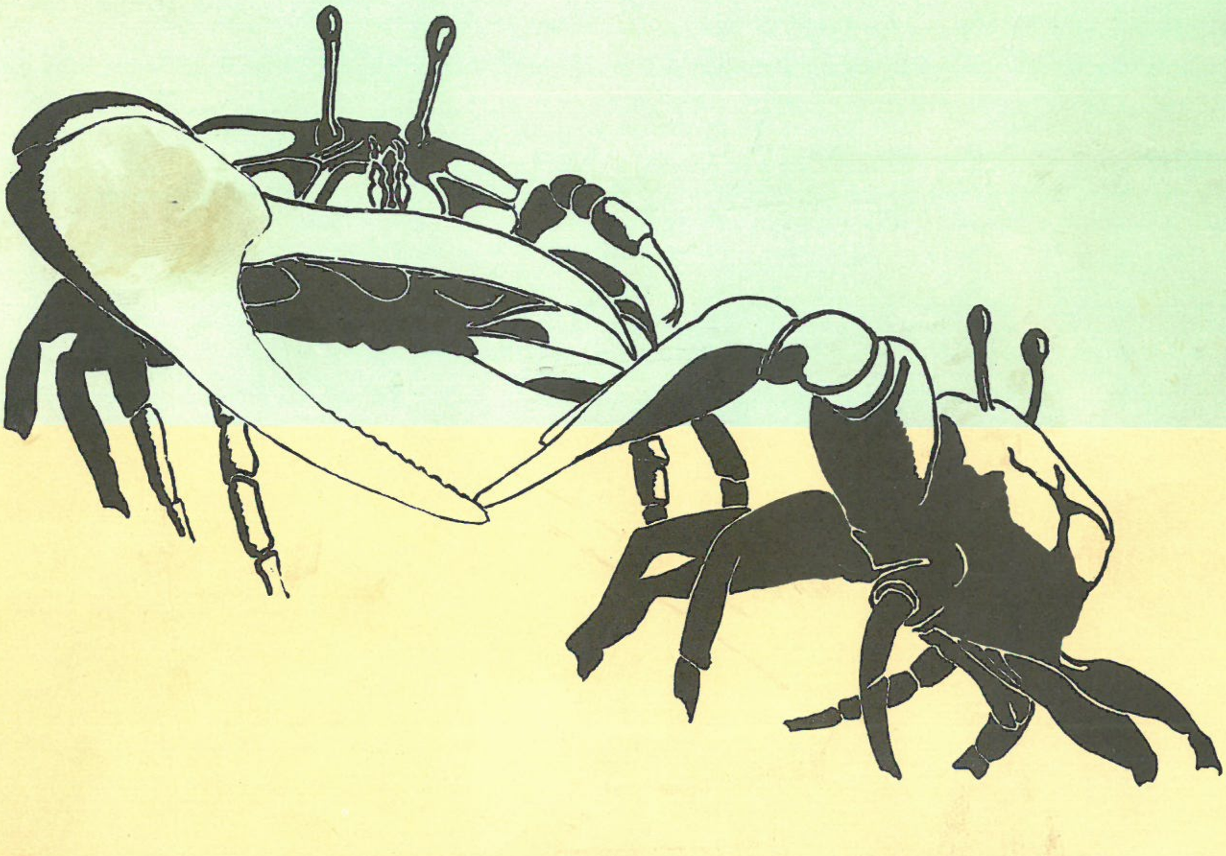
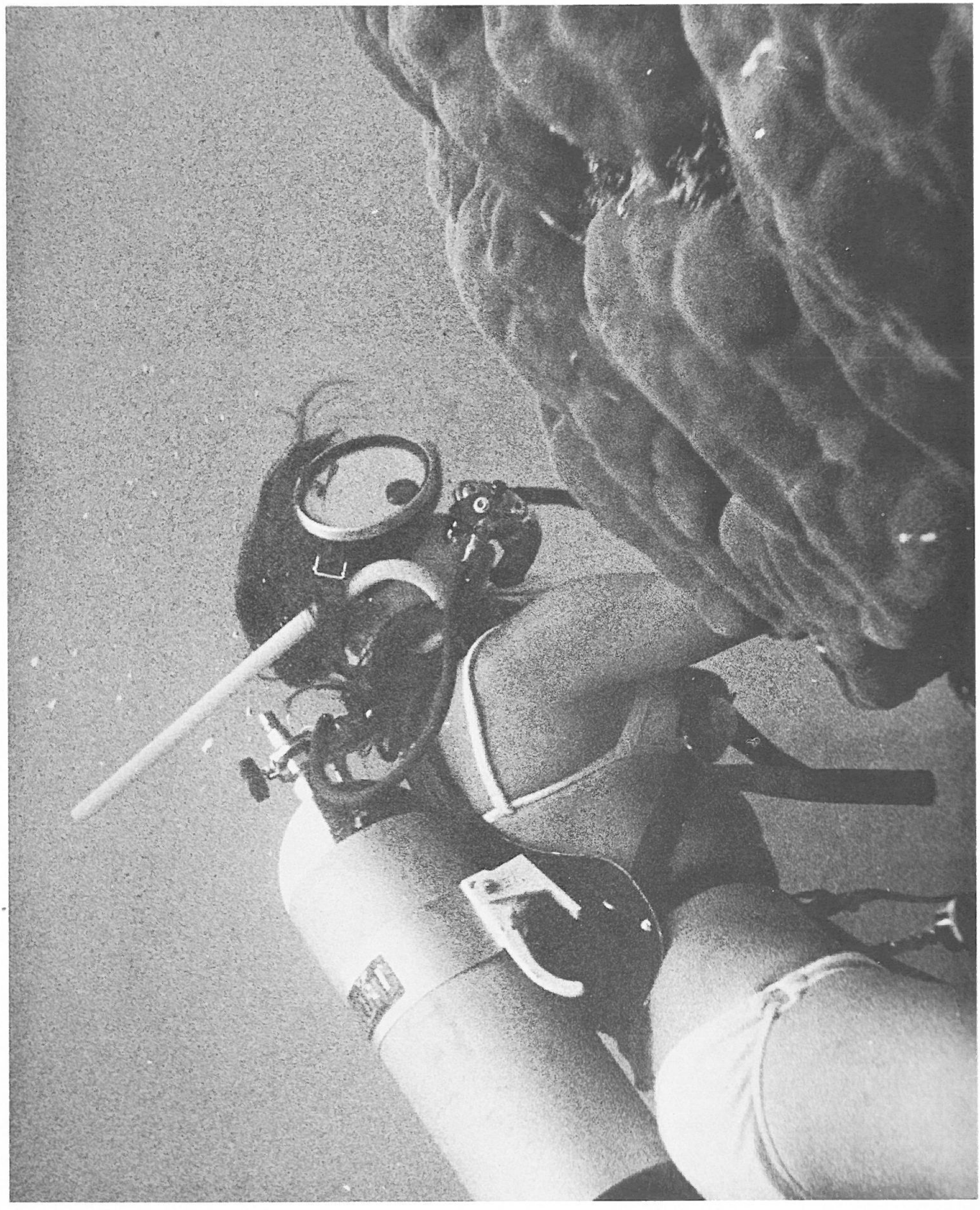
UNIVERSITY COLLEGE
OF
NORTH WALES

PRELIMINARY REPORT 1969

EDITED BY D.A JONES



BANGOR-WATAMU EXPEDITION



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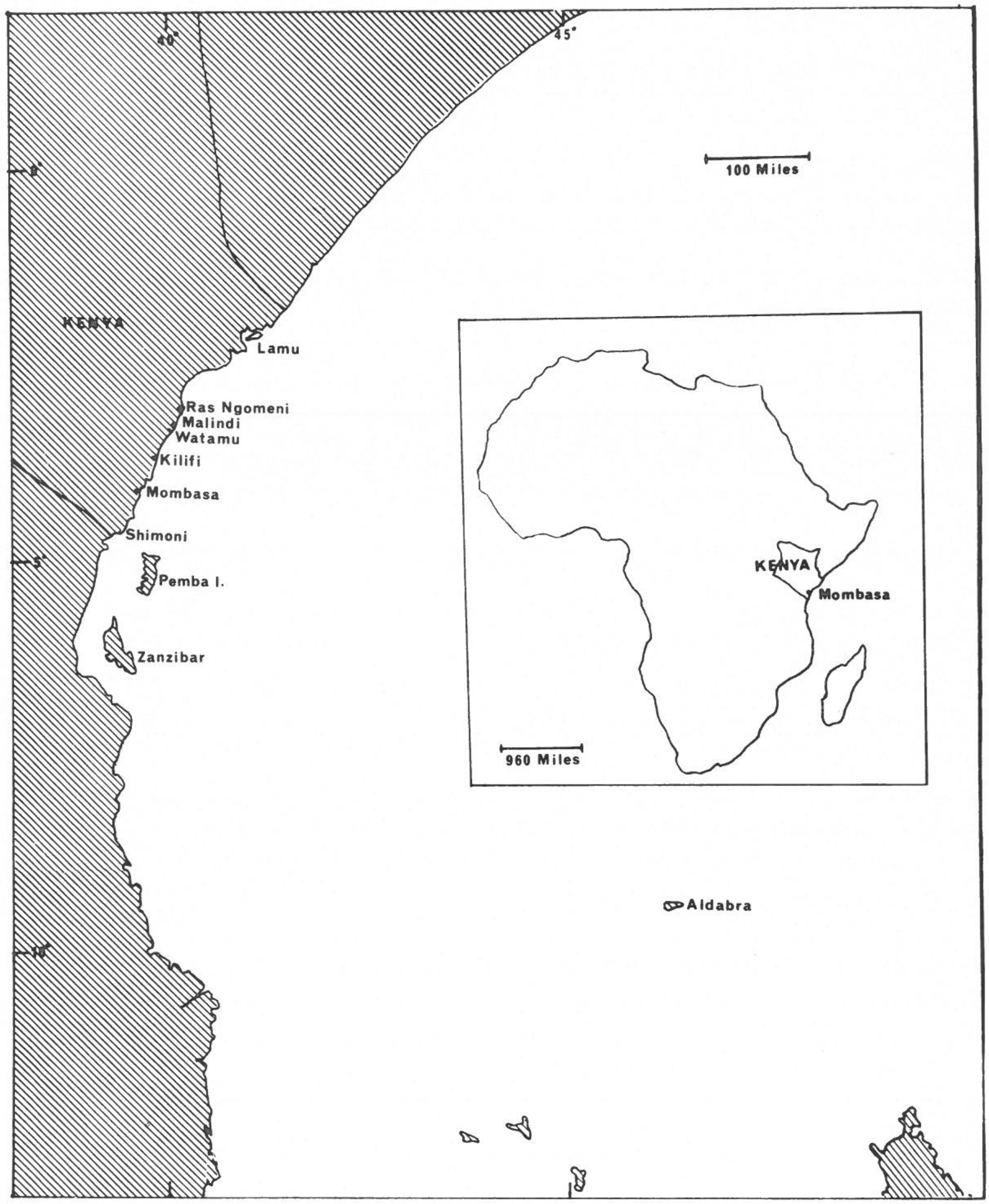


FIG. 1 East African coastline showing position of Watamu in relation to Aldabra.

