COASTAL ECOSYSTEMS

Figure 10 : Reforestation at Jilori

COASTAL FOREST AND BUSHLAND

The coastal forest communities of Kenya exist mainly as isolated blocks which show high levels of species endemism and comprise a total of about 83,800ha in a narrow belt which extends inland for about 30km. The forests are characterized by dense or moderately dense stands of tall trees, species of the genera *Sterculia, Chlorophora* and *Memecylon*. The drier woodlands include stands of *Cynometra, Manilkara* and *Afzelia*. Centuries of human occupation have reduced the forest element which was originally more extensive. Mangrove swamps occur in tidal estuaries and lagoons while coconut palms are common above high tide. A complex of many bush types occur in the high bush area. Scattered baobab trees present a striking appearance while the prevalence of mango trees underlines long human occupation of the more productive areas.

There are an estimated 257,200ha of coastal evergreen bushland. Characteristic woody plants found in this area include *Crossopterix febrifuga, Piliostigma thonningii, Annona chrysophylla, Heeria mucronata, Lantana camara, Rhus natalensis, Securinega virosa*, etc. These areas are not noted for abundance of wildlife except for monkeys, baboons, birds and rodents.

The coastal high bush merges into the hinterland foreland region through a transitional vegetation where Acacia species and *Euphorbia candelabrum* are more prominent. Other chief constituents including *Diospyros, Terminalia* and *Combretum* species may also be found in the transition zone.

Coastal palm stands, which total about 55,500ha, are characterized by *Hyphaene* and *Borassus* palms on open grasslands. Such areas are important for birds and monkeys.

COASTAL GRASSLANDS

Many open areas at the coast are dominated by rank growth of grass about 2-3m high. In the Tana River Delta alone, approximately 67,000ha are covered by floodplain grasslands. A variety of grassland associations occur, including a widespread tall grass found in heavy black clays and areas with open water which is dominated by *Echinochloa haploclada* with *Bothriochloa glabra, Setaria splendida* and other less common species. Sedges (*Cyperus* spp.) are common in the wetter areas and they may be dominant in permanent swamps. In areas with more sandy soils and less risk of flooding, usually the levees associated with the old and present Tana River courses, a variety of grass species occurs. The two main grasses are *Digitaria alscendens* and *Sporobolus confunis*. A third grassland type is dominated by tall stands of *Panicum maximum* growing to a height of over 2m in places. On the inland side of the coastal sand dunes and mangroves, a salt tolerant grassland occurs which is dominated by the tough, spiky *Sporobolus spicatus* in association with the salt bush *Suaeda monoica*.

MARINE BEACHES AND DUNES

Marine beaches and dunes occur along the coastal areas and are usually characterized by bare sand dunes. Often they are only lightly vegetated by highly specialized colonizing plants, but at times the woody vegetation cover can be relatively heavy at 70%. Common plants include *Balanites* sp., *Dombeya* sp., and *Grewia* sp., which can form a thick shrub layer while common tree species include *Hyphaene coriacea, H. compressa, Garcinia livingstonei, Euphorbia candelabrum* and *Afzelia quanzensis. Ipomea pes-caprae*, a creeping vine, forms a dense mat seaward above the high water mark. There are an estimated 27,000ha of beach and dunelands in Kenya.

ESTUARIES AND OTHER WETLANDS

The Kenya coast has a number of estuaries which came about as a result of sea-level rise (or land subsidence) during recent geological time. These include Mombasa, Shimo la Tewa, Kilifi, Turtle Bay and the area around Lamu. These estuaries are the flooded lower courses of rivers that about 18,000 years ago flowed to a shoreline that may have stood about 160m lower than it does today, and thus several kilometres offshore.

These estuaries are generally sheltered from high energy waves and receive fine-grained sediments from inflowing streams. Their shores have been colonized by mangrove trees and associated plants. Several human-induced changes have also taken place in these estuaries. The clearing of mangrove forest for example, exposes the soft shores and leads to erosion. On the other hand, increasing amounts of sediment brought down by rivers such as the Tana and the Athi-Galana-Sabaki complex, are fed into the inshore environment, leading to accretion.

The Sabaki forms a very important floodplain at its lower course near Malindi. In the last 80km, the river drops 100m and forms a broad floodplain in which permanent and temporary lakes are common. There are subsistence fisheries on the lower reaches of the Sabaki River operated by the Orma and Giriama people. Lungfish (*Protopterus* spp.) and catfish (*Clarias* spp.) are the largest fish of the Sabaki with the latter reaching up to 10kg in weight. Two cichlid species (*Sarotherodon mossambicus* and *S. spirulus nigra*) also occur in the lower Sabaki and reach up to 2kg in weight.

Freshwater prawns are also abundant and make a valuable contribution to the local fishery. The main species are *Macrobrachium lepidactylus* (which reaches 40g in weight), *M. rude* and *M. scabrinsculum.*

The Tana River delta is Kenya's only major ocean delta. It is a low-lying area composed largely of sediments brought down by the river. It is subject to frequent flooding and changes in the network of channels and canals. The input of water is almost exclusively from the river itself because of the net outward flow of water, except in situations where invasions of saltwater occur such as under certain meteorological conditions. The delta maintains high levels of productivity in a dynamic balance which revolves around the frequency, extent and duration of flooding. Water circulation transports nutrients, influences a wide variety of habitat types, flushes away wastes, controls salinity and disperses and nurtures larval stages of a number of coastal organisms.

The basins of oxbow lakes and the deeper parts of dammed lakes where water remains for most of the year include Lakes Bilisa, Shakababo, Kongolola, Kitumbuini, Dida Warede, Harakisa, Moa and Kenyatta. In these lakes, profuse growths of true aquatic plants occur. The Nile cabbage or water lettuce (*Pistia stratiotes*) carpets the water surface and interspersed with it are the water lily (*Nymphaea lotus*) and the floating aquatic fern (*Azolla nilotica*). Lake Bilisa is an expansive wetland dominated by grasses, sedges, floating macrophytes and submerged macrophytes. The dominant plant species include aquatic grasses (*Bothriochloa bladhii, Echinochloa haploclada*), sedges (*Cyperus frerei, C. heterophylla, C. tuberosus*), floating macrophytes (*Pistia stratiotes, Azolla nilotica, Lemna spp.*) and submerged macrophytes (*Ceratophyllum demersum*). The lake has abundant bird life and fishing is a major activity with 145 tonnes of fish captured in 1990. The Orma people harvest aquatic grasses as fodder for their livestock. They also use sedges for thatching.

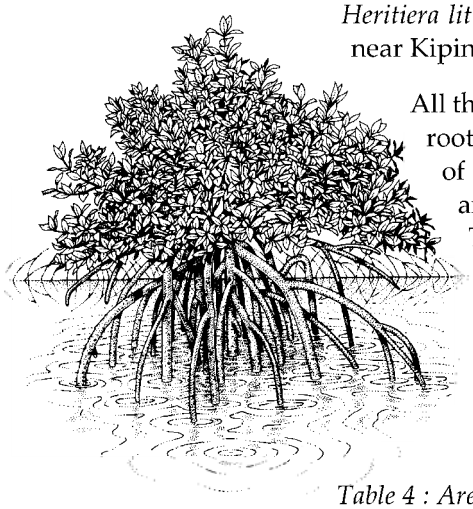
Lakes Shakababo and Kongolola have relatively clear waters and among the fish species that made up the 82 tonnes caught in 1991, were 'Barabara' (*Oreochromis mossambicus*), 'Chokole' (*Synodontis zambesiensis*), 'Pawa' (*Mormyrus sp.*), 'Pumi' (*Clarias mossambicus*), 'Borode' (*Labeo gregorii*), 'Kamongo' (*Protopterus amphibius*) and 'Mkunga' (*Anguilla mossambicus*).

