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Establishment of a Monitoring Program

Rapid Assessment of the Macrofauna of the Primeiras and Segundas Archipelago's Mangrove Forests and Sea Grasses

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Maputo, 2007

Acknowledgements:

We wish to thank the WWF of Mozambique, whose financial support made this research possible.

Special thanks to Messrs Sabino and Sharamadan for their kind and tireless support, from the assessment phase and throughout the fieldwork.

Thanks to Mr. Faustino and the Angoche Artisenal Fishermen's Association for their availability and support throughout the team's stay in Nampula province. Thanks to Mr. Lauchan for his availability.

To the Secretary of the Island of Sajá, we extend our thanks for his hospitality and assistance.

To the people of Mombassa, many thanks for the welcome you extended us and for the headquarters you provided.

We extend our thanks as well to all who contributed, directly and indirectly, to the success of this assessment.

* Cover photography, showing one of the canals between the Islands in front of the city of Angoche, by Daniela C. de Abreu,

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Executive Summary

This report presents conclusions drawn from the rapid assessment of Angoche's (Angoche District) and Mocoroje's (Moma District) mangrove forests and seagrass beds, in the Province of Nampula.

The study was conducted in November, 2006 and locally assisted by the Angoche Artisenal Fishermen's Association in Nampula. The study's objective is to describe the fauna (macrofauna) of the aforementioned habitats, thereby providing a preliminary characterization of region's proposed conservation area.

In Angoche, the assessment was conducted on the Islands of Mombassa and Sajá which face the city of Angoche; in Moma, the assessment was carried out in Mocoroje, at the estuary of the Ligonha River.

Forty-five species of benthic fauna were observed in the mangrove forests that were visited, with crustaceans being the group of organisms with the most frequently-recorded species. The Mombassa mangrove forest is known to have a large number of species of epibenthic fauna with 33, while that of Sajá is habitat to 25 species and 18 in the Mocoroje forest. The abundance of species in these three mangrove forests, however, can be regarded as moderate when compared to that reported in the Island of Inhaca, in the province of Maputo.

Fiddler crabs (*Uca annulipes)* are common to mangrove forests and are of great ecological importance. These crabs were present throughout the area we visited in considerably dense populations (from 22 to 39 specimens/m^2) relative to the numbers indicated in the literature for other regions in Mozambique and neighboring countries. Given the fiddler crab's diversity and substantial ecological importance thanks to its role in the ecosystem, the species may be considered a candidate for future monitoring.

Escaramujos (the popular name for mollusks of the *Littoraria* genus) are organisms found in mangroves and much appreciated as a food source by the people of the three mangrove forest areas that were visited. Considerably dense populations of these mollusks are found and do not exhibit signs of suffering pressure from exploration in any of the mangrove areas. They are, however, a food source for the population and an example of organisms that depend directly upon mangrove trees at risk of being felled. Monitoring of escaramujos is therefore recommended, and would

provide yet another indicator of the state of mangrove forest conservation.

As regards the fauna that visit the mangrove areas at high tide, only two species – one shrimp and the other fish – were observed in the Sajá and Mocoroje mangrove forests. These species presented low levels of density and biomass, possibly attributable to the consequences of exploration which these forests clearly evince, such as the clearing of mangrove trees in coastal areas now left open and exposed.

An analysis of the team's data pertaining to fisheries resources is crucial to better understand the phenomenon of visiting fauna, especially as regards those organisms found in the mangrove areas of these zones. Seasonal monitoring (a sampling during the dry season and another during the rainy season) of the visiting fauna, especially the shrimp, in these mangrove forests would be the ideal method of ascertaining the state of conservation of this fauna and their contiguous habitats, such as seagrass beds.

In all, six (considered a moderate number) seagrass species were observed in the areas visited. The principal species encountered in Mombassa and Sajá were the *Zostera capensis*, *Cymodocea serrulata* and *Halodule uninervis*. In Mombassa, the *Halophila ovalis* species was also found; and, Sajá we observed the *Syringodium isoetifolium* and *Halodule wrightii* species, all found in the seagrass beds in the country's southern region. Though considered moderate in number, these seagrass species account for 55% of the total number found in Mozambique and 46% of the number of species that occur in the East Africa region.

Although both areas present what can be considered a reasonable degree of seagrass cover, acute evidence of exploration was observed in both grass banks; indeed, large open areas, created by fishing gear (such as trawl nets) were found in the region.

A total of twenty-seven species of benthic fauna were observed in the seagrass beds, the greatest number of these being crustacean varieties. Local fishermen reported that many species are currently exceedingly difficult to catch as they are becoming ever smaller. These same fishermen attribute this phenomenon to the consequences of trawling, a claim the plausibility of which is easily confirmed upon examining the banks.

Though the degree of seagrass cover would appear reasonable, inspection of these banks' state of conservation evinces signs of over-exploration. We therefore recommend annual monitoring of the cover and specific seagrass diversity (yet another indicator), along with the faunal diversity of these banks in order to assess the state of conservation of the seagrass beds.

In Mocoroje, at the estuary of the Ligonha River, a mussel bank of the *Arcuatula capensis* species was identified with a high, 96.3% cover in an area of 400m2. This is another species exploited by the local population, who begin to gather mussels at the bank in December. Despite the bank's favorable state of conservation and high percentage of mollusk cover, we suggest that their numbers be monitored.

Crucial to measures designed to mitigate the effects of the local population's clearing mangroves for diverse purposes is financial and technical assistance to the Angoche Artisenal Fishermen's Association project/initiative, consisting in the replacing/recovering of mangrove forests. We furthermore suggest that support be given to expand initiatives to other mangrove areas in districts such as Moma. The promotion of tourism in the mangrove forests is recommended. Hiking activities and guided tours to appreciate the marvelous local flora and fauna could be yet another source of earnings for the local community and a means of alleviating pressures caused by over-exploration of these resources.

For the state of seagrass beds to improve, we would recommend efforts to raise the awareness of the local population concerning the importance of these seagrass beds, along with measures to encourage trawl fishermen to avoid these beds. Indeed, it is crucial that local fishermen be encouraged to employ non-destructive gear such as longlines when fishing in the seagrass beds.

1. Introduction

This report presents the conclusions of the rapid assessment of the mangrove forests and seagrass beds in Angoche (Angoche district) and Mocoroje (Moma district), in Nampula Province. The study was conducted in November of 2006 with the local support of the Angoche Artisenal Fishermen's Association of Nampula to describe the fauna (macrofauna) of the aforementioned habitats, rendering possible a preliminary characterization of a conservation area in the region.

Mozambique has Eastern Africa's second greatest mangrove area (400,000 hectares) and, according to Saket and Matusse (1994), Nampula, with approximately 54,300 hectares, ranks third among the country's provinces in mangrove cover.

Given human subsistence needs, the mangrove forests are showing signs of loss and damage from demographic expansion along the coastal zone. The use of mangroves as a traditional source for firewood and building materials accounts for the greatest deforestation to date in Mozambique. Without question, any pressure upon mangrove resources will affect other coastal ecosystems, particularly given the interrelationships of these resources (Macia, 2004). The seagrass beds stand out as an important element of these coastal ecosystems.

Seagrass beds, with their miry or arenaceous substratum, are a common habitat of East Africa's intertidal zone. Besides protecting the coast from erosion by allowing the sedimentation of particles, the beds are home to a number of species, some occurring in highly elevated densities albeit having undergone over-exploration in recent times. Populations along the coast that depend upon fishing and gathering invertebrate species for their daily food consumption have, in some instances, accelerated the degradation of species habitats through the use of destructive fishing techniques and aggressive invertebrate-gathering methods (Bandeira, 1995).

