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Fish species composition and distribution in Kilifi Creek

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Introduction

Estuaries with mangroves and mudflats have high aquatic biodiversity. These ecosystems play important roles as sheltering, feeding, nursery and spawning grounds for finfish and shellfish (Vidthayanon & Premcharoen 2002). Some species occur both as juveniles and as adults in these areas while others move as adults to other biotopes such as deep zones in the coral reef and *vice versa* (Van der Velde *et al.* 1995). Kambona (1974) observed that commercial fisheries yield in the Indian Ocean are based mainly on coastal species particularly migratory pelagic and demersal species from estuaries and coral reefs. Highly detrimental fishing methods such as the use of dynamite and beach seines as well as indiscriminate shell fish collection have contributed to the depletion of various coastal resources on the Indian Ocean coast (Matthes 1974).

Understanding the assemblages of organisms and how they change in species numbers and abundance depending on existing biotopes is of great interest to ecologists as well as fisheries managers (Washington 1984). Ter Morshuizen *et al.* (1996) studied the distribution patterns of fishes in the Great Fish River (South Africa) and established that euryhaline marine taxa of the families Mugilidae and Sparidae dominated the catch in the river (salinity of <1‰), the

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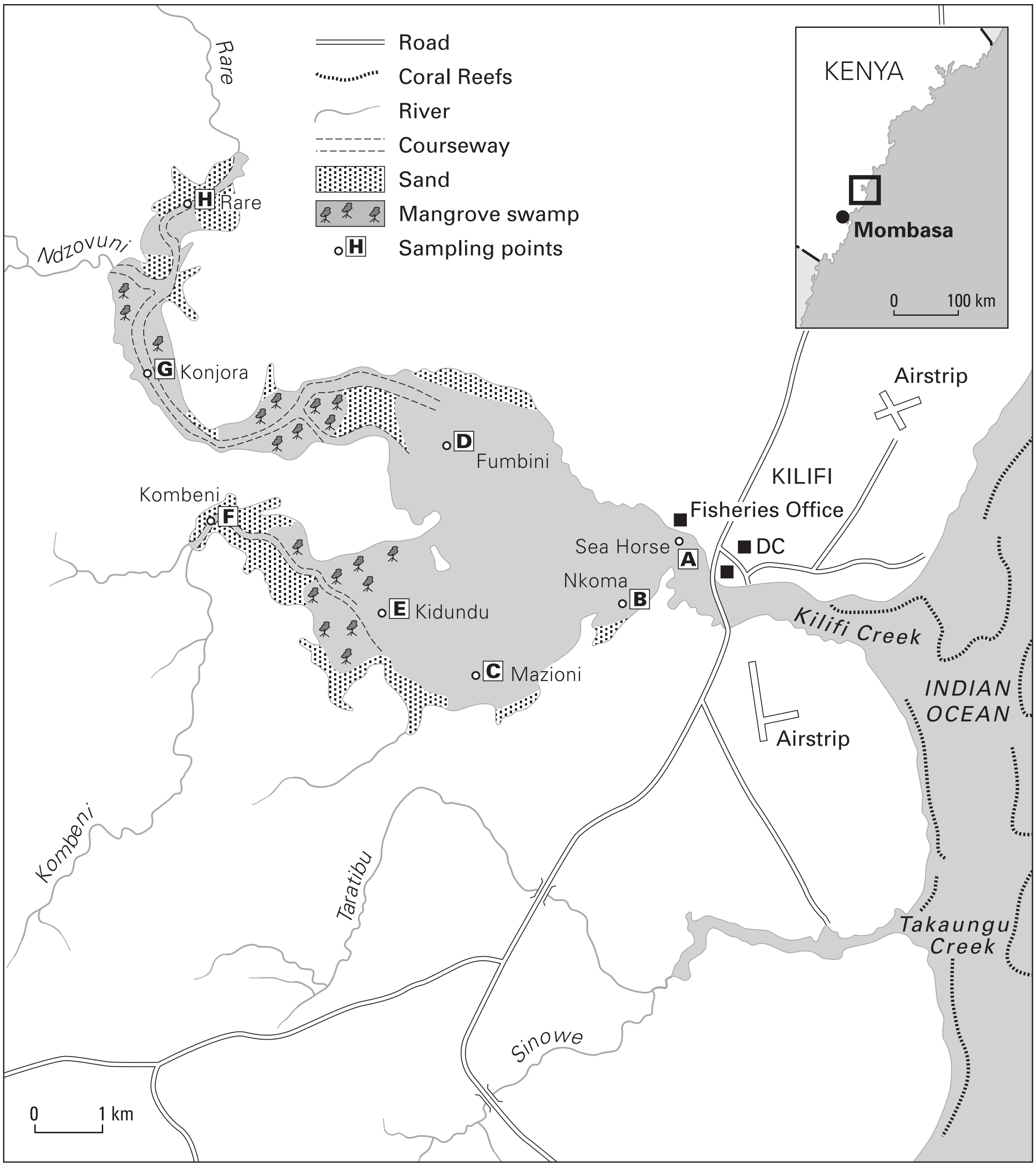


