

A GENERAL ECOLOGICAL SURVEY OF SOME SHORES IN NORTHERN MOÇAMBIQUE

by

MARGARET KALK

(University of the Witwatersrand, Johannesburg)

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i. INTRODUCTION

The shores of northern Moçambique are well within the tropics, reaching latitude 10° S at the northern limit. Collections of shore animals have been made from time to time and authors of taxonomic studies have frequently pointed out affinities of the fauna with that of the west Pacific. The coast is considered part of the Indo-west-pacific province of Ekman.

Tropical features such as confluent coral reefs, fields of *Cymodocea* on intertidal flats and zoned mangrove swamps persist as far south as Inhaca Island (latitude 26° S) in Southern Moçambique (KALK, 1954 and 1958, MACNAE and KALK, 1958), as a result of the influence of the warm equatorial waters of the southward flowing Moçambique current. A number of tropical species intrude even into Natal in South Africa for the same reason (STEPHENSON 1944 and 1947, SMITH 1952 and 1953). But in Natal and to a lesser extent at Inhaca the gross facies of the upper levels of the rocky shores are not unlike warm temperate South African shores and might be termed sub-tropical in character. The lower shores at Inhaca have many more tropical species than Natal, but

are not so rich in species nor in individuals as are tropical shores. A general ecological study of the wholly tropical shores of northern Moçambique, promised to be of some interest, and a first survey was carried out therefore, in November 1955.

Moçambique Island (latitude 15° S) at the northern end of the Province was chosen as a base. It has both semi-exposed and completely sheltered shores with rock and sand habitats. At Chakos, the north-east point of Moçambique Bay and at the Isle of Goa some 8 Km. east of Moçambique Island are beaches exposed to the full force of the ocean. These, as well as the typical semi-sheltered shore at Baixa da Pinda (latitude 12° S) at the south-east point of the Bay of Memba, were examined. Sheltered shores in Conducia Bay, Nacala Bay and at Quissimajalo were also inspected. For comparison, additional places in the south of the Province were visited, such as Santa Carolina (latitude 22° S) and the rocky shore of Inhambane (latitude 24° S), where the University of Cape Town Survey had been investigating the estuary. The locations of the places visited are indicated in Fig. 1, which also shows the direction of the ocean currents that are responsible for the nature of the littoral fauna of the southern African coasts.

ii. GENERAL PHYSICAL CONDITIONS OF NORTHERN MOÇAMBIQUE SHORES

The temperature of the air at the meteorological station at Mossaril in Moçambique Bay has a mean minimum of 20.0° C and a mean maximum of 30.6° C with a mean annual temperature over the last 25 years of 25.3° C. This is 2.5° C higher than at Inhaca and 4.8° higher than at Durban in Natal. Sea temperatures have not been recorded near land, but the range at these latitudes is given as 24° C in August and 28° C in February (SVERDRUP, JOHNSON and FLEMING, 1942), a slightly higher mean than that of the air. A record of sea surface temperature at latitude 20° S in the Moçambique Channel by the «William Scoresby» at 18 hours on 4-7-50 was 24.24° C. while the temperature of the air was 23.3° C.

An average of 955 mm. of rain falls in the year, two thirds of it in the summer months (Relatórios dos Observatórios, 1954). The rivers flow only in the summer months, and mangrove lines the greater portion of the sandy sheltered shores. But at Moçambique Island itself (as well as at the Isle of Goa), there is no mangrove; there is no fresh water at all, neither river, spring nor well. There is no evidence that the salinity of the surface water is other than that of the Indian Ocean at this latitude, namely 35.1 parts per thousand (Discovery Report, 1955). As a consequence of lack of river water, the sea is exceptionally clear during the greater part of the year. The coral reef is

reputed in naval circles to be the most clearly visible along the coast of the whole Province. Details were easily seen while snorkeling above the reef in 10—15 m. of water.

The tidal range is greater than in South Africa, being 4.0 m. at the northern end of the Province, and the pattern of tides is semi-diurnal and equal (Tabelas de Mares, 1955).

There are a number of bays at these latitudes with very sheltered shores. But even those fully exposed to the Indian Ocean are semi-sheltered, since a submerged coral barrier with occasional breaks stretches across the entrance to the bays. Strong wave action is thus exceptional since the force of the waves is lost when they break on the bar. The east shore of Moçambique Island and that of Baixa da Pinda were thus typical of the area.

iii. THE FAUNA ON THE SHORES OF MOÇAMBIQUE ISLAND

Moçambique Island is small (3 x 0.4 km.), but very densely populated. Its fortifications rise sheer from the sea at high tide, but when the tide is low, a sandy beach about 100 m. wide is exposed on the west, and on the east a beach, mostly rocky, about 350 m. wide. The island is almost in the centre of Moçambique Bay (15 x 10 km.) and an outer ring of islands and rocky shoals gives some shelter from the Indian Ocean. Fig. 2 shows the position of the island, the shallows of the bay and the deeper channels along which the breakers travel, meeting north-east of the island. The greatest amount of wave action is thus at the north-east point on the edge of the channel opposite a gap in the bar. There is a well-developed submerged reef about 5 km. distant and a good deal of coral in the shallow water of the bay.

The semi-exposed shore

The north-east shore has a vertical drop of 4 m. over a horizontal distance of 350 m. From highwater a fairly steep slope of sand 50 m. long, extends to mean tidal level ending in an interrupted wall of sandstone rock 3 m. high, eroded into little turrets and pinnacles. The remainder of the shore, below mean tidal level, takes the form of two rocky platforms with a shallow step between them at a distance of 250 m. down the shore (Plate I).

The platforms are a patchwork of sand-covered rock and bare rock, so that the communities characteristic of either sand or rock exist here side by side, at all levels on the lower shore. The sand is of varying depths, and accumulations occur in shallow pools or heaped around ridges between the pools. There are little nests of deeper moist sand in hollows or merely thin

layers covering rock. Both sandy and sand-free rock are fully colonised by plants and animals. The distribution of the common animals is shown in Fig. 3.

The supralittoral fringe

In the sandy slope behind the rock barrier at the level of mean high neap tides, the sand mussel, *Donax faba* and the crab, *Ocypode ceratophthalmus*, are present. *Coenobita rugosus*, a land hermit crab is common in *Nerita* shells.

On the rocks at high level, a little black lizard, scampered among the rock crabs, *Grapsus strigosus*, and numerous crested blennies, *Antennablennius bifilium*, leapt from ledge to pool when disturbed. Species of *Nerita* are common, namely *N. plicata*, *polita*, *textilis* and *undata*^{*}. Periwinkles are uncommon, although *Littorina obesa* and *Tectarius natalensis* were both found. There are many false limpets, *Siphonaria carbo*, in crevices and an unidentified small white conical patellid^{*}.

The midlittoral

At the foot of the high level rocks on their landward side, is a band of closely packed bivalves *Perna dentifera*. These are asymmetrical, white, black-edged mussels which are present where protection from wave action is afforded, and are also characteristic of the rocks inside the bay. Very few barnacles, and only *Chthamalus dentatus*, were seen above and below the pearl oysters. There are more of them on the seaward sides of the rocks.

The clean golden sand below the rocks is dotted with rings of tentacles protruding from holes. Some were from burrowing edwardsiid anemones others from *Holothuria pervicax* and still others from terebellid worms that could not be extracted whole.

