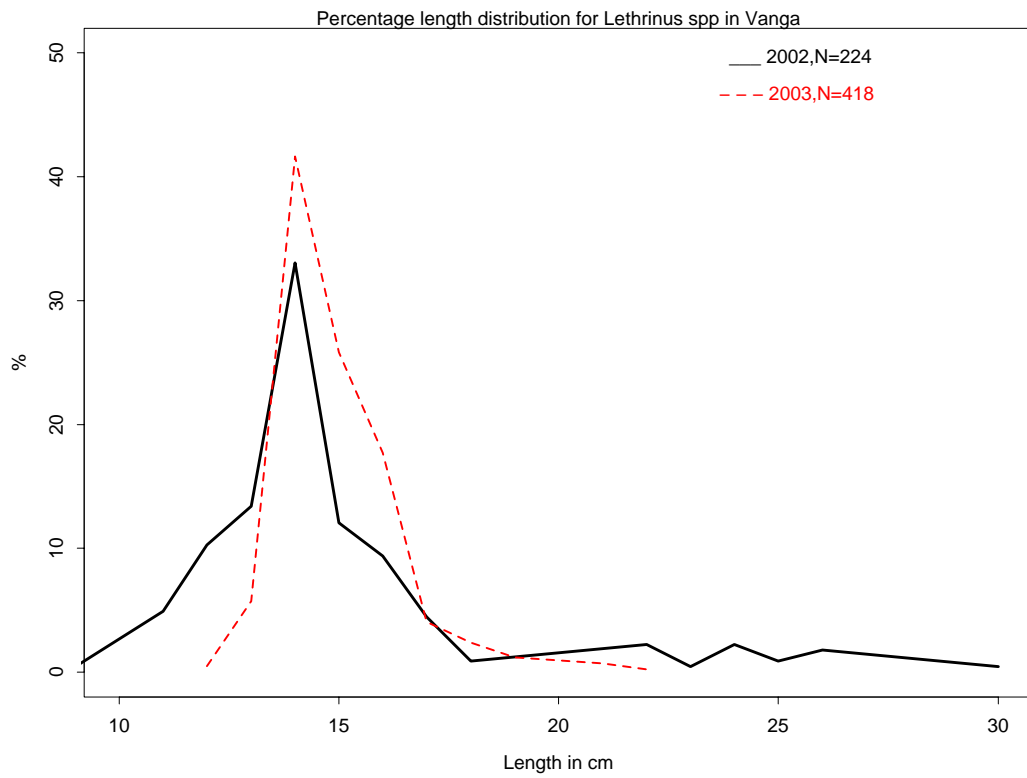
Figure 19: Length distribution for *Lethrinus spp* from Vanga in 2002 and 2003.

Percentage length distribution for Lutjanus spp in Vanga
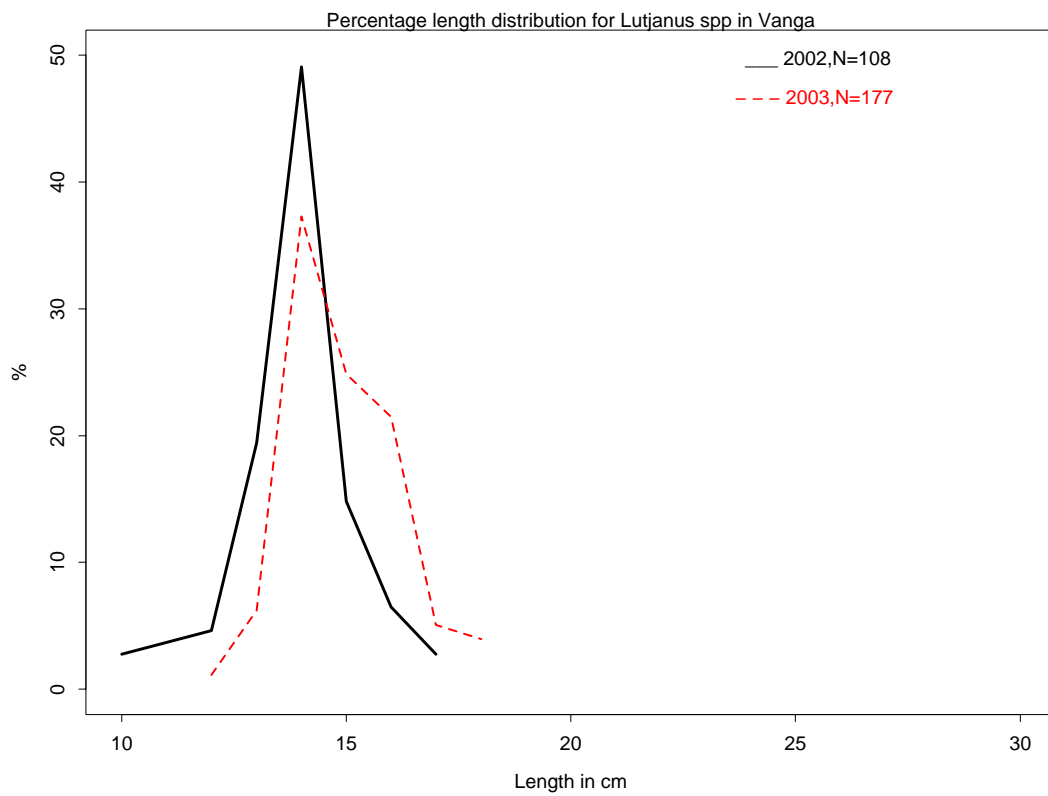
Figure 20: Percentage length distribution for *Lutjanus spp* from Vanga in 2002 and 2003.
