Assessment of mangrove status and fish community in Pangani estuary

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Abstract

A study was conducted in Pangani mangrove forest aimed at assessing mangrove vegetation structure, regeneration capacity and associated fish community. A total of 753 ha of mangrove area were assessed. A 100 m² plots and sub plots of 25m² were established for assessing mangrove regeneration capacity. Fish community assessment was conducted along the estuary starting at 1000 m from river mouth towards upstream. Fishing was done adjacent to the area where transects for mangrove study were established. A monofilament gillnets and seine net with a dimension of 50 m length and 1.5 m width and a mesh size of 2.5 inches were used. Pangani mangrove forest is composed by eight species dominated by Avicenia marina in terms of relative density (29%), relative frequency (29%) and importance value (0.69). Avicenia marina, Rhizophora mucronata and Ceriops tagal had the highest regeneration capacity for juveniles class one (JCI), two (JCII) and three (JCIII) respectively both in terms of dominance and coverage. The highest DBH, height and basal area were shown by Lumnizera racemosa (49.89±89 cm), Rhizophora mucronata (11.99±1.28) and Lumnizera racemosa (0.25±0.11 m2) respectively. Seventeen fish species from fifteen families were recorded during this study. Predominant fish families in terms of number were Clupeidae (62%) followed by Mugilidae (13%) and Hemiramphidae (9%). The highest and least contributions in terms of weight were Clupeidae (68%) and Engraulidae (0.19%) respectively. This study indicated that predominant mangrove species have also high regeneration capacity. Furthermore, length frequency distributions of the predominant fish species confirm breeding and nursery role played by mangrove forest. It is therefore recommended that management of Pangani mangrove forest should be strengthened to enhance fisheries production.

Key words: *Mangrove forest, fisheries, regeneration capacity, climate change*

Introduction

Mangroves have both ecological and socio-economic importance so as to sustain daily life of human being and other terrestrial and aquatic organisms (Bosire *et al*., 2008). Mangrove forests also have greater roles to play against climate change. Carbon from the atmosphere is sequestered and stored in mangroves with high possibility to reduce greenhouse gasses (Donato *et al*., 2011). The mangrove–derived detritus make formation and export of dissolved organic matter to the ocean. This makes the mangrove areas rich in many species of living organisms (Rönnbäck, 1999). Most of the finfish use mangrove areas as nursery areas for their fry and fingerlings due to high level of protection against predators, strong wave actions and exposure to temperature and light (Kathiresan and Bingham, 2001: Kathy, 2008). Interaction of various species of aquatic organisms with the mangroves make potential interconnected ecosystem for fishery (Kathiresan *et al*., 2001: Ellison, 2007; Kimirei, 2012). However, almost all the services offered by mangroves are largely depending on the forest community structure and regeneration capacity. The mangrove status in Tanzania has been given by Semesi (1996) and Wang *et al*. (2003) without looking on the importance value index and regeneration capacity.

Studies related to the services offered by mangroves along the Tanzanian coast have been focused on management (Semesi *et al*., 1998); re-mineralization of organic carbon (Machiwa, 1998); its role on harboring juvenile fishes (Lugendo, 2007; Mwandya, 2009); and connectivity to other marine ecosystems (Kimirei, 2012). The role of mangroves in supporting fisheries production can be assessed by looking on the fish community structure within the forest. This can be determined by using length data and density. Length data are commonly used to construct length frequency distribution which can be used to estimate growth rates, age structure and other aspects of fish population dynamics including recruitment. Therefore, analysis on length frequency distribution is one of the mostly commonly used tools for fisheries assessment. It also applied to assess the health and integrity of the ecosystem. The present study aimed at assessing the status of Pangani mangrove by looking on the mangrove vegetation structure and regeneration capacity. Also, it aimed at assessing fish community using relative abundance and length frequency distribution of the predominant fish species.

Materials and Methods

Study area

This study was done at Pangani district in Tanga region along Pangani estuary. The estuary runs for about 35 km inland from the Indian Ocean, with brackish waters extending for over 10 km from the beach head. Pangani estuary represents the terminal end of Pangani River which originated around highlands of Kilimanjaro Mountain. Pangani, Tanga and Muheza comprise the Northern zone of the Mangrove Management Project (MMP). Pangani mangrove forest is located within Pangani district and covers an area of about 988 ha (Semesi, 1996).