On the raised ridges throughout the length of both platforms, the marine angiosperm, *Diplanthera uninervis* is dominant, growing about 10-15 cm. long. Sandy depressions and pools are overgrown with the flowering plants *Cymodocea serrulata* and *C. rotundata*. Where the sand is not so thick, the brown alga *Padina commersonii* occurs at middle levels. A short mixed algal turf surrounds the rims of pools. *Valonia macrophysa*, *Colpomenia* sp. *Turbinaria ornata* and a species of *Ulva* spread over rock boulders, and *Halimeda cuneata* or *Hormophysa triquetra* occur in pools. One of the commonest is a siphonous green alga like a ball of string, *Valoniopsis pachynema*.

^{*} Not found at Inhace.

Cymodocea ciliata is confined to the lower platform, i. e. to the infralittoral fringe. In general, the plant population on the shore is predominantly of marine angiosperms, as on a sheltered tropical shore. Algae take a second place, but are by no means rare, probably because there is sufficient wave action to prevent the deposition of silt.

In the small wet pockets of sand, handfuls of the yellow enteropneust, *Ptychodera flava* could be collected. In deeper patches of sand on the lower platform there are occasional mounds formed by the worm casts of a large enteropneust, probably *Balanoglossus studiosorum*.

The most conspicuous animals on the shore are echinoderms. The brittle stars *Ophiocoma valenciae*, *O. scolopendrina*, *Placophiothrix venosa* and *Ophiactis modesta*, in pools among the plants, are not hidden from view but very actively feeding and moving. The cucumbers *Holothuria atra*, *H. leucospilota*, *H. difficilis* and *Actinopygia mauritiana* are littered about in profusion and sometimes coated with sand, but not burrowing. The sea urchin *Echinometra mathaei* is crowded so densely in pools of all kinds that there is scarcely room to set foot.

Whenever the rock surface is not very sandy, colonies of *Zoanthus sansibaricus* form a thick coat. But other zoanthids were not seen. The rock ridges between the pools are crowded with masses of the asymmetrical bearded mussel, *Modiolus barbatus*, instead of by barnacles as in the south of the province and in Natal. This mussel also packs the vertical face of rock between the two horizontal platforms. Although this species forms part of the diet of the native population and bushels are removed every day of spring tides, the numbers on the rocks and among the *Cymodocea* are incredibly high. The intense decimation of their numbers has no apparent effect.

The lower shore appears to have no barnacle population, except at the north-east point, where the strong current in the channel sweeps into the bay, and there it is crowded with *Balanus amphitrite* var. *communis*.

In the shallow pools there is a wealth of tropical animals. The gastropods are those typical of sheltered shores such as *Cerithium caeruleum*, *C. morus* and *C. kochi*, *Planaxis sulcata*, *Nerita albicilla* and *Turbo marmoratus*. Lower down the shore Columbelloids such as *Columbella fulgurans*^{*} and *C. mendicaria* are common. Many species of crabs such as *Xantho exaratus*, *Etisus laevimanus*, *Pilumnus vesputilio* and *P. trichophoroides* were seen.

There are some large coral pools on the first platform containing animals more typical of the lower platform. Both may be considered as an extension of the subtidal on to the shore, an infralittoral fringe.

Coral pools and the coral reef

Large circles of corals enclosing shallow water form pools and the following species were collected: *Pavona frondifera*^{*}, *Coeloria lamellina*^{*}, *Pori-*

*tes porites**, *Pocillopora verrucosa*, *P. damicornis bulbosa*, *Stylophora pistillata*, *Montipora venosa* and *Favia favius*. Alcyonacea, very large anemones and sponges (unfortunately not yet identified) are also present. The sea urchins, *Tripneustes gratilla*, and *Prionocidaris pistillaris** accompanied the ubiquitous *Echinometra mathaei*; species of *Holothuria*, *Stichopus chloronatus* and the starfishes *Linckia multifora*, *Culcita schmideliana*, *Nardoa variolata**, *Protoreaster linckii* and *Asterina burtoni* are common. Ophiuroids are very numerous including a number of Ophioderms as well as Ophiocomids and Ophiotrichids.

The associates of the coral were not extensively studied, but conspicuous animals were collected. The usual coral crabs such as *Trapezia cymodoce* and *T. guttata* were common as well as other xanthid species such as *Chlorodopsis areolata**, *Hypocolpus diverticulatus**, *Libinia plumosa* (which carries a tiny anemone in each chela) and *Lissocarcinus orbicularis* (which is associated with *Holothuria atra*). The spider crabs *Dehaanius 4-dentatus* and *Elamena mathaei*, *Menaethius monoceros* were known from the south, and *Micippe philyra**, and *Pseudomicippe nodosa** were new records.

Some Polychaeta were taken from the dead bases of corals, loose rocks and algal turf around the edges of pools. Two thirds of them proved to be similar to the species found with coral debris and with the sandy worm tubes of *Idanthyrsus pennatus* in the south. Six species including the plume worms *Fabricia mossambica** and *Chone collaris** had not been found further south. The sipunculid *Physcosoma stephensoni* was as common as in Natal.

A description of a tropical shore cannot ignore the fish population, since the numbers of species and of individuals make them a conspicuous section of the shore community. Eels are numerous and active, travelling from pool to pool when disturbed. The only ones caught were *Echidna nebulosa*, *Siderea picta* and *Ariosoma anago**. The gobies *G. albomaculatus**, *G. nebulosus*, *G. capistratus* and *Bathygobius fuscus*, the blennies *Halmablennius dussumieri*, *Omobranchus striatus* and the blenny-like *Enneapterygius obtusirostre** were collected. Numerous coral fishes belonging to the genera *Abudefduf*, *Amphiprion* and *Chaetodon*, and various labrids and tobies typical of coral reefs were seen.

Submerged coral growing in 1-10 m. of water was observed at various points north-east of the island nearer the mainland, to see whether there were any major differences from the coral reef at the end of its range in the south, that had not been revealed in the infralittoral fringe of coral pools. Several were noted:

The dominant coral over large areas is *Galaxea clavus**. Colonies grow 5—10 m. high in impressive solid pillars constructed of cylindrical pipes about 10 cm. in diameter. The polyps were visible and their colour cast a brick-red glow over the reef. This species had not been found in the Inhaca reef.

Several species of the more delicate genus *Acropora* were taken: *A. arcuata*, *loripes*, *thurstoni*, *listeri*, *quelchi* and *decipiens*. There is a rich growth of

the stinging hydroid coral, *Millepora alcicornis*^x in which the little barnacle *Pyrgoma milleporae*^x is embedded. There are no fire corals in the southern reefs. Additional species of *Pocillopora* are present: *P. setchelli*^x and *P. modumanensis*^x, and *Seriatopora verrucosa*^x. There are large plates of *Turbinaria* arranged like a giant lettuce, rippling mounds of *Montipora* and solitary slabs of the large fungid *Herpolitha limax*^x. All of these genera are similar to those recorded in the coral reefs of the New Hebrides (BAKER, 1925) and the Great Barrier Reef Islands (STEPHENSON, STEPHENSON, SPENDER and TANDY, 1931), but very few of the species are common to the west and east Pacific Ocean.

The associates seen on the shore in coral pools are characteristic of the fully developed subtidal reef: giant anemones, green and white alcyonaceans, and in addition there are port-wine coloured gorgonids, huge fan-like sponges and tridacnid clams. Echinoderms are not conspicuous and it was not possible to investigate the coral fishes or smaller associates.

The sheltered shore

The west shore of Mocambique Island facing the bay is still more sheltered than the east. Vertical rocks form a cliff above high tide down to mean tidal level. The rest of the shore consists of gently sloping sand flats, leading down to the channel.