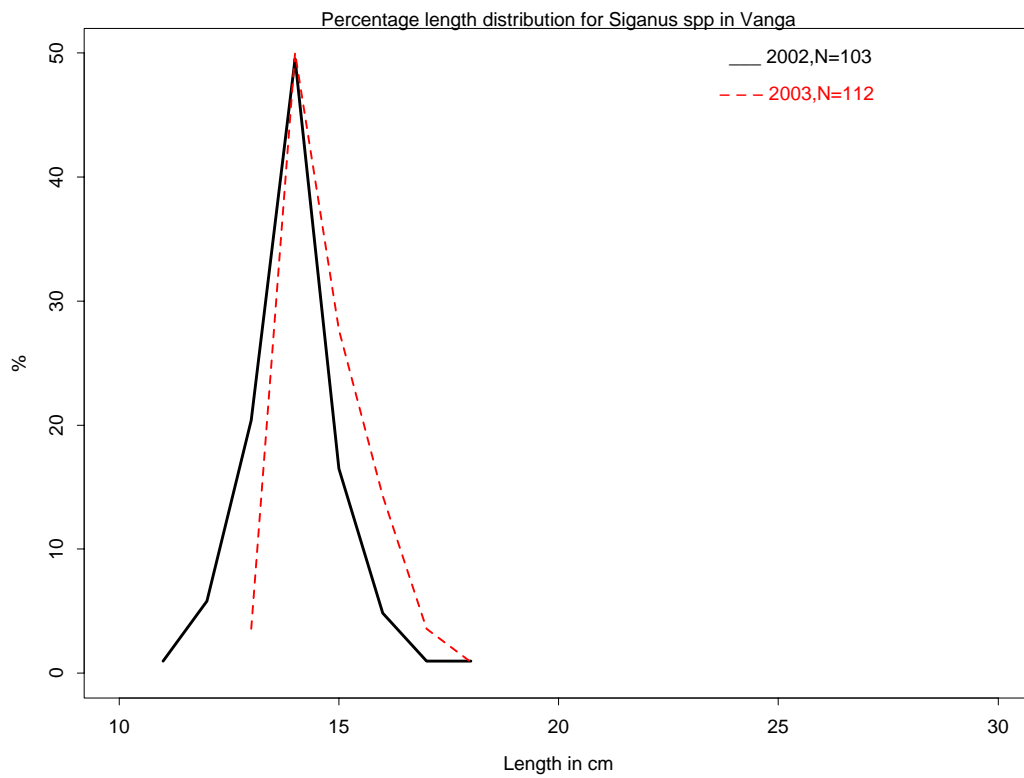
Figure 21: Percentage length distribution for *Siganus spp* from Vanga in 2002 and 2003.
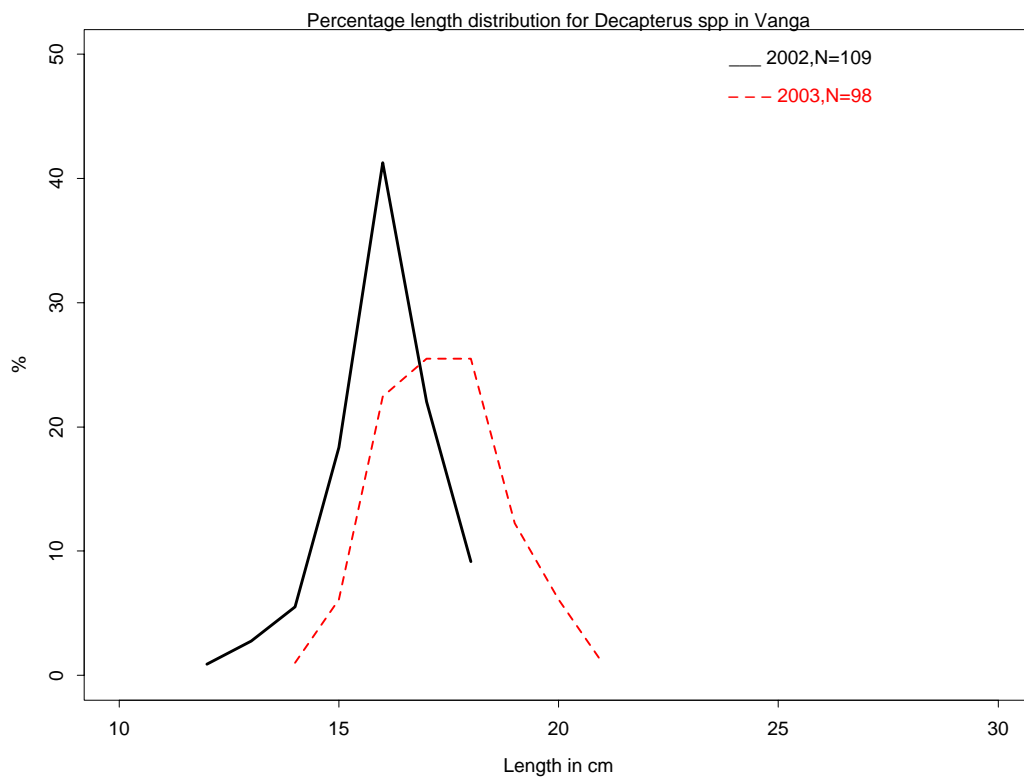
Figure 22: Percentage length distribution for *Decapterus spp* from Vanga in 2002 and 2003.

