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Distribution of Seagrasses and Common Seaweeds Around Nampula Province (Northern Mozambique) with Emphasis on Moçambique Island

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***Abstract*—**The diversity and distribution of seagrasses and common seaweeds in Nampula province was studied. The field work took place between January and April 2002. 11 seagrasses and 53 common seaweed species were identified at Moçambique Island. From all studied sites, Fernão Veloso and Moçambique were the most diverse in seagrasses whereas Relanzapo and Ilha-dos-Sete-Paus in seaweeds. Seagrasses and seaweeds were mapped in Moçambique Island and grouped in nine community types namely: *Thalassia hemprichii/ Halodule wrightii, Thalassia hemprichii/* macroalgae, *Sargassum* spp. /*Cystoseira* spp, *Nanozostera capensis/ Cymodocea rotundata/ Halodule wrightii, Cymodocea rotundata, Thalassodendron ciliatum/* Macroalgae, *Thalassodendron ciliatum/Syringodium isoetifolium, Thalassodendron ciliatum,* and *Syringodium isoetifolium*. All the above communities covered up to 70% of the total intertidal area, with *Thalassia hemprichii*/macroalgae being the largest community in Moçambique Island. Common species such as *Thalassodendron ciliatum, Syringodium isoetifolium,* and *Sargassum* spp. occur mainly in sublittoral fringe; while *Thalassia hemprichii, Cystoseira myrica Laurencia papillosa* at midlittoral and *Enteromorpha* and some *Ulva* sp. close to the shoreline. The present study contributes to fill up the lack of information regarding the community ecology of seagrass and seaweed in the Nampula province.

INTRODUCTION

Seagrasses and seaweeds have long been recognized as important resources; specially in shallow waters as they provide habitat, food resources, fisheries, invertebrates as well as ecological functions (e.g. Green & Short, 2003). Most research in marine botany, in Mozambique has been carried in the southern part of the country, particularly in Maputo Bay (Bandeira and Björk, 2001, Critchley *et al*., 1997).

At present, there are studies being carried out in the Northern Mozambique region, particularly at Mecúfi and the Quirimbas archipelago (Bandeira & Antonio 1996, Bandeira *et al*., 2001, Carvalho & Bandeira 2003), focusing on seagrass and seaweed assemblages, mapping, microhabitat characterization and species value including subtidal macroalgae. It has however been difficult to extend research to the northern part of Mozambique due the difficulties of access to such remote areas. This is the first record on both seagrasses and seaweeds of Nampula province.

This study aimed to quantify and map seagrasses and seaweeds as well as to identify their zonation patterns, focus given to Moçambique Island, the former capital of Mozambique until XIX century and today a world heritage site (http://hrc.unesco.org; Van Berrs and Matshine, 1998).