Traditional land-use practices of small-scale agriculture, pastoralism and fishing have, in the main, maintained the ecological balance of the Tana River Delta for thousands of years. However, more recent human influence has been very strong in the Tana Delta. Most notably, the draining of land for agriculture and the control of water flow for irrigation and hydro-power production have left their mark.

MANGROVES

There are 8 species of mangrove trees and shrubs found along the Kenya coast - *Rhizophora mucronata, Ceriops tagal, Bruguiera gymnorrhiza, Sonneratia alba, Xylocarpus granatum, Avicennia marina, Lumnitzera racemosa and Heritiera littoralis.* The mangrove swamps along the Kenyan coast cover approximately 53,000 hectares (see Table 4) with the largest stands occurring in the Lamu area and the Vanga-Funzi coastal system near the Kenyan-Tanzanian border. The mangrove forests around Lamu are the second largest on the Eastern African coast and amount to 460km^2.

None of the mangrove species is endemic to Kenya. The commonest Kenya mangrove species are *Rhizophora mucronata* (the red mangrove) and *Avicennia marina* and both are found all along the entire Kenyan coast. On the other hand, *Heritiera littoralis* is found only in a small pure stand at the Tana River estuary near Kipini.



All the Kenyan mangroves except *Sonneratia* are viviparous, most have stilt roots and pneumatophores. *Avicennia* and *Sonneratia* are the first colonizers of the swamps. Once established, mud accumulates around their roots and produces favourable conditions for *Ceriops* and *Rhizophora* species. The latter is the commonest and most important constituent of the Kenyan mangrove swamps. It usually occupies the most favourable sites between *Sonneratia* and *Avicennia* on the creek edges, with *Ceriops* on the landward side. *Bruguiera* is normally found scattered within stands of *Rhizophora*.

Table 4 : Areas of mangrove on the Kenyan coast

locality	district	area (ha)
Kiunga	Lamu	3,025
Lamu	Lamu	30,475
Kipini (Witu)	Tana River	1,595
Mto Tana (Witu)	Tana River	250
Mto Kilifi (Witu)	Kilifi and Tana River	2,335
Mto Fundisa (Ungwana Bay)	Kilifi	330
Ngomeni	Kilifi	1,815
Mida Creek	Kilifi	1,600
Takaunga	Kilifi	30
Kilifi Creek	Kilifi	360
Mtwapa Creek	Kilifi and Mombasa	525
Tudor Creek	Mombasa	1,465
Port Reitz	Mombasa and Kwale	1,575
Maftaha Bay (Gazi)	Kwale	615
Ras Mwachema	Kwale	5
Funzi Bay	Kwale	2,715
Vanga	Kwale	4,265
total		**52,980**

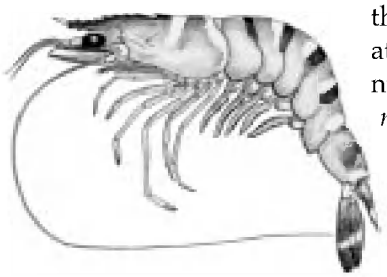
Coastal geomorphology and other abiotic factors influence the zonation of mangroves. In the Western Indian Ocean, *Sonneratia alba* and *Rhizophora mucronata* are usually at the outermost edge on the seaward side, followed by a *Ceriops tagal* zone in the intermediate levels, then by an *Avicennia marina* zone at the higher shore levels, and lastly, *Lumnitzera racemosa*, which usually occurs as a narrow fringe behind the *Avicennia marina* zone at the highest landward zone. Mangroves on the Kenyan coast exhibit this typical zonation pattern. Of the other species, *Bruguiera gymnorrhiza* occurs frequently just above the *Rhizophora* zone, while *Xylocarpus granatum* is most often found well above the *Avicennia* levels. This pattern of zonation exhibited by mature, adult trees, is reflected in the survival pattern of specific seedlings whose dispersal appears to follow both the 'self-planting' and the 'stranding' theories.

Figure 11 : Zonation in a mangrove swamp at Mtwapa Creek

Kenyans have traditionally exploited the rich natural products of the mangrove swamps as well as various parts of the trees themselves (see Table 5). Mangrove vegetation has also been cleared in many places for solar saltworks and, more recently, prawn farms. Loss of mangrove since pre-agricultural times is thought to amount to 70%. However, estimates of the area of mangroves in Kenya have remained constant over the past 20 years, despite extensive subsistence and small market use.

Mangrove forests are an important, if not critical, habitat for a variety of terrestrial and aquatic plants and animals many of which may in turn play an important part in coastal economics. The terrestrial fauna includes many species of birds, reptiles including crocodiles, mammals (pigs and monkeys) and insects; while the terrestrial flora mainly comprises fungi, lichens and mistletoes. At the Tana River near Kipini as well as at the Ramisi River, the animal life is abundant when compared to other mangrove areas in Kenya. Very large crocodiles are very evident here as

are herds of hippopotamus. Frequent marks of buffalo and other large mammals are also commonly found in these mangroves. Other smaller mammals that are known to inhabit mangroves are baboons, duikers, rodents and fruit bats. Bird life is rich and varied in most mangrove forests but especially so at Mida Creek. Many birds depend on the mangrove ecosystem for their existence, but even larger numbers roost on the mangroves and feed on the rich fish resources offshore. Other birds use the mangrove forests as resting and feeding stations as they migrate from and to the rest of Africa.



Penaeus monodon

The aquatic flora and fauna are much more diverse. Many (possibly up to 90%) of the species found in the mangrove forests are known to spend their entire life, or at least a major part of their life cycle in these areas. These species include a number of prawns (*Penaeus indicus, P. monodon, P. semisulcatus, Metapenaeus monoceros*); crabs (*Scylla serrata, Uca* spp., *Sesarma* spp. and *Birgus latro*); molluscs (oysters such as *Brachydontes* spp., and *Crassostrea cucullata*; and cockles, *Donax* spp.).

Mangroves are also of critical importance for a number of coastal fish species. Although they inhabit deeper waters when adults, many species of fish use mangrove areas to feed and as a nursery for their young. The fry of these species stay in the mangrove throughout their juvenile stages benefiting from the shelter, protection and abundant food. Although the role of mangroves in the life cycles of coastal fish in Kenya is not yet fully understood, it is known to be a very important one. Artisanal, commercial and subsistence fisheries, all rely on mangroves for a large part of the catch.