Map 1.1 Kilifi Creek with location of sampling points

head (salinity of 1-4‰) and the estuary (salinity of >4‰). This was attributed to the fact that estuarine associated fish taxa are usually more tolerant of low rather than high water salinity. At Kariega estuary (South Africa), Paterson & Whitfield (2000) observed that the intertidal salt marsh creek and adjacent eel-grass beds function as nursery areas for juvenile fish although the two habitats are dominated by different ichthyofaunal families.

Along the Kenyan coast, shallow-water fish fauna have been documented at Gazi (Kimani *et al.* 1996; Wakwabi 1999); Tudor Creek (Little *et al.* 1988), Diani (Obura 2001) and unprotected and protected reefs along the Kenyan coast (McClanahan 1994). The distribution of fish and other marine organisms shows large variation depending on different biotopes with different physico-chemical characteristics. Kilifi Creek is one of the largest creek systems along the Kenyan Coast, comprising various biotopes that include patches of coral reef, mudflats with and without seaweeds and estuarine ecosystems. This research utilized the opportunity offered by the variation in conditions to study the relationship between fishery organisms and various physico-chemical parameters in the creek.

Study area

Kilifi Creek is located some 55 km north of Mombasa city. The deepest part of the creek is approximately 38 m at the entrance and a distance of about 4 km (500 m wide) separates the ocean from an open lagoon known as Bahari ya Wali. The total area of the creek and Bahari ya Wali is 22.4 km^2. The western side of the creek is extensively covered with mangrove trees of different species covering an area of approximately 360 ha. There are two main water channels winding in between the mangrove forest of which the southern arm is short, without permanent streams, while the northern arm is longer with two permanent streams, Ndzovuni and Rare that join to form the Konjora which leads into Bahari ya Wali (Map 1.1). There are two rainfall seasons, the long rains between April to July and short rains between October to December. Fishing goes on continuously within the creek. Eight sampling sites were selected: Sea Horse, Fumbini, Konjora and Rare to the north and Nkoma, Mazioni, Kidundu and Kombeni to the south towards the creek mouth.