On the rocks the main difference from the east side is the presence of scattered oysters, *Crassostrea cucullata* below the *Perna dentifera* belt. Among loose stones at midtidal level, the serpulid worm, *Pomatoleios kraussi*, which forms a dense belt in Natal, occurs as isolated calcareous tubes. Beneath the stones were many brittlestars such as *Ophiocoma scolopendrina* and *O. valenciae*, the sea-cucumbers *Holothuria hilla* and *H. erinaceus*^x, two tropical plume worms *Fabricia mossambica*^x and *Chone collaris*^x, and some terebellid species *Thelepus setosus*^x and *Terebella ehrenbergi*^x.

The dominant worm is *Mesochaetopterus minutus* whose colonies of sandy tubes form large hillocks. The usual scavenger gastropods of sand flats such as species of *Nassarius*, *Natica* and *Polynices* roam the surface and their shells are often inhabited by hermit crabs such as *Clibanarius longitarsus*, *C. padavensis* and *C. virescens*, *Diogenes senex* and *D. avarus*. The burrowing brittle star *Amphioplus integer*, the sipunculid *Siphonosoma cumanensis*, eels, gobies and burrowing anemones were frequent. Burrowing polychaetes were abundant in the sand.

A striking feature of the middle shore is a patch of rock just below mean tidal level which was covered with a brilliant green *Ulva*-like alga. Marine angiosperms covered the lower shore and division into zones was just recognisable, since they were compressed into about 50 m. of shore. *Diplanthera uninervis* soon gave place to an association of *Cymodocea serrulata* and *C. rotundata* and within a few metres *C. ciliata* was dominant.

The dominant animal on the lower shore is a large *Balanoglossus* (*studiosorum*?) and numbers of the pink enteropneust *Willeyia delagoae* (?) were also found. Cucumbers and sea urchins similar to those on the east shore were plentiful.

Among the *Cymodocea* weed, fungid corals such as *Fungia costulata*^x and *F. cyclolites*^x, red and green alcyonaceans, burrowing anemones and small corals (usually *Pocillopora* spp.) are abundant. The hammershell *Malleus legumen*^x and the bivalve *Circe pectinata* occur very frequently.

Deserving of special mention is the little spider crab *Cyphocarcinus capreolus*, which is compressed like a shrimp; it carries a twig of *Cymodocea* on its rostrum. This has been collected at Inhaca, but not otherwise recorded south of the Red Sea. Another spider crab, *Eumedomus granulatum*, and the brittle star, *Ophiothela beauforti*, were found on the sea urchin, *Eucidaris metularia*.

iv. STRONG WAVE ACTION ON THE ISLE OF GOA AND AT CHAKOS

The Isle of Goa with its lighthouse near the entrance to Moçambique Bay, is 8 km. east of Moçambique Island. Waves break on the shores and are almost 3 m. high, so that the effect of exposure to wave action could be seen in very definite form. It could well be assumed that the fauna there would be typical of the few really exposed rocks that exist at these latitudes.

The vertical cliff on the south-east was rather shaded during the heat of the day. Hundreds of the large yellow *Grapsus maculatus* were seen, confirming that it is the grapsid of exposed tropical shores. Chitons 10 cm. long with spiny girdle, *Acanthopleura brevispina*^x, and *Oncidium*^x sp. of similar size were common, *Nerita* spp. were the only gastropods at high level and periwinkles were rare, even on the rockfaces more sheltered from the waves.

There were no oysters and no band of bivalves, but a large pink barnacle, a *Tetraclita* species was dotted on the vertical cliff, and on the horizontal platform to some extent. *Thais intermedia* and *T. mancinella*, *Cellana capensis* and *Siphonaria oculus* were present but infrequent, but small anemones were found in every crevice. The blue *Eriphia scabricula*^x was the commonest crab.

The flat platform on the midlittoral was rather bare of animals, but covered with a closely-knit green algal growth. There was no *Cymodocea* (characteristic of sheltered shores) to be seen. At the lower levels there were communities of red and brown algae including articulated corallines. Under loose stones there were colonial tunicates such as *Aplidium* spp. *Polyclinum macrophyllum*^x, *Didemnoopsis sansibaricum*^x and *Didemnum psammatoedes*^x.

Sponge coated the edges of pools. Brown zoanthids were present but did not occupy large enough areas to form a belt.

The lower levels of the shore were populated with coral species forming isolated colonies or pools just as on Moçambique Island. The extent of this fringe was lessened by the configuration of the rock which fell away into deep water at low spring tide.

v. SHELTERED SHORES IN NORTHERN MOCAMBIQUE

The small rivers of northern Moçambique wend their way to the sea through flat land covered with dense mangrove. A typical estuary then broadens out into extensive *Cymodocea* covered flats making a wide sheltered bay with a narrow channel down the centre. The entrance to the bay is for the most part barred by submerged coral. Even when the rivers are dry, tidal water extends many miles inland up small channels in the mangrove. From the air the colour of the trees enables one to pick out the course of these channels and to detect a distribution pattern which one cannot easily distinguish on foot, for the density of the vegetation hinders investigation. *Rhizophora mucronata*, with its darker leaves, lines the banks of the channels, and the lighter yellower *Ceriops tagal* occurs on the drier parts of the swamp. *Avicennia marina*, the pioneer, is taller and fringes both the seaward edge, mixed with *Sonneratia alba*, and the older inland parts. *Bruguiera cylindrica* indicates wetter pockets. On the inland edges of the swamps there are large bare sand flats only flooded at spring tides, not yet colonised by trees nor by halophytes.

From what has been seen of the mangroves at Lumbo and Mossaril in Moçambique Bay and at Geba near the Bay of Memba, the animals and plants follow a similar zonation pattern to that described for the Inhaca mangrove (MACNAE & KALK, 1958). Though the species are different, the zonation is similar to that in the Batavian mangroves (VERWEY, 1932) and the Malayan swamps (WATSON, 1928).

The landward fringe is populated by the grapsid, *Sesarma*, the hermit crab *Coenobita* and the land crab *Cardisoma carnifex*. The bare flats at the level of high spring tides support only *Uca inversa*, the biggest of the fiddler crabs. *Avicennia* fringes give sufficient shade and water for *Uca annulipes* and *U. chlorophthalmus*. The wetter interior of the swamp is riddled with burrows of different species of *Sesarma* and *Uca* and the banks of the channels populated by the mud-skipping goby, *Periophthalmus*. The mangrove molluscs *Pyrasus palustris*, *Cerithidium decollata* and *Cassidula labrella* and the sheltered shore periwinkle *Littorina scabra* are common.

The bays visited departed from the general plan mentioned above according to the gradient of the shores. The periphery of Conducia Bay near Saua Saua, where a clear fresh spring comes to the surface above high tide level has, on a distinct slope, only a narrow fringe of mangrove consisting entirely of *Avicennia* with *Uca annulipes*. The greater part of the flats lies just below mean tidal level and is composed of fairly clean sand occupied by thousands of *Dotilla fenestrata*, a soldier crab, which makes only temporary dugouts and follows the tide down and back again, feeding on the way. They select food from the sand and reject little round fuzzy balls of sand that form a loose crumbly surface layer. The *Cymodocea* areas are narrow and confined to the banks of a deep channel in the centre.