Sampling and Data collection

Mangrove vegetation structure

A belt transact line was established perpendicular to the shoreline. The distance between transects was established by considering the nature of the forest including zonation of mangrove species. The length of transect depended on the shore topography. Along transects a plot of 10 m x 10 m was established. Within each plot, mangrove trees were identified and counted. Mangrove species were identified using Richmond (2002) keys guide. The following mangrove vegetation parameters were established:

- DBH = Diameter at breast height
- Basal area (m^2) of each species = 0.005 x DBH
- Relative density = no. of individuals of a species / total no. of individuals of all species x100.
- Relative dominance = total basal area of a species / basal area of all species x 100

Regeneration capacity

To determine regeneration capacity of mangroves seedlings and saplings, within 10 m x 10 m plot a sub-plot of 5 m x 5 m was made. In each sub-plot occurrence of seedlings and saplings of different species was recorded and grouped according to their height classes. Seedlings less that 40 cm in height was classified as juvenile class one (JCI), saplings between 41 and 150 cm height were classified as juvenile class two (JCII, while juvenile class three (JCIII) was for all small trees with heights greater than 151 cm but less than 300 cm (Kairo *et al*., 2002).

Fish community associated with mangrove forest

Fish community was studied adjacent to transects used to study the mangrove community structures. A monofilament gill net of the dimension of 50 m length and 1.5m width with mesh size 2.5 inches was used. The net was set at 1800 hours and retrieved 0600 hours, and stayed overnight. Also, the seine net of the same dimension was used for fish sampling. Fish caught were identified, counted, measured and weighed. Lengths were measured using ruler to the nearest millimeters. Identification of fish species was carried out using FAO marine fish identification keys (Bianchi, 1995).

Results

Mangrove vegetation structure Structural attributes of mangrove forest in Pangani is given in Table 1. The highest and lowest DBH of mangroves was shown by *Lumnitzera racemosa* (49.89±21.48 cm) and *Brugiera gymnorrhiza* (10.89±1.31 cm) respectively. The highest and lowest height was shown by *Rhizophora mucronata* (11.99±1.28 m) and *Ceriops tagal* (4.15±0.23 m) respectively. The biggest and smallest basal area was shown by *Lumnitzera racemosa* (0.25±0.11 m^2) and *Brugiera gymnorrhiza* (0.05±0.01 m^2) respectively

. **Table 1. Structural attributes of mangrove forest in Pangani**

Species	DBH (cm)	Mean height (m)	Basal area (m²)
Avicennia marina	19.01±2.59	8.41±0.99	0.10±0.01
Brugiera gymnorrhiza	10.89±1.31	4.27±0.35	0.05±0.01
Ceriops tagal	12.35±1.42	4.15±0.23	0.06±0.01
Heritiera littorina	22.61±9.79	8.89±2.52	0.11±0.05
Lumnitzera racemosa	49.89±21.48	2.97±0.29	0.25±0.11
Rhizophora mucronata	19.43±1.90	11.99±1.28	0.10±0.01
Sonneratia alba	22.29±4.99	5.79±0.72	0.11±0.02
Xylocarpus granatum	19.39±2.01	5.34±0.81	0.10±0.01

Table 2. Importance values (I.V) of mangrove species in Pangani mangrove forest

Species	Relative Values (%)			Importance Values (I.V)
	Density	Dominance	Frequency	
Avicennia marina	29.35	10.81	29.03	69.19
Brugiera gymnorrhiza	10.87	6.19	16.13	33.19
Ceriops tagal	19.57	7.02	22.58	49.17
Heritiera littorina	5.43	12.86	3.23	21.52
Lumnitzera racemosa	3.26	28.37	6.45	38.08
Rhizophora mucronata	16.30	11.05	6.45	33.80
Sonneratia alba	6.52	12.68	6.45	25.65
Xylocarpus granatum	8.70	11.02	9.68	29.40

Relative density, dominance and frequency of mangroves species in Pangani is given in Table 2. Pangani mangrove forest is composed of eight species predominated by *Avicennia marina* (29.35%) followed by *Ceriops tagal* (19.57%) and *Rhizophora mucronata* (16.30%). In terms of relative frequency the leading species are *Avicennia marina* (29.03%), *Ceriops tagal* (16.13%) and *Brugiera gymnorrhiza* (16.13%). *Avicennia marina* had the highest importance value (69.19) followed by *Ceriops tagal* (49.17) and *Lumnitzera racemosa* (38.08) (Table 2). Importance value index indicates the structural importance of a species within a stand of mixed species.

