

Coastal marine biodiversity in East Africa

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The Indian Ocean coastline of mainland Africa is over 9 500 km long and comprises the tropical coasts of Somalia, Kenya, Tanzania and Mozambique, plus the subtropical and warm-temperate Indian Ocean coastline of South Africa. The regional marine fisheries catch (Indian Ocean catch only for South Africa) is about 200 000 t, more than 80 % of which is taken from Mozambique and Tanzania. Regional fisheries are dominated by intense artisanal and subsistence sectors, although there are also several commercially important industrial fisheries, mostly targeting lobsters, prawns and squid. No reliable species lists exist for individual countries of tropical Africa, but 11 257 marine species are recorded from the western Indian Ocean region (island states included) and 11 980 species from South Africa (including Atlantic coast). Comparing these lists by taxonomic group, and with similar lists for Europe (29 713 known species) reveals great disparities in taxonomic coverage and large gaps in the data, especially for smaller sized organisms. It is concluded that less than half of species actually present in East Africa have been described. Existing data are also based largely on shallow-water surveys and the benthic invertebrates of deeper waters, especially those of the continental slope and abyssal zone, remain virtually unexplored.

[Key words: Marine biodiversity, species richness, East Africa]

Introduction

The aim of this paper is to try to evaluate the current state of knowledge of marine biodiversity along the east coast of Africa. This analysis was undertaken as a contribution to the workshop 'Coastal and Marine Biodiversity of the Indian Ocean' held in Goa, India in December 2003. This in turn forms a contribution to the wider Census of Marine Life Programme (<http://www.COML.org>), a decade long, international effort to document and evaluate the state of knowledge of global marine biodiversity.

For the purposes of this review 'East Africa' is taken to include the entire Indian Ocean coastline of mainland Africa. This extends from Cape Agulhas (the southernmost tip of Africa and the boundary between the Atlantic and Indian Oceans) to the northern border of Somalia. The Red Sea is thus excluded. The total length of this coastline is over 9 500 km and is made up of Somalia (3 000 km), Kenya (600 km) Tanzania (1 434 km), Mozambique (2 700 km) and the Indian Ocean coast of South Africa (1 800 km). In terms of the recognized Large Marine Ecosystems (LME) of the World, this region incorporates the entire Agulhas Current and Somali Coastal Current LME, with a small section in the

extreme south falling into the Benguela LME, and the Gulf of Aden coast into the Arabian Gulf LME.

In biogeographic terms most of the East African coastline falls within a fairly uniform 'Tropical Western Indian Ocean' region, which also includes the western Indian Ocean islands. The physical characteristics and marine biota of this region are described in detail elsewhere¹. The region is characterized by a narrow continental shelf (on the mainland) and a tropical Indo-Pacific biota. The dominant coastal habitats are mangrove forests, seagrass beds and coral reefs, interspersed by extensive tropical sandy beaches and periodic lagoon and estuarine systems. In southern Mozambique this tropical zone merges gradually into a subtropical East Coast Province – the last true coral reefs extending just across the border into South Africa. The subtropical zone incorporates the whole of the South African province of KwaZulu-Natal and extends on southwards to about East London, where it in turn merges into a warm-temperate South Coast or Agulhas Province². The fauna and flora of the warm-temperate region are both quite distinct from those of the tropics and are characterized by high rates of endemism^{2,3}. The subtropical zone consists mainly of

a mixture of tropical and warm temperate elements⁴. More detailed descriptions of the South African coastline and its marine fauna and flora, as well as lists of references, can be found in the standard field guide to the region⁵.