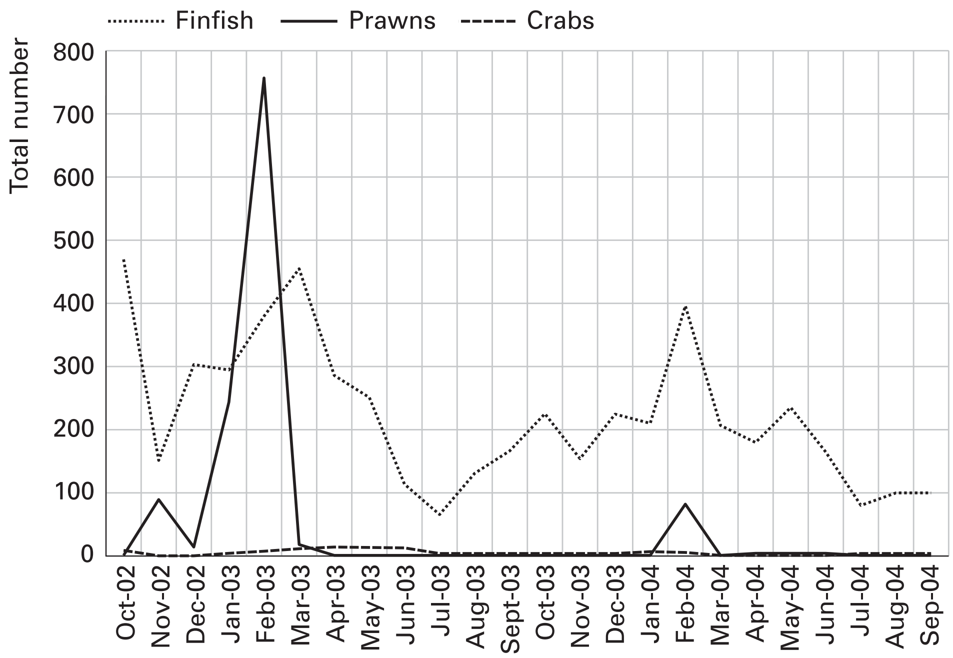
Method

Fishing was carried out at each sampling site during the day using a canoe. The sampling period took four days during neap tides every month from October 2002 to September 2004. A castnet (19.1 mm mesh size, 7.6 m^2) and gillnets

(50.8, 63.5 and 76.2 mm mesh sizes, depth 166 cm and 100 m long each), were used for fishing at all sites. Water was obtained from the surface (below 10 cm) using a scoop bucket (Volume 5 litres) and from the bottom region using an improvised bottom water sampler (Volume 3 litres) for analysis of physico-chemical parameters. These included temperature (mercury thermometer), dissolved oxygen (Winkler method), salinity (Hand held Atago refractometer), inorganic phosphate and nitrate (Parsons *et al.* 1984). Depth and secchi disc transparency was also measured directly at each site. The overall monthly means for each site were calculated from means of both surface and bottom water samples for the above parameters.

All organisms obtained during fishing were identified and classified into orders, families and species where possible according to Smith & Heemstra (1986); Whitfield (1998); Fischer & Bianchi (1984) and Eccles (1992). The individuals of each group were counted and the total numbers recorded. To assess spatial and seasonal variation between finfish communities, the following four diversity indices were used: i) Margalef's species richness index (R) (Zar 1966), ii) Shannon-Weiner diversity index (H') (Zar 1996), iii) Pielou's evenness index (J') (Zar 1996) and iv) Simpson's diversity index (D) (Krebs 1978).

Figure 1.1 Total monthly fishery organisms landed from October 2002 to September 2004



Multi-Dimensional Scaling (MDS), clustering analysis and diversity indices calculations were performed using PRIMER. Principal Component Analysis (PCA) was performed using Pc ord 4 programme, for multivariate analysis of ecological data. SPSS was used to relate physico-chemical parameters to seasons and the diversity indices.

Results

Crustaceans

Four crustacean species were caught but in low numbers at most study sites. Though there were site-specific variations in totals, the crustaceans were always present at Kidundu, Kombeni and Rare (Table 1.1). Specifically, the prawn species *Penaeus indicus* was abundant at Kidundu and Rare, while *P. monodon* dominated at Kombeni. These sites were mudflat areas, but at the Kidundu site mudflats were covered with seaweeds hence were a nursery and feeding ground. The site at Kombeni was hypersaline with high temperatures and high concentrations of phosphates and nitrates and hence *P. monodon* which prefers these conditions dominated. However, it is worth noting that prawns were absent from Sea Horse and Nkoma. The abundance of prawns for both species peaked in February and *P. indicus* was the most abundant species on average (Figure 1.1).