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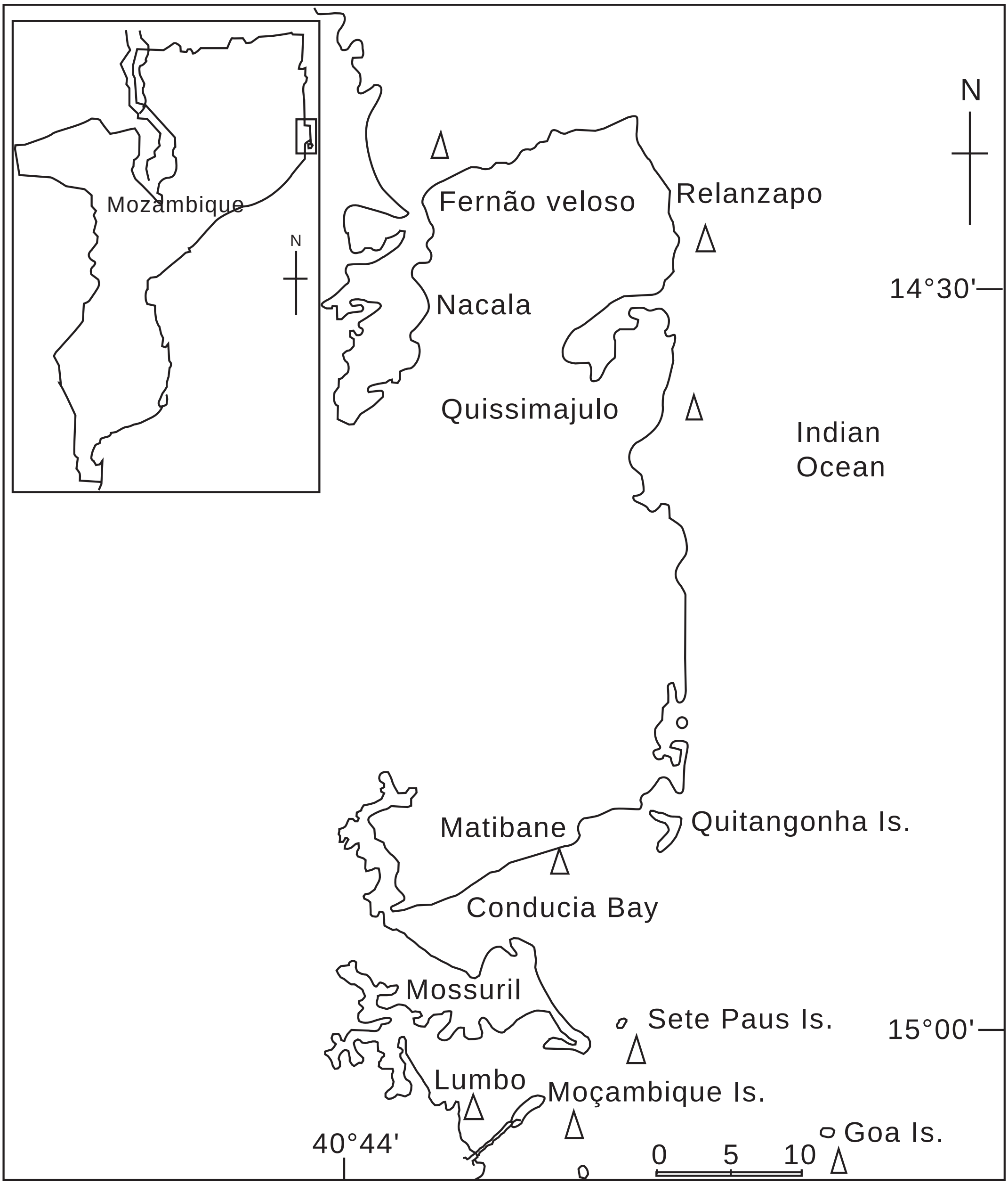

Fig. 1. The geographical setting of study area in Nampula Province (sampling sites indicated by triangles)

MATERIALS AND METHODS

Area of study

The present study was carried out in the coastal areas located between Moçambique Island and Nacala in Nampula province (Figure 1) between January and April 2002. Moçambique Island lies about 200 km south of Nacala town. The Mozambique Channel current, flowing north to south, influences the climate of coastal Moçambique Island and Nacala. Moçambique Island has two seasons, cool from May to October and hot from November to April. The mean annual temperature is about 25ºC and mean annual rainfall is about 750mm (Meteorological data provided by the National Meteorological Institute).

Moçambique Island (15º 01 S, 40º 00 E) is a small Island of approximately 2300 m in length and 300 m width. Tides are semidiurnal with amplitude ranging from 0.2 to 4.5 m (Instituto Nacional de Hidrografia e Navegação, 2002). Although being small in size, this historic island houses some 42,407 people (census of 1997, www.ine.gov.mz), already posing considerable pressure to the surrounding marine resources.