Resource Utilization

Since these data are generally given country by country, each of the coastal nations in the region is discussed separately below.

i) Somalia

Little information is available on the fisheries and even less on the marine biodiversity of this region. Fisheries resources are thought to be greatly under-exploited, due mainly to a collapse in infrastructure and capacity⁶. Aid agency studies indicate that Somali marine resources could support an annual catch of 300 000 t of fish and 10 000 t of crustaceans, whereas actual catches are only about 2000 t, including 450 t of lobster, 100 t of shark, and 20 t of shrimp⁶. Fish are caught by subsistence fishers with line and hooks, gill nets, drift nets and purse seine and are normally consumed locally within 24-hours of capture. The lobsters are exported to United Arab Emirates. No data are available specifically on the marine biodiversity of Somalia, or on scientific capacity, although this is thought to be extremely limited. There are no known mariculture activities, information on marine invasive alien species, or existing marine reserves, although some have been proposed⁷.

ii) Kenya

The 600 km coast of Kenya is almost continuously fringed by coral reefs, except where river systems create conditions of low salinity and turbidity, which limit coral growth⁸. National fisheries production is about 170 000 t, but the vast majority of this is taken from freshwater lakes and marine landings vary between only 5 000 t and 8 000 t. This is taken by some 5 000 fishers, 4 000 of which can be considered as artisanal and who operate mostly between the shoreline and the reef. The fishery is based on relatively few species, the most important of which are demersal forms (3 000 t). There is also a significant commercial prawn trawl fishery.

Kenya has one of the most extensive networks of marine protected areas in the region and these are spread fairly evenly along the coastline. The largest and best known complex is the Malindi Marine

National Reserve (213 km²), which encloses the Wamatu and Malindi Marine National Parks. Other important MPAs are the Mombasa Marine National Park (10 km²) and Reserve (200 km²), the Kiunga Marine National Reserve and the Kisite Marine Park (11 km²) and Mpunguti Reserve (28 km²). Two more protected areas have been proposed - The Tana River Delta Wetland Reserve and the Diani Chale Marine Reserve⁸.

iii) Tanzania

Total annual fisheries catch in Tanzania is about 350 000 t, but most of this is taken from the major inland lakes in the region. Marine fisheries catches are around 50 000 t (only 14% of the total). Small-scale artisanal fisheries account for the majority of fish caught and these activities involve more than 43 000 fishermen, mainly operating in shallow waters within the continental shelf and using traditional fishing vessels and methods. More than 500 species of fish are utilized, with reef fishes forming the most important category. Destructive fishing methods, such as drag nets and dynamite fishing, pose a serious problem, as they destroy important habitats for fish and other organisms, and there is a long-term trend of over-harvest of fishery resources⁹. Other environmental threats to coastal biodiversity include exploitation of mangroves (for firewood and construction and to clear sites for rice farms, mariculture ponds and salt pans); collection of mollusks for the shell trade and habitat destruction as a result of inappropriate fishing practices¹⁰.

There are two marine parks in Tanzania, Mafia Island Marine Park and Mnazi Bay – Ruvuma Estuary Marine Park. Other marine protected areas include Chumbe Island Coral Park (privately-run) and Menai Bay Conservation Area, both located in Zanzibar¹⁰. The seaweed *Eucheuma denticulatum* has been deliberately introduced from the Philippines for mariculture purposes¹ and although this has some mild effects on the surrounding biota, these seem to be insignificant compared to the large socio-economic benefits¹¹. No other invasive alien species have been reported⁷.

iv) Mozambique

The coastline of Mozambique is both extensive, at 2 700 km, highly diverse and relatively pristine. For example, it harbors the largest remaining populations of dugong in East Africa¹². Total marine fisheries catch in 1997 was estimated at 114 000 t, of which

80 000 t was taken by the artisanal sector and 34 000 t by the industrial sector. The potential catch is estimated at 391 000 t, indicating that at least some sectors are under-developed. However, much of the coastal population lives in abject poverty, and this results in extreme pressure being placed on coastal resources. The fishing sector was estimated to provide employment for 89 000 people in the artisanal and 900 in the industrial sectors¹³. Fisheries also provide approximately 40% of national export earnings, with the prawn fishery the most valuable sector.