Table 5 : Economic use of mangroves in Kenya

SPECIES	Poles	Tannin & Dyes	Boat-building	Fuel	Medicinal & Food	Various
Avicennia marina		6% tannin, dyes	dhow ribs, canoes	wood used for lime burning	aphrodisiac, contraceptive	drums, carts, beds
Bruguiera gymnorrhiza	boriti, nguzo, telephone poles	53% tannin, dyes		firewood	fish smoking	fishing stakes
Ceriops tagal	fito, mapau, nguzo	24-42% tannin		high quality firewood & charcoal		fishing stakes, fence posts
Heritiera littoralis		14-15% tannin	dhow masts	good firewood & charcoal		
Lumnitzera racemosa	building poles			good firewood & charcoal		
Rhizophora mucronata	majority of building poles	12-50% tannin, dyes		good charcoal		fence posts, fish traps, fishing stakes
Sonneratia alba		15% tannin	boat ribs		camel fodder, condiments, medicaments, fruit edible	carpentry, native huts, fishnet floats
Xylocarpus granatum	poor quality building poles	33% tannin	dhow masts	firewood	fruit infusion, aphrodisiac, medicinals	handcarts, buildings

Sonneratia alba

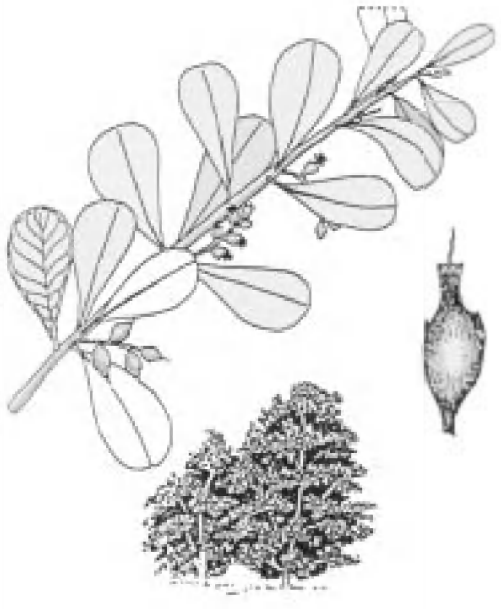
Avicennia marina

Ceriops tagal

Rhizophora mucronata

Figure 12 : Species of mangroves on the Kenya coast

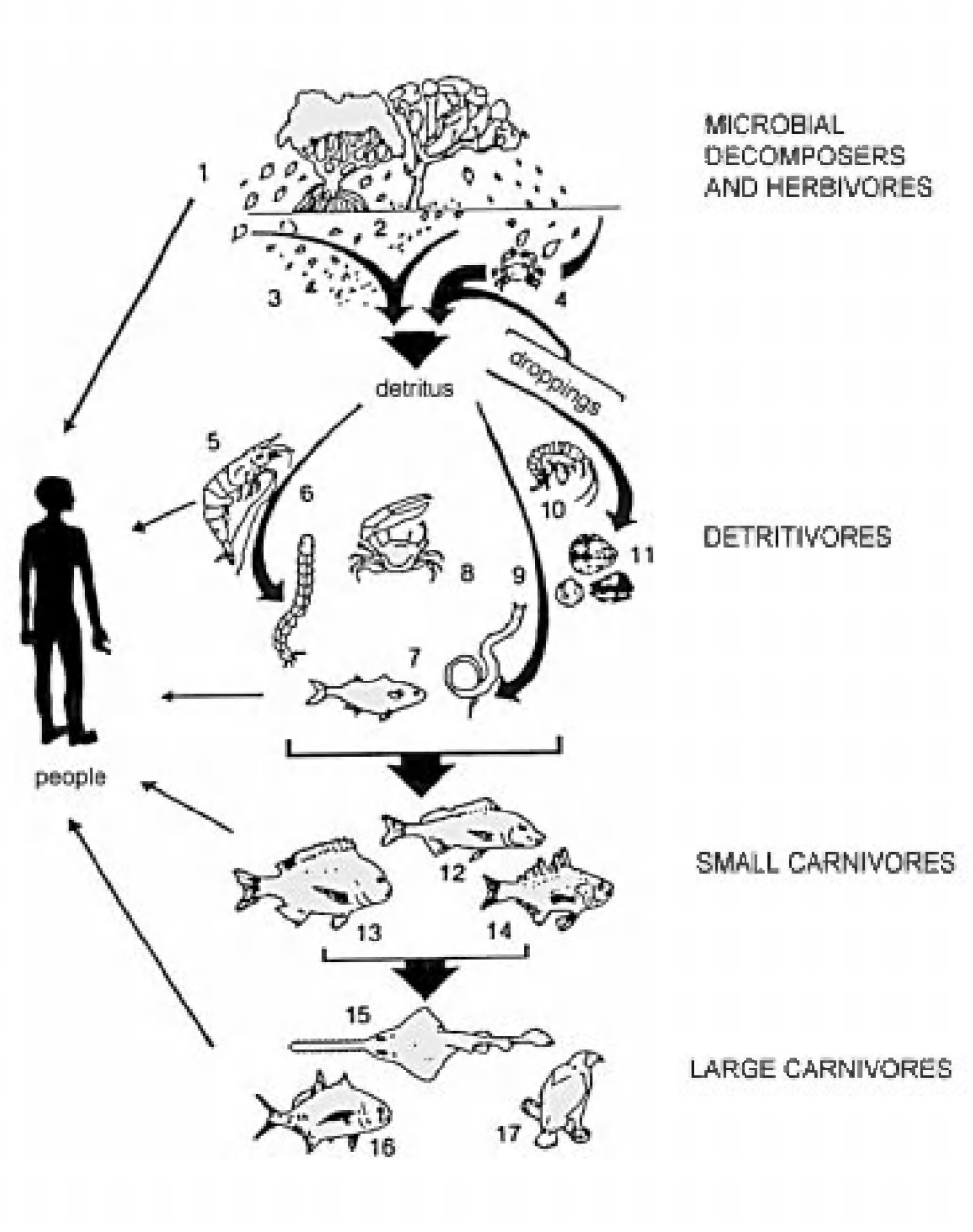
Xylocarpus granatum



Lumnitzera racemosa

Figure 12 : continued

Figure 13 : Mangrove poles ready for the market

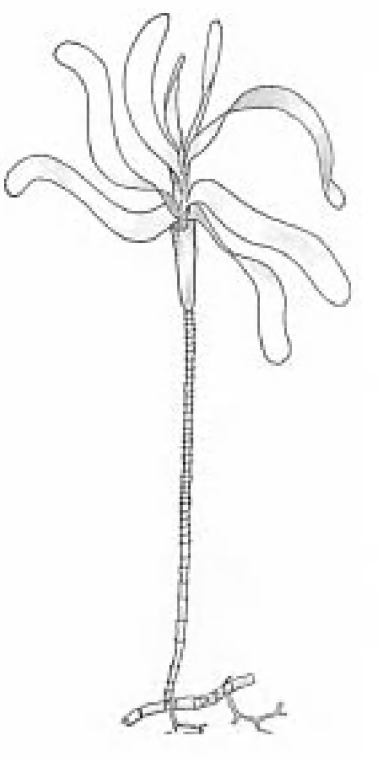


1	leaves	10	amphipods
2	algae	11	bivalve molluscs
3	fungi,protozoa, bacteria	12	grunters
4	sesamid and grapsid crabs	13	emperors
5	shrimps	14	pony fish
6	insect lava	15	sawfish
7	mullet	16	trevallies
8	fiddler crabs	17	sea eagle
9	worms		