INTRODUCTION

Background to the Expedition

The original idea of the Expedition came from Richard Thompson Coon after talks with Mr. Russell-Smith in February 1967 about the area called Watamu on the coast of Kenya (Fig. 1). With Keith Brander a small group was gradually formed to plan a realistic programme for a shallow water marine ecological survey, and when we later discovered that the Watamu area was to be made into Kenya's first Marine National Park, we decided to go ahead with these plans.

At this stage we sought advice from a number of people on the feasibility of the project and the merits of a study in this particular area: these included Professor F. W. Rogers Brambell, F.R.S., Sir Maurice Yonge, F.R.S. and Mr. Ian Pritchard of Watamu. As a result we decided that it would be an advantage to have one or more members of the university staff with us and Dr. N.W. Runham and Dr. C. J. Bayne were invited to join the expedition. The Principal, Dr. Charles Evans, F.R.C.S., agreed to act as patron for the expedition and Professors Rogers Brambell and Crisp to act as sponsors. Professor Dodd also agreed to act as a sponsor when he took the chair in Zoology at Bangor.

In the summer of 1967 Dr. H.I. Jones, one of the original members of the expedition, visited Watamu to investigate the area and the facilities available locally. In the autumn we made our first grant applications, circularised firms and started to order equipment. By the beginning of March 1968 flight passages had been booked and a shipping date fixed, but we were forced to delay as we had not received final decisions on several major grants. In the middle of April we were forced to cancel the plans for that summer due to the continuing uncertainty about the financial position. We had raised about £2,500 out of a total budget of £3,500, but the risk that the remaining grants would not be forthcoming was too great to take.

Fortunately four members of the expedition, Chris Bayne, Keith Brander, Bill Humphreys and Allister McLeod were able to take part in Phase V of the Royal Society Expedition to Aldabra (see Map 1) from July to December 1969 and there carried out work similar to that planned for Watamu. This also enabled all four to spend a week at Watamu in transit. As a result of these visits and experience gained on Aldabra many changes were made in the equipment - a great deal of which we discovered could be obtained locally - but the work programme was changed very little.

Meanwhile planning for summer of 1969 continued, although several changes in personnel took place. Drs. Runham and Bayne, David Guiterman and David Sigee dropped out. Dr. D. A. Jones and his wife, Wendy, joined and Dr. Quentin Kay took over as botanist. We had greater success with our grant applications in 1969 and by the beginning of March were confident that we could go.

The team which finally came to Kenya is listed below. It has not been possible to mention all those who have helped us in this introduction because there are far too many of them. Instead a special section is devoted to this at the end of the report.

Personnel

	Main interests
Mr. K. Brander, B.Sc., Fisheries Labs., Lowestoft.	Annelida and Mollusca
Miss P.C. Fraser, B.Sc., 8, Gordon Road, Ealing, W.5.	Porifera, Coelenterata
Mr. W. Humphreys, B.Sc., 35, The Avenue, London, W.4.	Echinodermata
Mrs. W.I. Jones, Marine Science Labs., Menai Bridge.	Admin. agent and Caterer
Dr. D.A. Jones, Marine Science Labs., Menai Bridge.	Crustacea and Plankton
Dr. Q. Kay, Dept. Botany, Swansea U.C.	Marine Angiosperms and Algae
Mr. A.A. McLeod, B.Sc., Marine Science Labs., Menai Bridge.	Crustacea
Dr. A.A. Myers, Dept. Zoology, Dar es Salaam U.C.	Amphipoda
Mr. R. Thompson Coon, B.Sc., P.O. Box 340, Malindi, Kenya.	Pisces

Visiting Scientists

Visits and assistance were received from several scientists either resident in Kenya or travelling through and who were interested in our work. The Senior Fisheries Development Officer (Mombasa), Mr. Wilkinson, took a keen interest in the work and, together with Mr. T. Allefree (retired F.O.), provided much useful information on past and current marine research in Kenya. Dr. Carleton Ray (Johns Hopkins University, Baltimore), who was currently engaged in a general survey of Marine Parks and inshore conservation in Kenya, worked with us during his stay at Malindi and suggested that we might compile a Marine Guide to the Park. During August we were also pleased to meet Mr. Peter Scott who supplied us with valuable information on local coral fish.

Dr. Quentin Kay received help and advice from Professor and Mrs. Isaac at the Botany Department, U.C. Nairobi. Dr. E. Jaasund (Botany Department, Dar es Salaam U.C.) helped considerably with the botanical research programme in the Park, spending a week with the expedition during August.

A BBC team joined the expedition for five weeks during July and August filming the expedition's work for a 50 minute colour film in the 'World About Us' series. The team consisted of Mr. Ned Kelly, producer, together with

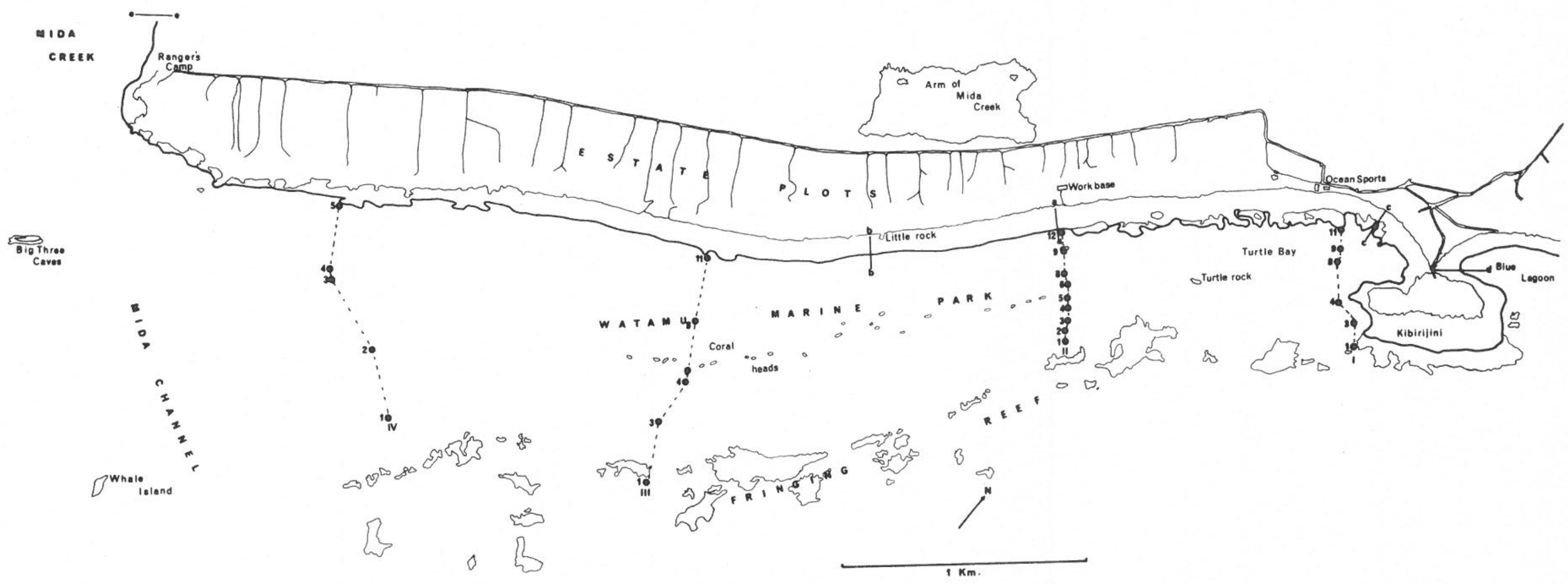


FIG. 2 Topographical map of Watamu Marine Park; I-IV sublittoral transects; a - e intertidal transects.

Les Jackman and Ron Peggs, cameramen specialising in close up cine-photography, assisted for a short period by Alan Root. During their stay they concentrated on filming behavioural sequences of many of the animals in the Park, and as we will have access to the negative film and receive a copy of the completed film, their work will add a new dimension to the research programme of the expedition.

Aims of the Expedition

The first Marine Parks in tropical Africa were opened to the public in 1968 by the Kenyan Government at Casuarina and Watamu (Fig. 2), an area where little marine research has been carried out in the past. Thus, apart from local knowledge, little was known of the diversity or range of habitats present within these Parks, nor of the fauna and flora inhabiting them.

An investigation into the ecology of the Marine Parks was, therefore, judged to be of considerable importance both for their efficient management, for the tourist, and as a base-line on which future changes in the Park can be measured. On a wider basis, an ecological survey on the Kenyan coast is of considerable scientific value as it not only contributes to the knowledge of the East African reef, where previous studies have concentrated on the area south of Dar es Salaam, but also is of comparative value in view of the current marine research programme on Aldabra (400 miles off East Africa).

The expedition conducted research in the Watamu Marine Park from July - September 1969 in order to accomplish the following aims:-

a) Prepare a map of the Park showing the type and extent of the major ecological habitats present.

b) Make duplicate collections of the fauna and flora of the Park.

c) Carry out individually various research projects of a more specialised nature.

d) Submit a detailed report on the work of the expedition to the Kenyan Government together with other interested bodies, including suggestions for improvement of the Park.

The map of the ecological habitats (Fig. 7) was based on a series of enlarged aerial photographs supplemented by transect samples and investigation of habitats both by diving and from the air. Collections of fauna and flora found in the Park were taken quantitatively where possible, together with detailed information on habitat, range and depth, so that these collections can now be related to the habitat maps. Whilst some identification of collections was completed in Kenya the remainder will be identified on their return to Britain both by expedition personnel and other experts who have offered their assistance. Part of the duplicate named collection is already in the Nairobi Museum where it forms the basis of a marine research section. The rest will follow as identification is completed.

The individual research projects carried out at Watamu are listed together with a summary in this report. As expedition members complete their work it is hoped that it will be brought together for a full expedition report next year.

Finance

The expedition accounts are not yet closed at the time of writing, however, an audited statement of accounts will be published in the future. The following donations were received and are gratefully acknowledged:-

	£	s	d
The Percy Sladen Memorial Fund	350	0	0
The Royal Society	1507	0	0
The Ministry of Overseas Development	500	0	0
The East African Wild Life Society	600	0	0
The Worshipful Company of Drapers	120	0	0
The Gilchrist Educational Trust	50	0	0
The Duke of Edinburgh (St. George, Royal Society of)	50	0	0
The Students' Union, U.C.N.W.	50	0	0
Miscellaneous donations	43	1	0
Personal contributions	350	0	0
U.C.N.W. Grant for Travel	125	0	0
	3745	1	0
BBC Contract for filming	500	0	0
British Universities Society of Arts (Loan)	200	0	0

Expedition Itinerary

June	27	Dr. D. Jones, Mrs. W. Jones, Miss P.C. Fraser, R. Thompson-Coon, K. Brander, A. McLeod depart Gatwick and arrive Nairobi.
	28	W.J., P.C.F., R.T.C. and A.M. to Mombasa by train.
	29	W.J., R.T.C. to Watamu.
	30	D.J. and K.B. to Mombasa by train.
July	1	K.B. and P.C.F. to Watamu
	2	D.J. and A.M. to Watamu
	12	W. Humphreys arrived Watamu.
	15	BBC team N. Kelly, R. Peggs and L. Jackman arrive Watamu
	18	Expedition crates arrived Watamu
	26	Dr. Q. Kay and Mrs. A. Kay arrived Watamu.
August	4	Mr. A. Root arrived Watamu. Dr. C. Ray visited Watamu.