There are currently only two MPAs in the region – the Bazaruto Marine Park and Inhaca and Portuguese Island Reserves. Five new areas are proposed⁷. The country's legislation also does not promote sustainable resource usage, because of the priority it gives to free access to all natural resources¹².

v) South Africa

Since the region under consideration here only incorporates the eastern half of South Africa, it is difficult to separate national statistics to apply only to that section of the coastline. It is estimated that 3.6 million South Africans depend largely on coastal food sources through subsistence activities, and almost all of these are along the Indian Ocean coast. The national fishing industry lands between 400 000 and 600 00 t per annum, depending upon the variable abundance of small pelagic fish, but commercial fisheries on the east coast make up only a very small percentage of the national catch, perhaps of the order of 25 000 t. This consists mostly of inshore trawl, line-fish, squid, rock lobster and prawn sectors. There are also significant subsistence and recreational shore angling fisheries in this region. Recent reviews describe the invertebrate and algal fisheries of the region¹⁴, as well as the recreational linefishery¹⁵, which has several hundred thousand active participants and lands nearly 3 000 t of fish per annum.

South Africa already has a network of no less than 112 marine protected areas, which together make up 17 per cent of the coastline¹⁶, and has several other new marine reserves under consideration. However, most of these reserves are either extremely small in size, still permit angling or other exploitative activities, or protect only selected species (for example, some are simply abalone or rock lobster sanctuaries). Many are also very poorly policed. As a result there are in reality only a handful of large, no-

take reserves that provide effective protection for significant areas of coastline. At present the subtropical east coast is relatively well protected by the adjacent St Lucia and Maputaland reserves (140 km shore length) and the warm-temperate south coast by the Tsitsikamma (57 km) and De Hoop (51 km) reserves. Several introduced marine species are known from the region¹⁹, but only one of these – the Mediterranean mussel *Mytilus galloprovincialis* - is invasive along the east coast.

The known - State of Knowledge of the Marine Biota

The African marine biota is, in general, poorly explored and any estimates of species richness will be very preliminary. Two approaches at quantifying patterns of species richness are possible. The first is to attempt to list and compare the known biota of entire countries, or regions. The second is to take well-known taxonomic groups and use them as 'proxies' in an attempt to compare species richness in different regions.

i) Estimates of overall biodiversity

Several attempts have been made to record the marine biodiversity of countries in this region. The known marine biota for Kenya has been tabulated⁸, but this list is so incomplete, it has little value - for example species-rich groups such as Bryozoa and Ascidiacea are not included, while numbers of Porifera and Annelida are given as an implausible 2 and 10 species respectively! A similar listing for Mozambique¹² omits such diverse groups as Bryozoa, Porifera and Annelida, and fails to mention or include data from several critical taxonomic references to the marine fauna of the area²⁰⁻²².

The best lists are those that tabulate the known marine biota of the Western Indian Ocean^{1, 23} and of South Africa¹⁸. These are reproduced as Tables 1 and 2 respectively, with the latter modified to include algae²⁴. Note that neither of these areas correspond exactly to the regions as defined in the present review. The Western Indian Ocean analysis includes the island of Comoros, Madagascar, Mauritius, Reunion and Seychelles, while that of South Africa incorporates both Indian and Atlantic Ocean coasts. Nevertheless, these regions correspond quite well to the tropical and subtropical/temperate coasts of East Africa, so are instructive.

The most obvious observation from these two lists is that the total numbers of species listed in both are

Table 1. — Estimated species of major macrofloral and macrofaunal taxa recorded from littoral and shallow sublittoral waters of the western Indian Ocean^{1,23}.