Figures 23 to 26 show the length distributions for two species common to both areas by gears. There were minor differences in the length distributions with the different gears. For all cases it is clear that all the gear types targeted fish of 20-60 cm lengths in Lamu and 10-20 cm lengths in Vanga. The gill nets in Lamu targeted 20-40 cm sized fish while the shark nets targeted larger fish of 40-60 cm for the two species *Lethrinus* and *Lutjanus*.
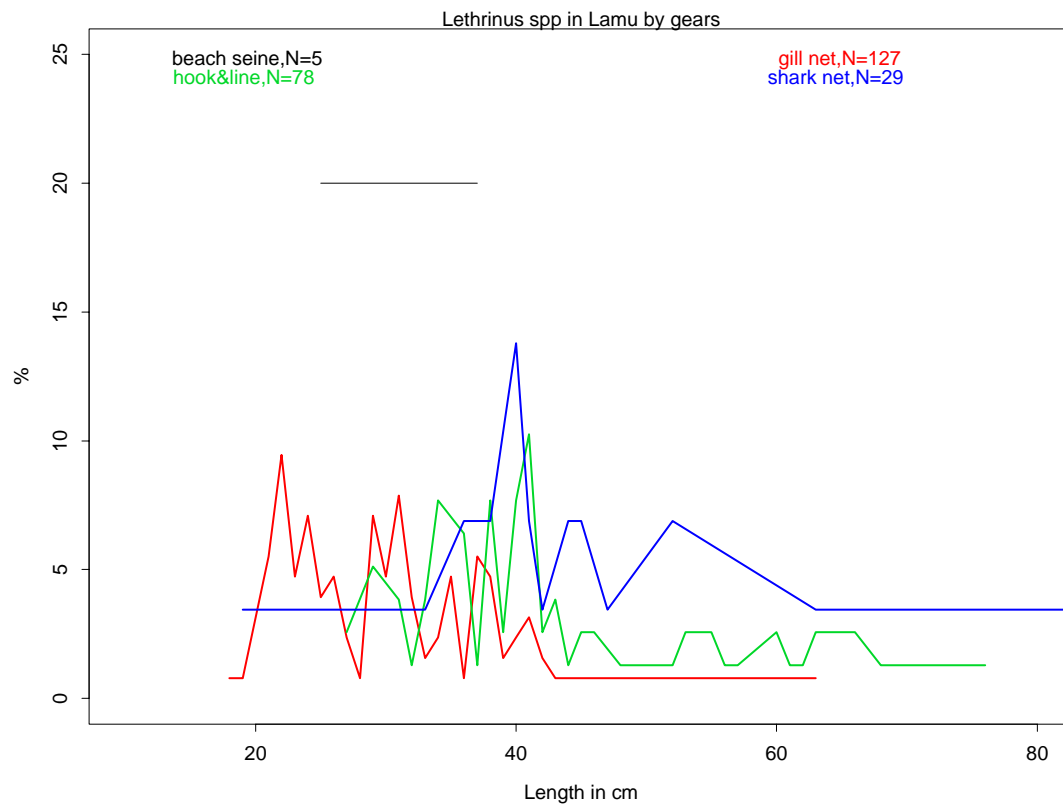
Figure 23: Length distributions by different gears in Lamu for *Lethrinus spp*.
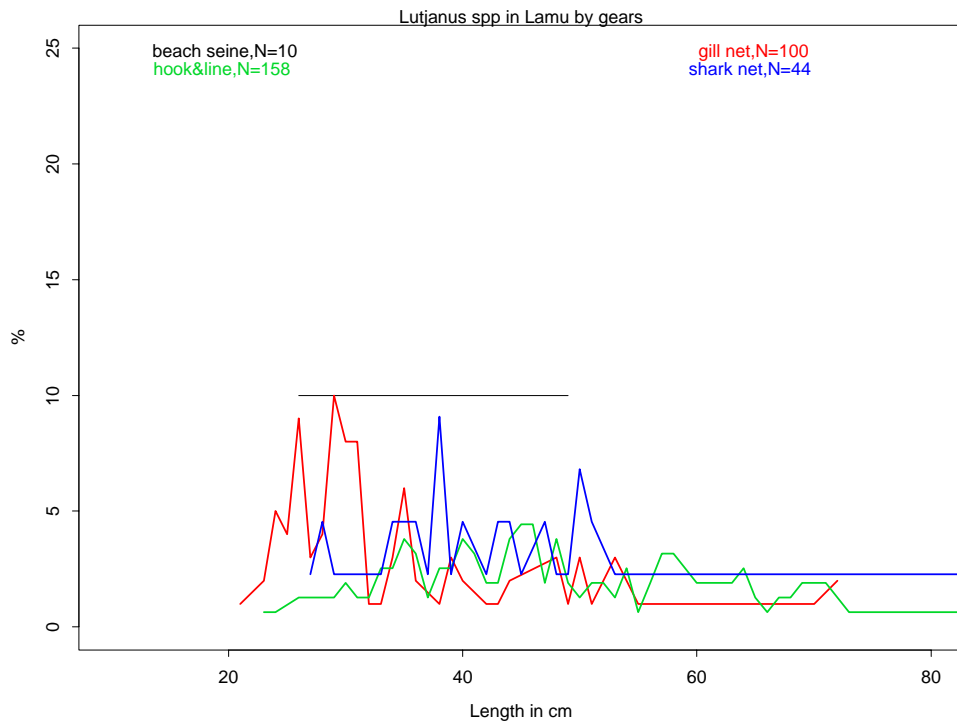
Figure 24: Length distributions by different gears in Lamu for *Lutjanus spp*.
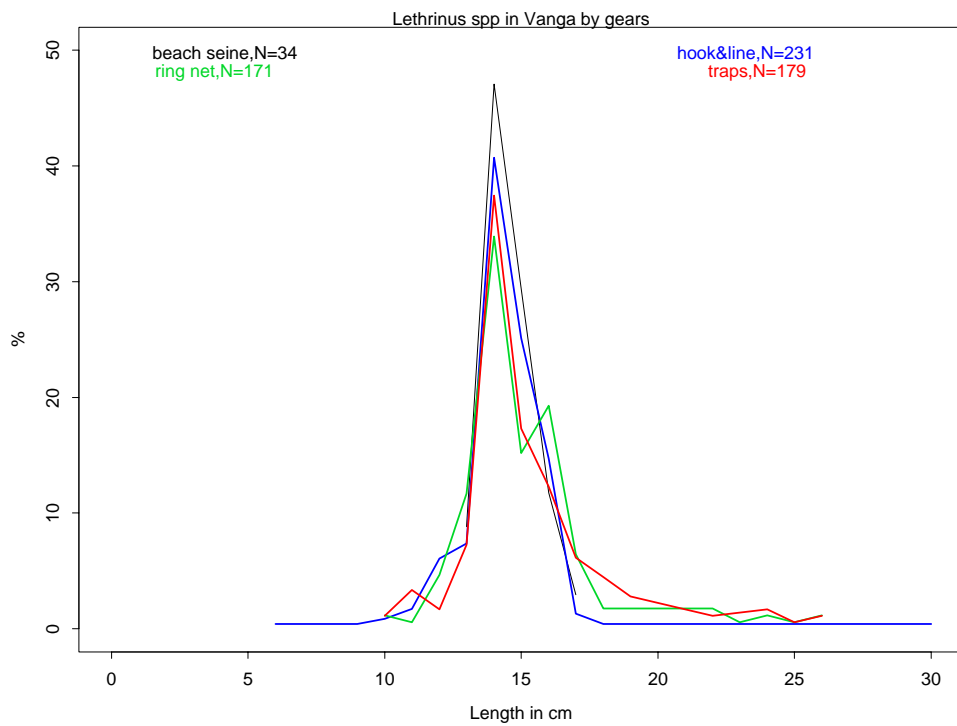
Figure 25: Length distributions by different gears in Vanga for *Lethrinus spp*.
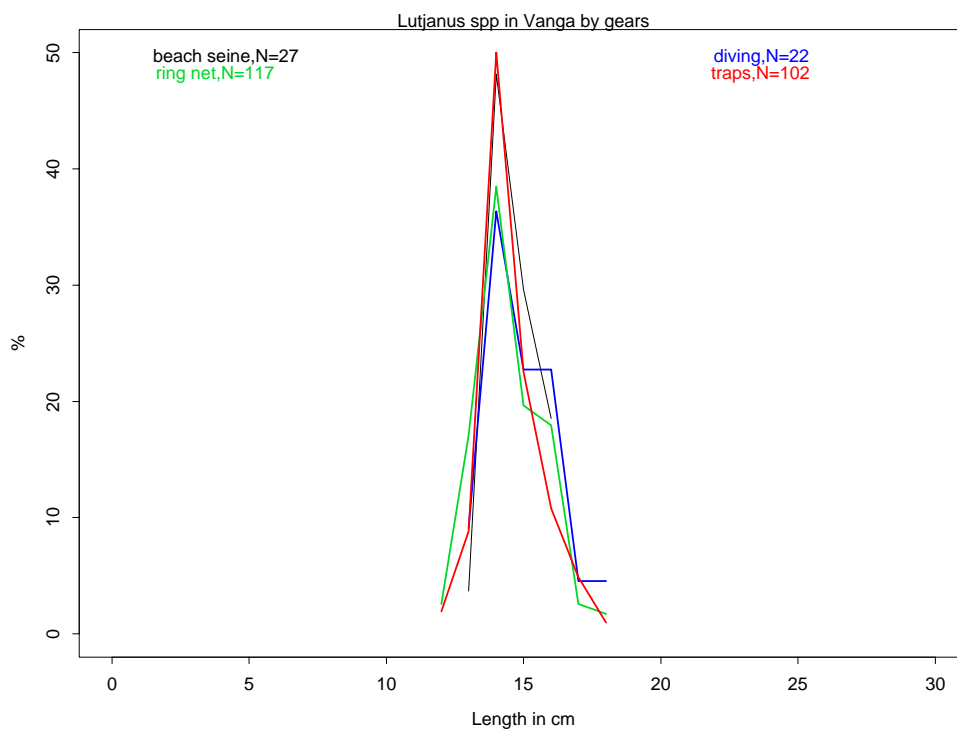
Figure 26: Length distributions by different gears in Vanga for *Lutjanus spp*.