August	6	P.C.F. and K.B. overnight at Rangers Camp Mida.
	14	Mr. A. Root departs Watamu.
	15	Dr. E. Jaasund and family arrive Watamu.
	17	BBC team depart.
	20	Dr. Jaasund departed.
	23	Mr. Peter Scott visited.
	29	P.C.F., K.B., W.H., A.M. visited Casuarina Park collecting. Slide show for Lion's Club at Malindi Fishing Club.
	31	W.H. to Ngomeni collecting trip.
September	1	P.C.F., K.B., W.H., A.M., D.J. to Kilifi and Horns Bay collecting trip.
	5	Dr. and Mrs. Myers arrived Watamu. P.C.F. and K.B. overnight Rangers Camp - training rangers.
	8	Dr. and Mrs. Myers departed, Dr. and Mrs. Kay departed Watamu.
	9	D.J. and W.J. departed Watamu
	10	W.H. and A.M. departed to join R.V. Manihini at Mombasa. P.C.F. and K.B. overnight Mrs. Didhams.
	11	P.C.F. and K.B. gave slide show for Rangers and others Malindi.
	12	P.C.F. and K.B. to Ngomeni collecting trip.
	14	P.C.F. and K.B. conducted aerial survey of park with Mr. Glover.
	16	Dr. and Mrs. Kay depart Nairobi for U.K.
	18	Dr. and Mrs. Jones depart Nairobi for U.K.
	21	Slideshow for Rangers, P.C.F. and K.B.
	24	P.C.F. and K.B. to Shimoni collecting trip.
	26	W.H. and A.M. return Mombasa meet P.C.F. and K.B.
	27	W.H., A.M., P.C.F., K.B. to Voi.
	28	W.H., A.M., P.C.F., K.B. overnight to Nairobi.
	30	W.H., A.M., P.C.F., K.B. depart Nairobi for U.K.

WATAMU PARK PHYSICAL FEATURES

Introduction

Off the East African coast there is little or no continental shelf, the coastline is bordered by fringing reefs on the seaward side of which there is a steep slope so that the depth of water increases to several hundred fathoms in a very short distance offshore. Newell (1957) has shown that the stratification found in the open Indian Ocean extends right up to the fringing reefs with no evidence of "upwelling" or mixing of water masses, thus the hydrography of the open sea is important when considering inshore areas. The East African Coastal Current which forms the whole of the water mass off the coast of Kenya is derived from the Southern Equatorial Current and moves northward throughout the year but differs markedly in its characteristics according to the monsoon period.

During the southern monsoon (April - October), the current velocity is accelerated up to 4 knots by the strong trade winds, whilst in the northern monsoon (November - March), the current is impeded by the northerly winds and is deflected by a reversal current flowing down the African coast, both currents flowing out to sea forming the Equatorial Counter Current (See Fig. 3). During the southern monsoon the South Equatorial Current is displaced northwards and a westerly current along the north Australian coast brings Pacific Ocean water of high salinity from the Malayan Archipelago region. The effects of these water movements are shown in average seasonal salinities of surface waters compiled for the East African coast (Newell, 1959)(Fig. 4a), highest values occurring at the end of the southern monsoon, the time lag being due to the time taken for Eastern Indian Ocean Water to reach the Kenyan coast.

Figure 4b shows the seasonal pattern of temperature in surface waters throughout the year (from Newell, 1957). As water temperature is primarily dependent upon meteorological conditions, highest values are reached in summer months during the northern monsoon, lowest during winter months when the strong winds of the southern monsoon have an added cooling effect.

Sea Water Temperature, Watamu

The sea temperature was recorded from July 7th to September 9th, 1969. A water sample was taken each evening at approximately 6 p.m. from shallow water in Turtle Bay (See Fig. 2).

During this period there was no great variation in the water temperature. The average temperature was 26.0 $^{\circ}$C. The maximum temperature was 27.2 $^{\circ}$C on the 18th July and the minimum 25°C on 23rd July.

It was found that the temperatures recorded at the time of spring tides were higher than those recorded at neap tides. At Watamu at springs, low tide occurs at noon and midnight; at neaps at 6 a.m. and 6 p.m. The highest temperatures were, therefore, recorded when high tide occurred in the early evening. This is shown in Fig. 5 where water temperature is plotted against the difference

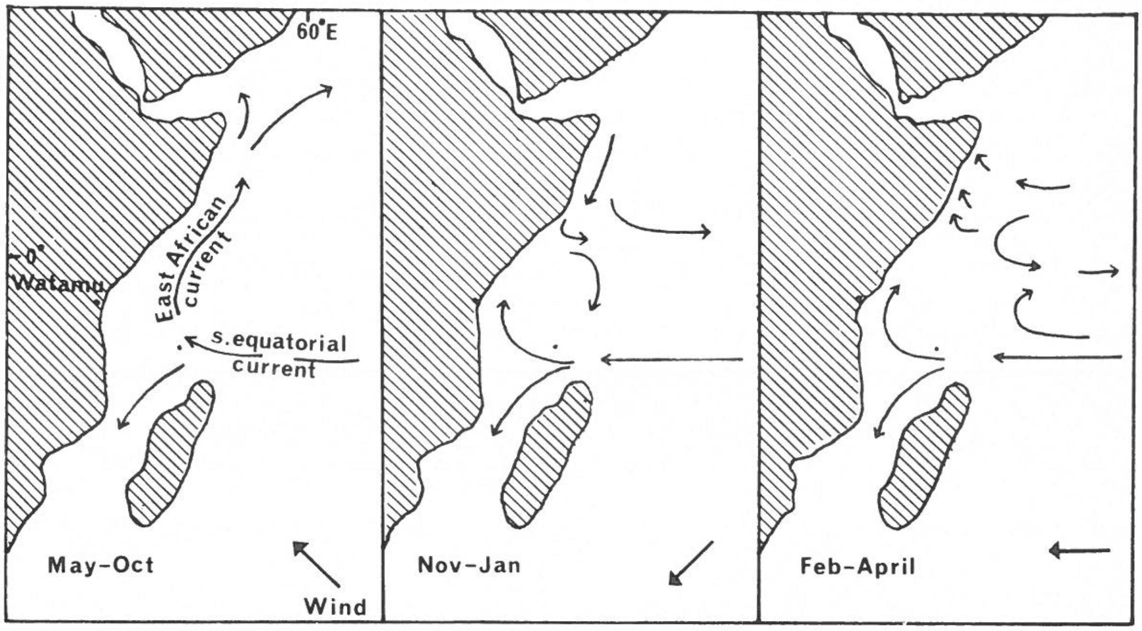


FIG. 3 Seasonal changes in the pattern of water currents off the East African Coast after Newell 1957.

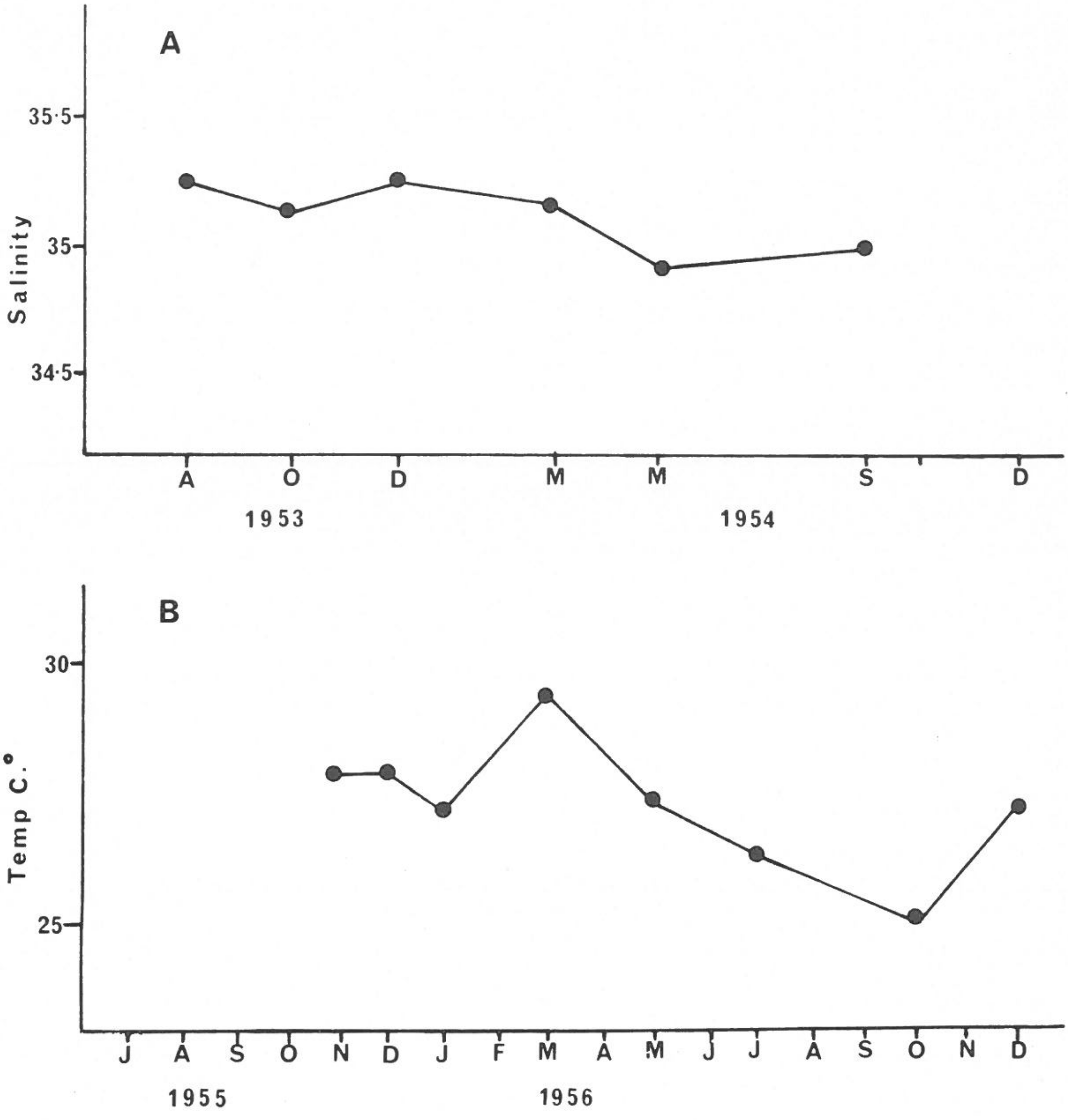


FIG. 4 *A, seasonal pattern of salinity changes in East African coastal waters; B, seasonal pattern of temperature changes in East African coastal waters, both after Newell 1957.*