All crabs caught during the study belonged to the Brachyuran order. The crabs were caught every month throughout the study period and in all sites except Konjora. More *Portunus pelagicus* were caught at Mazioni, Kidundu and Fumbini while *Scylla serrata* were more abundant at Rare. There were more *P. pelagicus* individuals caught on average than *S. serrata* (Table 1.1).

Table 1.1 Composition and distribution of crustaceans (prawns and crabs) collected at study sites within Kilifi Creek.

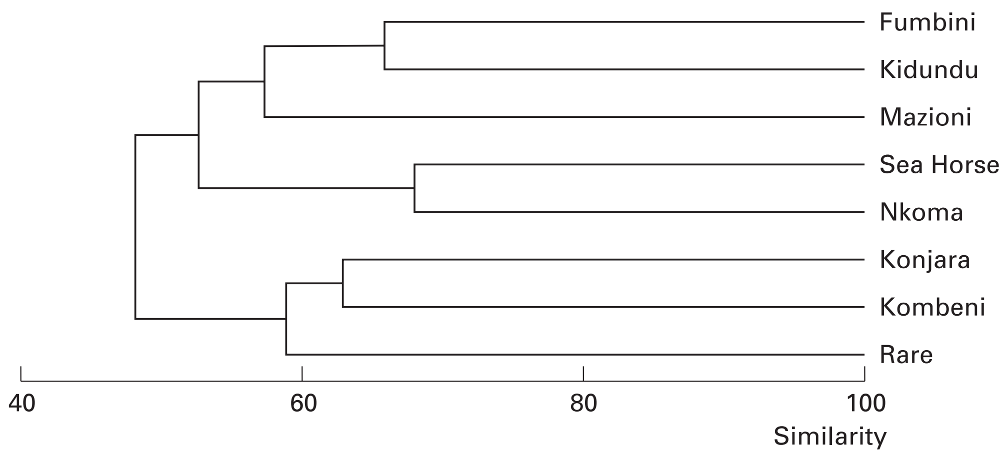
Species/Site	SH*	NK	MZ	FU	KD	KM	KN	RA	Total
Penaeus indicus	0	0	85	1	845	5	1	356	1293
Penaeus monodon	0	0	0	0	3	13	0	4	20
Scylla serrata	2	4	2	3	3	4	0	6	24
Portunus pelagicus	5	6	20	39	23	1	0	4	98
Total	7	10	107	43	874	23	1	370	1435

* Legend SH-Sea Horse NK- Nkoma MZ- Mazioni FU- Fumbini
KD- Kidundu KM- Kombeni KN- Konjora RA- Rare

Finfish

Finfish landings were high during the north-east monsoon and low during the south-east monsoon (Figure 1.1). From the nine orders identified at Kilifi and their distribution at each study site, the order Perciformes had the largest number of species (50 total) and this order also had the highest number of species at each site (Table 1.2). Finfish in the order Clupeiformes and Perciformes occurred at all the study sites but other finfish orders were found at some sites and not others. The highest number of species were recorded at Nkoma over the study period (39) while the lowest number of species were encountered at Konjora (21). Although the site at Sea Horse had only four orders of finfish, the total number of species (34) was still amongst the highest of the sites due to the large number of species in the order Perciformes (31). Only two finfish orders were recorded at Konjora and hence the low diversity recorded at this site. Figure 1.2 shows the Bray-Curtis species similarity dendrogram of fish species rank order during the study period. Sea Horse and Nkoma were distinctly different from the other sites since they were the deepest sites within the study area.

Figure 1.2 Similarity dendrogram of fish assemblages rank order in Kilifi Creek by site



Diversity indices

During the first year, diversity indices were high at all sites but a sharp decrease was observed towards the end of the second year. The indices were again notably high during the north-east monsoon. F-test showed no significant differences between the north-east and south-east monsoon seasons when the diversity indices were compared [R ($F_{1,178}$=0.02, p=0.88); J' ($F_{1,172}$=3.89, p=0.05); H' ($F_{1,184}$= 0.15, p=0.6); and Simpson's ($F_{1,178}$=0.57, p=.45)].