As seagrasses form the food chain of many coastal marine ecosystems, their loss would certainly provoke deleterious consequences for marine mammals such as dugongs that rely upon these ecosystems (Kuo *et al*., 1996). Such a situation calls for additional information relative to seagrass ecology, especially that based upon studies and research carried out in developing regions (Kuo *et al*.,

1996) where information is scarce and the local populations rely directly upon the exploration of these resources for their subsistence.

Exploration of these fragile ecosystems engenders grave consequences and gives rise to the need for establishing management plans designed to assuage this destruction of mangrove forests (Saket e Matusse, 1994) and seagrass beds (Kuo *et al*., 1996).

The present assessment is of the utmost importance in terms of information relative to the macrofauna of this region's mangrove forests and seagrass beds. The meager bibliography concerning these resources renders their description difficult, together with a steps towards the establishment of a data base to be later used for comparative purposes.

2. Methodology

Survey Area

The present assessment was conducted between November 1 and 10, 2006, in the districts of Angoche and Moma, and in the south and southwest of the city of Nampula, in Nampula Province. The Angoche study was conducted on the islands of Sajá (16° 16' 367 S/ 39° 48' 978 E) and Mombassa (16° 12' 853 S/ 39° 52' 675 E), situated directly across from the city. In Moma, the study was carried out in Mucoroge, at the estuary of the Ligonha River (the frontier that separates the provinces of Nampula and Zambézia), with coordinates 16° 53' 131 S/ 39° 08' 345 E (Figure 1).

The samplings at the various habitats occur during low tide along the live tide.

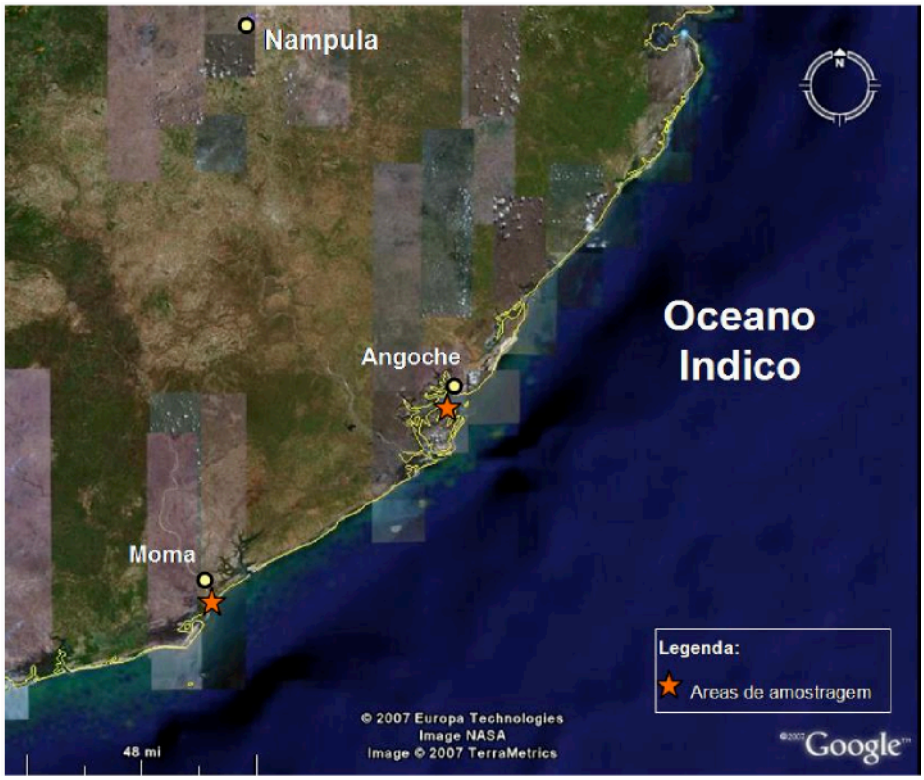

Figure 1. Map illustrating the districts of Angoche and Moma in Nampula Province, and the areas of the present rapid assessment's samplings (Adapted from Google Earth, 2007).

Mangrove Forest

Epibenthic Macrofauna

Epibenthic macrofauna assessment was conducted during low tide, with a recording of all species of organisms observed along a transect in the three mangrove species associations found on the islands of Mombassa and Sajá (Angoche) and the two associations in Mocoroje (Moma). Unidentified organisms were gathered into flasks and preserved in a 5% formalin solution for later identification in the laboratory.

Six rectangles of 0.25 m^2 were randomly made at the upper portion of the mangrove forest - characterized by the presence exclusively of *Avicennia marina* in each area visited – to estimate the density of the fiddler crab, or *Uca annulipes* species, which abounds in this area of the mangrove forest.

In order to compare data obtained from each area visited within the mangrove forest, an ANOVA unifactorial (α= 95%) statistical test was conducted after having tested normality and homogeneity assumptions for variation within the data set.

Endobenthic Macrofauna

Five sediment samples were gathered with a tube of standard mobile substrata to a depth of 30 centimeters for each of the mangrove species associations in each area. The sediment was graded through a 1 mm mesh screen. The organisms retained in the screen were transferred to flasks and preserved in a 5% formalin solution and later identified in the laboratory.

Gastropods: Littorinidae

Two transects were made in each mangrove area. Littorinidae species were gathered from trees within a 10 m^2 area by three people for a period of five minutes in each of the mangrove tree species associations identified. The organisms were placed in flasks and preserved in a 5% formalin solution and later counted and identified in a laboratory. Only one transect was made in Mucoroge (Moma) given the conditions present at the sampling site, the Ligonha River estuary, marked by an extensive network of canals which, when the tide would rise rapidly, left many areas isolated and inaccessible.

Visiting Fauna

Four stationary 9 m^2 nets were randomly placed at the *Sonneratia alba* / *Avicennia marina* association in the Sajá (Angoche) Island and Mocoroje (Moma) mangrove forests. All of the captured animals were placed in flasks and preserved in 5% formalin and later counted and identified in the laboratory.

Seagrass Beds

Four or five 50-meter transects were done at low tide in the Mombassa and Sajá (Angoche) Islands seagrass beds. Along each transect were placed five 0.25 m^2 squares to ascertain the seagrass cover and five 1 m^2 to assess epibenthic macrofauna species. As only epibenthic macrofauna species were observed outside the transects, a list was made of species observed outside of the squares, together with those observed by local fishermen who operate in these very seagrass beds.

Conditions in these beds (extremely miry areas that impede mobility and tide cycles that force work to be done at an extremely accelerated pace) do not allow for the creation of additional transects, thereby limiting data acquisition.

In Mocoroje (Moma), no seagrass-bed assessment was conducted given its restricted accessibility and the fact that the district lies within the province of Zambézia, where the team lacked the necessary credentials that would officially justify their presence and work. However, a mussel bank (*Arcuatula capensis*) was observed at the Ligonha River estuary, where a small survey was conducted. Ten 0.25 m_2 squares were placed in two 400 m^2 areas to ascertain the mussel species cover. Biomass data were not gathered as such exercise would require removal of specimens from the area.

Assessment of arenaceous areas was not carried out given constraints of climate, tide and the location of these areas relative to the remaining habitats that were surveyed.

Constraints

Conditions in the sampling terrain and areas are difficult. Both the mangrove forest and seagrass-bed areas are extraordinarily miry, to the point of impeding mobility. Furthermore, the tides cycle is very rapid, forcing work to be carried out at a considerably accelerated pace.