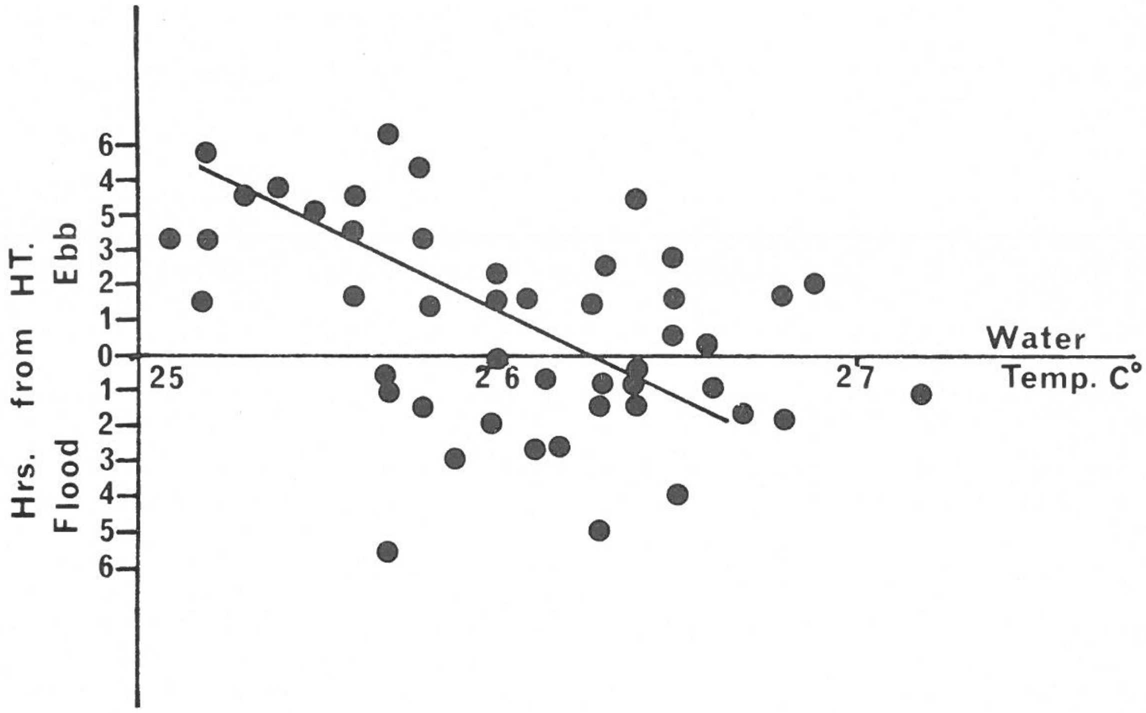
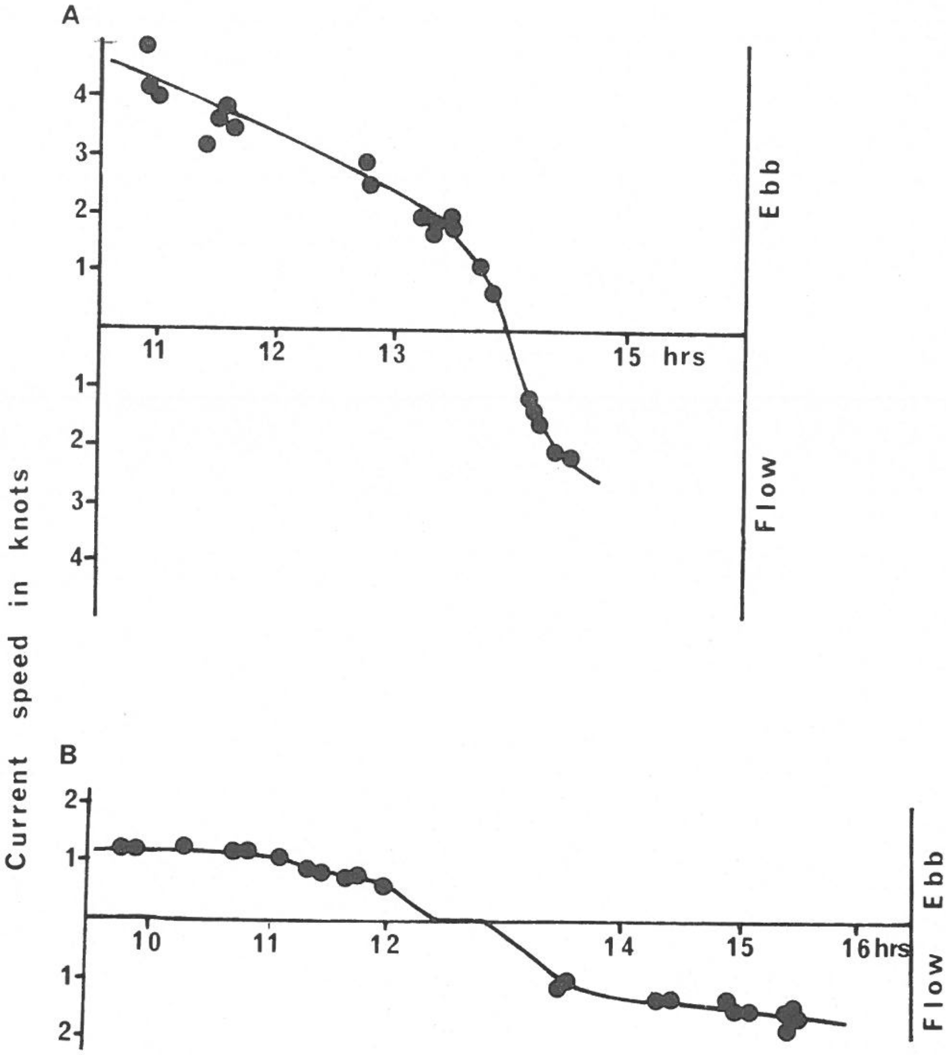


FIG. 5 *Graph showing relationship between water temperature and tidal height for Watamu from July 7 - Sept. 9, 1969.*



knots x 0.52 = m sec⁻¹

FIG. 6 *Graphs showing current speed and duration over part of two tidal cycles taken in the entrance to Mida Creek; a, spring tide of 29.8.69; b, neap tide 6.9.69.*

between the time at which the temperature was recorded (6 p.m.) and the time of the nearest high tide. The earth absorbs heat from the sun faster than does water. When the sandy beach is exposed during the day (as happens at springs) it absorbs heat which is later lost to the rising tide. Consequently when high tide is in the early evening the water is then at its warmest.

Tides and datum

The tides are of the mixed semidiurnal type typical of this part of the Indian Ocean. Admiralty Tide Table predictions for Kilindini were used with no correction. There is a lag of several hours in Mida Creek and the amplitude is considerably smaller than the oceanic amplitude. The large saline pond behind the road (arm of Mida Creek - Fig. 2) has a weekly tide, corresponding to the spring and neap periods and an amplitude of only a foot.

As we were not equipped to carry out any large scale levelling of the park area, all heights are only approximate and are relative to the tidal datum for Kilindini throughout this report. A local datum was established by noting tidal heights and relating these to a bench mark on the beach in front of the house. Unfortunately this bench mark was washed away, when the sea cut back the sand cliff on which it stood, towards the end of our stay, but by then we had levelled it relative to the concrete floor of the house. In order to relate soundings to the datum and to mean tide level the time when they were taken was noted, and from this the tidal height could be found and corrected for.

Measurements of the current in Mida Creek

On each tide there is a considerable flow of water in and out of Mida Creek. At the entrance the channel is narrow and strong currents develop. The fauna and flora found in this area is greatly influenced by the currents and is very different from that found in Turtle Bay.

The current was measured by recording the time taken for small floating objects to travel a 50 metre course, which was stationed in the middle of the channel at its narrowest point, opposite the Ranger's Camp (Fig. 2). Recordings were also made using fluorescein dye in the surface layers of the water. Similar results were obtained by both methods indicating that the effect of the wind on the floating objects was negligible.

Below are graphs of the recordings made during part of two tidal cycles (Fig. 6). On the spring tide of 29-8-69 the maximum current recorded was 4.7 knots during the ebb. There was a lag of 2hrs. 28 mins. between the time of predicted low water and the end of the ebb period. The period of slack was extremely short. On the neap tide of 6-9-69 the fastest current recorded was 1.2 knots. There was a lag of only 25 mins. between the predicted high tide and the end of the inflow.

In general, high water slack is shorter than low water slack and is longer at neaps than at springs. Also the time lag between the predicted times of high and low water and slack is greater at springs than neaps.

The maximum current we recorded was 4.7 knots, and it is unlikely ever to be much greater than this, but the currents make diving dangerous, as a diver can only just swim against a 1.5 knot current. On a spring tide the sea is often rough and the strong current carries silt out to sea from the mangrove areas further up the creek, which reduces visibility considerably. The best time to dive in Mida is at high water slack on a neap tide when the period of slack is long and visibility good.

MAJOR HABITATS

Intertidal rock

The category "intertidal rock" is subdivided into "platform" and "cliffs". In the Watamu area and along most parts of the coast visited, there is almost horizontal platform, which is generally about 3' below MTL, backed by an almost vertical champignon cliff, which may be anything from 10' to 50' high.

Platforms: Flat intertidal rock platforms are fairly extensive in the park (see Fig. 7). The largest area of platform is that in front of Kibirijini, which continues for several miles north of Watamu village. This type of platform is also typical of much of the coast south of Mida as far as Kilifi (Fig. 1). In some places it may be divided into an outer and an inner platform by a channel running parallel to the coastline and at Horns Bay, ten miles north of Kilifi, this channel is up to 30' deep.

The platform at Kibirijini is about 15 metres wide under the S.W. facing cliffs, but widens to about 150 m. in the middle of the seaward side, where it extends out to the reef. The platform on the sheltered side is sandy and higher than that on the seaward side, a feature also seen on the Turtle shown in diagrammatic profile in Fig. 8. Going round the south corner to the exposed side the sand gradually disappears and algae and pools increase. The front edge of the platform is formed of algal turf and there is a step of 10-20 cms. The level of the seaward platform rises toward Blue Lagoon and the height of the step increases. In Blue Lagoon it is about 60 cms high and made of several steps.