Figure 14 : Ecological relationships within the mangrove environment

SEAGRASS MEADOWS AND SEAWEEDS

Seagrasses

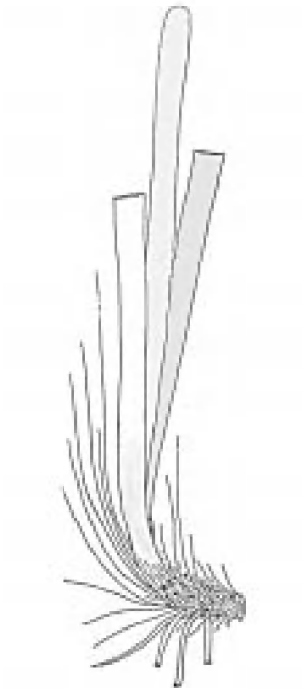


Cymodocea ciliata

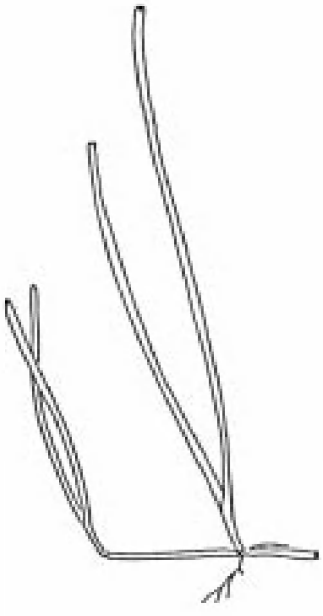
Seagrasses are not really grasses, but marine flowering plants. They are found predominantly in sandy and muddy areas where their roots can penetrate and provide easy anchorage. Seagrass meadows provide a habitat for a variety of commercially important fish species. Also found are the more mature specimens of those fish whose early life stages are found near the estuaries and mudflats. Seagrass beds are trawlable using larger mesh sizes and in this way various species of rays, octopus, holothurians, etc, can be fished. These areas are also the feeding grounds for endangered species such as the green turtle (*Chelonia mydas*), the hawksbill turtle (*Eretmochelys imbricata*) and the dugong (*Dugong dugon*).

Twelve species of seagrass have been recorded from Kenyan waters namely, *Cymodocea ciliata, C. rotundata, C. serrulata, Halodule uninervis, H. wrightii, Halophila balfourii, H. minor, H. ovalis, Syringodium isoetifolium, Zostera capensis, Enhalus acoroides and Thalassia hemprichii.* Most studies of seagrasses have concentrated on their ecology and taxonomy and very little work has been done on their distribution, densities and productivity. None of the species is endemic and while most have a wide distribution in the Indian, Pacific and Atlantic oceans, all but *Zostera* are confined to the tropics.

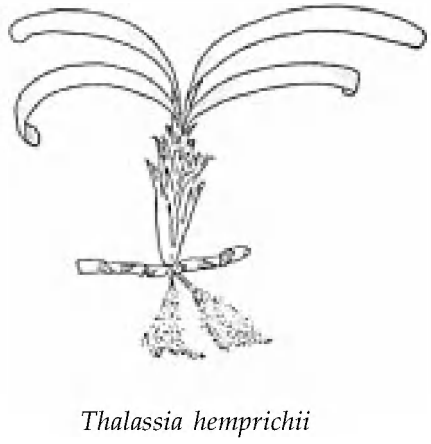
The most abundant species in Kenyan waters are *Cymodocea ciliata* and *Thalassia hemprichii* which are found in most places where the substrate is rock or old coral covered to a greater or lesser degree by sand. They root firmly in the substrate and can withstand rough wave action. *C. ciliata* does not do well in sheltered creeks away from the open sea. In locations where it is never exposed by low tides it



Enhalus acoroides



Zostera capensis



Thalassia hemprichii

Figure 15 : Various seagrasses of the Kenya coast

reaches its maximum development. *T. hemprichii* does sometimes occur in sheltered places where it assumes luxuriant growth and may root to considerable depth. However, it too suffers stunting in areas where it is uncovered by low tides.

All but two of the other species are also quite common although they are less conspicuous because of their smaller size. The first exception is *Enhalus acoroides* which is restricted to the Lamu area and Mida Creek where it grows in deep water away from the open sea. The rhizome of this species is edible and is eaten by the people of Lamu who call it Mtimbi. The second rare species is *Zostera capensis*, but this is not surprising since it is normally more at home in cold or cool temperate regions.

The major threat to seagrass meadows comes from excessive sedimentation of shallow coastal waters resulting from the erosion of agricultural lands. Turbidity also tends to cut down the light penetration and seagrasses cannot flourish under such conditions.

Seaweeds

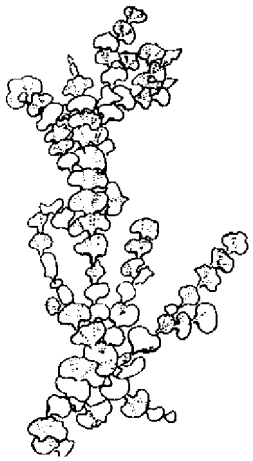
The seaweed species occurring along the Kenyan coast can be assigned to one of four groups, conveniently distinguished by their colour - blue-greens, greens, browns and reds.

One blue-green seaweed species which is ubiquitous on the Kenya coast is *Lyngbya majuscula*. It is very variable in size and is found on the rock surface at varying levels. It also occurs as an epiphyte on the leaves and stumps of seagrass plants in dense clumps streamed out into the water like tresses of grey-black hair, 15cm or more in length. Also widespread and with similar habits is the tufted *Symploca hydnoides*.

The green seaweeds are found in shallow water where they are able to make the best use of sunlight and grow better than those of other species. They include the bright green sea lettuce, with *Ulva pertusa* growing in continuous sheets while others like *Ulva reticulata*, are delicately perforated and net-like. They are much sought after by grazing fish and molluscs and are often found at the water's edge at low tide. Another green seaweed in shallow waters is *Enteromorpha* spp. Its bright green sheets often form hollow tubes and may appear filamentous, but others are more like deflated balloons (e.g. *Enteromorpha flexuosa*). The seaweed *Chaetomorpha crassa* is common in rock pools where it resembles tangled masses of thick, bright green nylon fishing line. Each of these three green seaweed groups are highly resistant to changes in salinity and temperature and can cope with the wide range of conditions encountered in the intertidal zone.

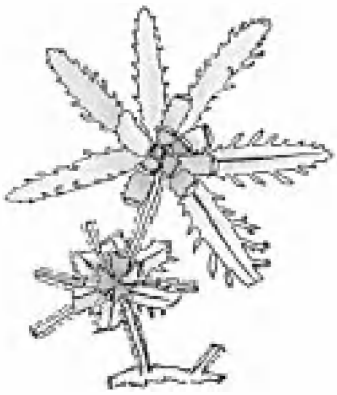
The green seaweed that has exerted the greatest effect on the Kenyan coast is *Halimeda*, which is represented by several species, all with rather oval, fleshy "leaves" impregnated with calcium carbonate. *Halimeda opuntia* forms thick, greyish-green mats, ten or more centimetres deep in the lagoons, which crunch as you walk over them. The calcium carbonate of any that are eaten by herbivores, is not digested and passes out as a fine white sand. This accumulates together with the thick layer of bleached skeletons of dead *Halimeda* to form what are often erroneously referred to as 'white coral sands'.