RESEARCH METHODS

Seagrass and seaweed specimens were collected between January and April 2002 in eight areas namely: Moçambique Island, Lumbo, Goa Island, Fernão Veloso, Relanzapo, Sete Paus Island, Quissimajulo and Mossuril. Species identification was carried out using the literature available for the region (e.g. Jaasund 1976, Bandeira 1997, Coppejans *et al*., 1997, Green & Short, 2003) and voucher specimens deposited at Herbarium, Universidade Eduardo Mondlane Herbarium (LMU), Maputo. Macrolagae species names followed Silva *et al*. (1996) classification.

Mapping of botanical communities were undertaken only at Moçambique island following an intensive groundtruting carried out in the intertidal areas during low spring tide and observation from small boats for the adjacent subtidal areas (McKenzie *et al*., 2001). During low spring time periods, the exposed area of the island doubles due to an extensive intertidal range. Delineation of the contours of the seagrass and seaweed beds were carried out in the field using a map 1:10 000. This *in situ* observation through intense field observation was successfully given the small size of Moçambique island; the method test already elsewhere (see Kirkman, 1996, Mckenzie *et al*., 2001).

The composition of both seagrass and macroalgae was determined using a nominal scale of frequency of species occurrence: highly frequent, frequent or present. 'Highly frequent' corresponded to species which occurred in quite all observations during groundtruthing; 'frequent' corresponded to species observed at least half of the observations during groundtruthing and 'present' corresponded to quite rare species, which were observed only few times (Bandeira, 2002, Sidik et. al., 2001). The communities were then characterized by one, two or three dominant species and named after the highly frequent species (e.g. Coppejans et. al.1992, Bandeira, 2002). For communities with small areas, such as *Cymodocea serrulata* and *Syringodium isoetifolium*, the dominant species were identified using visual estimates of percentage cover, based on density classes (Tomasco *et al*., 1993). Contours of the communities were drawn in a larger field map while on groundtruting as stated above.

Transects of at least 50 m were established to assess the zonation patterns of both seagrass and seaweed species. Ten transects (6 scattered at the east coast and 4 at the west coast of Moçambique Island), running from the coastline to the low water spring tide level, were marked and samples collected from 1.0 m^2 quadrats at 10 m intervals along the transect. The data set for transects was analyzed using cluster techniques with the program Statistica 5.5 to investigate possible ecological affinities between and among seagrasses and seaweed species within (Bandeira & António, 1996, Green & Short 2003). Water temperature and salinity were measured using thermometers and laboratory refracrometer respectively.

RESULTS

Extensive intertidal areas of up to 1 km length occurred around Moçambique Island. Overall, seagrasses and seaweeds covered about 70% of the entire intertidal area around this Island. Twelve species of seagrasses distributed in three families were recorded from Nacala to Moçambique Island (Table. 1), of which eleven species were identified around Moçambique. Sixty-eight common macroalgae species were identified in the entire study site of which 53 (24 Chlorophyta, 18 Phaeophyta and 11 Rhodophyta) identified for Moçambique (Table. 1). Seagrasses tended to occur on areas with sand coverage while seaweeds occurred on coral reef habitats and in seagrass beds. The first habitat (living and fossil coral reef), supported numerous seaweed species such as *Sargassum* spp., *Turbinaria ornata*, *Dictyota* spp., and *Halimeda* sp. which were the most common in intertidal and subtidal fringe zones, while species such as *Galaxaura* spp. and *Udotea* sp., were common in the subtidal zone. *Halimeda* spp. was, in general the most dominant group in and around coral reef areas. The most common seaweed species in seagrass areas were *Caulerpa* sp., *Hypnea cornuta*, *Halimeda macroloba* and *Ulva* spp.