Regeneration capacity

Percentage dominance of mangrove juvenile classes indicating regeneration capacity in

Pangani is given in Table 3. Mangrove juveniles class one (JCI) was dominated by *Avicennia marina* (91.41%) followed by *Ceriops tagal* (3.44%) and *Rhizophora mucronata* (2.92%). Class two (JCII) was dominated by *R. mucronata* (34.62%) followed by *C. tagal* (28.85%) and *A. marina* (17.31%). The highest and least dominance for juvenile class three (JCIII) were *C. tagal* (47.92%) and *Brugiera gymnorrhiza* (2.08%) respectively. Coverage of mangrove juvenile classes is given in Table 4. Mangrove juvenile class one (JCI) was dominated by *A. marina* (688.31ha) followed by *C. tagal* (25.88 ha) and *R. mucronata* (21.99 ha). Juvenile class II was dominated by *R. mucronata* (260 ha) followed by *C. tagal* (217.21 ha) and *A. marina* (130.33 ha) and juvenile class III was dominated by *C. tagal* (360.81 ha) followed by *A. marina* (141.19 ha) and *X. granattum* (94.13 ha).

Table 3. Percentage dominance of mangrove juveniles classes (CI, CII and CIII)

Species name	JCI (< 40 cm)	JCII (41 -150 cm)	JCIII (151 -300 cm)
Avicennia marina	91.41	17.31	18.75
Brugiera gymnorrhiza	0.17	-	2.08
Ceriops tagal	3.44	28.85	47.92
Heritiera littorina	-	-	-
Lumnitzera racemosa	0.69	11.54	8.33
Rhizophora mucronata	2.92	34.62	10.42
Sonneratia alba	-	1.92	-
Xylocarpus granatum	1.37	5.77	12.50

Table 4 Coverage (ha) of mangrove juvenile classes (JCI, JCII and JCIII)

Species name	JC I (< 40 cm)	JCII (41 -150 cm)	JCIII (151 -300 cm)
Avicennia marina	688.31	130.33	141.19
Brugiera gymnorrhiza	1.29	-	15.69
Ceriops tagal	25.88	217.21	360.81
Heritiera littorina	-	-	-
Lumnitzera racemosa	5.18	86.88	62.75
Rhizophora mucronata	21.99	260.65	78.44
Sonneratia alba	-	14.48	-
Xylocarpus granatum	10.35	43.44	94.13

Fish community

Fish species composition and their size range from Pangani mangroves are given in Table 5. A total of 447 individual species and seventeen fish species from fifteen families were recorded from Pangani estuary. Most of these fish species were juveniles. Predominant fish families in terms of number were Clupeidae (62%) followed by Mugilidae (13%) and Hemiramphidae (9%). The highest and least contributions of fish species in terms of weight were Clupeidae (68%) and Engraulidae (0.19%) respectively. Other families with individuals less than five were Ephippidae, Gerreidae, Lutjanidae, Serranidae, Scorpaenidae and Lethrinidae.

Size structure of three predominant fish species in Pangani estuary

Length frequency distributions of three predominant families are given in Figure 1. *Hilsa kelee* (Clupeidae) and *Hyporhumphus* *dussumieri* (Hemiramphidae) showed a single mode indicating a modal class of 130-149 mm and 140-150 mm respectively. *Valamugil buchanani* (Mugilidae) showed two humps with modal classes of 70-80 and 160-180 mm.

Discussion

Avicennia marina, *Ceriops tagal* and *Rhizophora mucronata* are more abundant compared to other species due to ecological characteristics that favours good condition for thriving. Pangani estuary has large area covered with compact sandy flats and newly deposited sediments from the river. The estuary has fully discharged fresh water that combine with seawater during high tides and causing the deposition of sediments throughout the mangrove areas. The contribution of freshwater flow into marine ecosystems particularly on mangroves and its associated fisheries has been reviewed by (2011). According to Sotthewas (2008) Pangani estuary has salinity levels and varied tidal inundation which also provide good environmental condition for mangrove growth. According to Semesi *et al*. (1998) *Avecinnia marina* and *Rhizophora mucronata* contributed more than 70% of the mangrove area in Bagamoyo, Tanzania. It has been reported that *Rhizophora mucronata* and *Ceriops tagal* dominate the higher intertidal areas corresponding with the upper topographical limit of the area flooded during neap tide periods (Dahdouh-Guebas *et al*., 2002).

Mangrove forests have an efficient mechanism for natural regeneration, particularly in areas within mangrove stands where site degradation has not taken place. According to Wang *et al*. (2003) disturbance of Pangani mangrove forest have been reduced for the past ten years from 1990s to 2000s.