At Quissemajalou near Nacala, the estuary has steep banks at high level and the greater part of the flats are towards low tide level; they are covered with *Cymodocea serrulata* and *C. rotundata*. The brittle star *Ophiocoma valenciae* had a density of around 50 per sq. m., and the tips of their outstretched arms touched their fellows. Many large green anemones, *Stoichactis* sp. with commensal fishes and prawns were anchored in the sand.

In Nacala Bay, rocks occur at high level and the gradient of the sandy shore was steep. There, *Cymodocea ciliata* is the chief species and it grows luxuriantly reaching over a metre high. Snake-like orange and spotted synaptids poise gracefully among the weed, licking the hydroids from the leaves with their tentacles in a leisurely way. On the rocks a sheltered-shore grapsid, *Metopograpsus oceanicus*^x, was taken. After a few metres of *Cymodocea ciliata*, the bottom drops suddenly to 27 m. deep.

In general, the distribution of the common animals and plants in the sheltered bays was like the west shores of both Moçambique Island and Inhaca Island. The relative proportions of the communities or organisms depended on the gradient of the shore, which in turn is a function of the size of the river and the tidal movements in the estuary.

vi. ECOLOGICAL PATTERNS ON THE SHORES OF SOUTHERN MOÇAMBIQUE

The coast of Sul do Save is characterised by a series of north pointing spits of land enclosing bays where small rivers enter the sea. The most southernly is the Inhaca peninsula; 200 km. further north a smaller replica occurs at Inhambane. Near Vilancoulos 300 km. to the north, the spit continues northwards as a series of low islands in the same line, forming the Bazaruto group including Ilha da Santa Carolina. Rocky headlands are exposed to wave action at the points of these land spits and otherwise the whole coast is a protected gentle sandy slope, since it is sheltered by an offshore submerged coral barrier.

The fauna of the rocks at Cabo Inhaca have been described in some detail (KALK, 1958). At Inhambane there is a similar cliff with wave cut terraces some of which are immersed at high tide and in some places there are two intertidal platforms. The plant and animal zonation does not differ from that on the exposed coast at Cabo Inhaca and at Ponta Abril on the Inhaca Peninsula.

It may be described briefly as being divided into a number of fairly clearly defined belts:

1. A supralittoral fringe extending above mean high spring tide level for 2 or 3 metres as a result of the splash and spray of waves, where the periwinkle *Tectarius natalensis* is abundant and above it *Littorina obesa* is common. Individuals of tropical species of *Nerita* are present.
2. The upper midlittoral on the cliff face is plastered with the tiny barnacle *Chthamalus dentatus* among which the large pink barnacle *Tetraclita serrata* occurs in large numbers. The oyster *Crassostrea cucullata* forms a distinct belt below. At Inhambane in rock crevices there are conspicuous clusters of the bivalve *Perna dentifera* which at Inhaca was less obvious and small in size. *Siphonaria oculus* and *S. dayi* and some *S. carbo* are frequent over the base of the cliff.
3. The lower midlittoral zone commences with large colonies of the vermetid mollusc, *Novastoa* sp. followed by a carpet of algal turf which is interrupted only by large sheets of zoanthids such as *Palythoa nelliae* and *Zoanthus zanzibaricus* among which are many sandy tubes of the polychaete, *Mesochaetopterus minutus*. Lower down the shore boulders are encrusted with sandy tubes made by the Sabellariid worm, *Idanthyrsus pennatus*. The tubes are inhabited by a host of commensals very similar to those associated with coral. Among the algae, some limpets, *Patella barbara*, may be found.
4. The infralittoral fringe is occupied partly by pure communities of smaller brown or red algae, partly by *Cymodocea ciliata* and to some extent by the tunicate *Pyura stolonifera*, which is particularly abundant under overhangs.
5. Coral is found only occasionally as isolated heads on the lower shore, but infratidally confluent fields of coral exist as at Inhaca.

The sheltered shores of Sul do Save are usually sandy. Sheltered rock has only been seen at Ilha da Inhaca and Ilha da Santa Carolina although

it is present at Xai Xai, for example, and some parts of the Inhambane estuary and, no doubt, other places not visited. Where the slope is very gentle and there is some influence from fresh water either as seepage as at Inhaca or from rivers as at Machangulo, Inhambane and the mouths of other rivers, the shores above mid-tidal level are occupied by mangrove. Otherwise gentle sandy slopes are found lapped by small waves. The lower parts of the shores are always occupied by belts of marine angiosperms.

In the extreme south of the colony at Inhaca Island the sheltered rocks are coated with the *Chthamalus dentatus* and *Crassostrea cucullata* on the upper shore. Periwinkles are far fewer, *L. africana* is rare and *Tetraclita serrata* apparently absent.

At midtidal level and on the lower shore wherever silt is not deposited, as for example on living coral bases, *Balanus amphitrite* var. *communis* is the chief barnacle. *Septifer bilocularis* is the commonest bivalve and the coral debris supports a medley of reef associates including a number of colonial tunicates, molluscs, xanthid crabs, sea cucumbers and brittle stars. Where rock offers a suitable substratum on the banks of deep channels with swiftly flowing tidal currents, a confluent reef occupies the infralittoral fringe and spreads to the infralittoral zone.

At Santa Carolina (latitude 21° 30' S), the rocky shores already have a more tropical appearance even at high levels. *Littorina africana* was not found and presumed to be absent. *Siphonaria carbo* which commences its range at Inhaca is very common and *S. capensis* was not found. *Acanthopleura*, the tropical chiton was present. *Crassostrea* was infrequent and *Melina dentifera* a little more common than at Inhambane. *Septifer bilocularis* was still present as well as colonies of the blue Vermetid, *Novastoa* sp. A white shelled Vermetid present as isolated individuals at Inhaca forms dense colonial masses. *Patella barbara* was not seen. The lower shore on the east coast consists of a flat platform with masses of coral debris and coral pools, while the west coast consists of fields of *Cymodocea*.

When the sheltered shores are sandy at high levels the slopes are inhabited by the crab *Ocypode* and bivalve *Donax*. In the more sheltered areas *O. ceratophthalmus* and *D. faba* are the species; when wave action is a little stronger, *O. kuhli* and *D. incarnata* and perhaps other species of *Donax* are found. Land hermit crabs, *Coenobita cavipes* and *C. rugosus* occur above high tide mark.

The mangroves in the south differ from those in the subtropical bays and estuaries of Natal which have been described for St. Lucia Bay (DAY, MILLARD BROEKHUYSEN, 1953), for Richards Bay (MILLARD and HARRISON, 1954) and Durban Bay (DAY and MORGANS, 1956), in that the zonation pattern of the trees and crabs is more fully developed. The pattern of the trees is similar to that of Kenya and Tanganyika (GRAHAM, 1929, WALTER H. and STEINER, 1937) apart from the absence of *Sonneratia alba* which occurs only further north.

Avicennia marina grows on both seaward and landward fringes of the mangrove swamp. *Rhizophora mucronata* lines the waterways, with *Ceriops tagal* and *Bruguiera cylindrica* mingled in a dense central thicket. Grapsid and Ocypodid crabs follow the topographical pattern from dry to wet in the order *Uca. inversa*, *U. annulipes*, *U. chlorophthalmus*, *U. urvillei* and *U. marionis* for fiddler crabs and the order *Sesarma eulimene* and *S. meinerti*, *S. guttata* and *S. catenata*, *S. longipes*, and *Ilyograpsus rhizophorae* for grapsids.