Seagrasses and common seaweeds of Moçambique Island comprised nine different communities: *Thalassia hemprichii*/*Halodule wrightii*, *Thalassia hemprichii*/Macroalgae, *Sargassum* spp. /*Cistoseira* spp., *Nanozostera capensis*/*Cymodocea rotundata*/ *Halodule wrightii*, *Cymodocea rotundata*, *Thalassodendron*

Table 1. Seagrass (s) and seaweed abundancy at each plant community at Moçambique Island

	Th/Hw	Th/MC	Sp/Cp	Nz/Cr/Hw	Cr	Tc/MC	Tc/Si	Tc	Si
Seagrass									
Cymodocea rotundata (s)	++	+	-	+++	+++	+	-	+	-
Cymodocea serrulata (s)	+	-	-	+	++	+	-	-	-
H. minor(s)	+	-	-	+	+	+	-	-	-
H. stipulacea (s)	+	-	-	+	-	-	-	-	-
H. uninervis(s)	-	-	-	-	++	-	+	++	-
Halodule wrigthii(s)	+++	-	-	+++	++	-	-	-	-
Halophila ovalis (s)	+	+	-	+	+	-	-	-	-
Nanozostera campesis(s)	-	-	-	+++	++	-	-	-	-
Syringodium isoetifolium(s)	-	-	-	-	-	-	+++	++	+++
Thalassia hemprichii(s)	+++	+++	+	-	+	+	+	++	+
Thalassodendron ciliatum(s)	-	+	++	-	-	+++	+++	+++	++
Chlorophyta									
Anadyomene wrigthii	+	-	+	-	-	+	-	-	-
Boodlea composita	+	+++	+	++	+	+	-	-	-
Boergesenia forbesii	+	++	+	+	-	+	-	-	-
Chaethomorpha crassa	+	++	+	+	-	++	-	-	-
Caulerpa lentillifera	+	+	-	+	-	-	-	-	-
C. mexicana	+	+	-	+	-	-	-	-	-
C. microphysa	+	+	-	+	-	-	-	-	-
C. serrulata	+	+	-	+	-	-	-	-	-
C. recemosa	+	+	-	+	-	-	-	-	-
C. sertularioides	+	+	-	+	-	-	-	-	-
Chlorodesmis hildebrandtii	-	-	+	-	-	+	-	-	-
Codium geppei	++	+	+	++	-	-	-	-	-
Dictyosphaeria cavernosa	++	-	++	-	-	+	-	-	-
Enteromorpha intestinalis	-	-	+	-	-	+	-	-	-
Halimeda discoidea	+	++	++	+	-	+	-	-	-
H. macroloba	++	++	+	-	-	+	-	-	-
H. velasquezii	+	+	+	-	-	+	-	-	-
H. opuntia	+	+	+	-	-	+	-	-	-
Ulva reticulata	++	++	+	+	+	-	-	-	-
U. pertusa	++	++	+	+	+	-	-	-	-
U. pulchra	++	++	+	+	+	-	-	-	-
U. rigida	++	++	+	+	+	-	-	-	-
Valonia aegagropila	-	-	+	-	-	+	-	-	-
V. macrophysa	-	-	+	-	-	-	-	-	-
Phaeophyta									
Cystoseira myrica	-	-	+++	-	-	++	-	-	-
C. trinodis	-	-	+++	-	-	++	-	-	-
Colpomenia sinuosa	-	-	+	-	-	+	-	-	-
Dictyota adnata	-	-	+	-	-	+	-	-	-