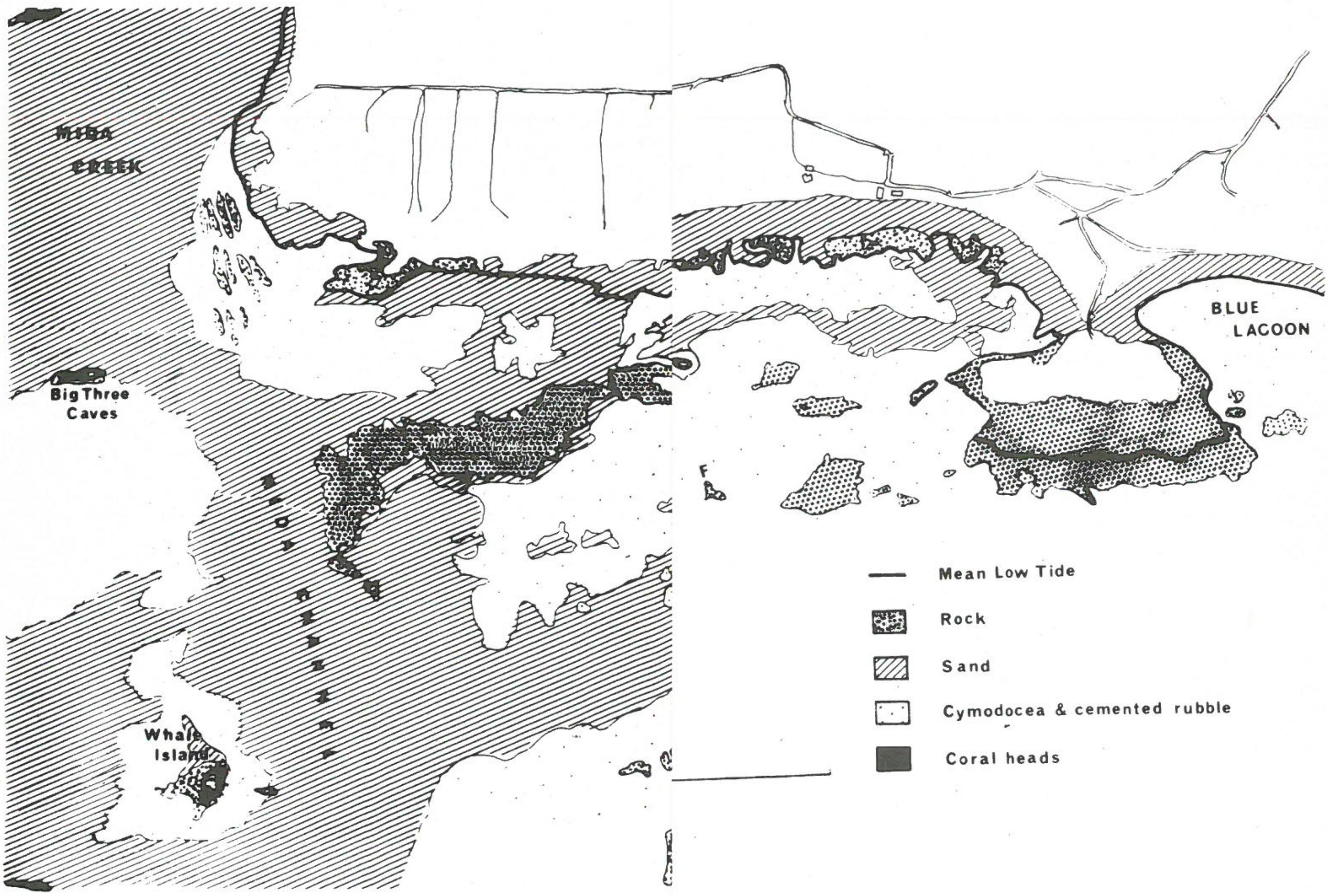
Seaward platforms throughout the park occur at a very uniform level of 3' above datum (c.f. MLWN 4.2 ft., MLWS 0.9 ft.) which means that they are uncovered on all spring tides for periods of up to three hours. These include the wide platforms in front of Ocean Sports and Seafarers, those around the Turtle and Whale Island, the platforms at the end of the peninsula and the roof of the Big Three cave, also the narrow platform running parallel to the beach close inshore opposite our work base and further along towards Mida (Fig. 7).

The fauna of these platforms is rich, especially in the pools, which may be up to 70 cms deep and contain many species from deeper water.

Cliffs: The position and extent of rocky cliffs in the park is shown on the map (Fig.7). With the exception of a short stretch of red crumbly sandstone near the mouth of Mida, all the rock is "champignon" limestone.

The seaward cliff on Whale Island is a typical high energy cliff, slanting back at about 40-45^{o} and it is the only cliff of this type in the park. The seaward cliffs on Turtle Rock and Kibirijini are medium energy cliffs (Stoddart, 1967), standing almost vertically, while the other leeward and sheltered cliffs are all of the low energy type, showing varying degrees of overhang.

Figure 8 shows the overhang on the leeward side of the Turtle, the vertical seaward face and the zonation of organisms on both sides. In general one finds that sedentary intertidal organisms occupy higher shore levels on exposed shores than on sheltered ones and this is found to be the case on the Turtle and other cliffs in the Park. One also finds marked faunistic differences between sheltered and


MIDA CREEK
Big Three Caves
Whale Island
BLUE LAGOON
F
Mean Low Tide
Rock
Sand
Cymodocea & cemented rubble
Coral heads

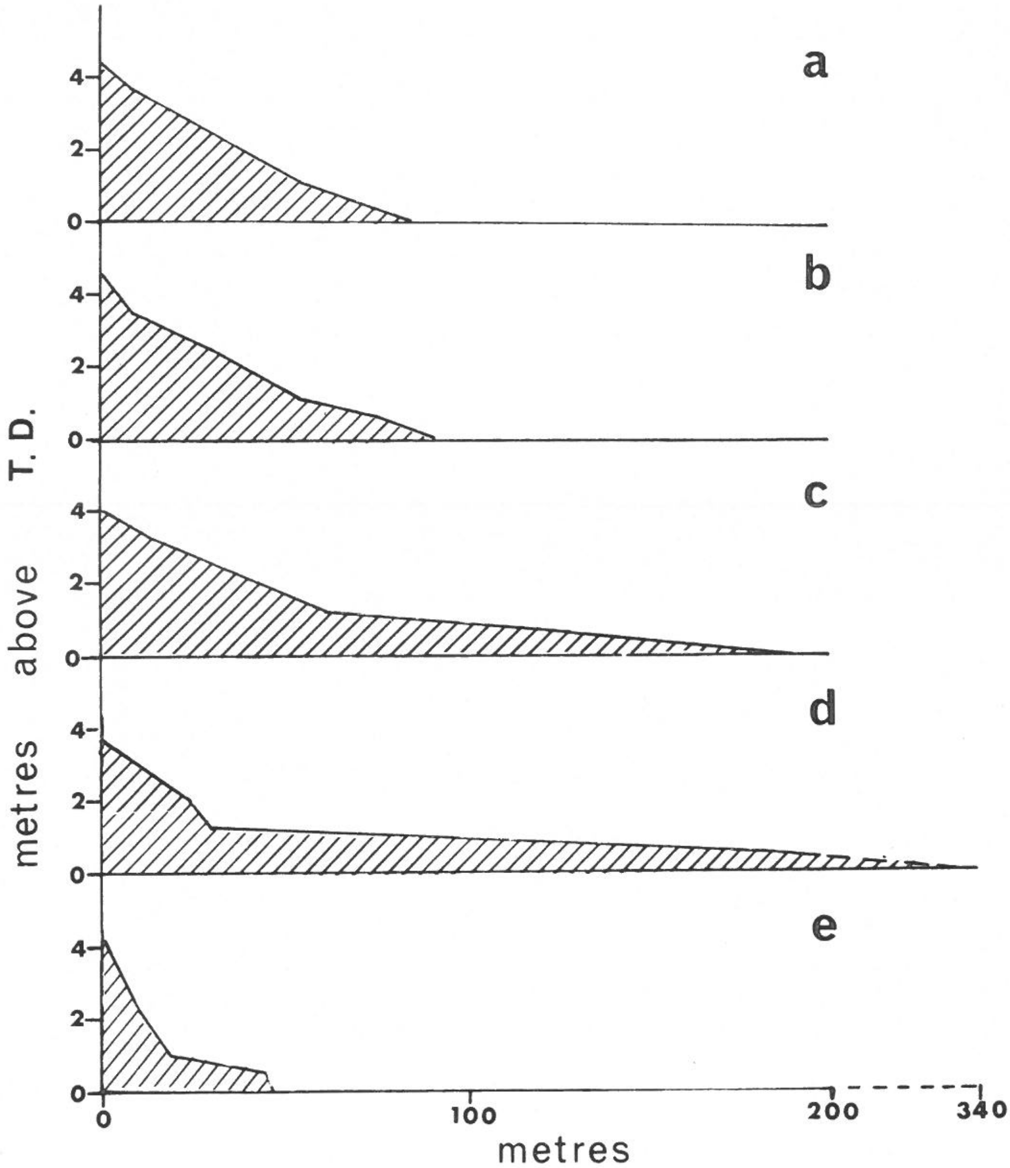


FIG. 9 *Profiles of sand/mud intertidal beaches taken at various intervals along the shore of Watamu Marine Park, (see Fig.2) T.D., tidal datum for Kilindini taken from Admiralty tide tables.*

TABLE I: Range in feet above datum.

a = absent

p = present

	Exposed			Sheltered		
	Kibirijini	Turtle	Whale Island	Kibirijini	Turtle	Whale Island
Chthamalus sp.	12-5	15-8	15-6	11-6	p	9-7
Tetraclita sp.	9-3	9.5-3	15-3	9-6	8.5-7.5	8-5
Balanus sp.	a	a	a	9-6	a	a
Acanthopleura sp.	14-5	14.5-5	16-7	10.5-8	9.5-5	12-5
Limpet	15-6	14.5-8	20-5	12-8	9.5-8	13-6
Crassostrea cucullata	6	9.5-5	16-5	10.5-8	8.5-7.5	p
Vermetid sp.		7-3		a	a	a
Mytilus sp.	3		a	a	a	a
Nerita sp. (black & white)	17-14	a	-16	-10.5		p
N. plicata	-17		a	a		
Littorinid sp.	-16		-18		13.8-11.2	-12
small black Drupe	7.5-4	10-4				
pink calcareous alga	11-3	p	p	a	p	10-
blackening organism		-15	-19			
sponge					13.8-12.5	
anemones	a	a	a		8.5-7.5	
Eriphia sp.	10	p	p	p	p	p

exposed shores. On Turtle Rock most species occur in greater abundance on the exposed side, with the exception of Grapsid crabs and Eriphia sp. Certain species such as Mytilus sp. and vermetids are found only on exposed cliffs, while others such as Balanus sp. and anemones, are found only in shelter. The degree of exposure may not be the factor limiting the distribution of a species, since one only finds pools with their associated fauna on sloping high energy cliffs, while shade dwelling animals tend to be confined to overhanging cliffs. Table I gives the distribution of some of the common intertidal species. Few species of algae are found on the cliffs, the brown ones (Bostrychia binderi etc.) being confined to shaded overhangs and the pink calcareous ones occurring up to a height of 10' on medium energy cliffs.

Fauna of intertidal rock

The faunal zonation of the south end of the seaward cliff on Kibirijini is given in Table I. The cliff overhangs in places and slopes back at others, so that it is possible to climb it. The top of the slight overhang is at 16' and the cliff flattens off at about 21' to merge into the jagged champignon spray zone surrounding the peninsula. Skinks are found on the top of the Turtle and in this spray zone.

Numerous small caves in the lower parts of the cliff have water dripping through them and are inhabited by the rock crab Grapsis maculatus, together with the smaller dark coloured Geograpsis lividus, small rock gobies, anemones, a few Holothuria and a large flat six-plated barnacle. In the middle of the seaward side of Kibirijini there is a pocket beach, shelving steeply to a low sloping cliff. This cliff is much whiter than the cliffs on either side and does not support any pink calcareous algae, Crassostrea, Tetraclita or crabs, but Chthamalus sp. is abundant. A cave behind the beach going back 40' supports a dense population of Ocypode kuhlii but very little else.

Near the foot of the cliffs tightly wedged into cracks a red and white xanthid crab is common and below this at the base of the cliffs the porcellain crab Petrolisthes is found. Related to the hermit crab this crab feeds on plankton material when the tide is in, using its setose (hairy) mouthparts to sift its food from the water.