4.2.4   *Length weight relationships for selected species*

Figures 24, 25 and 26 show the length weight relationship for the three most common species *Lethrinus*, *Lutjanus* and *Siganus* in Lamu. The **b** estimates in Lamu ranged from 1.95 to 2.32 for the three species. Data on weights was not available for Vanga so it was not possible to do the length weight relationships.
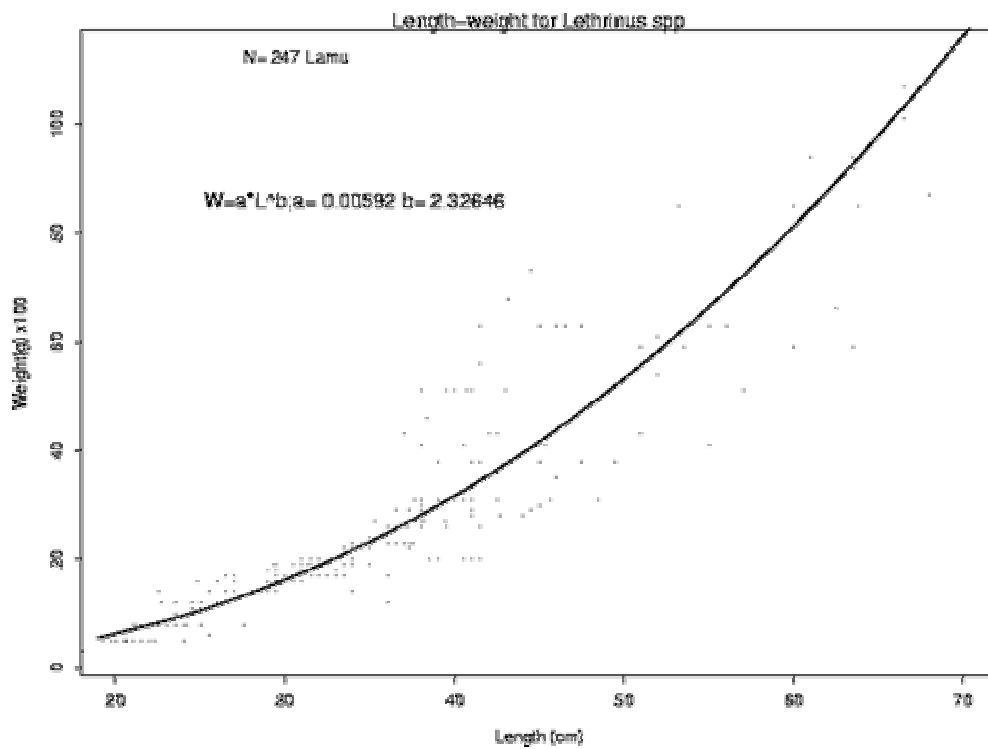
Figure 27: **Length weight relationship for *Lethrinus spp* in Lamu.**
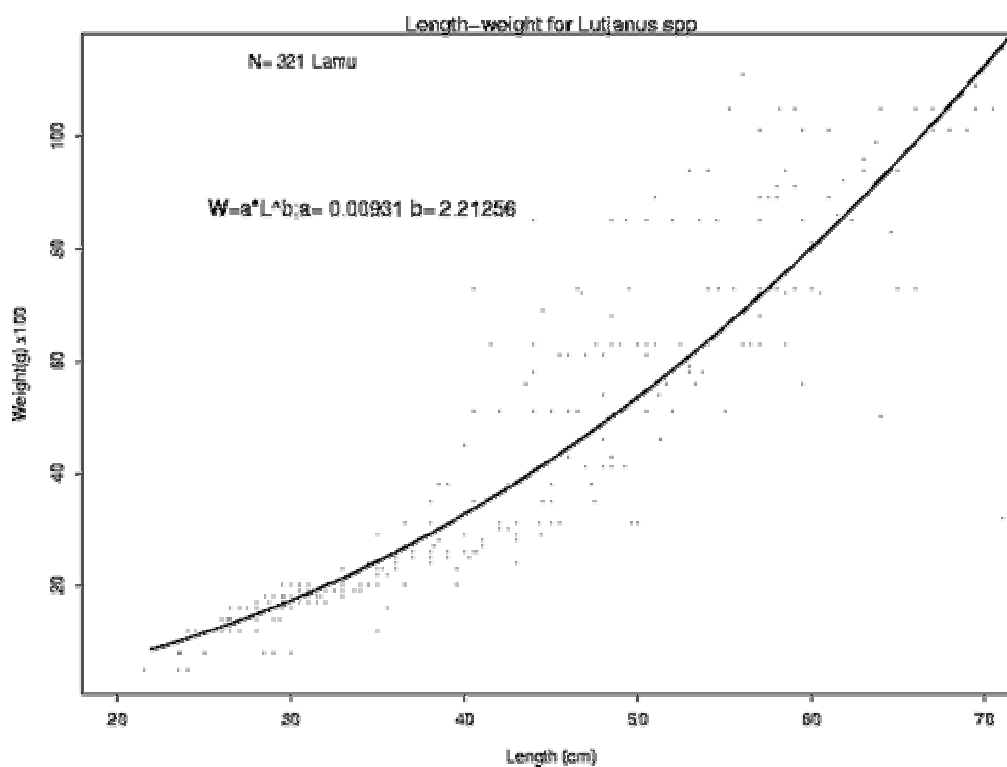
Figure 28: **Length weight relationship for *Lutjanus spp* in Lamu.**
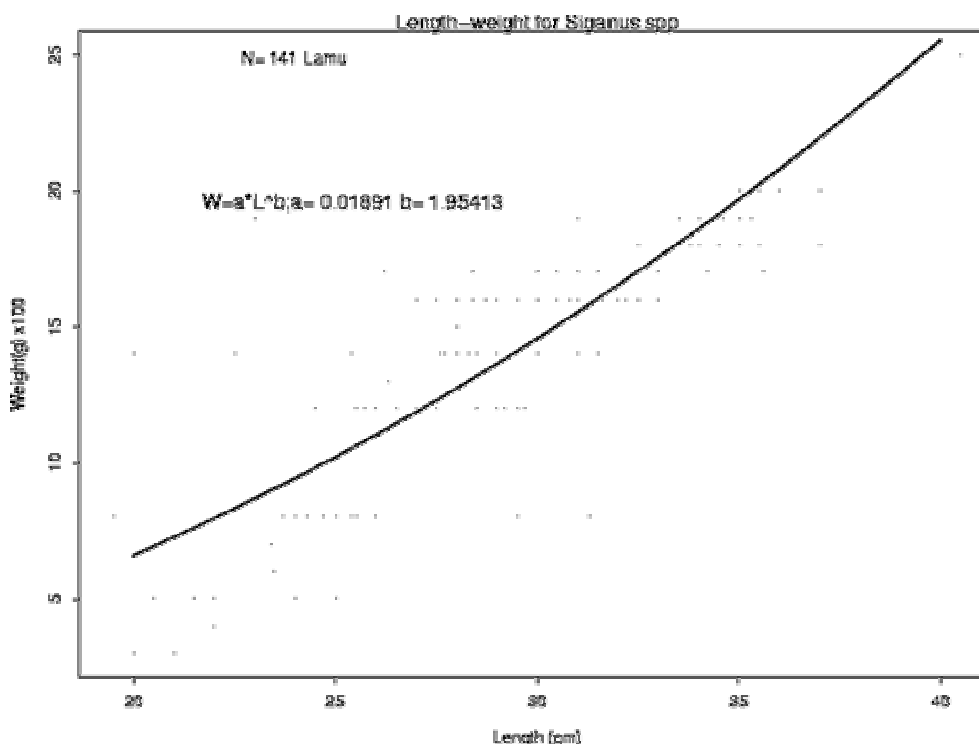
Figure 29: Length weight relationship for *Siganus spp* in Lamu.