The lower parts of the sandy shore from midtide to the infratidal are covered with fields of marine angiosperms. The first belt is dominated by *Diplanthera uninervis* with which a little *Halophila ovalis* is mixed. It extends to the level of average low tide, giving way without a gap to an association of *Cymodocea serrulata* and *C. rotundata*. Below mean low springs *Cymodocea ciliata* or *Thalassia hemprichi* occur and with it may be mixed *Syringodium isoetifolium*, with its distinctive slender cylindrically rolled leaves.

There is sometimes a wet muddy «tubicolous worm zone» above the angiosperm belts where *Phyllochaetopterus elioti* is the dominant worm and *Macrophthalmus grandidieri* the dominant crab. This is a distinctive feature on the west coast of Inhaca Island. Drier patches of sand are dominated by *Dotilla fenestrata* at middle and lower levels. Sometimes large clean sand banks on the lower shore support an association of *Astropecten* and *Echinodiscus* with some pennatulids and alcyonaceans, while muddier sand banks are the homes of large numbers of bivalves.

The most conspicuous animals among the *Cymodocea* are echinoderms, and worm casts of *Balanoglossus* are dotted about in great numbers. The infauna is rich and varied.

vii. DISCUSSION

Shores fully exposed to wave action are few in northern Moçambique because waves break offshore on the coral barrier. Where they do exist they differ from southern exposed shores at Inhambane and Inhaca in the following points:

The *supralittoral fringe* in the north has very few or no littorinids, but many more individuals and one more species of *Nerita*. The chiton *Acanthopleura brevispinna*, is numerous and was traced as far south as Santa Carolina (latitude 22° S).

In the *upper midlittoral* the common large pink barnacle is probably a different species of *Tetraclita*; *Chthamalus dentatus* appears to be absent. The oyster belt of the south is lacking and *Siphonaria* spp. did not form a distinct association on the horizontal rocks of the middle shore, but were sparse and

scattered. There was no *Novastoa* belt. This Vermetid belt is probably a sub-tropical feature.

In the *lower midlittoral* an algal turf is not conspicuous. Few zoanthids are present, but anemones occur in crevices. Provinces of the sandy worm tubes of *Idanthyrsus pennatus* are present only when the sand for their construction is available.

The absence of the sandy worm tubes of *Idanthyrsus pennatus* which were such a conspicuous feature of the lower shore on the exposed coasts of Inhaca and again at Inhambane was striking. It was probably due to the absence of the required sand grains on a shore wholly made of smooth rock. There was no intervening sand slope between the rock platforms and the steep cliff on the Isle of Goa. This Sabellariid worm is found on tropical rocks where there is a coarse sand slope, as for example at Chakos, the northernmost tip of the bay of Moçambique. There the usual wide band of sandy tubes was found under an overhang just below middle tidal levels. There were few living worms on the surface and the thickness of the colony was about 30 cm.; it was very strongly cemented together. On the other hand, the *Novastoa* (*Vermetus*) belt seems peculiar to Inhaca and Inhambane in the south. Coral intrudes from below and becomes more important than algae at lower levels. The tunicate *Pyura stolonifera* (characteristic of warm temperate shore) was not seen, but colonial tunicates are a feature of crevices and the crypto-fauna.

The *infralittoral fringe* is dominated by coral. Of the 25 coral species collected, 7 had not been found further south.

Where the shores are *sheltered* and sandy and there is fresh water influence, mangroves of the same pattern and with similar populations of crabs and molluscs as in the south of the colony grow extensively. There is at least one additional species of mangrove tree and possibly more crabs. The fields of *Cymodocea* in the sheltered bays are like those in the south and gastropod molluscs, hermit crabs and polychaetes are similar. There are, however, many more species of echinoderms, coelenterates and bivalve molluscs and these occur in much greater profusion. There are some different species of polychaetes, and the midtidal zone dominated by *Phyllochaetopterus elioti* as at Inhaca was not seen. The main zonation pattern is otherwise not altered.

On the more typical *partly-sheltered shores* with a patchwork of sand and rock, there are features in common with both exposed and sheltered shores in the south. But there are two important changes in dominant animals that form belts on parts of the upper and middle levels of the shore.

An association of pearl oyster, *Perna dentifera*, has taken the place of the oyster, *Crassostrea cucullata* so characteristic of both exposed and sheltered rocks on subtropical shores. This bivalve occurs as very few small individuals at Inhaca and becomes larger and more numerous at Inhambane; while in the

north it is a dominant animal on the *upper midlittoral* rocks. The dominant bivalve on the rocks of the *middle shore* is *Modiolus barbatus* while *Septifer bilocularis* is characteristic of sheltered subtropical rocks and *Mytilus perna* of the exposed warm-temperate rocks. *Modiolus* is also abundant on the surface of sand amidst Cymodocea or algae.

On the *lower shores*, the algal turf and zoanthids, conspicuous in the south, alternate with patches of marine angiosperm, which were restricted to pools and to the infralittoral fringe on the exposed southern shores. Nereid and polynoid worms inhabit the turf and echinoderms dominate the Cymodocea. Corals are more conspicuous on the lower shore, and their associates which are cryptic in habit amongst coral debris at Inhaca, are abundant in pools formed by rings of corals.

The extent of the coral in the infralittoral fringe and in the infralittoral is much greater in the north; there are more species and more tropical associates occur with them.

The appendix lists species that were collected on the shores of northern Moçambique. This sample of the fauna includes 74 species not present at Inhaca Island, which is 25% of the total. At Inhaca Island about 15% of its total list of identified animals (about 1,000) was not tropical in distribution. These species have now dropped out or become rare and the fauna is entirely tropical in the north of Moçambique.

In the south of the Province, the Moçambique current and the shallow standing water in coves are warmer than the air. The warmer effect of the sea temperatures is felt longer on the lower levels of the shores which are longer immersed. The upper and middle rock levels reveal the effect of the cooler air by the subtropical nature of the fauna, while that in sand is kept at a more constant temperature and is fully tropical even in the south of the Province.

It appears that in northern Moçambique the temperatures of both air and water are high enough for full development of tropical associations on upper and lower levels of the exposed and sheltered shores.

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Crustacea & Mollusca

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Animals from the Tropical Shores of Northern Moçambique

Rock

Sand

Coelenterates (38)

- | | |
|--|---------------------------------|
| Acropora arcuata (Brook) | *Fungia costulata Döderlein |
| A. decipiens (Brook) | *F. cyclolites Lam. |
| A. listeri (Brook) | *Herpetholitha limax Esper. |
| *A. loripes (Brook) | |
| A. quelchi (Dana) | |
| *A. thurstoni (Brook) | |
| Favia favius (Oken.) | |
| *Galaxea clava Dana. | |
| Goniastrea halicora (Ehrb.) | |
| *Goniopora sp. | |
| Meandrina lamellina (Ehrb.) | |
| *Millepora alcicornis L. | |
| *Montipora ramosa (Bernard) | |
| M. venosa (Ehrb.) | |
| Pavona frondifera (Lam.) | |
| Pocillopora damicornis bulbosa (Ehrb.) | |
| *P. modumanensis Vaughan | |
| *P. setchelli Hofmeister | |
| P. verrucosa (Ellis & Sol.) | |
| Porites porites Pallas | |
| *Seriatopora histrix Dana | |
| Siderastrea sideraea (Ellis & Sol.) | |
| Stylophora pistillata Esper. | |
| Alcyonacea spp. M. 71/55, 72/55. | Alcyonacea spp. M. 29/55, 39/55 |
| Anemone sp. M. 59/55 | Cerianthus sp. cf. In. 17/55 |
| Gorgonid sp. cf. In. 90/56 | *Gorgonid M. 73/55 |
| Microspicularia sphaeroma (?) | Stoichactis sp. cf. In. 11/55 |
| Zoanthus natalensis Carlgren | |
| *Zoanthid sp. M. 70/55 (Purple) | |
| Zoanthus sansibaricus Carlgren | |

* Not found at Inhaca.