The brown seaweeds are often more robust and tend to be larger than the greens. Their colour is designed for intermediate depths below the low tide mark, as well as in the deeper lagoon pools and channels. The largest type on the Kenyan coast is *Sargassum* which can form impressive 'algal forests' similar to those of the

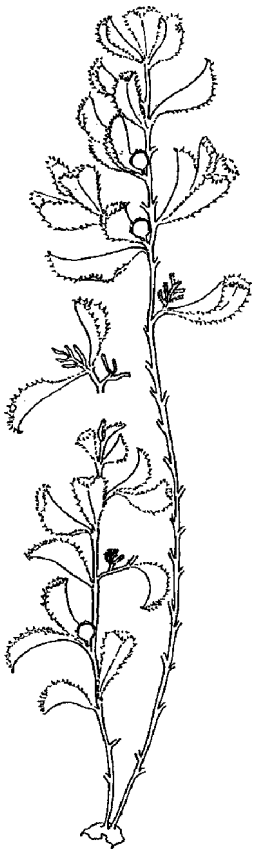


Halimeda opuntia

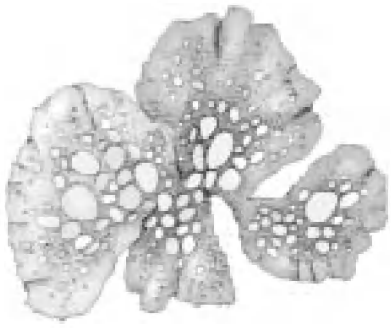
Turbinaria



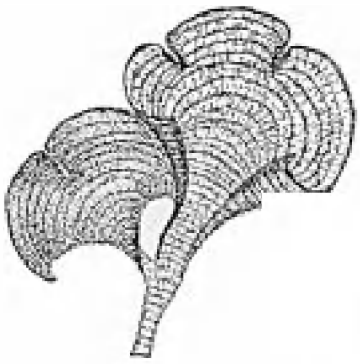
Amansia glomerata



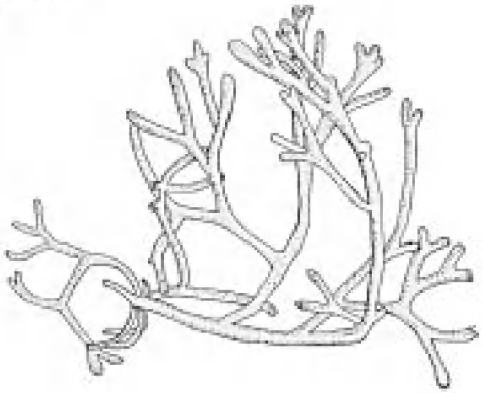
Sargassum duplicatum



Ulva pulchra



Padina boryana



Gracilaria crassa

Figure 16 : Various algae of the Kenya coast

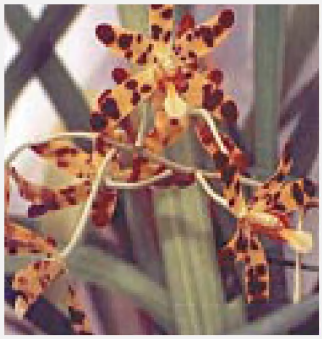
temperate kelps to which it is related. Many brown seaweeds, including some *Sargassum*, have air bladders in their fronds to hold them vertically above their holdfast, enabling them to make the best use of the penetrating sunlight. Another brown seaweed, common on the Kenyan coast is *Turbinaria*. This alga has tetrahedral lobes which are often hollow. It is found in areas where strong currents occur and its heavy structure allows it to hold on and resist all but the strongest buffeting.

A brown seaweed that stands out on the edge of rock pools is *Padina boryana*, which is very beautiful with its concentric tracery of creams and browns and a slight iridescence. Other species of this genus are more gross, but all have light bands made by crystals of calcium carbonate on their rounded lobes. Also among the brown algae are *Ectocarpus* spp. and *Giffordia* spp. which are common and important components of the filamentous algal turf which normally covers every available space in lagoons and on reefs.

The red seaweeds are adapted to living at depths where their red pigment is very effective in absorbing the light wavelengths that are able to penetrate through the water. However, this ability does not confine red seaweeds to deep waters. A profusion of red seaweeds can be found in shallow rock pools and channels, where they are able to grow under overhangs and in dimly lit caves where other seaweeds cannot survive.

There are probably more species of red seaweeds than browns and greens put together in the Kenyan shallows alone. They range from the gelatinous *Laurencia* to the fragile and brittle articulated corallines such as *Amphiroa fragilissima*. None are very large and many live as microscopic epiphytes on the larger brown seaweeds. Some are calcified and rocklike, such as *Porolithon onkodes*, others are leafy like *Amansia glomerata* and yet others are finely filamentous like *Ceramium*.

Seaweeds have a number of commercial applications in addition to their use as a food in their natural state. Thickening and gelling agents such as the alginates



COASTAL ORCHIDS THREATENED WITH EXTINCTION

Ansellia africana, commonly known as the leopard orchid because of its yellow flowers heavily blotched with dark maroon, belongs to the family Orchidaceae and is listed as endangered under the Convention on Trade in Endangered Species (CITES). Like other members of the orchid family, this species is highly valued for its beauty. As a result they have been collected excessively from the wild from Shimba Hills, Kwale, Msambweni, Port Reitz, Tiwi and Gazi by local people who sell them to hotels, tourists and the general public.

Many of those who sell and buy the orchids have no idea how to care for them. The host tree is cut down and clumps of orchids are jammed into tins and left in the hot sun, or they are separated by cutting, destroying the roots in the process. As a result of poor handling, only a small percentage of the orchids collected survive, only to be cut and hung in dark lounges, or placed on unsuitable hosts in too much shade where they struggle.

The species and its hosts are now considered in danger of extinction unless urgent action is taken to curb the indiscriminate collection from the wild.

used in soft cheeses and ice-cream, are extracted from seaweeds. Agar, also a seaweed product, is used in the preparation of microbiological media for use in the laboratory culture of bacteria, fungi, etc. Iodine and bromine, which are concentrated by seaweeds from the surrounding seawater, can be easily extracted. House plant food preparations are extracted from seaweeds, and they are often spread on to fields as a mulch. A broad survey of Kenyan coastal waters has shown that there are no sites with significant stands of commercially important seaweeds and therefore none could be considered available for harvest from the wild. Any exploitation of existing natural stands of commercially important seaweeds will lead to irreparable damage to primary productivity in the coastal zone and drastically change the biotope where they occur.

Of the seaweeds that are exploited internationally on a commercial basis, only those in the two genera *Gracilaria* and *Eucheuma*, are found in Kenyan waters. Of these, *Gracilaria* sp is widely distributed within the intertidal waters of the Kenya coast and studies on their distribution pattern show some species to be of a wider occurrence than others. Some are even found as epiphytes on seagrasses, but most grow on rocky shores and only a small number of species are found growing in sandy habitats. Studies of this genus to date have concentrated on its ecology, taxonomy and biochemistry and no attempts have been made to quantify *Gracilaria* stands in Kenyan waters.