Length-weight relationships for the other species for the years were done but due to data limitation the relationships were not comparable.

5   DISCUSSION AND CONCLUSIONS

5.1   Description of fishery

There are many fishing grounds along the Kenyan coast. About 80 major fishing grounds were reported in the 1984 resource survey (Mbuga). The results presented here show that there are more fishing grounds in Lamu than in Vanga. In the available reports, 13 fishing grounds were reported in Lamu but 3 in Vanga. This may indicate that the fishermen in Lamu are able to access more areas than fishermen in Vanga. This may be attributed to the types of vessels used in Lamu (more motor boats and sailboats as explained below). For both areas channels, lagoons and reef areas were the major fishing habitats. Both areas also have mangroves and sea grass beds, which are important habitats for fish. Wakwabi *et al*. (2003) reported that 80% of the marine production comes from the shallow coastal waters and reefs.

Three major types of vessels are commonly used in both areas: sail boats, motor boats and outrigger boats. These have remained the most commonly used vessels over the years and the same vessels were used in the early eighties (Mbuga 1984). No data on the number of different types of boats was available for the current study but in the 1981 survey, there were more canoes recorded than sail boats and motor boats in both areas (Table 1). By then, Lamu had advanced with more usage of sailboats and motor boats and fewer canoes than in Kwale district where Vanga also falls. In this study, no canoes were recorded in Lamu, however a few were still in use in Vanga. In Vanga it

has been reported that 57% of the fishermen use motorized canoes, 14.4% use outriggers and 28.6% use traditional dugout canoes (Ochiewo 2004). This shows advancement in the types of vessels with more use of motor boats. Wakwabi *et al.* (2003) reported 7,640 fishermen in 1995 and 8,022 in 2000 (5% increase) while the number of registered fishing vessels increased from 2,388 in 1995 to 2,687 in 2000 (13% increase).

The numbers of crew members by vessels varies from 1 up to 30 fishermen per vessel and depending on the type of fishery. A crew of 30 is common for the ring nets and such a big crew is necessary. This has also been reported in Tanzania where crew size could range from 3 to 30 fishermen per vessel, depending on the type of fishery (Jiddawi and Öhman 2002). A team of 8 to 25 fishermen was recorded for beach seines in the Southern coast of Kenya in the study on gear based management (McClanahan and Mangi 2004). A lot of the ring netters would use the more powerful vessels i.e. motor boats or sailboats. Sailboats and outriggers are made to suit rough weather and open offshore fishing and are mainly equipped with shark nets, drift nets, gill nets and line gears. On the other hand, canoes are equipped with beach seines cast nets and traps (Mbuga 1984). The size of the vessels, which are recorded in the current data, would be a better measure than the number of crew when standardizing the CPUE data. This could be done by giving the categories of the vessels, e.g. 0-5 m, 5-10 m.

More gears are used in Vanga than in Lamu, where only four types of gears are in use, with gill nets and shark nets being used in many of the major fishing areas. The usage of the gears did not seem to be affected by the seasons. In Vanga, gears were more diverse but ring nets, traps and beach seining were more commonly used. Studies have shown that the change towards motorized canoes in Vanga has led to a shift in fishing technology with more effective gears such as ring nets and long lines being used. Ring nets, which were introduced recently, have gained acceptance from the local fishermen. They have become popular as they land more fish at a lower cost than the other fishing gears while fence traps are loosing popularity (Ochiewo 2004).

The data available represented 4-7 % of the average catch recorded for the 2 districts. The total catch was shown to increase from one year to the next. Ring nets had the highest mean catch (203.79 ± 228.27 kg) but with higher standard deviations. The lowest mean catch was recorded for traps (18.02 ± 28.10 kg). Ring nets also recorded the highest CPUE (37.04 ± 99.31 kg/fisherman). However, it should be noted that the reliability of the results has been affected by the limitatuin of data.Comparing these results with those found by Obura (2001) the catches and CPUE recorded here are much higher. The figures recorded from Diani (south coast of Kenya) ranged from 1.63 kg to 3.65 kg for catch and 1 kg to 2.87 kg/ fisherman. However, all these figures in both studies reflect low total catches and catch per fisherman, which is a common feature in Kenya's coastal fishery.

The available data from 2002 and 2003 show a decrease in CPUE (for all gears, catch/fisherman per day) in Lamu but an increase in Vanga from one year to the next. Seasonally, the CPUE was higher during the NEM than in the SEM in both areas. This can be explained by the more calm conditions of the NEM. Previous studies have confirmed that catches and CPUE are higher during the NEM. Obura (2001), reported

that all gears studied recorded lower catches during the rough season (SEM) than during the calm season (NEM).

It is impossible to make any conclusions based only on these two years with the limited data. At least 4-5 years of data is required in order to use the CPUE for any assessment purposes. With more data available, different kinds of models, such as generalized linear models to calculate CPUE by gear using factors such as years, months, vessel type, crew number etc. could be done. CPUE data is widely used in fishery assessments and can be used to follow the trends in stock sizes over longer periods in the absence of any fishery independent data (surveys). For instance, a simple equilibrium model (Haddon 2001) of CPUE against the effort could be done and this can be used for calculation of an equilibrium Maximum Sustainable Yield. Generalized linear models using several factors such as years, months, vessel type, crew number etc. can be done and the following command in Splus can be applied:

glm(log(catch)~log(effort)+factor(year)+factor(month)+factor(vessel type)+factor(crew number),family=gaussian)

With information on gears, calculation of selection patterns can be done, e.g. for gill nets by mesh size.

5.2   Biological data

More than 50 species of fish were recorded from the data collected. The Kenyan coast is known to be rich in species (Iversen 1984) and 163 reef and reef associated species from 37 families from southern Kenya have been recorded (McClanahan and Mangi 2004). Many of the species caught were demersal reef associated fish, which have been reported to compose about 42% of the total marine output in Kenya (Wakwabi *et al*. 2003). Fishermen have preferences for certain fish (target species) but take any fish caught in the gear and few fish are discarded as inedible (Obura 2001). From the data collected, *Lethrinus spp* was the most common species caught. Lethrinids have been reported to be the most important marine fish, constituting about 31% of the total reef fish landings in Kenya (Kulmiye *et al*. 2002). Other common species were *Lutjanus* and *Siganus*. Lutjanids form the third most abundant group of fish in artisanal catch of the local reef fisheries in Kenya (Nzioka 1984).