Rock

Sand

Polychaeta (35)

- | | |
|---------------------------------------|-----------------------------------|
| Allmaniella inhacae (Day) | Arabella mutans (Chamberlin) |
| *Amphionome rostrata Pallas | Armandia longicaudata (Caullery) |
| Eunice afra. var. punctata Peters | Audouinia tentaculata (Mont.) |
| E. australis Quatref. | *Axiothella quadrimaculata Aug. |
| *Filograna implexa Berkeley | *Chone collaris Langerhans |
| Harmothoe dictyophora Gr. | *Clymene mossambica Day |
| Hydroides monoceros (Grav.) | *Fabricia mossambica Day |
| Idanthyrus pennatus Peters | Hyboscolex longiseta Schm. |
| *Lepidonotus (Thormora) jukesi Baird. | Lumbrinereis papillifera Fauvel |
| L. purpureus Potts | *Magelona cincta Ehlers |
| *Lumbrinereis heteropoda Marenz | Mesochaetopterus minutus Potts |
| Lysidice collaris Gr. | Scoloplos madagascariensis Fauvel |
| Nereis falcaria (Willey) | |
| *Opisthosyllis laevis Day | |
| *Perinereis nigropunctata Horst | |
| Phyllodoce (Sphaerodoce) quadrati- | |
| ceps Gr. | |
| Polymnia nebulosa (Mont.) | |
| Pomatoleios kraussi (Baird) | |
| Pseudonereis variegata (Gr.) | |
| Spirobranchus giganteus Pallas | |
| *Terebella ehrenbergi Gr. | |
| *Thelepus setosus Quatref. | |
| Trypanosyllis zebra Gr. | |

Mollusca (65)

- | | |
|--------------------------------------|-----------------------------|
| *Acanthopleura brevispinna (Sowerby) | Anadara natalensis (Krauss) |
| *Beguina variegata (?) | Atrina spp. |
| Gastrochaena dubia Penn. | Cardium burnupi Sow. |
| Lithodomus lithophaga L. | Circe pectinata L. |
| Modiolus barbatus L. | Codakia exasperata Rve. |
| Perna dentifera (Kr.) | Donax faba Gm. |
| Pinctada capensis (Sowerby) | D. incarnata Gm. |
| Tridacna squamosa Lam. | Malleus legumen Gm. |

* Not found at Inhaca.

Rock

Sand

Mollusca (65)

- | | |
|--|---|
| <p> <i>Cerithium morus</i> Lam.
 <i>C. kochi</i> Phil.
 <i>Cellana capensis</i> Gm.
 ^x<i>Columbella fulgurans</i> Lam.
 <i>C. mercatoria</i> Lam.
 <i>Conus ebraeus</i> L.
 <i>C. vermiculatus</i> Lam.
 <i>Cypraea onyx</i> L.
 <i>C. vitellus</i> L.
 <i>C. helvola</i> L.
 ^x<i>Dolabella</i> sp. M. 52/55
 <i>Drupa tuberculata</i> (Blainville)
 <i>Littorina obesa</i> Sowerby
 <i>L. scabra</i> L.
 <i>Mitra</i> sp.
 <i>Monilea obscura</i> Wood.
 <i>Nerita albicilla</i> L.
 <i>N. plicata</i> L.
 <i>N. polita</i> Lam.
 <i>N. textilis</i> Gm.
 ^x<i>N. undata</i> (Less.)
 <i>Peristernia leucothea</i> Melville
 <i>Planaxis sulcata</i> Born
 <i>Pusiosoma mendicaria</i> Lam.
 <i>Siphonaria carbo</i> Hanley
 <i>S. oculus</i> Krauss
 <i>Terebra affinis</i> Gray
 ^x<i>Sistrum horridum</i> (Quay)
 <i>Thais intermedia</i> Kiener
 <i>T. mancinella</i> (L.)
 <i>Tectarius natalensis</i> (Philippi) </p> | <p> ^x<i>Tapes sulcaria</i> L.
 ^x<i>Tellina scobinata</i> L.

 <i>Cypraea annulus</i> L.
 <i>C. tigris</i> L.
 <i>Harpa conoidales</i> Lam.
 <i>Melongena paradisaica</i> (Martini)
 <i>Murex brevispina</i> Lam.
 <i>Nassa arcularia</i> L.
 <i>N. coronata</i> Brugue
 ^x<i>N. margaritifera</i> ?
 <i>Natica didyma</i> Bolten
 <i>N. mariochinensis</i> Lam.
 <i>Polynices mamilla</i> L.
 <i>Strombus gibberulus</i> L.
 <i>Trochus nigropunctatus</i> Rve. </p> |
|--|---|

^x Not found at Inhaca.

Rock

Sand

Mollusca (65)

- Thecaria sp. M. 60/55
 *Trochus mauritianus Gm.
 Turbo marmoratus L.
 Urosalpinx heptagonalis Rve.
 *Vasum turbinellum L.
 Vermetus sp. In. 61/54
 *Vertagus obeliscus
 *Cavolina sp. M. 61/55

Crustacea (63)

- Actaea rüppellii (Krauss)
 Aniculus strigatus (Herbst)
 Charybdis merguensis de Man
 *Chlorodopsis areolata (M. Edw.)
 *Cryptodromia tomentosa (Heller)
 Dehaaninus 4-dentatus (Krauss)
 Elamena mathaei (Desm.)
 Epixanthus frontalis (M. Edw.)
 Eriphia scabricula Dana
 E. smithi McLeay
 Etisus laevimanus Randall
 Eucrate sulcatifrons Stimpson
 Eurüppellia annulipes M. Edw.
 Grapsus maculatus (Gatesby)
 G. strigosus (Herbst)
 *Hypocolpus diverticulatus (Strahl)
 Libya plumosa Barnard
 Menaethius monoceros (Latreille)
 Metopograpsus messor (Forskall)
 *Metopograpsus oceanicus
 *Micippe philyra (Herbst)
 Percnon planissimum (Herbst)
 Petrolisthes lamarcki (Leach)
 Pilumnus trichorhoides de Man
 Calappa hepatica (L.)
 *Calcinus gaimardi (M. Edw.)
 C. laevimanus (Randall)
 Clibanarius longitarsus (de Haan)
 C. padavensis de Man
 C. virescens (Krauss)
 Coenobita rugosus M. Edw.
 Cyphocarcinus capreolus (Paulson)
 Diogenes senex Heller
 D. avarus Heller
 Emerita austroafricana Schmitt.
 Eumedomus granulosus MacGilch
 *Hippa adactyla Fabr.
 Hymenosoma orbiculare Desm.
 Lissocarcinus orbicularis Dana
 Macrotholmus bosci Audouin
 Ocypode ceratophthalmus (Pallas)
 O. kuhli de Haan
 Philyra platychira de Haan

x Not found at Inhaca.