Eucheuma is extremely sparse and present only as isolated specimens along the whole of the Kenyan coast with the exception of the extreme southern parts around Shimoni where all the species recorded in Kenyan waters occur in rocky coral reef areas in appreciable amounts. This concentration of *Eucheuma* species around Shimoni could indicate that this is the northernmost limit of its natural geographical distribution along the African coast and that while climatological and other factors at Shimoni are favourable, conditions further north along the Kenya coast allow only sporadic and isolated occurrences.

CORAL

Coral reefs exist along most of the Kenya coast. They occur as coral flats, lagoons, reef platforms and as fringing reefs. The total area of coral reef in Kenyan waters is estimated at 50,000ha and the coral types include the families Portidae (*Porites* and *Goniopora* spp.) and Faviidae (*Meandrina* and *Favia* species).

The best known reefs are in the Malindi-Watamu area, most of which are included within the boundaries of the two Marine National Reserves and the two Marine National Parks. The entire area was designated as a Biosphere Reserve in May 1979. The Parks are a complex of fringing reef, channels, islands, offshore reefs, sand, clays, seagrass meadows and isolated coral heads. Most of the reef flat which dries at low tide is dominated by *Goniastrea retiformis* interspersed with *Acropora* colonies. *G. retiformis* is also the dominant species on adjacent reef slopes although the back reef slopes are dominated by *Galaxea*. On the landward side coral cover is less than 50%, with much of the substrate being occupied by *Halimeda* and rubble.

The marine fauna includes *Tridacna squamosa, Pinctada margaritifera* and many other molluscs. The green turtle (*Chelonia midas*) and the hawksbill (*Eretmochelys imbricata*) occur in the park. Whale Island is a nesting site for the roseate tern (*Sterna dougallii*) and the bridled tern (*S. anaethetus*). Some fish such as the parrot fish (*Leptoscarus vaigiensis*), and the crown-of-thorns starfish (*Acanthaster planci*) are specialized to feed on coral polyps. Other fish groups usually associated with

coral include moray eels (Muraenidae), damselfishes (*Abudefduf annulatus, A. xanthozonus*), acanthurida (*A. triostegus*), cardinal fish, wrasses, angelfish, scorpion fish, etc. Other fauna include the long-spined sea urchin (*Diadema setosa*), a variety of molluscs often anchored in the coral, the giant sea anemone, lobsters and turtles.

In addition to their undisputed value in attracting tourists, Kenya's coral reefs are also important for fisheries, with the tourism industry as one of the main markets for fish products. The most important fishery areas are in the north of Ungwana Bay, offshore near Lamu, and in areas some 20km and 80km north of Lamu respectively. Malindi and Lamu are important fishing ports with industry based on and around the coral reefs. The maximum sustainable yields along this part of the coast have been estimated by FAO at 5 tonnes/km^2. Unfortunately, tourism also creates demands on the inedible reef resources. Large quantities of shells and corals are known to have been collected in the Shimoni, Lamu and Kiunga areas and even within some marine parks. Many species are probably being overexploited and careless collection methods have led to serious habitat damage. Despite controls, large quantities of coral and shells are still exported from Kenya.

These pressures, coupled with silt deposition from rivers draining agricultural land and pollution from the cement industry, chemical and textile plants near Mombasa, domestic effluent, mining and oil discharges from tanker traffic, have diminished both the productivity and the species richness and diversity of the entire coast. Virtually all reef outside of the marine parks is degraded to some extent. In the extreme south, some coral has been destroyed by dynamite fishing even though this is minimal when compared to Kenya's neighbouring countries.

Recovery of degraded reefs is very slow and it could take up to 50 years for a reef damaged by dynamite fishing to repair itself.

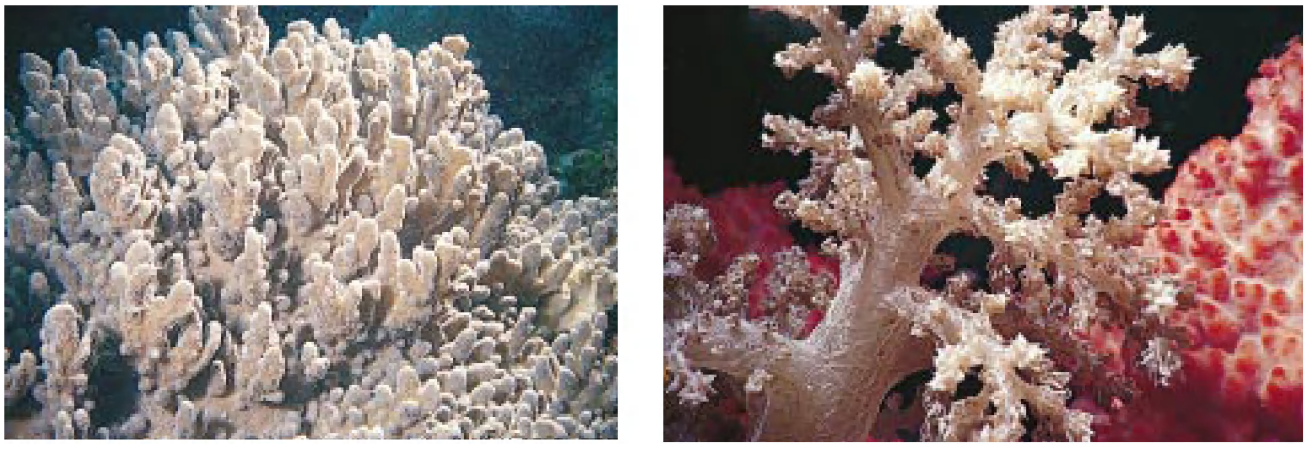


Figure 17 : Hard and soft corals abound along the Kenya coast

SPECIES AT RISK

The coastal and marine species which inhabit Kenyan waters have been little studied and the majority are not well known. However, the small and inconspicuous terrestrial species of the coastal zone such as the butterflies, other insects, small mammals, reptiles, etc, are probably even less known. All these poorly known or as yet unknown species are at risk as a result of their anonymity. Listed below are coastal and marine species which are known, some better than others, and which are considered at risk. These include the species that are endemic to Kenya; those which are listed in the IUCN Red Data Books as threatened; those that are migratory and which have their critical habitats spread over two or more countries; and, those commercial species that are threatened by over-exploitation or habitat degradation.

As can be expected the number of endemic species within any continental country is comparatively lower than the number of similar species from island nations. This is because many species roam throughout a range of habitats over and beyond national boundaries. However, Kenya would seem to have more known coastal and marine endemics than the other mainland countries of Eastern Africa, though this higher number may just be a reflection of the extent of research rather than the comparative richness of endemic species.

The 12 coastal and marine species which are endemic to Kenya are listed in Table 6 below. To these can be added the 6 species which Kenya shares with Tanzania (i.e. Ader's Duiker, *Cephalophus adersi*; Amani Sunbird, *Anthreptes pallidigaster*; Sokoke Pipit, *Anthus sokokensis*; East Coast Akalat, *Sheppardia gunningi sokokensis*; Spotted Ground Thrush, *Turdus fischeri fischeri*; Caecillian, *Schistometopum gregorii*) and a further 2 species which are endemic to Kenya, Tanzania and Mozambique (the Plain-backed Sunbird, *Anthreptes reichenowi*; and the East Africa Dragonet, *Callionymus marmoratus*).