A greater number of species were caught in Vanga than in Lamu with other species (mostly pelagic) being more common, i.e. *Decapterus spp, Scomberoides spp*, *Sardinella spp*, half beak, wolf herring and *Nemipterus spp*. This may indicate that Vanga is richer in species than Lamu. The richness in species can be explained in relation to the coral reef. It is known that the fringing reefs are patchy in northern Kenya because of the river discharges and the cold Somali current up welling, whereas a 200 km fringing reef dominates the South. The reported percentage (of the bottom) coral cover in southern Kenya was 19.5 compared to 11.1 in northern Kenya (Obura and Contributors 2002). The only pelagic fish that was common in Lamu was *Caranx spp*, while all the rest were demersal fish. In the case of Lamu, higher biomasses were recorded for hooks and lines and gill nets, which can be said to be the most important gears. Since data on weights was missing in Vanga no comparison can be made.

The results have shown that in Vanga smaller sized fish (juveniles) are caught (10-20 cm) with a very narrow distribution. In Lamu, larger sized fish (> 20 cm) were caught and a wider distribution was seen. One explanation for this could be that in Vanga many of the areas are nursery grounds and hence juveniles are being caught. It has been documented that the juveniles of *Lutjanus fulviflamma* constitute 60% of the catch in the mangrove-lined creeks which are their nursery areas (Kaunda-Arara and Ntiba 1997). Another explanation could be that there is growth over fishing in the area. In the study of the blue marbled parrotfish (*Leptoscarus vaigiensis*) in the south coast of Kenya (Mwatha and Ntiba 1999), it was reported that the fish recruits into the fishery at 11.7 cm, which is within the size range of fish caught in Vanga. It was also shown that *L. vaigiensis* attains sexual maturity at 16.8 cm giving an indication of growth over fishing taking place in the area. This could be the case in Vanga and could be an explanation for the diversity of gears observed in this area. As described in the Literature Review, the current system along the Kenyan coast is prevailed by the East African Coastal Current. The northern part is influenced by the Somali Current which brings with it nutrients (due to up welling) making more food available for the fish, unlike the southern part which is a down welling area. This may also explain the difference in the length distributions of the most common species. It is likely that the species belong to different stocks, since it has been reported in previous studies that the East African reef has a varied topography, which limits the distribution and seasonal migration of the demersal fishes in these waters (Nzioka 1979). However, more studies on the biology of fishes need to be conducted particularly on breeding and migration patterns in addition to their distribution and abundance.

Looking at the length frequency distribution of one of the common species *Lethrinus*, the peaks were at 15 cm for Vanga, 30 cm and 40 cm for Lamu. *Lethrinus harak* studied from the South coast of Kenya (Kulmiye *et al*. 2002) had percentage frequencies of up to 25 % for the length frequency distributions, with peaks at 21-22.9 cm for males and 25-26.9 cm for females, with the largest specimen caught being 38.8 cm, which is well above the ones recorded in Vanga.

For *Lutjanus spp*, the highest numbers of individuals recorded were from the 18-19 cm length group with higher percentage of males (61.3%) than females (38.7%) (Kaunda-Arara and Ntiba 1997). The length frequency distributions done from the data available collected for the different species did not show any distinct bimodal distribution. Two species showed a bimodal distribution in the length frequency distribution, they were *Siganus spp* and *Caranx spp*. in Lamu, giving an indication of growth for the species.

For the length weight relationship of the different species common in Lamu had **b** ($W=aL^{b}$) estimates ranged from 1.95 to 2.32. Data on weights in Vanga was lacking, hence no length weight relationship could be done. However, it would have been interesting to see the outcome of these, considering that it was mostly juvenile fish that were caught in this area. The relationships, and hence the growth in the two areas, could be compared.

5.3   Significance of the analyses done

Mapping: This is an important tool and gives a visual representation of the fishery in the different areas. With all the data collection points plotted in, it gives a clear picture of the fishery, differences and changes over the years. In addition it presents the situation on the ground to all the stakeholders in a simple and straight forward manner. For the managers this will be very useful.

Catch and CPUE: Catch and fishing effort information are the basic data required for fisheries studies and these may be supplemented by the regular collection of length-frequency data. A trend of falling catch rates may indicate that a fishery is being exploited above the sustainable rate and a decrease in the mean length of fish in the catch (estimated from length-frequency data) may indicate the same thing (King 1995). Fish catches in Kenya are said to be on the decline, but this has not been scientifically proven. Analyses of the catch and effort data will be important to verify this. Though the results from this study are not conclusive indications, of exploitation above sustainable rates were seen in some species in Vanga.

CPUE is the most commonly used index of relative abundance in fisheries studies and may be recorded in many ways (King 1995). It can help us know whether the relative abundance of one year within a given area is different from another year or whether the relative abundance of fish in one month is different from that of the previous month. CPUE data may also be used as indices of abundance to suggest species distribution by depth and area. This will be important for fishery management in Kenya.

With details on age composition available and time series of CPUE data, catch curves can be plotted. If information on age composition and fishery independent data (surveys) is not available, CPUE data may still be used to follow the trends in stock sizes over longer periods. For short lived species, CPUE data may also be used if recruitment occurs during well-defined periods. If this is so, the decrease in total CPUE over the period between one recruitment and the following will reflect the average mortality of all age groups combined (King 1995). The assumptions are that all age groups are equally vulnearble to the catching method and mortality is constant. The catch curves plotted are important in estimating mortality rates, information that is lacking in the Kenyan fishery.

Length-weight relationships: Length and weight data provide statistics that are a foundation to fishery research and management. In general it is recognized that fish weight is directly related to fish length and several different ratios have been developed to describe this relationship between fish length and weight (Tomasson pers.comm.)

Length-weight relationships of fishes are important in fisheries biology because they allow the estimation of the average weight of the fish of a given length group by establishing a mathematical relation between the two (Beyer 1987). They are also useful for assessing the relative status of the fish population. Besides this, the length weight relationship can also be used in setting yield equations for estimating the number of fish landed and comparing the populations in space and time. The

empirical relationship between the length and weight of the fish will enhance the knowledge of the fish about which studies are scant in Kenya.

6   RECOMMENDATIONS

6.1   Suggested improvements

Locations: Apart from giving the name or habitat of areas fished, data collection should include the GPS locations of the fishing areas. In addition, the depths of the locations should be recorded. This is important for mapping, giving reference positions and will be useful in plotting the contours and relating the fishery with depths. Such information could help in identifying important fishing areas and stock rich areas.

Use of codes: Use of codes for areas and names is recommended. This will simplify the data recording, entry and processing. Species names should also be coded and this will help avoid confuison especially where different traditional and common names are used in different areas and by different communities.

Additional Information:
Gears: the number and sizes of different gears used should be clearly recorded, i.e.lengths of nets, mesh size and hook size. The usage of more than one gear (if any) should also be reported. This information is important for the fishery description and assessing the gear selectivity.

Vessels: the number and size of the different vessels used in the areas needs to be recorded to trace the variations and will be useful in estimating CPUE by taking into consideration the size of the vessel as a factor. The length of the vessels can be grouped into categories e.g. 0-5m, 5-10m etc.

Weights: the weights of individual species should be recorded as this is important in finding the relationship with length (length weight relationship) and describing the condition of the fish.