The cliffs on Whale Island are much higher than any of the others, going up 47' vertically from the base on the lee side. This is the highest point on Whale Island and is 52' above datum. Zonation is similar to the other cliffs in the park, although even greater vertical uplift occurs on the seaward side.

Intertidal sand and mud

The intertidal zone within the boundaries of the park is characterised by a line of sand beaches interrupted at intervals by occasional rock platforms (Fig. 7). These beaches, which extend into the mangrove area of Mida creek in the south and into Blue Lagoon in the north, are subject to varying degrees of exposure and differ considerably both with regard to physical constitution and fauna and flora. Beach profiles together with sand samples for particle analysis were taken at the points indicated on Fig. 2 and results are given in Fig. 9 (a-e).

During the south-east monsoon period the main beach running parallel to the inner reef in Turtle Bay receives the full force of wave action at high tides

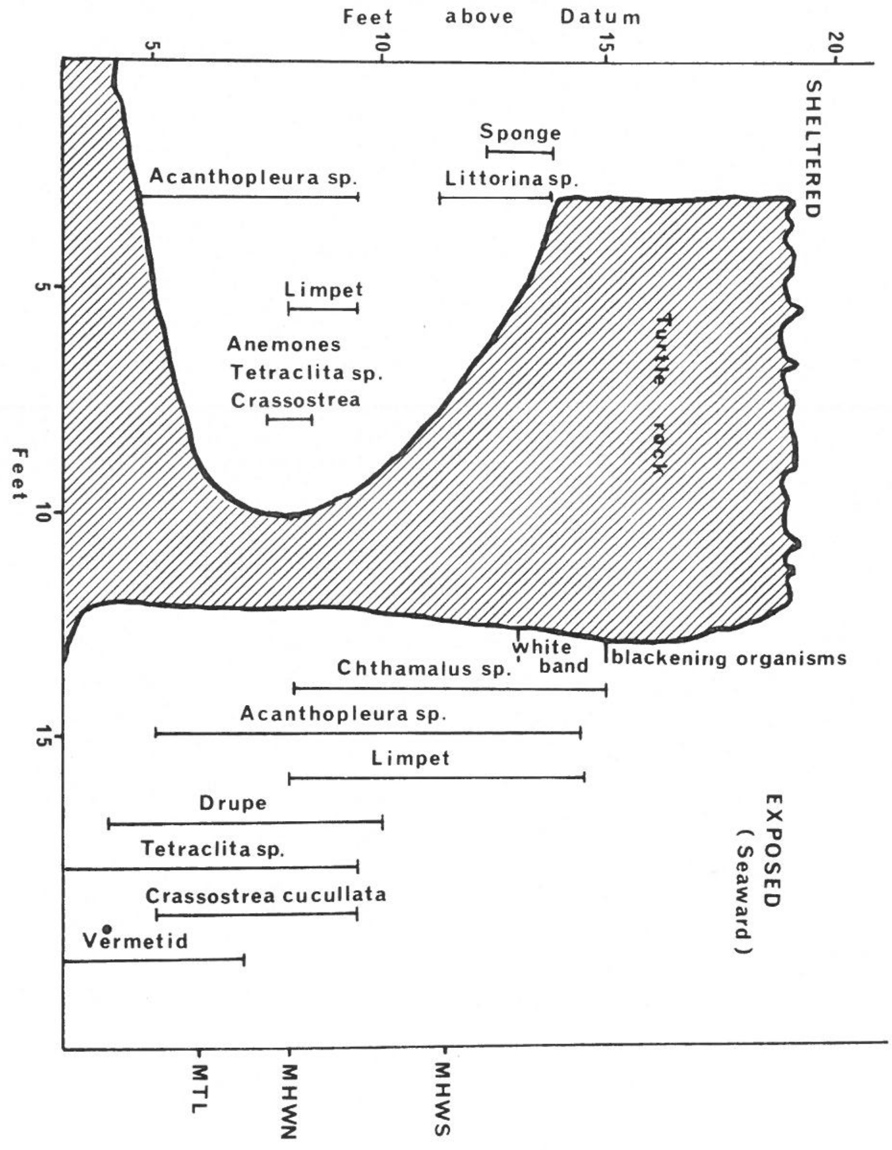
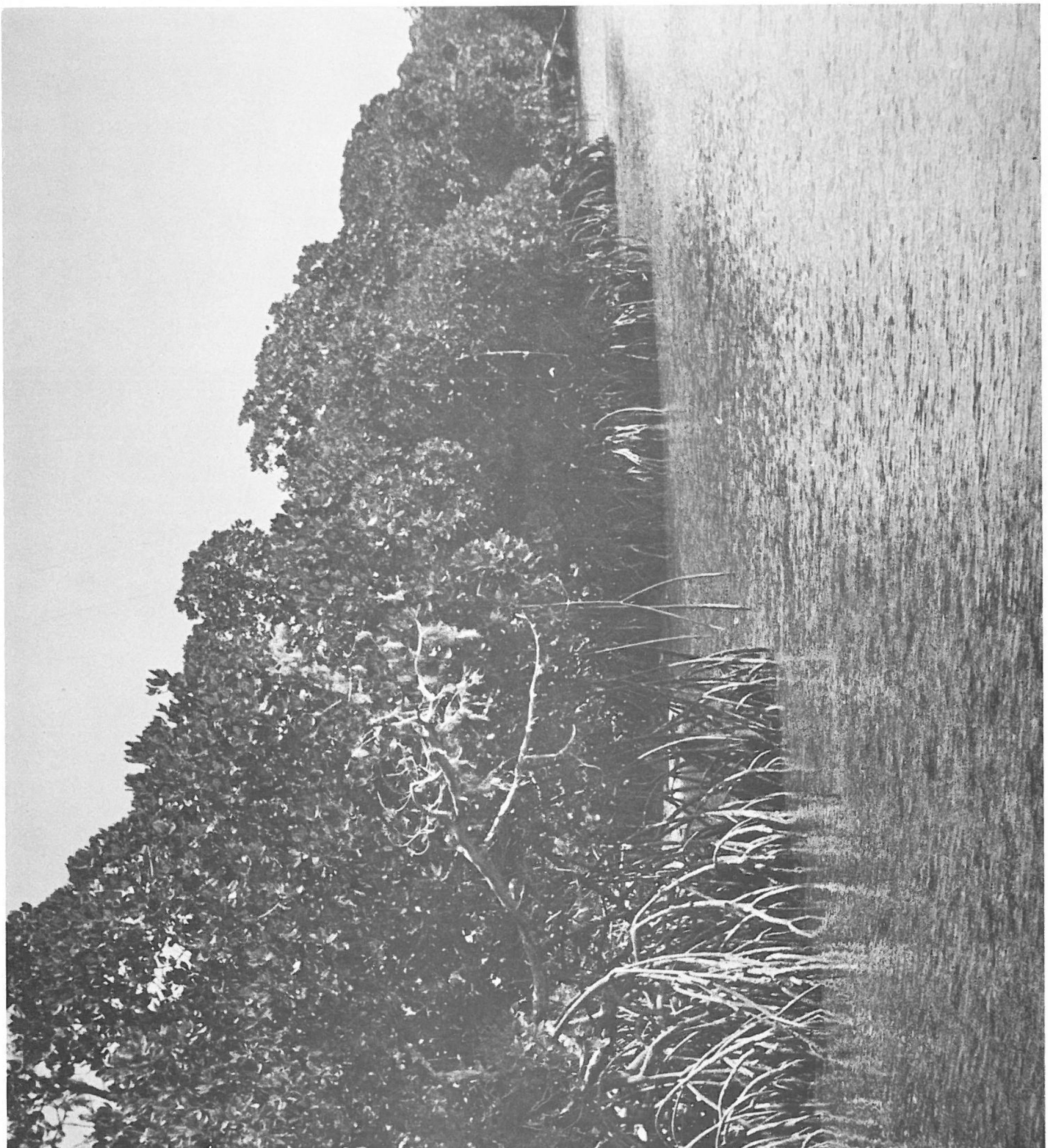


FIG. 8 Diagrammatic profile across Turtle rock (Turtle Bay) showing zonation patterns of common plants and animals.



as the waves, backed by the prevailing wind, sweep in over the reef. This beach (profiles a and b) has the shallowest angle measured from HWS-MTL when compared to profiles taken on other beaches (Fig. 9). This is in agreement with Shepard (1950) who has shown that a relationship exists between beach slope and wave action, high energy waves tending to be destructive and reducing steepness of beach slope. The exposed nature of the beach in the region of Profiles a and b is also confirmed by the particle size analysis which reveals a Md (mean diameter) of 0.343 mm, larger than that of any of the other profiles, for it is generally accepted that particle size is larger where wave energy is greater (Trask and Johnson, 1955; King, 1959). Standard deviation (.45) indicates that the sand is well sorted as might be expected on a beach receiving considerable wave action.

During the period July-September this area of the beach showed great mobility with large changes in profile, especially in the region HWN-HWS. On several occasions at spring tides during this period sand was removed to a depth of up to 1 metre on a single tide, and it is probable that these changes are not merely confined to monthly tides but also occur on seasonal basis due to the exposed mobile nature of this stretch of beach.

Profile c taken in the corner of Turtle Bay shows the effect of a small amount of shelter provided by Kibirijini (see Fig. 7). The beach slope is steeper above MTL due to the constructive action of smaller waves (Trask, 1955), and has a Md of .238 mm placing it in the fine sand category (Wentworth scale). A further dissimilarity between this profile and those of more exposed regions (a and b) is the extension of the beach area below MTL. The finer sediments below LWN, subject to less wave action, have become fixed by growth of the marine angiosperms <u>Cymodocea rotundata</u> and <u>Halodule wrightii</u>, and other species.

Reference to Fig. 7 shows that Blue Lagoon receives complete shelter from the south east trades and this is reflected in the short steep slope of the beach above MTL (Fig. 9d) giving way to extensive muddy sand flats and marine angiosperm 'meadows' (Macnae and Kalk, 1962) below this level. Particle size analysis shows a range from Md 0.266 mm at high tide to 0.176 mm below MTL, the standard deviation 0.98 indicates only moderate sorting. A negative value for skewness was obtained (-0.83) together with a high kurtosis value suggesting the presence of a coarse sand fraction washed in from a high energy region elsewhere (King, 1966).

The water table lies just below the surface of these flats at L.T., and where pools of standing water occur <u>Cymodocea ciliata</u> is present. Other common angiosperms occurring below LWN are <u>Cymodocea rotundata</u> and <u>Thalassia hemprichii</u>.

Profile e taken across a small sheltered beach among the mangroves (see Fig. 7) has a very steep slope down to MLWN with a predominance of medium to fine sand (Md .267). The lower part of the beach, containing poorly sorted sand, levels out to form a stable muddy sand flat similar to that found in Blue Lagoon, dropping off sharply, however, in the region of MLWS.

This profile is not characteristic of typical mangrove areas (Macnae, 1963) where there is generally a gentle slope between the tide marks, but owes its steep profile perhaps to the proximity of this beach to the main outlet channel of Mida Creek. The steep bank in the region of MLWS marks the edge of a strong current channel carrying the tidal flow of water into Mida creek. Particle size analysis at MLWS (Md 0.480 mm) shows a large coarse sand fraction consistent with a region of strong current flow across the sea bed.