3. Conclusions and Discussion

Mangrove Forests

In the Mombassa and Sajá Islands' mangrove forests of Angoche, three species associations of mangroves were found and sampling areas were therefore classified. The *Sonneratia alba / Avicennia marina* association was the most prevalent at the mangrove area closest to the water-line, at the forest's lower zone. After this association, the *Rhizophora mucronata / Ceriops tagal / Avicennia marina* (intermediary zone) was the most commonly encountered. At the mangrove forest's upper zone, adjacent to the terrestrial vegetation, only the *Avicennia marina* species was observed.

In Mocoroje, Moma, only two associations were observed: *Sonneratia alba / Avicennia marina* and *Rhizophora mucronata / Bruguiera gymnorhiza / Avicennia marina*. The *Bruguiera gymnorhiza* species substituted *Ceriops tagal* in the latter instance. Specimens of the *Lumnitzera racemosa* and *Xylocarpus granatum* species were also identified at the Sajá mangrove forest.

Epibenthic Macrofauna

Thirty-three macro-epibenthic species were identified in the mangrove forest of Mombassa Island, 25 in Sajá and only one group of 18 species in Mocoroje. Between the Mombasa and Sajá mangrove forests (but two of the large group of islands across from the city of Angoche), a total of 40 macro-epibenthic species was observed.

According to Macia (unpublished data), 45 marcro-epibenthic species occur in the Nacala Bay (Nampula Province) mangrove forest, only five species more than the total observed in the current survey for the Mombassa and Sajá Islands forests. One more observed species could have been included from additional visits and surveys in the sampling areas, though such was not possible given logistical and time constraints.

Guerreiro *et al* (1996), in a study of the macrofauna of Inhaca Island's (Maputo Province) mangrove sediment, identified among other groups of organisms 34 epibenthic macrofauna species for the Saco da Inhaca mangrove area, considered by the author as one of high-diversity, and 13 in the Ponta Rasa mangrove forest.

Despite the considerable geographic variation between Inhaca Island in the south of the country and the current research area, this data allow us a notion of the true meaning behind the total number of species found in both mangrove forests under consideration for this rapid assessment. We can, then, conclude that in terms of macro-epifauna, the Mombassa mangrove forest is highly diverse, whereas those of Sajá and Mocoroje are only moderately so. However, as it has been impossible to find any prior information relative to macro-epibenthos in these mangrove forests, any temporal comparison describing the current state of these areas is untenable.

Tables 1 and 2 provide lists of the species assessed at the Mombassa and Sajá Islands mangrove forests in keeping with predominant associations of mangrove-tree species; and, in Table 3, one finds assessed species found in the Mocoroje mangrove forest, in Moma, according to the two species associations of predominant mangrove trees.

In the Mombassa Island mangrove forest, outside of the referenced transect, we encountered the following species of crustaceans: *Dotilla fenestrata, Neosarmantium smithii, Portunus pelagicus* and *Thalamita crenata*.

Table 1. Species assessed in the three associations of mangrove species on Mombassa Island, in Angoche

Association	Taxon (Class, Species)
S. alba /A. marina	Crustacea
	Macrophthalmus boscii
	Macrophthalmus depressus
	Neosarmatium meinerti
	Pagrus hirtimanus
	Perisesarma guttatum
	Pseudograpsus elongatus
	Uca dussumieri
	Uca inversa
	Uca annulipes
	Uca urvillei
	Uca vocans
	Callianassa krausssi
	Alpheus obesumanus
	Balanus amphitrite
	Balanus trigonus
	Chirona sp.
	Chthamalus dentatus
	Tetraclita squamosa rofufincta

	Bivalvia	
		Saccostrea cucculata
		Isognomon sp.
	Gastropoda	
		Cerithidea decollata
		Littoraria pallescensis
		Littoraria scabra
		Littoraria subvitata
	Desmospongiae	
		Biemna fortis
		Lissodendoryx sp.
R. mucronata/C. tagal/A. marina	Crustacea	
		Uca inversa
		Uca annulipes
		Uca tetragonon
	Gastropoda	
		Cerithidea decollata
		Littoraria pallescensis
		Littoraria scabra
		Littoraria subvitata
A. marina	Crustacea	
		Metopograpsus thukuhar
		Neosarmatium meinerti
		Perisesarma guttatum
		Uca chlorophthalmus
		Uca dussumieri
		Uca in versa
		Uca annulipes
		Uca vocans
	Gastropoda	
		Cerithidea decollata
		Littoraria pallescensis
		Littoraria scabra
		Littoraria subvitata

Table 2. Assessed macrofauna species in three mangrove species associations on Sajá Island, Angoche

Association	**Taxon (Class, Family*, Species)**
S. alba /A. marina	Crustacea
	Nanosesarma minutum
	Neosarmatium meinerti
	Neosarmatium smithii
	Ocypode ceratophthalmus
	Perisesarma guttatum
	Scylla serrata

		Sesarma leptosoma *Uca annulipes* *Uca dussumieri* *Uca inversa* *Uca tetragonon* *Uca urvillei* *Uca vocans var. excisa* *Clibanarius longitarsus* *Callianassa sp.* *Balanus amphitrite* *Chirona sp.* *Tetraclita squamosa rofufincta*
	Gastropoda	*Littoraria pallescensis* *Littoraria scabra* *Littoraria subvitata*
	Desmospongiae	*Hymeniacedon pervelis*
R. mucronata/C. tagal/A. marina	Crustacea	*Perisesarma guttatum* *Sesarma leptosoma*
	Gastropoda	*Cerithidea decollata* *Littoraria pallescensis* *Littoraria scabra* *Littoraria subvitata*
	Gobiidae*	*Periophthalmus sobrinus*
A. marina	Crustacea	*Uca annulipes* *Metopograpsus thukuhar*
	Gastropoda	*Cerithidea decollata* *Littoraria pallescensis* *Littoraria scabra* *Littoraria subvitata*

Table 3. Macrofauna species assessed in two mangrove species associations in Mocoroje (Moma)

Association	**Taxon (Class, Species)**	
S. alba/A. marina	Crustacea	
	Perisesarma guttatum	

		Scylla serrata *Sesarna leptosoma* *Uca chlorophtalmus* *Uca dussumieri* *Uca inversa inversa* *Uca lactea annulipes* *Uca urvillei* *Uca vocans var excisa* *Alpheus sp.* *Balanus amphitrite* *Chirona sp.nov.*
	Gobiidae	*Periophthalmus sobrinus*
	Gastropoda	*Littoraria pallescensis* *Littoraria scabra* *Littoraria subvitata*
R. mucronata/B. gymnorhiza/ A. marina	Crustacea	*Perisesarma guttatum* *Sesarma leptosoma* *Uca urvillei*
	Gastropoda	*Cerithidea decollata* *Littoraria pallescensis* *Littoraria scabra* *Littoraria subvitata*

On the islands of Mombassa and Sajá and in Mocoroje, crustaceans correspond to 78%, 76% and 72% of identified species, respectively.

As in the present survey, of the 45 species observed by Macia (unpublished data), more than half are crustaceans. Along the same lines, Akil and Jiddawi (1999), in their observations of the flora and fauna of the Jozani-Pete (Zanzibar, Tanzania) mangrove forest, found crustaceans presenting the greatest number of species for the macro-epibenthos group considered in this study.

In the case of the three areas visited, the crustaceans were, then, the group having the greatest number of reported species. Additionally, these species were more often encountered in the *Sonneratia alba / Avicennia marina* association found in the mangrove swamp zone near the water line.