Target species: If possible target species should be recorded in form A as this can be related to the gear type and size as well as the fishing area (habitat).

Data: the data entry which is done by months is to be eventually stored in one file for analysis, with Catch ID linking forms A and B. For purposes of analysis the following fields will be used: station, year, North-South location, month, area fished, position (longitude and latitude), depth, vessel used, vessel size, number of crew, gear used, gear size, duration, total landing, catch ID, species, weight, total length and sex. It is recommended that the field labels should be simple and concise.
One of the problems stated in this study is the limitation of the data collected. There is a need to increase the data collection effort in areas where data is very limited, e.g. Lamu.

The proposed format of the improved data forms is as follows:

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE
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FISHERIES DATA: FORM A

Recorder……………………. Station…………………

Date	Boat used	Boat size	Crew no.	Area fished	Position	Depth	Gear used	Gear size	Time in	Time out	Total landing	Catch ID

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BIOLOGICAL DATA: FORM B

Recorder……………………. Station…………………

Date	Catch ID	Sub sample weight	No. of fish in sub sample	Species	Total length	Weight	Sex

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APPENDICES

Appendix I

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CATCH DATA: FORM A

Recorder... Ouwaro Maurice   Station... Lamu

Date	Boat Used	No. Crew	Area Fished	Gear Used	Mesh Size	Time In	Time Out	Total Landing (Kg)	CATCH ID #
02 July 01	Motorboat	3	Beyond reef	Hooks line	—	2/7/02	1/7/02	50 kg	02 July 01
04 July 01	Sailboat	4	Dodori	Gilnet	4"	4/7/02	3/7/02	36 kg	04 July 01
09 July 01	Sailboat	4	PATE	Hook & line	—	9/7/02	8/7/02	114 kg	09 July 01
10 July 01	Sailboat	4	PATE	Gilnet	2½"	10/7/02	9/7/02	53 kg	10 July 01
11 July 01	Sailboat	4	Dodori	Gilnet	4"	11/7/02	10/7/02	60 kg	11 July 01
12 July 01	Sailboat	4	PATE	Gilnet	2½"	12/7/02	11/7/02	70 kg	12 July 01
15 July 01	Sailboat	4	Dodori	Gilnet	2½"	15/7/02	14/7/02	70 kg	15 July 02
15 July 02	Sailboat	4	PATE	Hook & line	—	15/7/02	14/7/02	50 kg	15 July 02
16 July 01	Sailboat	4	PATE	Gilnet	2½"	16/7/02	15/7/02	82 kg	16 July 01
17 July 01	Sailboat	4	MANDA TOTO	Gilnet	2½	17/7/02	16/7/02	75 kg	17 July 01
18 July 01	Sailboat	4	MANDA TOTO	Gilnet	2½	18/7/02	17/7/02	87 kg	18 July 01
19 July 01	Sailboat	4	PATE	Hook & line	—	19/7/02	18/7/02	141 kg	19 July 01
22 July 01	motorboat	3	Beyond reef	Hook & line	—	22/7/02	21/7/02	48 kg	22 July 01
23 July 01	Sailboat	4	PATE	Hook & line	—	23/7/02	22/7/02	80 kg	23 July 01
24 July 01	sailboat	4	MANDA TOTO	Hook & line	—	24/7/02	22/7/02	40 kg	24 July 01
25 July 01	Sailboat	4	Dodori	Gilnet	2½	25/7/02	24/7/02	78 kg	25 July 01
26 July 01	Sailboat	4	FAZA	Hook & line	—	26/7/02	25/7/02	69 kg	26 July 01
26 July 02	Sailboat	4	MANDA TOTO	Gilnet	4"	26/7/02	25/7/02	50 kg	26 July 02
29 July 02	Motorboat	3	CORAL REEF	HOOK AND LINE	—	5.00 Am	4.30 Pm	20 kg	29 July 01
— '' —	Sailboat	4	LAGOON	BEACH LINE	2½"	8.30 Am	4.00 Pm	60 kg	29 July 02
30 July 02	Sailboat	4	LAGOON	GILLNET	—	9.00 Am	3.30 Am	47 kg	30 Jul 01
— '' —	MOTORBOAT	3	BEYOND REEF	TARIFFE	6"	8.30 Am	1.30 Am	45 kg	30 Jul 02
— '' —	Sailboat	4	Mud seagrass	BEACH SEINE	2½"	9.00 A	4.30 Am	5 kg	30 July 03
31 July 02	Sailboat	4	lagoon	Gilnet	6"	9.30 Am	3.30 Am	60 kg	31 Jul 01
01 Aug 02	Sailboat	4	mud flat	Gilnet	3½"	8.00 Am	4.30 Pm	400 kg	01 Aug 01
02 Aug 02	Motorboat	3	Mango shella	Tariffe	6"	02/8/02	01/8/02	100 kg	02 Aug 01
03 Aug 02	Sailboat	4	Matondoni	Beach Seine	3¾"	8.30 Am	3.30 Am	50 kg	03 Aug 01

* Catch ID#: Day, First Two Initials of the Month, Number: i.e 22SE1, 22SE2, 22SE3, 2OC1

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CATCH DATA: FORM B

Recorder.. Okwaro Maurice.   Station.. Lamu

Date	Catch ID#	Sub Sample Weight	No. of Fish in Sub Sample	Species	Weight	Total Length	Sex	Lengths of Others of the Same Speci in the Sample
02 July 01	02 July 01	7.95kg	04	Caranx sem	2.25kg	62.5cm	M	
								WT2kg TL59cm M
								WT2.5kg TL60cm F
								W12kg TL50.5cm
04 July 01	04 July 01	19.8 kg	0B	Caranx sex fasciatus.	5kg	78.5cm	f	
				Caranx sem	3kg	62.5cm	f	
								WT3kg TLb2cm M
			Mugil seheli	1kg	47cm	f	
								WT600g TL39cm M
								WT500g TL36cm M
				Keiwa	3.5kg	54cm	M	
								WT3.2kg TL53cm f
09 July 01	09 July 01	17.45 kg	16	Kusi	1kg	43.5cm	M	
								WT1kg TL44.5cm M
				epinephelus tanuma	750g	38.5cm	M	
								WT350g TL30.5cm M
								WT750g TL38cm M
				Caranx sem	900g	47cm	M	
								WT900g TL46cm M
								WT1.5kg TL51.5cm M
								WT1.5kg TL52cm f
				Pomadys mul timaculatum	1kg	45cm	f	
								WT800g TL42cm M
								WT1kg TL44cm M
								WT1kg TL43.5cm f
				Lutjanus bo har	500g	37cm	M	
								WT500g TL35.5cm M
				DUGUA	4kg	61cm	f	

Appendix II

Number of species caught in lamu and Vanga in the two years (2002 & 2003)