Table 5 Fish species composition in Pangani estuary

Family	Species name	Percentage occurrence		Size range	
		Number	Weight (g)	Total length (mm)	Body weight (g)
Ariidae	*Arius madagascariensis*	2.00	7.73	180.0-295.0	113.7-365.0
Carangidae	*Carangoides caeruleopinnatus*	2.00	1.57	67.0-210.0	5.0-221.3
Clupeidae	*Hilsa kelee*	62.00	68.00	119.0-150.0	35.0-65.0
Engraulidae	*Stolephorus heterolobus*	1.12	0.19	60.0-110.0	5.0-11.0
Haemulidae	*Pomadasys commersonni*	2.26	1.76	50.0-188.0	2.6-90.0
Hemiramphidae	*Hyporhamphus dussumieri*	9.00	1.39	15.9-170.0	5.0-10.5
Mugulidae	*Valamugil buchanani*	13.00	3.64	40.0-187.0	1.1-93.6
Mullidae	*Upeneus tragula*	2.24	0.55	70.0-98.0	5.0-15.6
Sciaenidae	*Johnieops sina*	2.46	1.77	80.0-100.0	5.0-100.0
Others (6)		3.90	13.39	32.0-298.0	2.5-815.0

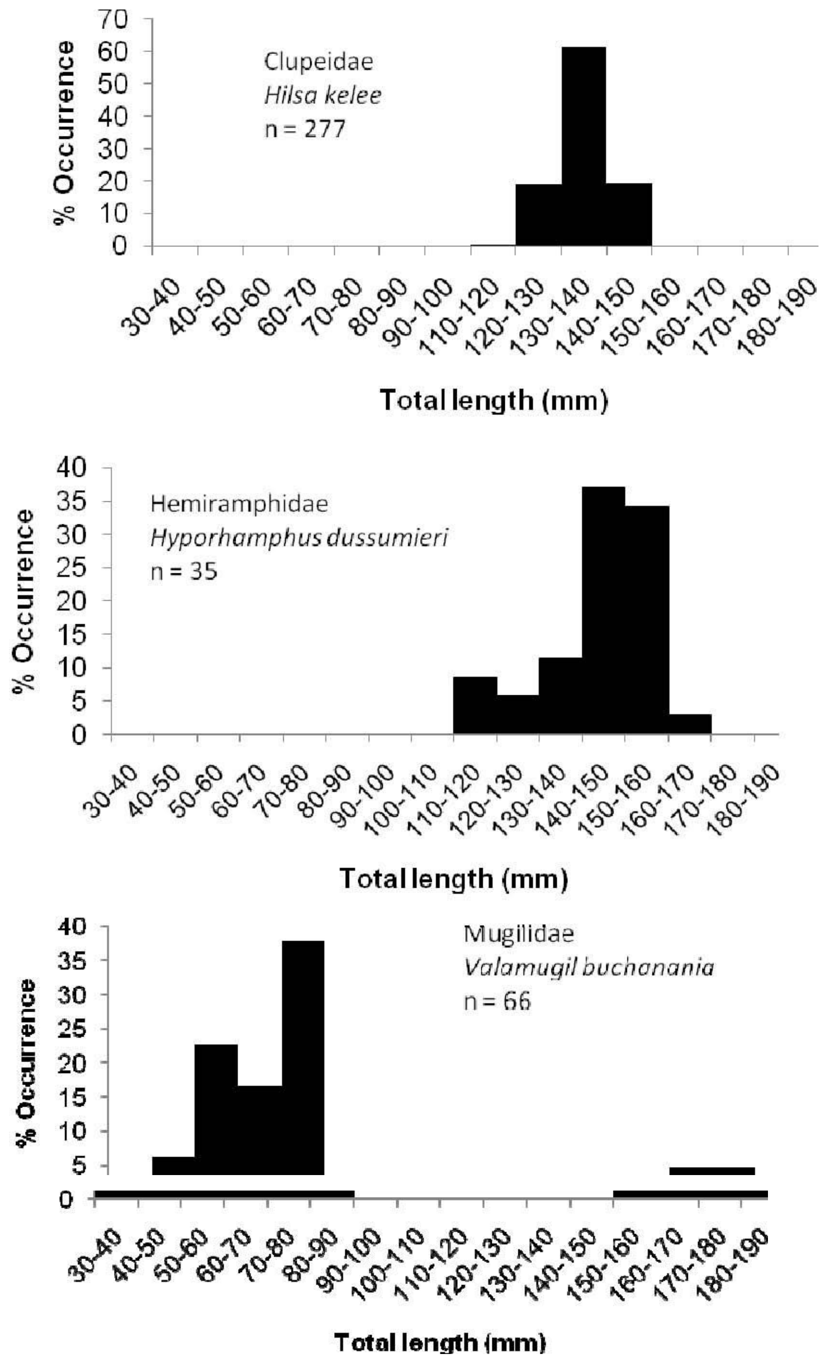

Figure 1. Length frequency distributions of *Hilsa kelee*, *Hyporhumphus dussumieri* and *Valamugil buchanania*