	Th/Hw	Th/MC	Sp/Cp	Nz/Cr/Hw	Cr	Tc/MC	Tc/Si	Tc	Si
D. bartayresiana	-	-	+	-	-	+	-	-	-
D. humifusa	-	-	+	-	-	+	-	-	-
D. cervicornis	-	-	+	-	-	+	-	-	-
D. divaricata	-	-	+	-	-	+	-	-	-
Hormophysa cuneiformis	-	-	++	-	-	++	-	-	-
Hydroclathus clathrantus	-	-	+	-	-	+	-	-	-
Padina boryana	-	-	+	-	-	+	-	-	-
P. boergeseni	-	-	+	-	-	+	-	-	-
Sargassum binderi	-	-	+++	-	-	++	-	-	-
S. aquifolium	-	-	+++	-	-	++	-	-	-
Stypopodium zonale	-	-	++	-	-	-	-	-	-
Turbinaria ornata	-	-	++	-	-	++	-	-	-
T. conoides	-	-	++	-	-	++	-	-	-
T. decurrens	-	-	++	-	-	++	-	-	-
Rhodophyta									
Amphiroa anceps	+	-	+	-	-	-	-	-	-
A. fragilissima	+	-	+	-	-	-	-	-	-
Acanthophora specifera	+	-	++	-	-	+	-	-	-
Actinotrichia fragilis	+	-	+	-	-	+	-	-	-
Bostrychia tenella	-	-	+	-	-	-	-	-	-
Chondria dasyphylla	-	-	+	-	-	-	-	-	-
G. salicornia	-	-	++	-	-	++	-	-	-
Gelidiela acerosa	-	-	+	-	-	+	-	-	-
Hypnea cornuta	+	+++	+	++	+	+	-	-	-
Jania adhaerens	+	+	+	-	-	+	-	-	-
J. rubens	+	+	+	-	-	+	-	-	-
Laurencia papilosa	-	-	++	-	-	++	-	-	-

+++= High frequent ++= frequent += present, Th/Hw =*Thalassia hemprichii/Halodule wrightii*, Th/S=*Thalassia hemprichii/Seaweeds*, SP/Cp=*Sargassum* spp./*Cystoseira* spp., Nc/Cr/Hw=*Nanozostera capensis/Cymodocea rotundata/ Halodule wrightii*, Cr=*Cymodocea rotundata*, Tc/S=*Thalassodendron ciliatum*/Seaweeds, Tc/Si=*Thalassodendron ciliatum/Syringodium isoetifolium*,Tc=*Thalassodendrom ciliatum*, Si=*Syringodium isoetifolium*.

Table 2. Seagrass and common macroalgae species at Nampula Province (Northern Mozambique)

Site	Substract type	Seagrass Species	Chl	Seaweed species Pha	Rod	Total macroalgae
Moç. Is	S, M, R	11	24	18	11	53
Lumbo	S, M	8	21	18	10	49
Goa Island	R	2	22	18	23	63
Fernão Veloso	S, M, R	10	24	18	10	52
Relazanpo	R	2	25	18	23	66
Sete Paus Is	R	2	22	18	23	63
Quissimajulo	S, M, R	3	1	0	0	1
Matibane	S, M, R	8	22	12	2	36

S=Sand substract
M= Muddy substract
R= rocky substrate

ciliatum/*Macroalgae*, *Thalassodendron ciliatum*/ *Syringodium isoetifolium*, *Thalassodendron ciliatum* and *Syringodium isoetifolium*. The boundaries of each community type were drawn and the seagrass and seaweed map was then established (Figure 2). Ground cover varied from community to community, being lower in *Cymodocea rotundata* and higher in the *Thalassia hemprichii*/Macroalgae.

The transects data (Figure 3a) enabled better visualization of the patterns of zonation observed in the map such as the assemblages of communities as *T. ciliatum / S. isoetifolium* and *T. hemprichii* / macroalgae. The cluster analysis dendrogram (Figure 3b), confirm the community assemblages by showing close affinities of the associated species e.g. *T. ciliatim* with *S. isoetifolium; N. capensis* with *H. wrightii* and macroalgae