The site at Fumbini had the highest abundance of finfish collected during the study period (Table 1.3). Comparisons between sites showed that the Margalef's species richness index was highest at Sea Horse (2.2) followed by Nkoma (1.8) and Kidundu (2.1) but lowest at Konjora (1.2). The site at Mazioni had the highest mean Pielou's evenness (0.90) while Fumbini (0.68) had the lowest evenness. The mean Shannon-Weiner diversity index was high at Kidundu (1.5), Sea Horse (1.45) and lowest at Konjora (0.73). However, Simpson's index was high at all sites within the Bahari ya Wali (between 0.56 and 0.76; Map 1.1).

Table 1.2 The number of species in each finfish order and the total number of species recorded at each study site.

Order	SH*	NK	MZ	FU	KD	KM	KN	RA
Anguilliformes	1	1	1	1	1	0	0	0
Aulopiformes	1	1	0	0	1	1	0	0
Clupeiformes	1	3	3	2	3	2	1	1
Elopiformes	0	0	0	0	0	1	0	0
Gonorhynchiformes	0	1	0	0	0	1	0	1
Perciformes	31	30	19	22	29	23	20	23
Pleuronectiformes	0	1	1	1	1	0	0	0
Siluriformes	0	1	0	1	1	0	0	0
Squatiniformes	0	1	0	1	1	0	0	1
Total	34	39	24	28	37	28	21	26

* Legend: See Table 1.1

Physico-chemical parameters

Table 1.3 shows the means of the physico-chemical parameters together with the mean number of fish collected for each study site. The parameter with the largest mean variation was nitrates that was highest at Rare and lowest at Mazioni. Mean phosphate concentration was high at Rare but low at Kidundu. Variation among sites, however, was low in respect of salinity, temperature and dissolved oxygen. Both Sea Horse and Nkoma were deep sites and also had the highest secchi transparency. Fumbini and Kidundu had the highest mean number of fishes, followed by Sea Horse and Nkoma, but Konjora had the lowest.

Variation in physico-chemical parameters between the north-east monsoon and south-east monsoon was tested and a significant difference was observed in the concentration of phosphate and temperature ($F_{1,184}$=22.51, p=0.00; $F_{1,184}$= 48.06, p=0.00 respectively) while no significant difference was observed in the concentration of nitrates, dissolved oxygen, salinity, secchi transparency and depth ($F_{1,184}$=0.71, p=0.40; $F_{1,184}$=0.88, p=0.35; $F_{1,184}$=0.10, p=0.75; $F_{1,184}$=1.20, p=0.27; $F_{1,184}$=1.16, p=0.28 respectively).

The PCA analysis identified two groupings based mainly on environmental characteristics of the different biotopes of Kilifi creek (Figure 1.2). The secchi transparency and depth were important physico-chemical factors at the sites at

Table 1.3 Means and S.E. of physico-chemical parameters and the number of fish (N=24 months*).*