Taxonomic group	Minimum number of species	Taxonomic group	Minimum number of species
Microalgae ¹¹	265	Caridea	150
Mangroves	10	Palinura	20
Seagrasses	12	Thalassinidea	20
Macroalgae	1011	Anomura	50
Porifera	200	Brachyura	465
Ctenophora	20	Scaphopoda	10
Scyphozoa	30	Polyplacophora	39
Hydrozoa	100	Prosobranchia	2550
Octocorallia	300	Opisthobranchia	400
Ceriantharia	20	Pulmonata	20
Actiniaria	30	Bivalvia	667
Corallimorpharia	10	Cephalopoda	20
Zoanthidea	5	Echinoidea	62
Scleractinia	200	Holothuroidea	148
Antipatharia	10	Asteroidea	58
Platyhelminthes	100	Ophiuroidea	132
Echiura	22	Crinoidea	19
Sipuncula	50	Phoronida	5
Polychaeta	300	Brachiopoda	5
Oligochaeta	10	Bryozoa	500
Cirripedia	30	Hemichordata	20
Nemertea	59	Chaetognatha	50
Amphipoda	300	Thaliacea	30
Isopoda	100	Ascidacea	100
Stomatopoda	30	Pisces	2000
Dendrobranchiata	10		
		Total species	11 257

remarkably similar at 11 000 –12 000. However, composition of the two lists is very different in many respects. For example microalgae make a significant contribution to the biota of the Western Indian Ocean, but are not listed for South Africa, as no species list has yet been compiled for that region. Conversely Nematoda, which account for 338 South African species, are not included in the Western Indian Ocean list. The main conclusion to be drawn from these lists is thus that they reflect more on the differing states of taxonomic knowledge of the two regions than any actual differences in species richness.

ii) Proxy groups

More reliable country-by-country species lists are available for a number of the better known groups, particularly plants and vertebrates (Table 3). Some of

the component groups (eg Reptilia, Mammalia) contain too few (and too widespread) species to reveal any significant patterns. However, seaweeds, fish and birds are both sufficiently well known, and sufficiently speciose, to be analysed on a country-by-country basis (although, with the exception of birds, even these lists are certainly incomplete).

It is likely that the four tropical countries in this list have similar seaweed species diversity (Bolton-pers comm). Differences in total species number are mainly due to sampling effort, with the diversity of Somalia and Mozambique seriously underestimated due to paucity of collecting effort. The higher species number in South Africa probably reflects the greater range of environmental conditions found there, as well as greater taxonomic effort applied to this region.

Table 2—Known marine biodiversity of South Africa (after Gibbons¹⁸)

Phylum	No of RSA spp	No of RSA endemics	% of RSA Endemism
Algae	850	ca 340	ca 40
Placozoa	0	0	0
Porifera	289	10	3
Cnidaria	842	238	28
Ctenophora	11	0	0
Nematoda	338	30	9
Platyhelminthes	28	17	61
Rotifera	0	0	0
Tardigrada	0	0	0
Gastrotricha	0	0	0
Kinorhyncha	1	0	0
Gnathostomula	0	0	0
Annelida	766	161	21
Mollusca	3062	1592	52
Crustacea	2333	719	31
Chelicerata	115	57	50
Brachiopoda	31	15	48
Bryozoa	280	99	35
Echinodermata	410	187	46
Echiura	21	1	5
Priapula	1	0	0
Entoprocta	6	0	0
Loricifera	0	0	0
Sipuncula	47	0	0
Pogonophora	1	1	100
Phorona	0	0	0
Chaetognatha	28	0	0
Nemertea	17	5	29
Hemichordata	11	2	18
Chordata	2492	362	15
Total/average	11980	3836	32.02

Fish diversity appears to bear some relationship to length of coastline, but is significantly higher in the south, perhaps due to inclusion of sub-tropical and temperate forms (especially in the case of South Africa). It is also difficult to disentangle the effects of sampling effort from any real differences in species richness in this group. The bird data are considered accurate and the higher figures for South Africa and Kenya/Somalia probably reflect greater marine productivity, due to the presence of centres of upwelling in these countries²⁵.

Table 3:— Numbers of species of seaweeds²⁴, marine fish (from Fishbase) and seabirds²⁵ recorded from each of the coastal counties of East Africa (note that South African data include both west and east coasts).