Enhalis acoroides is present at this level on the edge of the channel but is replaced by Cymodocea serrulata as the predominant angiosperm at higher levels on the flats extending up to MLWN. The mangroves Rhizophora mucronata and Brugiera cylindrica together with Avicennia marina are common above MLWN, the pneumatophores of the latter ramifying through the sand. At higher levels Brugiera cylindrica and Ceriops sp. are dominant merging with terrestrial vegetation at HWS level.

Fauna of Sand and Mud Habitats

Although many of the animals from collections have not yet been identified it is immediately obvious that qualitative and quantitative differences in fauna occur on the beaches studied both in relation to the exposure of a beach and to vertical distribution on a beach. Zonation on beaches has been discussed by Dahl (1952) who concluded that faunistically it is possible to recognise three zones; a subterrestrial Talitrid-Ocypode belt, a mid-littoral "Cirolana belt", and a sub-littoral fringe. Macnae and Kalk (1962) as a result of detailed studies on the sand and mud flats of Inhaca Island have produced a similar scheme, subdividing the mid-littoral region, however, into upper and lower zones. Examination of the analysis profiles together with fauna of beaches in the Watamu park shows that the latter scheme is applicable and it is used in the description of the fauna.

Supra-littoral fringe: This marks the seaward fringe of terrestrial vegetation and the sand at this level HWS consists of wind blown sand only rarely covered by the tides but often littered with drift line debris. Above this zone the only true marine animals collected were the white hermit crab Coenobita rugosus inhabiting dead shells, often from terrestrial snails, and occasional Ocypode kuhlii.

The zone itself is characterised by Talitrid amphipods which reached densities of over $1000/m^2$ on exposed regions of the beach in Turtle Bay, but which were only found in smaller numbers ($16/m^2$) on the sheltered shores of Blue Lagoon and Mida Creek. The other dominant species found at this level of the beach were the ghost crabs Ocypode kuhlii and O. ceratophthalmus for although these species were found at all levels they showed a clear peak in this zone.

Counts taken on these crabs at Watamu confirm the observations of Macnae and Kalk (1962) in that O. kuhlii dominates on exposed shores whilst O. ceratophthalmus prefers sheltered areas. O. ceratophthalmus reached densities of 1.8 and $1.2/m^2$ at this level in Blue Lagoon and Mida, O. kuhlii being virtually absent, however, in Turtle Bay counts revealed densities of up to $5.4/m^2$ for this species, O. ceratophthalmus occurring only in a ratio of 1:300.

In the mangrove area of Mida above the high tide mark large burrows of Cardisoma carnifex are found descending to the water table where this large brown crab is able to wet its gills without exposure to predators.

Mid-littoral zone: Characterised by a steep slope leading onto sand flats on sheltered beaches and a more gentle slope on exposed beaches in Turtle Bay.

Donax sp. (Lamellibranchia) was abundant in this zone,-especially on the more exposed beaches as was a polychaete reaching densities of 264/m ^{2}at MTL in the sand beach at Turtle Bay. However, the Eurydicid Isopods dominate the sand fauna in this zone with 5 species, 2 Eurydice, 2 Excirolana and 1 Pontegeloides present. The distribution of these species differed both from exposed to sheltered beaches and also according to vertical zonation as has been recorded elsewhere (Jones, 1967, 1969). The Excirolana species occurred higher on the shore than the other species and were restricted to the more exposed shores in contrast to the Pontegeloides sp. which occurred only on sheltered shores. On these shores the burrows of the red and black mangrove crab Sesarma smithii were often abundant where the substream consisted of soft mud.

Lower mid-littoral zone: Encompassing the sandy mud flats extending from the lower end of the steep slope at around MLWN on sheltered shores to MLWS. Exposed beaches in contrast showed no such delimitation in the mid-littoral, the beach sloping gently down from MHWS to LWS. This zone was also occupied by Isopods of the genus Eurydice together with a species of Sphaeroma on exposed beaches, however, in contrast on the sheltered shore in Blue Lagoon the mud/sand flats were dominated by populations of Uca marionis. The males of these fiddler crabs have one chela greatly enlarged and in the mating season it is used for sexual display. The presence of the genus Uca is revealed by numerous pseudo-faecal pellets which are deposited around the burrow entrances during feeding, the material initially being collected by the smaller chelae, paired in the female, single in the male.

Among the mangroves at this level another species of fiddler crab Uca annulipes was common feeding actively at low tide. Other species characterising this zone were Macrophthalamus grandidieri in muddy areas and a species of Dotilla, a small Ocypodid crab without an enlarged claw producing tiny pseudo-faecal pellets on the clean sand banks which occur occasionally among the wetter muddy areas.

On both exposed and sheltered shores the anomuran Albunea symnista was common, burrowing in clean sand wherever this occurred, the distribution of this species however, extends down into the sub-littoral. Quantitative sampling also revealed several species of polychaetes and sipunculids especially numerous in the muddy substrates of sheltered beaches which also contained several species of bivalve mullusc, these species have yet to be identified.

Infra-littoral fringe: Covering the area between average low tide and low water springs this area contained surface water at all times and on sheltered beaches was covered with heavy growths of Cymodocea serrulata and C. rotundata with C. ciliata in pools. On exposed beaches these angiosperms were absent and the beach fauna was sparse consisting of Hippid crabs (Albunea sp.) a single species of gastropod mollusc, together with a few polychaetes and three species of amphipod.

The fauna of sheltered shores was much more diverse containing elements associated with both the grass beds and the sand. Two species of bivalves were present in the sand together with at least four different species of polychaete collected from this level in Blue Lagoon and Mida Creek. The larger crustacea found were the box crabs Calappa hepatica and Matata lunaris together with a species of mantid shrimp (Stomatopoda) and several penaeid prawns. Smaller crustacea included Tanais sp. together with several amphipod species.

The grass beds contained a rich and diverse fauna which is described in detail elsewhere.

Sub-littoral area of Turtle Bay and Mida Creek

We are concerned here with those areas of the Park which are never exposed to the air even at extreme low water. The survey includes the sub-littoral areas extending into the Reserve area of Mida Creek.

Rock platforms surround the raised limestone islands of Turtle Bay and form a fringe along Kibirijini, extending discontinuously southwards and diverging seaward from the beach. In Mida Channel a section remains intact to form the Big Three Caves. This platform transgresses the littoral/sub-littoral boundary (Fig. 7). The elevation of the platform ranges up to 3' above datum. The section remaining at the entrance to Mida Creek (Big Three Caves) rises 6-8' above the floor of the channel. From Figure 7 it can be seen that much of Turtle Bay is composed of marine angiosperm beds ranging from just above LWS down to a depth of 8'. They are increasingly broken southward from Kibirijini by sand channels and pockets, rubble accumulation and patches of coral growth until the channel to Mida Creek is reached. The beds are terminated seawards by the shallows in the surf zone of the inner reef. A 10' deep channel starts just north of Turtle Rock and runs southwards through the Coral Gardens at between 10' and 15' and on towards Whale Island.

The inner reef surf zone is exposed at ELW (Extreme Low Water) in the north of the Bay but is elsewhere submerged and extends down to about 6' in the surge channels which break through at frequent, although irregular intervals. This region is broken by eroded areas filled with coral rubble and sand accumulation and in some places contains a moderate coral growth with patchy extensions of the marine grass beds. The general level here is formed of a sand and rubble substrate cemented by algal growth.

Mida Channel broadens and shallows seawards from the Big Three Caves, until, in the region of Whale Island it merges with the surf zone. The main channel passes to the north of the Big Three and forms the main outflow from Mida Creek becoming increasingly important as the tide falls. At other times much water movement occurs over the shallows bordering the channel and to the south of Big Three. The Channel becomes deeper and more confined as it passes into the Creek, reaching a maximum depth of 25' in the region of the Park-Reserve boundary. Between this point and the Big Three the channel contains many large limestone boulders, caves, overhangs and deep scour holes maintained by the 4 knot current. Otherwise the bottom varies from a complete cover of encrusting corals and sponges, through angiosperm beds to open sand and scoured rock.

In the direction of the Creek head the channel becomes increasingly restricted and shallower owing to dendritic branching and fades out amongst the mud flats and the mangrove fringes. The mud flats stretch from the intertidal zone and shelve gently into the channels, or, where the mud is consolidated by marine grass beds, the flats drop off in low, 4-8' cliffs into the channel - this is especially noticeable where the creek narrows towards the mouth.

Fauna of sub-littoral region

It has been possible to delineate several types of ecological habitat within the Park (Fig. 7) and the dominant fauna of each habitat is now described.

Subtidal rock platform: The most exposed rock platforms are off Kibirijini and Whale Island where the alga Turbinaria ornata forms a belt near LWS and Sargassum sp. another from LWS to - 2 m in most exposed areas. On the flats are numerous mussels, small octopi, the giant clam Tridacna sp., strombids and the rock boring bivalve Lithophaga sp.. Juvenile crawfish, Panulirus versicolor, the Portunid crab Thalamita sp., the Grapsid, Percnon sp. and mantis shrimps, (Stomatopoda) all are abundant. The conspicuous echinoderms are the black to variegated Ophiuroid Ophiocoma scolopendrina and the large deep green urchin Stomopneustes variolaris. The brown regular urchin Tripneustes gratilla overlap here from angiosperm beds and accumulate at low tide in rock pools.

The more sheltered inshore rock platforms are dominated botanically by the algae Padina sp., Turbinaria sp., Cystoseira trinodes and Sargassum sp. with Dictyosphaeria sp. and Gracilaria sp. becoming more important with increasing exposure. The conspicuous animals here are similar to those of the exposed platform with mussels becoming more abundant and the large black urchin Diadema setosum in more sheltered areas. The oval regular urchin Echinometra mathaei bores shallowly into the rocks or inhabits the crevices and the red and white shrimp Stenopus hispidus is also common hanging upside down on overhangs. Small coral growths are present in this area mainly Favids and the alga Porolithon sp. Sponges are particularly abundant in sheltered spots and beneath overhangs covering the surface or boring extensively within the rock.

Angiosperm Beds and Associated Rubble and Sand Pockets: These areas cannot be readily defined by their macrofauna despite the extreme contrast presented by the total absence of any conspicuous flora within the sand and rubble pockets. Towards the end of the S.E. Monsoon extensive areas of the marine angiosperm beds are heavily eroded and only the root mats remain. These marine pastures are composed essentially of Cymodocea ciliata and locally C. rotundata, Syringodium isoetifolium and Thalassia sp. become dominant and Cymodocea serrulata and Halodule sp. are present.