The Coast appears to be the habitat for the majority of Kenya's internationally threatened species. Of 159 species of trees and shrubs that are considered threatened, 38% of them come from the Coast; of the 71 species of threatened birds, 27% inhabit the Coast; while out of 9 threatened mammal species, 55% are in the Coast environment. These percentages are the highest for each of the three groups and only the afromontane

Table 6 : Marine and coastal species endemic to Kenya

	common English name	scientific name
MAMMALS	Striped bush squirrel	*Paraxerus flavivittis*
	Coastal red-legged sun squirrel	*Heliosciurus rufobrachium undulatus*
	Giant Cane rat	*Thyronomys swinderianus*
	Thomas silvery mole rat	*Heliophobius spalax*
	Golden-rump elephant shrew	*Rhynchocyon cirnei chrysopygus*
	Coastal suni	*Neotragus moschatus kirchenpaueri*
BIRDS	Tana River cisticola	*Cisticola restrica*
	Malindi pipit	*Anthus melindae*
	Sokoke scops owl	*Otus ireneae*
	Clarke's weaver	*Ploceus golandi*
FISHES	Mombasa butterfly cod	*Pteropterus mombasae*
PLANTS	Euphorbia	*Euphorbia warkefieldii*

environment shows any similar concentrations of threatened species, even though in the latter, the number of species is half that inhabiting the Coast.

The following Table 7 comprises those Kenyan species that are thought to be threatened in some way or another. Species considered Endangered are in danger of extinction and their survival is unlikely if the causal factors continue operating unchanged. They include taxa whose numbers have been reduced to a critical level or whose habitats have been drastically reduced or altered. Vulnerable species are those believed likely to move to the Endangered category in the near future if the causal factors continue operating. Their populations are currently showing declining trends either because of over-exploitation or as a result of extensive destruction of their habitat or some other serious disturbance. Species with small world populations which are neither Endangered nor Vulnerable but are still considered at risk are classified as Rare. These are usually taxa confined to small geographical areas or thinly scattered over a more extensive range. Indeterminate/Status Unknown species are thought to be either Endangered, Vulnerable or Rare, but the information available is not sufficient to determine precisely which category they should be assigned to. Species that are commercially threatened may not be threatened with extinction at present, but their rate of exploitation is such that their long-term commercial sustainability is at risk. These would include species that have been overexploited to the point of local extinction.

The two marine species that are considered Endangered in Kenya are the Green Turtle and the Hawksbill Turtle. They are both discussed in the section further below. Another turtle, the Loggerhead as well as the Dugong are classified as Vulnerable. Three bird species and a mollusc are considered as Rare and two molluscs and the Spiny Lobster have been classified as Commercially Threatened. The rest of the list requires further research before the remaining four species could be placed in any one category with certainty.

Table 7 : Threatened marine and coastal species in Kenya

	common name	scientific name	status
MAMMALS	Dugong	*Dugong dugon*	vulnerable
BIRDS	Sokoke Pipit	*Anthus sokokensis*	status unknown
	Amani Sunbird	*Anthreptes pallidigaster*	rare
	East Coast Akalat	*Sheppardia gunningi sokokensis*	rare
	Clarke's Weaver	*Ploceus golandi*	status unknown
	Spotted Ground-Thrush	*Turdus fischeri fischeri*	rare
REPTILES	Green Turtle	*Chelonia mydas*	endangered
	Hawksbill Turtle	*Eretmochelys imbricata*	endangered
	Loggerhead Turtle	*Caretta caretta*	vulnerable
MOLLUSCS	Triton's Trumpet	*Charonia tritonis*	rare
	Green Snail	*Turbo marmoratus*	commercially threatened
	Fluted Giant Clam	*Tridacna squamosa*	indeterminate
	Small Giant Clam	*Tridacna maxima*	insufficiently known
	Pearl Oyster	*Pinctada spp.*	commercially threatened
CRUSTACEANS	Spiny Lobster	*Panulirus spp.*	commercially threatened

MARINE TURTLES

Out of the world's eight species of marine turtles, five have been recorded on the East African coast. Out of these, the two that are found commonly nesting on the Kenyan shores are the green turtle (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*).

There are 22 known nesting beaches stretching from Funzi Island on the south coast to north of Manda Island in the Lamu archipelago. The nesting season follows the northeast and the southeast monsoons with the peak of nesting for the green turtle between March and June and for the hawksbill turtle between December and January. The Olive Ridley turtle (*Lepidochelys olivacea*) was recorded nesting at Ras Tenewi Island 20 years ago.

Traditionally, marine turtles have always been utilised, but over-exploitation of their meat, oil, shell, leather and eggs now threatens their survival. Incidental capture of the green turtles in fishing nets, including trawls, drift nets and gillnets, in the open sea results in many turtles being killed, often as they are trying to reach nesting beaches. Development along the Kenyan coast has also resulted in the widespread loss of turtle nesting sites. Security lights at night, walls and other structures, solid wastes especially plastic debris, oil and similar toxic liquid wastes and domestic sewage discharges all have an impact on the turtles. Some of these impacts are direct such as the deterring lights or the physical barriers hindering access to the beach. Others are more subtle such as the impact of toxic discharges and eutrophication on the seagrass meadows which are a prime source of food for the turtles.

A Sea Turtle Conservation Project has been established to enhance breeding populations through the protection of breeding sites, animals, eggs and hatchlings. Information on the occurrence, feeding, nesting grounds and threats, is obtained from local people; nests are identified from the telltale flipper marks on the sand; feeding areas established by noting the preferred seagrass species; and, the seasonality of nesting behaviour for both the hawksbill and the green turtle has been determined by correlating behaviour with phases of the moon, tide and monsoon seasons. Local people are given monetary rewards for the location and protection of nests *in situ* and the money goes towards a modest improvement in their subsistence living while reducing the threat to the turtles.

Safe nests are left and protected *in situ*, while eggs from endangered nests are carefully dug out, marked and transferred to hatcheries for incubation. After about 60 days, the newly hatched turtles are weighed and measured before being released. The release often involves local people as well as visitors from local

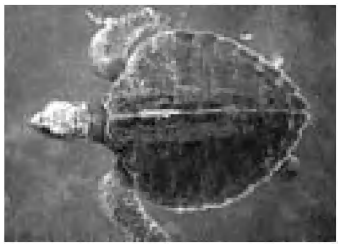


Figure 18 : Hawksbill turtle (Eretmochelys imbricata)

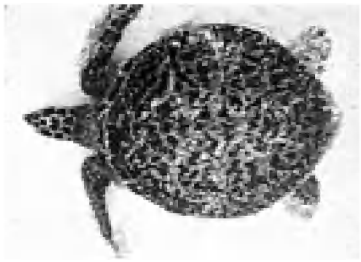


Figure 19: Olive Ridley turtle (Lepidochelys olivacea)

hotels, thus involving more of the wide community. A tagging programme is also planned so that more is learned about the turtle's behaviour and therefore their potential threats.

Ultimately, the only way to protect the turtles from extinction is to identify the most critical nesting beaches and either prevent development or ensure that existing development is in harmony with the survival of the turtles. Areas which have already been identified include, on the north coast - Nyali, Serena, Jumba ruins, Kikambala, Takaungu, Bofa, Watamu, Malindi, Mambrui, Robinson Island, Kipini, Ras Tenewi Island, Kipungani, Manda and Kiunga; and on the south coast - Shelly, Tiwi, Diani, Msambweni, Chale Island and Funzi Island.