Highest regeneration capacities were high generation capacity in Kenya for *R.* shown by *A. marina*, *R. mucronata* and *C. mucronata*, *A. marina* and *Ceriops tagal tagal* for CI, CII and CIII respectively. which concur with the present study. No Probably this has been attributed to the regeneration capacity shown by *H.* daily or periodic inundation by tidal water *littoralis* for all classes of mangrove as well as the deposition of water-borne juveniles. Probably differences in soil particles. Kairo *et al*. (2002) reported a regeneration capacity among the mangrove species might be attributed to species-specific reproductive modes or adaptation, direct human impact and climate change

The seeds of *Rhizophora mucronata*, *Ceriops tagal Bruguiera gymnorrhiza* and *Avicennia marina* develop into seedlings while they are still attached to the mother tree a phenomenon known as vivipary (Osborne, 2000); the fertilized seeds germinate whilst still attached to the parent plant. When the young plant falls off it spears the sediment and rapidly produces roots with sufficient growth just after two days to ensure seedling establishment (Osborne, 2000) and increase its chances of surviving. *Sonneratia alba, Heritiera littorina* and *Xylocarpus granatum* are not viviparous (Nybakken, 2004). Although *B. gymnorhiza* is viviparous, in the present study it shows low dominance percentage and coverage; probably this is due to human impact. The direct anthropogenic impact on mangrove forests includes; conversion to aquaculture, conversion to agriculture, overharvesting for timber, un-sustainable fishing other extractive uses, conversion to development, tourism and coastal infrastructure and pollution. It has been noted that *Sonneratia alba* has been harvested for making boat while *R. mucronata*, *C. tagal*, and *B. gymnorrhiza* are used for house building and almost all trees are used for making charcoal (Semesi *et al*., 1998).

Climate change has begun to compound the effects of many of these threats. The climatic factor which has been considered as the greatest challenges that will affect mangrove ecosystem is sea level rise. Mangrove may adapt to changes in sea level by growing upward or seaward. Mangroves have adapted special aerial roots, and buttresses to live in muddy, shifting and saline conditions. Therefore, they can expand their range despite sea level rise if the rate of sediment accretion is sufficient to keep up with sea level rise (McLead and Salm, 2006; Gilman, 2008).
It has been observed due sea level rise, salt intrusion is apparent upstream of the Pangani River (Sotthewes, 2008) hence probably this will lead into expansion of mangroves landward and alter the zonation pattern. Degradation and loss of mangrove ecosystem due to direct human and climate change impact may negate services it provides during extreme events and reduce its adaptive capacity with significant environmental social and economic consequences for coastal communities. Mangrove status including community structures and regeneration capacity strongly influences the community structure and abundance of fish within the forest and adjacent ecosystems including seagrass and coral reefs.

Almost all fish species recorded from the Pangani mangrove forest in this study are juveniles. It seems that these fish species utilize mangrove areas as nursery and feeding grounds due to the good conditions including less predation and availability of food. The fish families recorded for example Clupeidae, Carangidae and Hemiramphidae are of commercial fishery importance. The findings from this study concur with the findings reported by Lugendo (2007) in Chwaka bay Zanzibar. The similarities confirm the importance of mangrove ecosystem as the nursery ground for the commercially important fish species. Studies conducted along the Tanzanian coast showed that mangroves habour high density of juvenile within the mangrove ecosystem (Lugendo, 2007; Mwandya, 2009) for example Mugilidae and provide an intermediate nursery stage between mangroves and seagrass beds (Lugendo, 2007) for example Lethrinidae and between mangroves and reefs (Kimirei, 2012) for example Lutjanidae. Furthermore, the role of mangrove as nursery was confirmed by using length frequency distributions of the three predominant species. These species are neither reached first maturity stage nor common or maximum size. The size at first maturity for *Hilsa kelee* ranged from 14-15 cm while for *Valamugil buchanani* and *Hyporhamphus dussumieri* reach first maturity at 36 cm and 24.5 cm respectively. According to Bianchi (1985) the common and maximum sizes of *Hilsa kelee*, *Valamugil buchanani* and *Hyporhamphus dussumieri* are 20 cm and 25 m, 35 and 48 cm; and 19 and 30 cm respectively.

It can be concluded that predominant mangrove species also have high generation capacity. Fish community in the mangrove forest was dominated by juveniles indicating the big role played by this ecosystem as nursery. It is therefore recommended that management of mangrove forests should be strengthening so as to maintain its functions.

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