Parameters	SH*	NK	MZ	FU	KD	KM	KN	RA
Phosphates (µg/l)	0.65 (0.03)	0.72 (0.04)	0.63 (0.02)	0.7 (0.03)	0.58 (0.02)	1.06 (0.06)	0.65 (0.04)	1.11 (0.06)
Nitrates (µg/l)	1.37 (0.06)	1.27 (0.04)	1.21 (0.05)	1.28 (0.05)	1.32 (0.05)	1.49 (0.04)	7.08 (0.12)	11.06 (0.34)
Dissolved Oxygen (mg/l)	6.50 (0.02)	6.29 (0.02)	6.24 (0.02)	6.34 (0.03)	6.19 (0.02)	5.32 (0.02)	6.02 (0.04)	6.19 (0.04)
Temperature (^{0}C)	28.02 (0.06)	28.17 (0.06)	28.55 (0.07)	28.38 (0.07)	27.76 (0.07)	30.12 (0.09)	29.58 (0.08)	30.08 (0.08)
Salinity (‰)	35.19 (0.06)	35.22 (0.06)	35.46 (0.07)	35.32 (0.08)	35.48 (0.06)	37.46 (0.16)	33.21 (0.17)	29.85 (0.23)
Depth (m)	8.67 (0.08)	8.05 (0.08)	3.76 (0.02)	1.61 (0.01)	1.96 (0.02)	1.37 (0.02)	3.87 (0.03)	2.22 (0.03)
Secchi (m)	2.92 (0.03)	2.55 (0.03)	1.57 (0.02)	1.21 (0.01)	0.95 (0.01)	0.43 (0.01)	0.92 (0.01)	0.62 (0.01)
Fish (mean no. collected)	34 (1.59)	32 (1.36)	12 (0.56)	52 (2.14)	41 (1.44)	18 (0.8)	8 (0.36)	26 (0.9)

* Legend: SH- Sea Horse, NK- Nkoma, MZ- Mazioni, FU- Fumbini, KD- Kidundu, KM- Kombeni, KN- Konjora, RA- Rare

Sea Horse and Nkoma. The analysis of finfish species also showed that these sites were utilized by coral reef species. The site at Kidundu had a large area with a mudflat without seaweeds while the sites at Fumbini, Kombeni, Mazioni, Rare and Konjora grouped together because they were generally shallow with slightly varying physico-chemical parameters between the sites. The sites at Sea Horse and Nkoma had very high finfish diversities followed by Kidundu, though the most utilized areas based on the average number of individuals recorded were Fumbini and Kidundu (Table 1.3). The sites at Sea Horse and Nkoma that were situated at the entry point into the mangrove area of the creek also had some of the highest abundances of fish.

Discussion

Vance *et al.* (2002), reported that the distribution of *Penaeus merguiensis* is affected by mangrove type, water depth and topography/water currents. Of the two prawn species identified and collected from mangrove areas within Kilifi creek, high abundances of *P. indicus* were recorded at sites at Kidundu, Rare and Mazioni while the site at Kombeni had the highest number of *P. monodon*. The Portunid crabs recorded were both absent from Konjora, however, *Portunus pelagicus* was more abundant at Mazioni, Kidundu and Fumbini. These study sites were adjacent to both mangrove and sandy areas and did not show a distinct pattern with crustacean distribution. The shell fishes contributed to the fishery activity of Kilifi Creek both as a source of food and economic activity for fisher communities at the creek (Kyomo 1999).

The structure of an estuarine fish community depends on both biotic and abiotic factors such as salinity, temperature, turbidity and dissolved oxygen which varies between sites. Previous studies on other estuarine communities include Vidthayanon & Premcharoen (2002) with 199 finfish families in Thailand; Loneragan *et al.* (1986) with 24 families in Australia; Lin & Shao (1999) with 14 families in Taiwan; Mbande *et al.* (2005) with 31 families at Mngazana and 24 families at Mngazi estuary; Kimani *et al.* (1996) with 50 families at Gazi. The diversity of species recorded in this study included 38 families and 63 species and compares favourably with the previous studies. Whitfield (1994) observed that tropical and sub-tropical estuaries have higher species diversity than temperate ecosystems due to richer ichthyofauna associated with rivers and marine habitats on the Western Indian Ocean.

This study concurs with observations of Loneragan *et al.* (1986) that finfish species diversity correlates with distance from the estuary mouth. For example, the mean number of species was significantly higher at Sea Horse, Nkoma, Fumbini and Kidundu that were situated closer to the mouth of the Kilifi creek and lower at the remaining sites that were deeper in the creek. The main marine immigrants into the creek included *Leiognathus equula*, the *Mugilidae mugil-cephalus* and *Valamugil buchnani*, and *Gerres filamentosus* which were also recorded by Whitfield (2005).