Figure 20 : Green turtle (Chelonia midas)

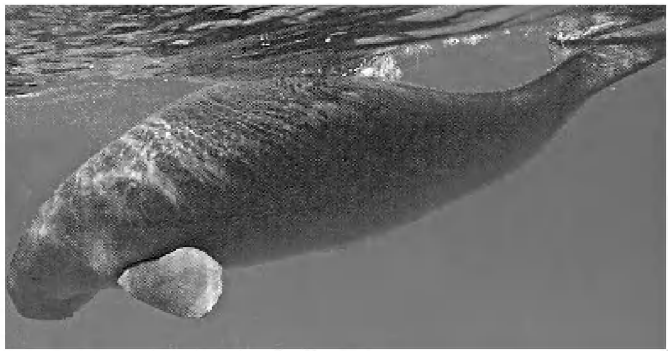


Figure 21 : Dugong dugon

MARINE MAMMALS

Popularly known as seacows or manatees, the herbivorous *Dugong dugon* is severely depleted throughout the shallow coastal waters of Somalia, Kenya, Tanzania and island waters. The dugong is heavily exploited by the local people for its meat, oil, skin and medicinal/aphrodisiac products. It is also killed by accidental drowning when caught in fishing nets, when hit by power boats and as a result of seismic exploration activity. Although it has legislative protection in much of the region, enforcement is inadequate.

The Kenyan coast, in common with the rest of the Indian Ocean, is an important habitat for a variety of Cetaceans which are severely depleted worldwide. In fact, the Indian Ocean is a sanctuary for great whales. Dolphins, however, are not protected and thousands are lost each year through incidental kills from fishing activities.

MIGRATORY AND OTHER COASTAL BIRDS

The Kenyan coast provides a number of habitats for migrating and local birds. In addition to the intertidal areas, especially mudflats, other habitats include creeks, narrow recesses in the coastline subject to tidal movement, estuaries, and salt pans which are small natural depressions flooded only occasionally and filled with salt deposits. Tidal creeks are often lined with mangroves which may form dense swamps and these are excellent habitats for a variety of bird species. Of the 1,100 bird species recorded in Kenya, more than 450 species (41%) are found in the coastal strip.

BIODIVERSITY IN ARABUKO-SOKOKE

The Arabuko-Sokoke forest has been identified as the most important area of land for biodiversity conservation in Kenya. Rare mammals, birds and plants abound in the forest. One bird species, Clark's Weaver, is found nowhere else in the world; another, the Sokoke Scops Owl, is known only from Arabuko-Sokoke and one small forest in Tanzania. The forest has been ranked by Birdlife International as the second most important forest for bird conservation in the whole of continental Africa.

Arabuko-Sokoke is also of enormous importance for the local people - more than 80,000 people around the forest depend on it for fuel, foods and medicines. Eco-tourism is being developed, and the East Africa Natural History Society now oversees an innovative project to train people living next to the forest to raise forest butterflies for export.

Figure 22 : Various terns and common noddy

Among the many species found in these localities, is the Great White Egret, almost 90 cm long, with striking white plumage, entirely black legs and a noticeably long black or yellow bill. It is a member of the heron family and closely related to the Yellow-billed Egret and the Little Egret.

Locally seen at coastal salt pans, estuaries and creeks is another similar sized bird, also with all-white plumage, but with bare red legs and face. This is the African Spoonbill with its distinctively shaped bill. In lagoons and estuaries it is often possible to come across the Sacred Ibis with its white feathers, bare black head and neck, and its down-curved elongated bill. A strange-looking bird, about 35cm long, with a large head and big yellow eyes, is the Water Thicknee which is widespread along the creeks and islands. The large eyes are an adaptation for its mainly nocturnal habit. In some respects the Thicknee resembles bustards. They can also be said to resemble plovers, however, they are a family in their own right.

Figure 23 : Verraux's Giant Eagle Owl

In the calm waters of creeks and estuaries it is common to find Fish Eagles which are widespread around Kenya. The Pied Kingfisher, with its distinctive black-and-white plumage, can be seen characteristically hovering over water in creeks and estuaries. Immediately its prey is spotted, the bird plunges headlong into the water with eyes closed and comes up almost immediately, with or without fish. Its chances of a successful catch are only about one in ten.

A great deal of shoreline is thickly wooded and when the indigenous trees in these forests are in fruit, it is usual to hear the loud raucous braying of the Silvery-cheeked Hornbill. This is about 70 cm in size and belongs to a distinctive group of

birds with a big down-curved bill, frequently surmounted by a large, often grotesque, growth on the upper mandible.

With distance inland from the sea, the bushy grassland is home for a slim bird with a long slightly down-curved bill and bright plumage with its very elongated central tail feather. This is the Carmine Bee-eater with its mostly carmine-red body, and greenish and cobalt-blue head, neck and rump. Between November and the end of March they are seen in their thousands roosting in the mangroves north of Mombasa. The Little Bee-eater offers a sharp contrast to its relative, being smaller in size and mostly green with a yellow throat and lacking the elongated tail feather. Along the course of coastal rivers and streams, in trees, bushes and reeds, can be seen and heard a noisy breeding colony of an entirely yellow bird with a bright orange head and black eyes. This is the Golden Palm Weaver frequently associated with its look-alike, the Golden Weaver which, however, has a chestnut head and pale red eye.

Further inland is the Arabuko-Sokoke Protected Forest which is home to some endemic and threatened birds. This forest is discussed elsewhere in this book.

Among the critical bird habitats on the Kenya coast, the islets off Kiunga at Ras Tenewi deserve special mention because they are the breeding and feeding grounds for a number of important marine bird species. These species include the Bridled Tern (*Sterna anaethetus*), the Roseate Tern (*Sterna dougallii*), the White-cheeked Tern (*Sterna repressa*), the Common Noddy (*Anous stolidus*) and the Sooty Gull (*Larus hemprichii*).

Eastern Africa as a whole receives 159 species of migrating birds and about 29 of these are waders or shorebirds. While the Greenshank is a common migrant to all the wetlands in Kenya, the largest numbers are recorded from the Coast. Another visitor, the Little Stint, is only 12.5cm in size and the smallest of the wintering shorebirds arriving by the beginning of August. A small dumpy bird, seemingly running at breakneck speed as it feeds along the tidal margins, is the Sanderling.

COASTAL GIANT MILLIPEDES

The Giant Millipedes of the Kenya Coast are not uncommon but they are certainly not well known. The largest of these is *Archispirostreptus gigas* which can grow to length of over 10cm. Like many other giant millipedes, *A.gigas* can cause serious localized seasonal damage to crops and small forestry seedlings. In dry conditions, millipedes turn to living plants as a source of food and they burrow down and seek shelter in crevices. On the other hand, under wet conditions their populations appear to increase explosively but they seem to confine their diet to leaf litter and other dead plant matter.

Epibolus pulchripes is more common on the Coast than its larger cousin. It is also more conspicuous with its bright orange-red legs. This species very seldom damages living plants, but instead is a very valuable agent in humus formation.

Predators of millipedes include the Civet, which is not found in large number on the Coast, the Banded Mongoose, and a number of birds for whom millipedes do not seem a main dietary item. Among those that are know to prey on millipedes are the Fiscal Shrike, the Red-Billed Hornbill and the Cuckoo.