The distribution of species is correspondingly related to location of mangrove species; additionally, both are influenced by environmental factors such as water level, temperature, sedimentation, tide levels, salinity and geology (Guerreiro *et al*, 1996; Macnae and Kalk, 1962). As the present study has the character of a rapid assessment, environmental parameters were not analyzed, thereby making it impossible to establish relationships between these parameters and species distribution according to the various mangrove associations. The presence of a greater number of crustaceous species in the *S. alba / A. marina* association is certainly related to environmental factors that favor their occurrence. Or, given the fact that the crabs are the most visible and ubiquitous of the mangrove forest's macrofauna (Hartnoll *et al*, 2002), they naturally correspond to the majority of observed crustaceous species groups.

Curiously, it is at the upper limit of the *S. alba / A. marina* association (in the case of Mombassa and Sajá Islands mangrove forests) that one finds evidence of human exploration; that is, clear signs of the felling of various mangrove species for purposes, according to the residents of both islands, of firewood extraction. Trees are also cut for construction material and domestic utensils production. The local population is conscious of the exploration to which they subject these areas, but see no alternative means of obtaining firewood. The mangrove forest visited in Mocoroje likewise presents signs of ever-intensifying exploration, especially in the mangrove banks closest to the river estuary.

Strömberg *et al* (1998), finding no variance in the number of crabs in deforested and intact mangrove forests, suggest this phenomenon reflects the extraordinary mobility of these particular organisms, together with their remarkable ability to find food far from their holes. In the present study, therefore, the fact that the greatest number of crustacean species (mostly species of crabs) was observed in areas showing evidence of high levels of human exploration does not necessarily mean that such exploration has negligible impact on the species diversity of this area, but rather that these species, given their remarkable mobility, have an equally-remarkable capacity of surviving under these conditions.

In the Mombassa and Sajá Islands mangrove forests we observed a considerable number of sponges of the *S. alba/ A. marina* association (Figure 2 e 3).

Figure 2. Two sponge species that grow atop pneumatophores of the Mombassa Island mangrove forest in Angoche (Photograph: Daniela C. de Abreu)

Figure 3. One of the sponge species that grows atop pneumatophores of the Mombassa Island mangrove forest in Angoche (Photograph by Daniela C. de Abreu)

We believe that this great number of sponges could owe itself to the naturals limits of distribution, occurring in the country's northern but not southern mangrove swamps; or, the reason may be the absence of a predator or species that would otherwise control the number of sponges in the region. On the other hand, this abundance could be the consequence of abiotic phenomena that favor the proliferation of sponges.

Fiddler crabs (*Uca)* are characteristic of mangroves, where they can occur in high densities (Skov *et al*, 2002). The *Uca annulipes* species is amply distributed throughout the Southern Hemisphere and is typically a predominant species within mangrove forests (Macia *et al*, 2001). As seen with the naked eye, these crabs tend to trundle the soil and find nourishment in its organic particles (Hartnoll *et al*, 2002). These actions alter the sediment's topography and the composition of its microflora in addition to promoting the system's bioturbation (Litulo, 2005; Skov *et al*, 2002), thus the species' ecological value is considerable. (Figure 4)

Figure 4. *Uca annulipes* species in the *Avicenia marina* zone of Sajá Island's mangrove forest, in Angoche (Photograph by Daniela C. de Abreu)

Table 4 presents the densities of *Uca annulipes* in the three mangrove forests that were visited. The Mombassa mangrove forests evince the lowest density of *U. annulipes*, though there are no significant statistical differences in the density of this species among the three areas (F= 1.97, p= 0.17).

Table 4. Average density and respective standard deviation of the *Uca annulipes* species inn the mangrove forests of the Mombassa and Saja Islands in Angoche and Mucoroje in Moma

Locale	Density (nº spec/ m^2)	SD (±)
Mombassa	22,00	19,39
Sajá	39,33	18,49
Mucoroje	36,67	8,91

The three mangrove areas present relatively lower densities of *U. annulipes* than those observed by Macia (unpublished data) in the Nancala Bay mangrove forest (44 ind/m^2), but superior to those observed by Hartnoll *et al* (2002) in the Saco mangrove forest of Maputo's Inhaca Island (16.28 ind/m^2), in Umtata (7.56 ind/m^2) in South Africa, in Zanzibar (19.68 ind/m^2) in Tanzania and in Mombassa (12.86 ind/m^2), in Kenya. After considering these density values for other areas and countries as referenced in the literature, we can regard the *U. annulipes* density in the areas of the present study as elevated.

As this group of organisms is of extraordinary ecological importance owing to its role in the ecosystem, it could be considered an indicator for future monitoring efforts. The method of counting the specimens is a simple one and the survey can be conducted by WWF inspectors after training in species identification and in the method itself.

Endobenthic Macrofauna

Species belonging to two taxons were identified in the visited mangrove forests: the Poliqueta and Sipunculida. The average density of endobenthic macrofauna in the Mombassa, Sajá and Mocoroje mangrove forests was 266.7 spec/m^2, 43.1 spec/m^2 and 27.5 spec/m^2, respectively. With the exception of the Mombassa forest, the other areas presented a lower density of bristleworms (polychaeta) that that reported by Ferreira (2005): 161.8 spec/m^2 for the Saco da Inhaca mangrove forest,170.6 spec/m^2 for the Ponta Rasa forest on Ilha da Inhaca, Maputo and 105.9 spec/m^2 for the Costa do Sol mangrove forest in Maputo's Costa do Sol neighborhood.

The Nereididae was the only family encountered in all of the mangrove associations observed in Mombassa, where the highest densities (611.8 spec/m^2) were recorded in the *Avicennia marina* zone (Figure 5).

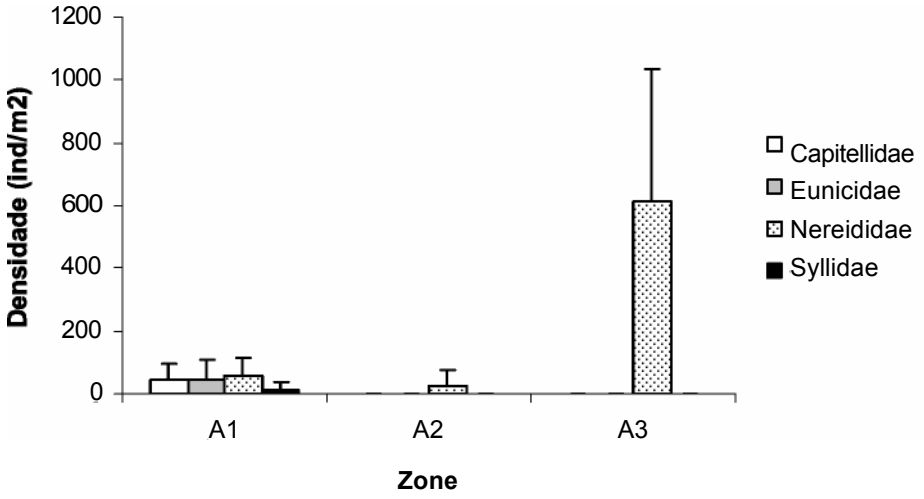

Figure 5. Average density and standard deviation of macrofauna families gathered in the Mombassa Island mangrove forest (A1- *A. marina* / S. alba; A2 – *R. mucronata / C. tagal / A. marina*; A3 – *A. marina*)

No specimens were found in the *Avicennia marina* zone on Sajá Island but, again, the Nereididae was the family with the greatest recorded density for both the *A. marina / S. alba* and *R. mucronata / C. tagal / A. marina* associations, with the latter presenting the highest organism density (47.1 spec/m^2) for this family (Figure 6).