Rock

Sand

Crustacea (63)

- | | |
|--|-------------------------------|
| P. vespitilio Fabr. | |
| *Pseudomicippe nodosa | |
| Thalamita crenata (Latreille) | |
| *T. picta Stimpson | |
| Trapezia cymodoce (Herbst) | |
| T. guttata Rüppell | |
| Xantho exaratus (M. Edw.) | |
| *Zosimus aeneus (L.) | |
| Alpheus edwardsi Audouin | Lysiosquilla maculata (Fabr.) |
| A. gracilis | Penaeid juveniles |
| *Calinnidea typa Stebbing | Pseudosquilla ciliata (Fabr.) |
| Sphaeroma serratum Fabricius | Processa aequimana (Paulson) |
| Chthamalus dentatus Krauss | |
| Balanus amphitrite va. communis | |
| Darwin | |
| *Pyrgoma milleporae (On Millepora coral) | |
| *Tetraclita sp. M. 72/55 | |

Echinodermata (48)

- | | |
|-----------------------------------|-------------------------------------|
| Asterina burtoni Gray | |
| Culcita schmideliana (Retzius) | |
| Linckia multifora (Lam.) | |
| *Nardoa variolata (Retzius) | |
| Protoreaster linckii (Blain) | Pentaceraster mammillatus (Audouin) |
| *Retaster cribrosus (von Matens) | |
| Ophiactis savignyi (M. & Trosch.) | |
| O. modesta Brock | Amphioplus integer (Ljungman) |
| Ophiocoma scolopendrina (Lam.) | |
| O. valenciae (Muller & Trosch.) | |
| *Ophioderma sp. | |
| Ophiomastix venosa Peters | Ophiothela beauforti (Engel) |
| Diadema setosa (Leske) | |
| Echinometra mathaei Blain. | Eucidaris metularia (Lam.) |

* Not found at Inhaca.

Rock

Sand

Echinodermata (48)

**Heterocentrotus mammillatus* (L.)
 **Prionocidaris pistillata* (Lam.)
Tripneustes gratilla (Lam.)
Actinopygia mauritiana (Q. & G.)
A. plegeja (Selenka)
Holothuria atra Jager
H. cinerascens Lampert
H. cumulus Clark
Stichopus chloronatus Brandt

Crinoid sp. M. 56/55

Salmacis bicolor Agassiz
Temnopleurus toreumaticus (Lask.)
Holothuria difficilis Semper
 **H. erinaceus* Semper
H. impatiens Gm.
H. leucospilota Lampert
H. hilla Lesson
H. parva Lampert
H. pervicax Selenka
H. scabra Jaeger (Santa Carolina)
Opheodesoma mauritiae Heding
Synapta oceanica (Lesson.)

Ascidacea (9)

**Aplidium altarium* (Sluiter)
 **A. petrense* Michaelson
 **Didemnopsis sansibaricum* Michaelson
 **Didemnun psammatodes* (Sluiter)
Eudistoma rhodopyge (Sluiter)
E. mobiusi (Hartmeyer)
E. passlerioides Michaelson
 **Herdmania morus* (Sav.)
 **Polyclinum macrophyllum* Michaelson

Pisces (18)

Abudefduf sordidus (Forsk.)
Amphiprion polymnus (Linn.)
 **Ariosoma anago* (Schlegel)

Enteropneusta (3)

Balanoglossus studiosorum van der Horst.
Ptychodera flava Eschscholtz
Willeyia delagoae van der Horst.
Branchiostoma sp.

* Not found at Inhaca.

Rock

Pisces (18)

- Antennablennius bifilium (Gunther)
Bathygobius fuscus Rüppel
Echidna nebulosa (Ahl.)
Epinephelus merra (Bloch)
*Enneapterygius obtusirostre Wun-
zinger
*Gobius albomaculatus Rüppel
G. capistratus Peters
G. nebulosus (Forsk.)
Halmablemnius dussumieri (Cuv)
Omobranchus striatus (Jatzow & Lenz)
Pardachirus marmoratus (Lacepede)
Pomacentrus annulatus Peters
Saurida gracilis (Q. & G.)
Siderea picta (Ahl.)
Stethojulis sp.

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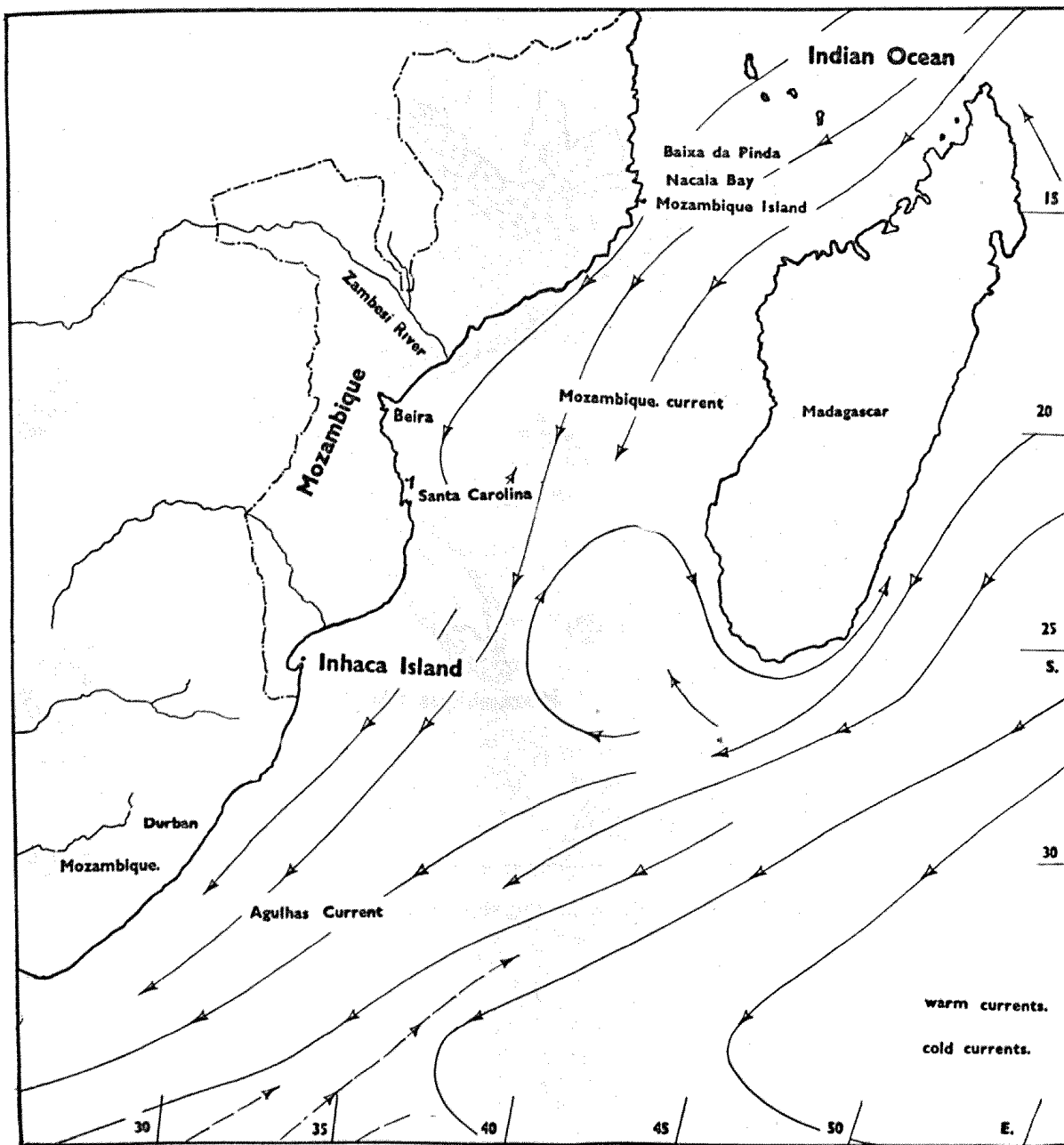


Fig. 1— Map of Southern Africa showing the ocean currents and the shores examined.