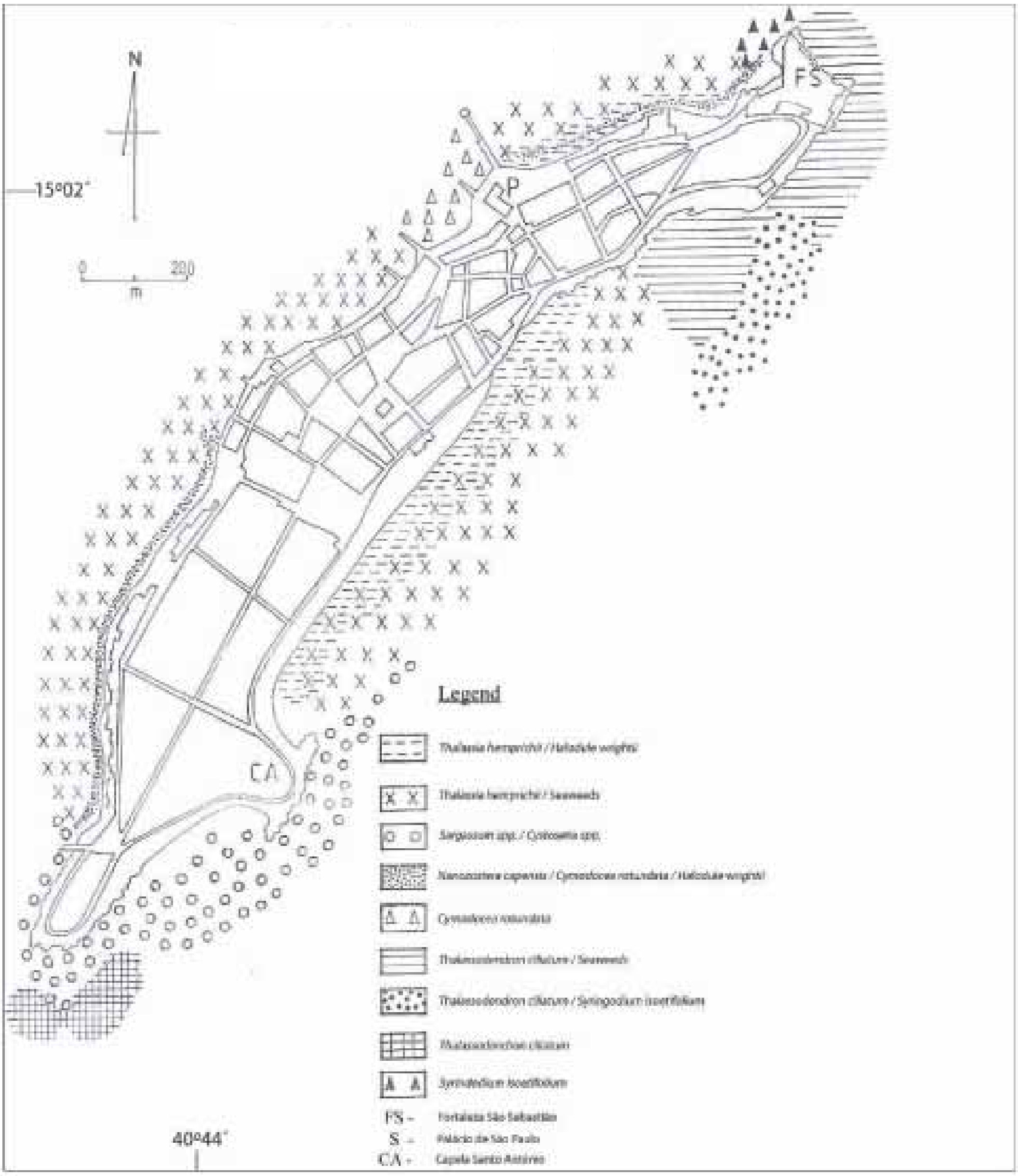

Fig. 2. Map of Moçambique Island showing seagrass and seaweed communities

themselves. The findings demonstrate that different seagrasses and seaweeds are found between the supralittoral fringe, the midlittoral zone and the infralittoral fringe.