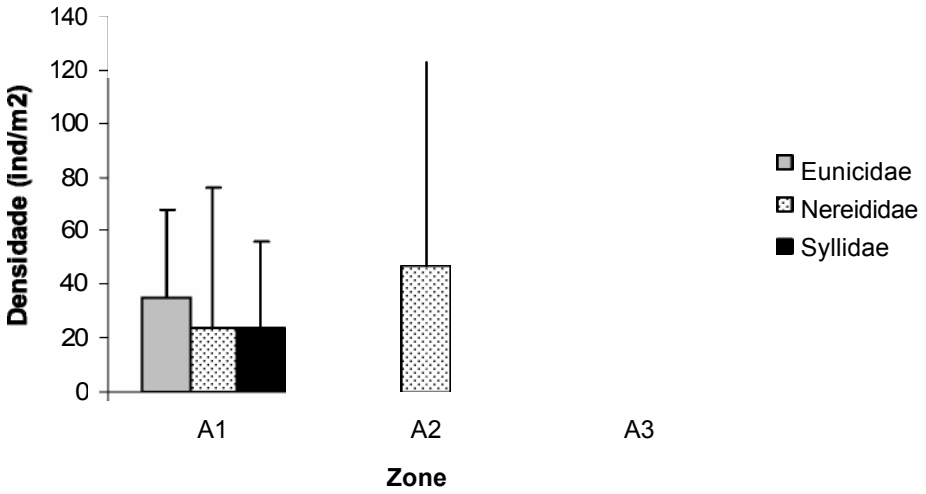

Figure 6. Average density and respective standard deviation of macrofauna families gathered on Sajá Island (A1- *A. marina* / S. alba; A2 – *R. mucronata / C. tagal / A. marina*)

In the Mocoroje mangrove forest, only Sipuncolidae were collected in the two types of mangrove association, with *R. mucronata / B. gymnorhiza /A. marina* presenting the highest density of 58.8 spec/m^2 (Figure 7).

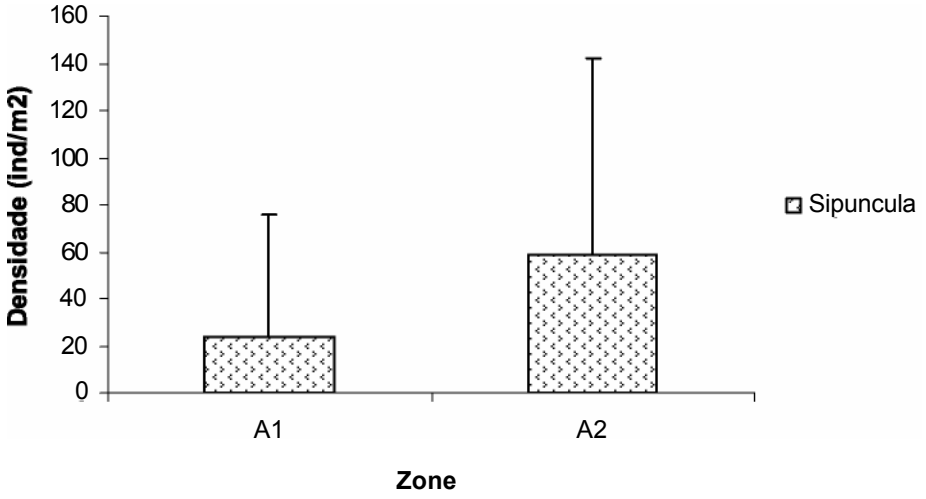

Figure 7. Average density and respective standard deviation of macrofauna families collected in Mocoroje (A1 - *S. alba / A.marina*; A2 - *R. mucronata / B. gymnorhiza / A.marina*)

As the principal prey along many food chains, polychaeta and sipunculidae comprise the chief food source of many fish and gastropod species (Richmond, 2002) and are extremely important to the mangrove ecosystem. The varying presence of these species in the different associations of the three mangrove forests that were visited might owe itself to the variety of environmental (soil moisture, size of sediment particles, salinity, etc.) and biological factors that govern the establishment of these communities (Ferreira, 2005, Guerreiro *et al*, 1996).

Strömberg *et al* (1998) observed significant differences in organism density between the community of endomacrobenthos of one explored mangrove area under pressure of deforestation and another intact mangrove forest, the latter presenting evidence of 20 to 40 times more organisms than the explored area. Therefore, the lesser density of endobenthic organisms observed in the *S. alba / A. Marina* association may be the consequence of human exploration, especially the felling of mangroves in this zone (at least in the case of the Mombassa and Sajá Islands mangrove forests).

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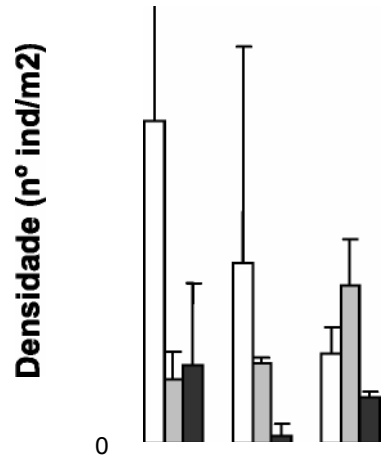


As indicated in Table 5, Sajá presents a greater specific composition (S=0.27) than the other areas and likewise of Shannon - Winner diversity (H'=0.99). Mombasa Island presents the lowest specific composition (S=0.06). Only one species was observed in the Mocoroje mangrove forest, which therefore presented negligible diversity. The equitability index indicates that the number of each species observed in Sajá are equitably represented in relation to Mombassa.

Table 5. Number of specimens collected in the study areas, specific composition (S), Shannon - Winner diversity index(H') and equitability index (E)

Local	N° of specimens	S	H'	E
Mombassa	68	0,06	0,46	0,33
Sajá	11	0,27	0,99	0,90
Mucoroje	7	0,14	0	0,00

The specific composition and diversity index numbers are considerably low; lower, in fact, than the values reported in Ferreira's study (2005) of the Costa do Sol mangrove forest in Maputo, now polluted by urban effluents. Again, such variations can be explained by the natural phenomena of latitudinal species distribution, environmental/biological conditions for their establishment, intensive preditoriness, or even disturbances arising from exploration of the habitat. It is therefore necessary to keep in mind that the sampling for the present rapid assessment may not be representative of the entire area of the three mangrove forests surveyed.

Gastropods: Littorinidae

Figure 8 shows that the three species of *Littoraria* in the three mangrove forests that were visited present considerably high densities, with *Littoraria scabra* indicating the highest densities in all three forests. Of the three zones that were studied, A1, that of the *A. marina* / S. Alba association, presents the highest density of this particular species.

Lit. scabra
Lit. pallescensis Lit. subvitata

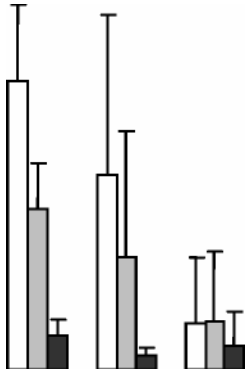
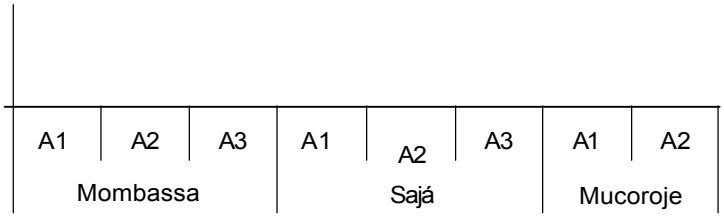


Figure 8. Average density and respective standard deviation of the three species of the *Littoraria* genus, observed in the Mombassa and Sajá Islands mangrove forests, in Angoche. Mocoroje (Moma) numbers correspond to absolute values; (A1- *A. marina* / S. alba; A2 – *R. mucronata / C. tagal / A. marina*; A3 – *A. marina;* in Mocoroje the association A2 is: *R. mucronata / B. gymnorhiza / A. marina)*



These organisms are much appreciated and consumed by the local population of the three mangrove areas that were visited. They occur in considerable densities and evince no signs of over-exploration, particularly given that the low density of *Littoraria subvitata* relative to other *Littoraria* species is a natural phenomenon and that the local people do not discriminate among the various species they gather. However, as we are dealing with a group of organisms that is directly consumed by the population, a monitoring of their numbers would be advised, particularly given these organisms'' dependence on mangroves and the risk they face from deforestation. Additional in-depth studies, therefore, would be needed to measure the impact of the local population on these organisms.