Ohowa (1996) reported that a mean phosphate concentration of 0.55 µg P/L limits phytoplankton growth. The mean phosphate values at all sites within Kilifi were higher than this level as well as phosphate concentrations reported for Vipingo and Nyali (Uku & Bjork 2001) which is not surprising since these are shallow lagoon reef sites. This indicates that phosphate concentrations are unlikely to be limiting phytoplankton growth in the Kilifi creek. The mean nitrate concentrations were highest at Rare where it could be attributed to decomposing organic matter from the freshwater Rare stream. Uku & Bjork (2001) report higher nitrate concentrations than at the Kilifi study sites and it not clear why this would be the case. Among other parameters that may have been affecting fish fauna in Kilifi, dissolved oxygen, temperature and salinity had the least variations and concurred with observations of McClanahan (1988). It was also observed that the areas most utilized by fish were Fumbini and Kidundu followed by Sea Horse and Nkoma that were near the mouth of the creek. The least utilized areas were Mazioni and Konjora, Rare that had the lowest salinity while Kombeni was hypersaline. This confirms finding from Ter Morshuizen *et al.* (1996) in the Great Fish River that showed that finfish spatial distribution was related to salinity changes.

A combination of various parameters influenced fish distribution within the study sites but the most outstanding physico-chemical factors were secchi transparency and depth at the sites at Sea Horse and Nkoma. The concentration of phosphates was the outstanding factor at the sites at Rare, Kombeni and Mazioni and to a small extent at Sea Horse and Nkoma. The concentration of nitrates was the outstanding factor at the Rare site, while dissolved oxygen, temperature and salinity were more or less uniform at all sites. These physico-chemical parameters were optimum at Fumbini and Kidundu sites where fish mean number were the highest observed but variations at the Konjora site in these physico-cheminal factors contributed to low numbers of finfish observed.

The diversity indices in aquatic ecosystems are controlled by a combination of history, biotic and abiotic factors but abiotic factors are the stronger influence on biodiversity (Therriault & Kolasa 1999). From this study, it can be observed clearly that the species number decreased significantly from the lagoon at Bahari ya Wali, towards the fresh water end as observed by Loneragan *et al.* (1986). This suggests that the species composition of the study area shows a spatial distribution from the creek mouth to the freshwater end since fish species of Konjora, Rare and Kombeni were distinctly different from those at Fumbini, Kidundu, Mazioni, Sea Horse and Nkoma (all within the lagoon). It also shows the use of various biotopes within the study site and that most members are marine immigrants visiting the area specifically to feed. Further research to study feeding habits of each species needs to be carried out to discern the importance of each study site for fisheries management.

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Summary

Ecological variation along the Kenyan coast influences fisheries composition. Kilifi Creek is a unique ecosystem along this coast because it is an open lagoon. A study of the fisheries fauna of Kilifi Creek was conducted between October 2002 and September 2004 at eight sites situated from the mouth to deeper waters within the creek. Monthly sampling for diversity and distribution revealed four crustacean and 63 finfish species. The crustaceans included two prawn species (*Penaeus indicus*, *P. monodon*) and two crab species (*Portunus pelagicus*, *Scylla serrata*). Crabs were absent from the Konjora site while prawns were absent from the deep sites within the creek. Fish in the order Perciformes dominated the catch at all the sites consisting of 74-95% of the catch. The fishery species landings were higher during the north-east monsoon (October-March) compared to the south-east monsoon (April-September) but Margalef's species richness index (p=0.88), Shannon-Weiner (p=0.6), Pielou's evenness (p=0.05), and Simpson's index (p=0.5) were not significantly different between seasons. Monthly measurements of

physico-chemical parameters also revealed that there were significant differences in the phosphate concentration (p=0.0) and temperature (p=0.0) between the north-east and south-east monsoon season but not in other physico-chemical parameters. The finfish composition differed at the different sites and a principal component analysis indicated that water transparency and depth were the main determinants of finfish distribution.