Species	Lamu	Vanga	Species	Lamu	Vanga
Mugil	154	8	'Mkeke'	5	0
Pomadasys	52	0	*Scarus*	1	169
Caranx	124	32	'Fume'	4	0
Lutjanus	321	285	*Arius*	3	0
Sarda	38	0	Crocodile fish	3	0
Lethrinus	247	642	*Decapterus*	2	207
'Pelee'	6	0	'Dugua'	13	0
Epinephelus	52	51	*Gerres*	15	3
Cephalopholis	5	0	*Tetraptunus*	9	0
Sphyraena	34	23	*Trachinotus*	6	0
Siganus	141	215	*Kyphosus*	2	0
Scomberoides	20	150	*Alectis*	1	0
Raja batis	30	0	Scad	5	0
Upeneus	27	38	Needle fish	0	77
Chanos chanos	26	0	*Chimaera*	0	11
Platax teira	3	0	*Nemipterus*	0	124
'Ngamia'	3	0	*Katsuwonus*	0	74
Lobotes	8	0	'Usigi'	0	163
Gaterin	60	12	*Sardinella*	0	141
Cheilinus	26	0	Pouter	0	87
Whale shark	1	0	Wolf herring	0	127
'Kidara'	7	0	Half beak	0	136
Elagatis	5	0	'Kibemberu'	0	18
Acanthopagrus	20	0	*Acanthurus*	0	59
Drapena	25	0	Unicorn	0	37
Argeutim	2	0	Others	31	26

Appendix III

Table :Species composition in Lamu 2002

Species	Beach seine	%	Gill net	%	Hook & line	%	Shark net	%
Mugil	7	18.4	80	15.9	8	2.3	0	0
'Mkeke'	0	0	5	1.0	0	0	0	0
Pomadasys	0	0	14	2.8	17	4.9	0	0
Caranx	9	23.7	18	3.6	36	10.1	4	7.5
Lutjanus	6	15.8	56	11.1	121	34.1	19	35.8
Sarda	0	0	7	1.4	8	2.3	0	0
Lethrinus	5	13.2	82	16.3	58	16.3	11	20.8
'Dugua'	0	0	4	0.8	8	2.3	1	1.9
Epinephelus	0	0	11	11.1	19	5.4	2	3.8
Sphyraena	0	0	12	2.4	17	4.9	0	0
Siganus	4	10.5	80	15.9	4	1.1	5	9.4
Scomberoides	0	0	7	1.4	2	0.6	0	0
Raja	3	7.9	8	1.6	8	2.3	0	0
Upeneus	0	0	19	3.8	0	0	0	0
Chanos	0	0	10	2.0	8	2.3	2	3.8
Gaterin	0	0	37	7.4	5	1.4	0	0
Cheilinus	0	0	17	3.4	3	0.8	5	9.4
'Kidara'	0	0	4	0.8	3	0.8	0	0
Acanthopagrus	4	10.5	7	1.4	9	2.5	0	0
Drapena	0	0	10	2.0	6	1.7	4	7.5
Others	0	0	15	3.0	15	4.2	0	0

Table : Species Composition in Lamu 2003

Species	Beach seine	%	Gill net	%	Hook & line	%	Shark net	%
Decapterus	4	9	35	14.7	4	3.5	8	10.0
Pomadasys	3	6.8	12	5.0	2	1.8	2	2.5
Caranx	4	9	20	8.4	21	18.6	9	11.3
Lutjanus	4	9	44	18.5	37	32.7	25	31.3
Sarda	7	15.9	6	2.5	10	8.8	0	0
Lethrinus	0	0	45	18.9	20	17.7	18	22.5
Epinephelus	2	4.5	2	0.8	9	8.0	3	3.8
Gerres	3	6.8	0	0	0	0	7	8.8
Sphyraena	0	0	0	0	3	2.7	3	3.8
Trachinotus	0	0	2	0.8	0	0	4	5.0
Siganus	8	18.2	31	13.0	4	3.5	0	0
Scomberoides	0	0	6	2.5	3	2.7	1	1.3
Raja	0	0	11	4.6	0	0	0	0
Upeneus	0	0	8	3.4	0	0	0	0
Chanos	2	4.5	4	1.7	0	0	0	0
Gaterin	4	9	10	4.2	0	0	0	0
Drapena	3	6.8	2	0.8	0	0	0	0

Table : Species composition in Vanga 2002

Species	Hook & line	%	Ring net	%	Traps	%
Caranx	0	0	6	0.8	26	10.4
Arius	5	9.3	51	6.6	52	20.8
Lethrinus	29	53.7	105	13.6	90	36.0
Decapterus	0	0	109	14.1	0	0
Epinephelus	0	0	0	0	17	6.8
Sphyraena	0	0	11	1.4	0	0
Siganus	0	0	53	6.9	50	20
Scomberoides	0	0	39	5.1	0	0
Upeneus	8	14.8	0	0	5	2
Chimaera	0	0	6	0.7	5	2
Nemipterus	5	9.3	0	0	0	0
Bonito	0	0	46	6.0	0	0
'Usigi'	0	0	91	11.8	0	0
Gaterin	7	13.0	0	0	5	2
Sardinella	0	0	76	9.8	0	0
Pouter	0	0	36	4.7	0	0
Wolf herring	0	0	96	12.4	0	0
Half beak	0	0	25	3.2	0	0
'Kibemberu'	0	0	11	1.4	0	0
Others	0	0	7	0.9	0	0

Table : Species composition in Vanga 2003

Species	B/seine	%	CC	%	Diving	%	H & L	%	R/net	%	Traps	%
Mugil	8	6.0	0	0	0	0	0	0	0	0	0	0
Scarus	18	13.4	0	0	7	11.9	5	1.6	84	17	23	2.9
Lutjanus	27	20.1	5	23.8	22	37.3	7	2.2	66	14	50	6.4
Lethrinus	34	25.4	4	19.0	23	39.0	202	63	66	14	89	11
Decapterus	0	0	0	0	0	0	0	0	44	9.4	54	6.9
Epinephelus	7	5.2	0	0	2	3.4	0	0	25	5.3	0	0
Sphyraena	0	0	0	0	0	0	0	0	12	2.6	0	0
Siganus	15	11.1	4	19.0	0	0	32	10	27	5.7	34	4.4
Scomberoides	0	0	0	0	0	0	7	2.2	1	0.2	103	13.2
Upeneus	1	0.7	0	0	0	0	0	0	24	5.1	0	0
Needle fish	5	3.7	0	0	0	0	0	0	19	4.0	49	6.3
Nemipterus	0	0	0	0	5	8.5	0	0	16	3.4	98	12
Bonito	0	0	0	0	0	0	0	0	11	2.3	17	2.2
'Usigi'	0	0	0	0	0	0	0	0	32	6.8	40	5.1
Sardinella	0	0	0	0	0	0	0	0	0	0	65	8.3
Pouter	0	0	0	0	0	0	7	2.2	15	3.2	29	3.7
Wolf herring	5	3.7	0	0	0	0	6	1.8	0	0	20	2.6
Half beak	14	10.4	8	38.1	0	0	7	2.2	24	5.1	58	7.4
'Kibemberu'	0	0	0	0	0	0	0	0	0	0	7	0.9
Acanthurus	0	0	0	0	0	0	31	9.7	0	0	28	3.6
Unicorn	0	0	0	0	0	0	15	4.7	0	0	2	0.3
Others	0	0	0	0	0	0	0	0	4	0.9	15	1.9

Key: B/seine- beach seine; CC- 'chachacha'; HL- hooks and lines; R/net- ring net