As this group of organisms is an indicator, future monitoring, given the simplicity of the counting method (see methodology chapter), can be conducted by WWF inspectors after training as to method and species identification. It is suggested that monitoring initially be conducted twice a year (once in the rainy again in the dry season) to verify the existence of seasonality in the occurrence of the various species. Should seasonality not be confirmed, monitoring can be conducted during either season.

Visiting Fauna

In all, only two species were observed in the Sajá and Mocoroje mangrove forests: the *Fanneropenaeus indicus* (prawn) and *Ambassis natalensis* (fish) (Figure 9). These species evince low biomass and density levels (Table 6) compared to the figures observed for these same species in the mangrove forests of Saco on Inhaca Island and Machangulo (Maputo province), where Cassamo (2005) relates for *F. indicus* a biomass of 0.35 g/m^2 and 0.69 spec/m^2 density in Saco, and a 10.36 g/m^2 biomass and 9.11 spec/m^2 density figure for the Machangulo and Inácio mangrove forests (2002). The same study reports, in the case of *A. natalensis* a density of 44.8 ind/m^2 and biomass of approximately 71.4 g/m^2 for Saco da Inhaca.

Table 6. Biomass and visiting fauna density of the Sajá and Mocoroje mangroves

Area	Species	Biomass (gr/m^2)	Density (n.º of spec./m^2)
Sajá	*Fanneropenaeus indicus*	0.77	0.03

	Fanneropenaeus indicus	0.02	0.06
Mocoroje	*Ambassis natalensis*	0.03	0.11

Figure 8. *Ambassis natalensis* specimens collected in the Mocoroje mangrove forest in Moma (photograph by Daniela C. de Abreu).

As visiting fauna seek out the mangrove forest for two principal reasons – food and protection from predators – we can understand the low density of organisms given the positioning of nets in more open, exposed and easily-accessible areas that these visiting fauna would avoid.

To better understand patterns of possible visiting fauna, we suggest an analysis of the research team's conclusions regarding mangrove forests. A seasonal monitoring - a sampling during the dry season and another during the rainy season – of the visiting fauna of these mangrove forests, especially prawns, is suggested to achieve a clear view of the state of conservation of these forests and their contiguous habitats, such as seagrass beds. This monitoring can follow the method employed in the present survey, with the work developed by the region's WWF inspectors, as much in the area of field work as later species identification.

Seagrass Beds

The seagrass beds assessed on Sajá Island presented a cover area slightly greater than the beds on Mombassa Island (Figure 9). Although both areas present what may be considered a reasonable percentage of cover, in both seagrass beds it was possible to observe dramatic evidence of exploration, usually in the form of large areas stripped open by fishing gear, such as trawls.

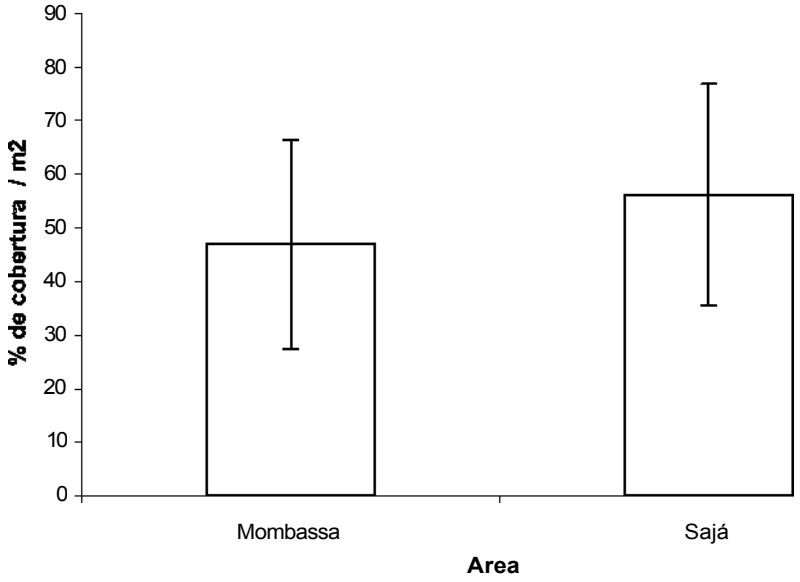


Figure 9. Cover-area average per square meter (and its standard deviation) of sea grass in the Mombassa and Sajá Islands beds.

In all, six seagrass species – considered a moderate number - were observed in the areas visited. Burbridge *et* al (1992) noted the same number of species on the seagrass banks of the Nancala Peninsula. Bandeira (2002), however, recorded a greater number on Inhaca Island (nine species, which the author considers moderately high) as did Hatton and Massinga (1994) and Bandeira and Carvalho (1996) in Mecúfi, where they recorded 10 species. The six species, then, correspond to 55% of 11, the number found throughout the country (Bandeira e Carvalho, 1996) and 46% of the number (13) of species occurring in Eastern Africa (Gullström *et al*, 2002).

The principal species of seagrass observed on both islands were *Zostera capensis*, *Cymodocea serrulata* and *Halodule uninervis*. In Mombassa, the *Halophila ovalis* species was also encountered and, in Sajá, the *Syringodium isoetifolium* and *Halodule wrightii* species were observed, though outside of the sampling area. All of these species can be found in the seagrass banks in the south of the country (Bandeira, 2002).

Figure 10 shows the percentage cover of each seagrass species on both islands. *Zostera capensis* is the species demonstrating the greatest percentage of cover for both areas.