DISCUSSION AND CONCLUSION

The presence of twelve seagrass species for Nampula is considered high especially when

	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500	520	540
As								x	x	x	x	x	x															
Bc	x	x	x	x	x	x																						
Bf	x	x	x	x	x																							
Cg	x	x	x	x																								
Cm										x	x	x	x	x	x	x	x	x	x	x	x	x	x					
Cr	x	x	x	x	x	x	x	x	x	x																		
Cs	x	x	x	x	x																							
Cp	x	x	x	x	x	x	x																					
Ct										x	x	x	x	x	x	x	x	x	x	x	x	x	x					
Dc	x	x	x	x	x	x	x																					
Gs	x	x	x	x	x																							
Hc	x	x	x	x	x	x	x	x	x	x																		
Hm	x	x	x	x	x																							
Ho	x	x	x	x	x	x																						
Hp	x	x	x	x	x	x	x	x	x	x																		
Hw	x	x	x	x	x	x	x	x																				
Lp										x	x	x	x	x	x	x	x	x	x	x	x	x	x					
Pp	x	x	x	x	x	x	x	x	x	x	x																	
Si											x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sp					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tc											x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Th	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					
Tp									x	x	x	x	x	x	x	x	x	x	x	x								
Up	x	x	x	x	x	x	x	x	x	x																		

Distance (in m)

Legend

As- *Acanthophora specifera*, Bc- *Boodlea composita*, Bf- *Boergesenia forbesii*, Cg- *Codium geppeii*, Cp- *Caulerpa* sp., Cm- *Cystoseira myrica*, Cr- *Cymodocea rotundata*,
Cs- *Cymodocea serrulata*, Ct- *Cystoseira trinodis*, Dc-*Dictyosphaeria cavernosa*,
Dp- *Dictyota* sp., Gs- *Gracilaria salicornia*, Hc- *Hypnea cornuta*, Hp.-*Halimeda* sp.,
Hm-*Halophila minor*, Ho-*Halophila ovalis*, Hs- *Halophila stipulacea*, Hu- *Halodule uninervis*, Hw- *Halodule wrightii*, Lp-*Larencia papilosa*, Nc-*Nanozostera capensis*, Pp-*Padina* sp,
Si- *Syringodium isoetifolium*, Sb - *Sargassum* binderi, Sp- *Sargassum* sp., Sz - *Stypopodium zonale*, Tc-*Thalassodendron ciliatum*, Th-*Thalassia hemprichii*, Tp- *Turbinaria* sp., Up- *Ulva* sp.

Fig. 3a. Transects around Moçambique Island (this include both seagrass and common macroalgae; zero meters corresponds to the level of lower water spring tide)