Country	Seaweeds	Fish	Marine birds
Somalia	211	846	71
Kenya	403	662	70
Tanzania	428	784	44
Mozambique	243	1734	63
South Africa	850	2000	94

The Unknown - Shortcomings in our Knowledge

It is clear from the above analyses that enormous gaps still exist in our knowledge of the marine biodiversity of East Africa. The current state of knowledge can be evaluated either by taxonomic group, or in terms of habitat and geographic region.

a) Taxonomic analysis:

On a taxonomic basis the only groups that are relatively well known across the region are the larger and/or more economically valuable taxa, such as flowering plants, seaweeds, all vertebrate groups, and to a lesser extent, the larger Mollusca and Crustacea. However, several other groups of ecologically important, taxonomically diverse and relatively large-sized organisms stand out as being poorly known. These include the Porifera, Bryozoa and Ascidiacea, groups which are all relatively difficult to identify without a high level of taxonomic expertise (Note: although Table 1 above does list many Porifera, most of these are from the islands, not the African mainland, which remains very poorly explored). As one moves to smaller and less conspicuous groups, so the state of knowledge becomes progressively poorer. Polychaeta and most of the smaller Crustacea, for example, are poorly described outside of South Africa. Meiofaunal groups (such as Nematoda and benthic Copepoda) and microfauna all remain extremely poorly known across the whole region.

In this context it is instructive to compare the African data with those available for other, better researched, regions. For example, the European Register of Marine Species (ERMS website: <http://erms.biol.soton.ac.uk>) lists 29 713 species known from European seas. It is most unlikely that this much higher figure reflects a greater biodiversity than that of the tropical Indian Ocean. Instead, it almost certainly reflects a much greater taxonomic effort and coverage in European seas. The effect this has on our estimates of biodiversity can be estimated

Table 4: — Comparison of reported species richness for some well-researched and other poorly known taxa between Europe, Western Indian Ocean and South Africa.

Taxonomic group	European taxa	W. Indian Ocean taxa	S. African taxa
Well-known groups:			
Pisces	1 349	2 000	2 000
Echinodermata	648	419	410
Mollusca	3 353	3 706	3 062
Decapoda	672	715	750
Macroalgae	1 702	1 011	850
Poorly-known groups			
Protozoa/microalgae	2 589	265	Not listed
Platyhelminthes	2 398	100	28
Nematoda	1 837	Not listed	338
Copepoda	2 944	Not listed	429

by comparing the numbers of described species in the Europe biota with those recorded from the Western Indian Ocean and from South Africa (Tables 1 and 2). A few such examples are given in Table 4.

It is interesting to notice from these data that the numbers of species recorded from well-known groups are remarkable consistent between the three regions, whereas numbers of species of lesser-known taxa are hugely under-represented from the Western Indian Ocean and in South Africa, relative to Europe. This is certainly a function of research effort and illustrates the poor state of exploration of African seas, rather than reflecting any actual differences in species richness. It is also important to note that the rate of description of European species (ERMS web site) has continued to remain virtually linear since about A.D. 1800, indicating that even the European list is still far from complete. The only logical conclusion to be drawn from this is that less than half (more likely less than a quarter) of marine species in the western Indian Ocean have been described!

b) Geographical and habitat coverage

Turning to the geographical and habitat coverage of the East African region the fauna of South Africa is by far the best known in the region, while that of Kenya and Tanzania has received moderate attention. Northern Mozambique and Somalia are very poorly explored, even in terms of larger coastal species. In all regions, however, there is a rapid decline in sampling effort with depth and with distance from the coast. Most of the existing collections are taken from close

inshore, or by shallow-water trawl or dredge. The benthic infauna is poorly known even at moderate depths, while that of deeper continental slope and abyssal depths is almost completely unexplored.

In conclusion it is evident that comprehensive taxonomic coverage of the marine biota of this entire region remains a monumental task, beyond the capacity of existing local taxonomic workforce, at least in the foreseeable future. Thus, if we are to gain an appreciation of the patterns of diversity in the region, it will be necessary to do this on the basis of indicator groups, or by the careful placement of systematic transects, rather than by the present system of haphazard and opportunistic description of new species as and when they are discovered.

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