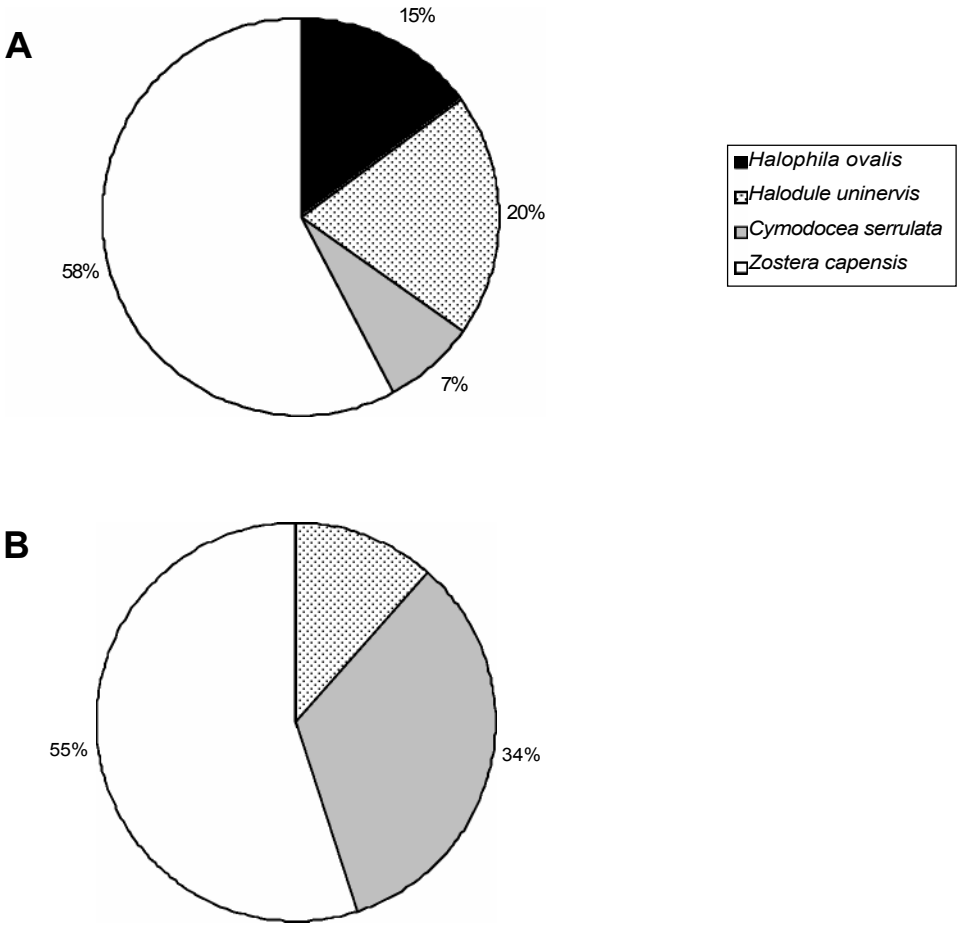


Figure 10. Percentage of cover per square meter for the various seagrass species of the Mombassa (A) and Sajá (B) Islands beds

The species of epibenthic macrofauna on the Mombasa and Sajá Islands seagrass beds are listed, respectively, in Tables 7 and 8. Twenty species were observed on Mombassa and 15 on Sajá, with crustaceans representing the largest species group for both islands. The Sajá Island seagrass bed evinced greater evidence of over-exploration than that of Mombassa, with consequently a relatively higher number of species.

Table 7. Species of epibenthic macrofauna observed in the Mombassa Island seagrass bed

Class	Species
Crustacea	*Elamena sindensis*
	Matuta lunaris
	Portunus sp.
	Scylla serrata
	Thalamita crenata
	Thalamita sp.
	Dardanus megistos
	Penaeus semisulcatus
	Panulirus homarus
B ivalvia	*T ellina alfredensis*
Gastropoda	*Cypraea maginalus*
	Murex pecten
	Polinices mammilla
	Volema pyrum
	Dolabella auricularia
	Stylocheilus longicauda
Demospongiae	a confoederata
	Callyspongi
	Xestospongia exigua
	Unidentified species
A nthozoa	*T halassianthus sp.*

Table 8. Species of epibenthic macrofauna observed in the Sajá Island seagrass

bed

Class	Species
Crustacea	*Ghonodactylus falcatus*
	Elamena sindensis
	Matuta lunaris
	Thalamita sp.
	Scylla serrata
	Metopograpsus thukuhar
	Dardanus megistos
	Metapenaeus stebbingii
	Pterygosquilla sp.
	Thenus orientalis
Gastropoda	*Cypraea marginalis*
	Murex pecten
	Polinices mammila
	Volema pyrum
Demospong iae	*Callyspongia con foederata*

None of the species listed in Tables 8 and 9 was observed within the sampling squares, although some were encountered during walks along the banks and in the nets of local fishermen. Some of the fishermen pointed out that these species, ever smaller in size, are increasingly difficult to come across because of trawl fishing in the banks. After observing the state of these seagrass banks, one finds this explanation entirely plausible.

Although the percentages of seagrass cover presented appear reasonable, a more in-depth study is advisable given the impediments to mobility in the banks and the possibility of therefore underestimating this cover area to the few areas where sampling could be carried out with relative ease. On the basis of what could be observed of the terrain, the sate of conservation of the seagrass banks bore clear signs of over-exploration.

We recommend yearly monitoring of the cover and specific diversity of the seagrass and faunal diversity of these banks, following, whenever possible, the sampling design presented in this report's sampling design. Technical support would have to be extended

to the WWF inspectors, at least during one of the beginning phases of this effort.

Monitoring of the mangrove forest's visiting fauna would likewise serve to assess the state of the seagrass beds, as various species, both of fish and prawns, migrate from these beds to "visit" the mangrove forest during high tide. The conclusions of this monitoring of the forest's visiting fauna would, in the long run, indirectly reflect the state/condition of the seagrass beds.

We would further suggest that WWF establish communication with SeagrassNet, the organization that conducts monitoring of the seagrass beds around the world, including very recently Mozambique's Inhaca Island. Indeed, the inclusion of the area of the Primeiras and Segundas in this global seagrass-bed monitoring effort would represent another step towards the creation of the proposed Conservation Area.

In Mocoroje, in the mussel bank of the Ligonha River estuary, *Arcuatula capensis* (Figure 11) presented a cover percentage of 96.3% in a 400m^2 area. The mussel species, once they reach lengths of 5 cm in December, are collected at the banks by the local people. (Figure 12).

Despite the bank's favorable state, the high percentage of mussel cover and the population's care in gathering the mussels only in December, a monitoring of this species' numbers is highly recommended. Because a biomass assessment would involve removal of specimens from their habitat, only the percentage of species cover should be determined.

The *Enteromorpha sp.*, a species of seaweed observed in this very bank, presented a cover percentage of 29.4% in an area of 400 m^2, and was furthermore found growing atop mussels and the *Macrophthalmus boscii* crab species at a density of 10.2 specimens per m^2.

Figure 11. The *Arcuatula capensis* species (photograph by Daniela C. de Abreu)

Figure 12. Mussel bank of the *Arcuatula capensis* species at the Ligonha River tributary in Mocoroje, Moma (photograph by Daniela C. de Abreu)

Recommendations

Presented here are proposals for activities to be developed, both to increase knowledge of the area's biodiversity in order to implement appropriate development strategies and to promote the conservation of the same.

Mangrove Areas

There is a need for an epibenthic macrofauna species assessment in areas outside of the population centers in order to obtain a real understanding of species diversity in habitats that have not undergone the ravages of over-exploration. We can, as such, achieve a solid grasp of the true state of conservation of the areas visited for purposes of this assessment.

Despite the high densities of the species of *Littoraria* in the mangrove forests that were visited, we suggest, as mentioned in the previous section, monitoring these species given their availability as a food source for the local people and their vulnerability to the felling of mangroves.

Monitoring of the numbers of the *Uca annulipes* species would, furthermore, be essential given the extraordinary importance of this species to its ecosystem.

We further recommend an assessment of the mangroves' visiting fauna, especially in those swamps and forests that are far removed from the population centers, in order to obtain data pertaining to species diversity. In addition, monitoring of the density and biomass of this visiting fauna (maintaining shrimp as the primary indicator) is suggested for the visited areas so as to ascertain their state of conservation and that of neighboring seagrass beds and mangrove swamps.

To mitigate the effects of mangrove deforestation, it is important that the Angoche Artisenal Fishermen's Association's project/initiative be financially supported in an effort to recover damaged mangrove forests and swamps. We furthermore suggest the extension of assistance to initiatives on behalf of other mangrove areas in the district, such as that of Moma District.

The promotion of tourism in the mangrove areas, such as guided boat tours through the canals at high tide (Figure 13) and hikes during the low tide, could prove to be an important alternative income source for the local community and, furthermore, may assuage the pressures of over-exploration upon these resources while contributing to the protection of the region's biodiversity. The guides for these tours should be members of the local community and rely upon the support of WWF inspectors. Distribution of the receipts generated by such activities must be openly discussed and agreed upon by the local people.