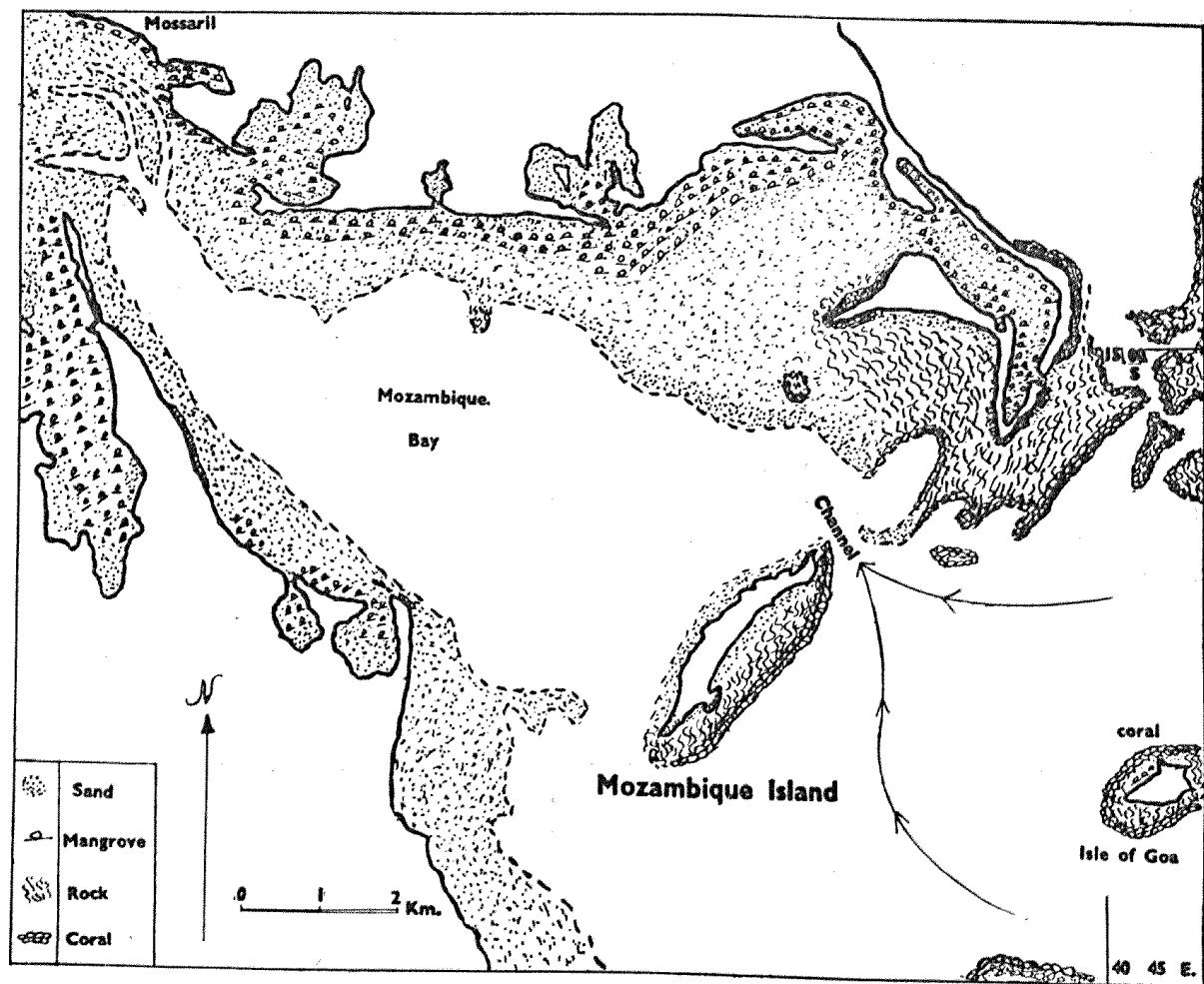


Fig. 2— Map of Moçambique Bay showing the shores, the islands and the coral reefs.

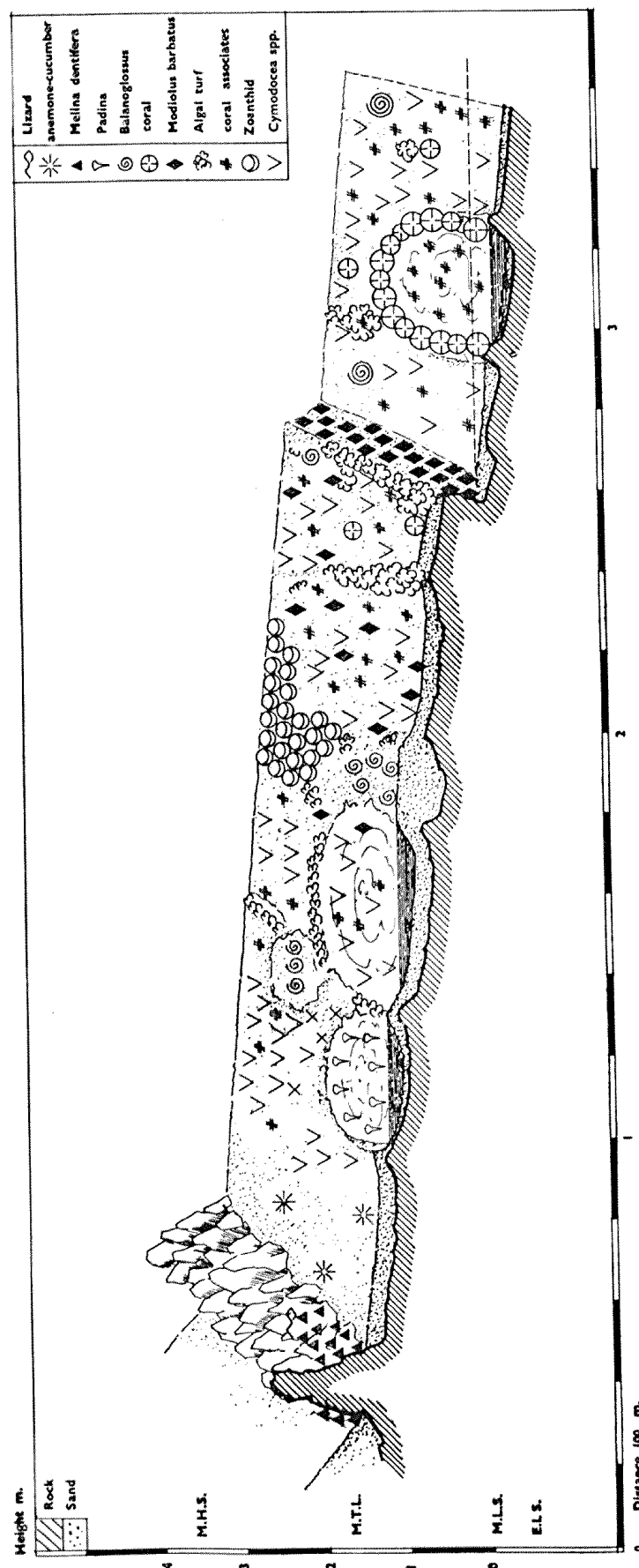


Fig. 3— The pattern of distribution of common animals on the north-east rocks, Moçambique Island.



The semi-exposed shore at the north-east point of Moçambique Island.