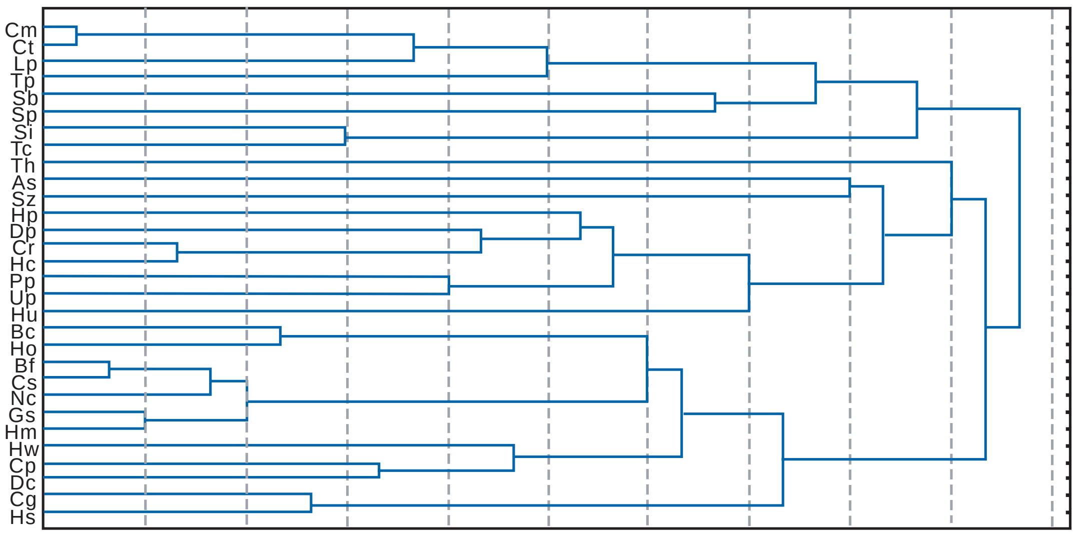

Fig. 3b. Cluster analysis of the transect results

compared to other seagrass assemblages in the world (see Green and Short, 2003) but relatively common for the WIO region. Moçambique Island, from where eleven seagrass species were reported, comprises about 90% of the total number of seagrass species occurring in Nampula and approximately 19% of the world seagrass species (Green and Short, 2003). This figure represents approximately 92% of the 13 species that occur along the entire eastern African coast (see Gullström et. al., 2002). This diversity for Moçambique Island is high, especially since it covers such a small area. Moreover, all eleven species could be found within only a small portion of the *Thalassia hemprichii*/seaweed [see Fig 2] community type. Others areas of Mozambique are useful for comparison, in particular Mecúfi, from where ten seagrass species were reported (Bandeira & António, 1996) and 101 seaweed species found (Bandeira *et al*, 2001; Carvalho & Bandeira, 2003), or Inhaca Island, in southern Mozambique, from where nine seagrass species are listed (Bandeira, 2002) and 205 seaweed species reported (Critchley *et al*., 1997).

The intertidal and subtidal seaweed flora of Moçambique Island seems to show affinities to the flora of the neighboring Tanzania (Jaasund, 1976; Oliveira *et al*., 2005). The present study provides one of first compilations of the seaweed flora for Moçambique Island, despite only the most common seaweed species being included here. It is recognised that several species were omitted, and that conclusively, based on the floristic ratio (Cheney 1997), calculated as only 2.7 indicating the existence of low numbers of seaweeds, in particular of Rhodophyta. This floristic ratio of Cheney - equal to (R+C)/P with R being the number of Rhodophyta species, C number of Chlorophyta and P of Phaeophyta species - indicates that a value <3.0 is of cold water flora and of > 6.0 of a tropical flora (Cheney 1977; Critchley at al., 1997). Further studies on intertidal and subtidal seaweeds, covering different areas, are still needed around the Nampula region, as are more seaweeds collections, including those for different seasons. The seagrass and seaweed community types observed in this study are similar to those observed along other parts of the Mozambican coast, such as the north beach of the Maputo city, where *Nanozostera capensis* is the dominant species and coexists with *Halodule wrightii* (Martins, 1997) and *Thalassodendron ciliatum* seagrass dominates subtidal areas (see Bandeira, 2002). GIS mapping, using LANDSAT imagery, for smaller areas such as Moçambique Island (ca. 3 km^2) was shown to be inappropriate because such images rely on relatively large pixel size (see McKenzie *et al*., 2001). SPOT satellite imagery in contrast, with a spatial resolution down as small as 2.5m^2 would provide more accurate seagrass mapping for Moçambique Island, as suggested elsewhere (see Pasqualini *et al*., 2005). The present study contributes to the description of seagrasses and seaweeds in the Nampula area. Further studies, focusing on growth, biomass and the role of seagrass and seaweed to the coastal communities are some of the recommended as follow-up activities. Research on growth and biomass of dominant seagrass and macroalgae species would provide baseline production information. Edible resources (namely invertebrates and fish) occurring within the botanical communities, and the sustainability of their exploitation, should be documented using both ecological methods and socio-economic techniques (such as interviews and market surveys).

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