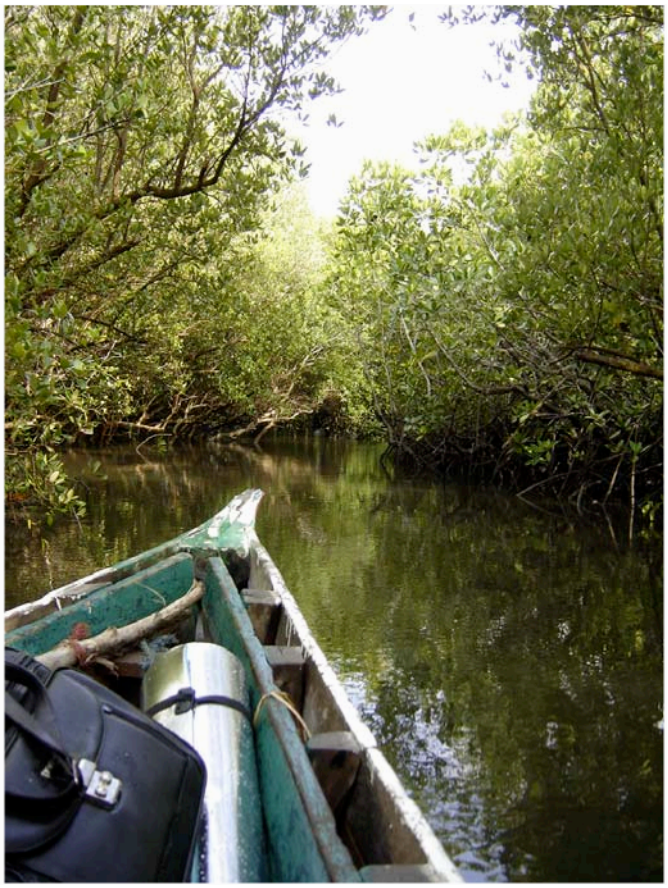


Figure 13. View of the canals among mangrove swamps between the Sajá and Mombassa Islands (photograph by Daniela C. de Abreu).

Seagrass Beds

Assessments of the state of conservation of other seagrass beds are recommended in order to better evaluate the degree of exploration that the beds in this area have undergone. On the basis of the team's observations in Angoche's Sangage zone, together with the presence of great quantities of seagrass residue on the beach (Figure 14), we can assume the existence of a vast seagrass area in this zone. Sangage, then, would be one of the areas suggested for conducting an assessment. Logistical setbacks rendered impossible a sampling of this area for purposes of this preliminary assessment.

Figure 14. Sangage beach, where it is possible to observe seagrass residue along the shore (photograph by Daniela C. de Abreu).

Annual monitoring of the visited seagrass beds (ascertaining cover, specific seagrass composition as well as associated epifauna) will be essential to determine evolution of the bed's conservation status. Equally important is basic research as to water circulation, currents and sedimentation in these areas to evaluate the influence of abiotic factors on these seagrass beds.

Measures designed to heighten the awareness of the local population as to the importance of preserving the seagrass beds, together with efforts that would discourage fishermen from trawling in these areas (perhaps employing longlines instead), are likewise recommended.

A partnership with SeagrassNet, which conducts seagrass-bed monitoring worldwide, including in Mozambique's Inhaca Island, is recommended. Including the Primeiras and Segundas area in this global effort would be an important step towards advancing the conservation proposal for the region.

Annual Monitoring the numbers of the *Ancuatula capensis* bank at the Rio Ligonha estuary in Mocoroje is essential as this species, much like the *Littoraria*, is greatly appreciated by the local population.

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APPENDECIS

Appendix A

Table of the general list of epibenthic macrofauna species observed in the mangrove forests of the visited areas.

Class/ *Family	Species
Crustacea	*Macrophthalmus boscii*
	Macrophthalmus depressus
	Thalamita crenata
	Ocypode ceratophthalmus
	Dotilla fenestrata
	Neosarmatium meinerti
	Neosarmatium smithii
	Nanosesarma minutum
	Perisesarma guttatum
	Metopograpsus thukuhar
	Sesarma leptosoma
	Pseudograpsus elongatus
	Scylla serrata
	Portunus pelagicus
	Clibanarius longitarsus
	Pagrus hirtimanus
	Uca dussumieri
	Uca inversa
	Uca annulipes
	Uca urvillei
	Uca vocans
	Uca vocans var. excisa
	Uca tetragonon
	Uca chlorophthalmus
	Callianassa krausssi
	Callianassa sp.
	Alpheus obesumanus
	Alpheus sp.
	Penaeus indicus
	Balanus amphitrite
	Balanus trigonus
	Chirona sp.
	Chthamalus dentatus
	Tetraclita squamosa rofufincta
Bivalvia	*Saccostrea cucculata*
	Isognomon sp.
Gastropoda	*Cerithide*
	adecollata Littora

ria pallescensis Litt oraria scabra
Litt oraria subvitata

Desmospongiae	*Biemna fortis*
	Lissodendoryx sp.
	Hymeniacedon pervelis
Gobiidae*	*Periophthalmus sobrinus*
Ambassidae*	*Ambassis natalensis*

Appendix B

Table of the general list of epibenthic macrofauna species observed in sea-grass beds in the areas visited and in Mocoroje's Mussel Bank

Class	Species
Crustacea	*Elamena sindensis*
	Matuta lunaris
	Macrophthalmus boscii
	Portunus sp.
	Scylla serrata
	Thalamita crenata
	Thalamita sp.
	Metopograpsus thukuhar
	Thenus orientalis
	Pterygosquilla sp.
	Ghonodactylus falcatus
	Dardanus megistos
	Metapenaeus stebbingii
	Penaeus semisulcatus
	Panulirus homarus
	Tellina alfredensis
Bivalvia	*Arcuatula capensis*
Gastropoda	*Cypraea marginalus*
	Murex pecten
	Polinices mammilla
	Volema pyrum
	Dolabella auricularia
	Stylocheilus longicauda
Demospongiae	*Callyspongia confoederata*
	Xestospongia exigua
	Unidentified species
Anthozoa	*Thalassianthus sp.*

Appendix C

Coordinates of Sample Areas

Mangrove Forest Area

Macrofauna and Littorinidae Sample:

Area	Mombassa	Sajá	Mocoroje
Lower	16 12.903S /39 2.754E	16 16.431S/39 49.202E	16 53.1 54S/39 08.362E
Middle	16 12.895S/39 52.725E	16 16.380S/39 49.227E	16 53. 245S/39 08.395E
		16 16.408S/39 49.068E	
Upper		16 16.401S/39 49.065E	-

Ucas count:

Mombassa	16 1 2.853S/39 52.675E
Sajá	16 16.367S/39 48.978E
Mucoroje	16 53.131S/39 08.345E

Visiting Fauna:

Net.	Mucoroje	Sajá
1	16 53.606S/39 08.497E	16 16.501S/39 48.839E
2	16 53.603S/39 08.497E	16 1 6.498S/38 48.845E
3	16 53.596S/39 08.497E	16 1 6.497S/39 45.864E
4	16 53.586S/39 08.498E	16 1 6.499S/39 48.845E

Area of Sea-Grass Tables

Cover:

Transect	Mombassa	Sajá
1	16 13.1 53S/39 52.378E	16 16.738S/39 48.642E
2	16 13.1 59S/39 52.379E	16 16.760S/39 48.655E
3	16 13.223S/39 52.314E	16 16.822S/39 48.617E
4	16 13.204S/39 52.279E	16 16.843S/39 48.597E
5	-	16 16.855S/39 48.580E

Arcuatula capensis bank in Mocoroje:

Area	
1	16 53.368S/39 08.303E
2	16 53.337S/39 08.295E