This area is dominated by the white spined, brown Tripneustes gratilla grazing on the 'grass'. It forms considerable aggregations of up to 70 animals, covering themselves with the detached grass leaves. The pink, toxic urchin Toxopneustes pileolus, the large pentagonal starfish Culcita schmideliana and the large heavy, 5-rayed red starfish Protoreaster lincki are widespread but only locally common. The flattened irregular urchin Laganum depressum occurs in sandy areas and Echinometra mathaei numerous amongst the grass roots. The large helmet shell Cypraecassis rufa is widespread, feeding to a large extent on Tripneustes gratilla. Several species of Cone shells (Conus spp.) occur and the large bivalve Codakia sp. and the pen shell Atrina sp. are common. The crustacea include the Acanthonychids Huenia proteus and Hyastenus spinosus living amongst the Cymodocea and Turbinaria and frequently having the appropriate weed growing on their rostra. Hermit crabs Pagurus spp. are widespread as are juvenile crawfish Panulirus sp., and a filter feeding, burrow dwelling Thallassinid. Commonly found in the grass beds are pipefish, sargassum fish and Cymodocea fish all having cryptic colouration and morphological adaptations for concealment amongst the grasses.

The isolated rocks and boulders within the grass beds have a fauna similar to that of the inshore rock platform including Lithophaga sp., numerous Ophuroids, especially Ophiathrum elegans, Ophiomastix venosa and Ophiocoma spp., the echinoids Diadema sp. Paraselenia sp. and Echinometra mathaei. Several species of sea cucumbers (Holothuroidea) and sea feather stars (Crinoidea) also occur here together with sponge crabs (Dromidae). Small patches of Millepore 'corals' occur widely and have a similar fauna to the rocks.

Sand Channels and Pockets: The sand channels lack any macrobotanical element and consequently the echinoids browsing upon marine angiosperms are in most places absent. In places, however, Tripneustes gratilla overlaps from the grass beds and Culcita schmideliana and Protoreaster lincki are also rarely present. The large molluscs cannot be distinguished quantitatively from those of the angiosperm beds. Among the crustacea the Hippid crab Albunea sp. occurs widely forming respiratory tubes to the surface of the sand with their long antennae. The box crab Calappa hepatica is common and the crabs Matuta sp. have their respiratory current highly modified for sand dwelling. The Thalassinidae form extensive, lined permanent burrows within the grass beds. Large green anemones of the genus Stoichactis are present in sand pockets and these harbour interesting commensals including a porcellain crab, the shrimp Perclimenes brevicarpalis and an active brown Hippolytid shrimp. Another association is found between certain Holothuria and the Portunid Lissocarcinus obicularis which may have a very variable carapace colouration.

Coral Heads: Coral heads occur in the sand channels and vary from small isolated growths to extensive 10' - 15' high coral heads in the Coral Gardens area. The heads consist primarily of Porites spp. supplemented more or less extensively by the branching Acropora spp., Pocillopora spp., by individuals of Fungia spp. and colonies of Cyphastrea spp., Galaxea spp., 'Brain' corals and Millepore coral.

Areas of living coral are generally poor in Echinoderms but the large black ophiuroid Ophiocoma erinaceus lives in cracks and holes in the coral and E. mathaei and Diadema sp. burrow into the surface. Beneath overhangs Diadema spp. and Echinothrix sp. may be present and the large blue starfish Linckia laevigata is locally abundant. The bivalve Tridacna squamosa lives attached to the coral, Barbatia sp. lives inside it and Lithophaga sp. burrows extensively through it. The other conspicuous molluscs are the tiger cowrie Cypraea tigris, the large oyster Pinctada margantifera and numerous species of nudibranchs. Amongst the marine worms (Polychaeta) the sabellid fan worms and serpulids are common in the coral.

It is amongst the corals that the Xanthid crabs attain their highest diversity, however, due to the large numbers involved and the difficulty in identifying them with certainty in the field, only a few can be described at present. Lybia tesselata is a small brightly coloured crab with small claws which it uses to hold two small anemones. It is suspected that these are used for offence, the crab utilising the Coelenterate's stinging cells to capture small prey. In among the fingers of live coral of the genus Pocillopora, Stylopora and Acropora are the red crabs Tetralia glaberrima and Trapezia cymodoce, the latter having a fringe of greenish setae on the external margins of its chelepeds. These crabs are well able to manœuvre themselves between the coral fingers and thus escape predators. Also living in the live Pocillopora heads is the red and black striped snapping shrimp Alpheus lottini. The snapping claw is a characteristic of the family, and is used for creating a shock wave which stuns small prey. Within the matrix of the coral are small Gall crabs, the females of which live entombed for life, their only communication with the sea being a narrow slit which serves to allow access of water, plankton, and the small errent male.

Amongst the dead coral and rubble are Alpheus parvirostris, a small snapping shrimp, Percnon planissimum a flattened brightly coloured and highly mobile Grapsid, small "rock lobsters" (Galatheids) and many other Crustacea. One of these is the rare Heteronucia angulata, a small reticulated crab looking very much like a piece of broken coral. The largest decapods present are the crawfishes Panulirus ornatus, and the black and white P. versicolor, sometimes to be seen outside their holes but more often secreted in crevices with their long white antennae projecting. Several species of Stomatopod inhabit this region, including Pseudosquilla ciliata, easily identified by the black "eye" mark on the side of the carapace.

Living coral provides numerous shelters for reef fish which live amongst the branches of the coral within the crevices and the holes formed by the complex growth forms obtained by the interaction of different coral species. The more conspicuous families involved include the Chaetodontidae, the Zanclidae, the Pomacanthidae, the Acanthuridae, Scorpidae and the Abudefdufidae.

The alga Turbinaria sp. occurs on the top of the Porites heads together with the large red alga Neurymenia fraxinfolia which extends down the more exposed sides of the heads. Various encrusting algae occur on the shaded sides of the heads including the genera Porolithon, Tenaciphyllum, Lithophyllum, Peyssonellia and Pocockiella.

Inner reef surf zone : The macrofauna of the surf zone mainly occurs associated with loose rocks trapped in the erosion hollows, the animals sheltering in or beneath the rocks. Certain areas are dominated by free living crinoids and the small purple urchin Paraselenia sp. tends to replace E. mathaei which is, however, still abundant. Toxopneustes reaches its greatest abundance in the deeper waters immediately shorewards from the surf zone but Tripneustes is still abundant within the surf zone being rolled to and fro by the waves. The cowries Cypraea lynx and C. isabella are common.

Mida Creek channel : From Big Three Caves to Park-Reserve Boundary.

Much of the bottom of the channel is covered by encrusting corals, delicate coral fields, soft corals, gorgonians and sponges. Tridacna squamosa is again present together with the spider conch, Lambis sp. the oyster Dendostrea hyolis and a wide range of nudibranchs. The crustacea are those associated with the coral areas. This section of Mida is very rich in Echinoderms, especially asteroids. Nardoa sp. is abundant in the same areas as the normally asymmetrical Linckia multiforis. Ophuroids of the genera Ophioplocus, Ophiothelia, Ophiothrix, Ophiocoma and Ophiarachnella are everywhere abundant. The holothurians, Stichopus variegatus Bohadschia spp. Halodeima sp. are common and Theleonota sp. present.

Mida Creek - grass beds : The channels near the seaward end of the creek are fringed by the angiosperm Enhalus acoroides widespread on the sandy bottoms from 1-10 feet below datum. Synaptid holothurians are widespread in this area and in the more sheltered positions large congregations of Diadema setosum occur. The molluscs Lambis sp., Codakia sp. and Pterid sp. are present.

The Bottom mud in Mida Creek: Characteristically contains large holothurians of the genus Bohadschia living in the mud and in certain areas of the mud dwelling starfish Astropecten sp. is abundant. Close inshore near the mangroves burrowing Alpheid shrimps occur living commensally with gobies and mud skippers (Periophthalmus). The shrimps appear to excavate the burrows whilst the fish act as 'watch dogs' warning the shrimps of impending danger.

Further offshore are the burrows of the large mangrove crab Scylla serrata, which can be seen at night near the mangrove trees and which is fished commercially. Many other burrowing crustaceans occupy the soft sides and bottom of the channel leaving excavated piles of mud on the surface, these include alpheids, callianassids and stomatopods. In the quietest waters the commercially fished prawn Penaeus monodon is found and at the waters edge numerous pagurids occur living in the shells of Terebralia, leaving trails on the surface of the mud as they sift off and consume surface debris.

MARINE BOTANY OF THE WATAMU DISTRICT

(Q. O. N. Kay).

Introduction

The marine environment of the Watamu area is varied and provides a wide range of habitats for plants. The marine flora is correspondingly rich. In the sub-littoral zone, macroscopic marine plants are absent only from areas of mobile sand, and actively growing coral, and sometimes gain a foothold even in these unfavourable habitats. Macroscopic marine plants are, however, absent from the upper part of the intertidal zone except on shaded cliffs (the Bostrychia binderi association) and in the extensive mangrove areas of Mida Creek. Considerable quantities of drifted plant debris - mainly dead leaves shed by Cymodocea ciliata - do, however, accumulate on the sloping sandy beaches of the upper part of the intertidal zone and the littoral fringe, and locally form banks more than a metre high.

In the lower part of the intertidal zone, extensive rocky reef platforms rising to a maximum height of about 90 cm. above MLWS occur. Most of these platforms are covered with a mat of marine algae which increases in density and number of species with decreasing height above MLWS, and shows marked zonation; algae are scarce or absent only in areas where drifting sand or a dense cover of sponges and corals prevents their growth. Many pools, of varying size and depth, occur in the platforms; some of the larger pools have a rich flora including several otherwise sub-littoral species.

Several marine angiosperms grow in sheltered, flat sandy areas in the lower part of the intertidal zone, and stabilise the sand with their extensive creeping rhizome systems. These vegetated sandy areas reach a maximum height of c.50 cm. above MLWS; pools, usually thickly vegetated, occur in sandy depressions in these areas.

In the sub-littoral zone, marine angiosperms are again dominant in vegetated sandy areas, and algae are dominant in most rocky areas. Extensive beds of the large angiosperm Cymodocea ciliata are a conspicuous feature of the sub-littoral reef flat, and the even larger species Enhalus acoroides, resembling a submerged Typha latifolia, is locally abundant in Mida Creek. The algal vegetation of rocky sub-littoral areas varies; the degree of exposure to waves and currents, the amount of shading, the turbidity of the water, the type of rock substratum, the amount of drifting sand, and the intensity of grazing by marine animals all affect the species composition of the algal community in varying degrees.

The Vegetation of Rocky Substrata

a) Reef platforms in the lower intertidal zone

Rocky platforms in the lower intertidal zone (the lower shore) are widespread on the coast of Kenya. They are easily accessible and their algal flora has been more intensively studied than that of the sub-littoral zone.

The rocky platforms on the lower shore in the Watamu area can be divided into two main classes, the upper platform and the lower platform. The upper platform is exposed during neap low tides, but the lower platform is exposed only during spring low tides. The two levels are floristically rather different. Zonation can be observed at both levels, but is clearest on the lower platform, where it is related to minor differences in height and to distance from the surf zone at extreme low water.

Scattered areas of upper platform occur fairly close to the beach, from Turtle Bay southwards to the entrance to Mida Creek (see Fig. 7) and also in Blue Lagoon between Kibirijini and Watamu Point. The surface of these inshore areas of upper platform appears relatively bare, but in fact often has a fairly dense growth of small filamentous algae. A limited number of larger algae grow in pools and where there is water seepage. Cystoseira myrica (Gmel.) J.Ag. and Padina commersonii Bory are particularly characteristic of this habitat, and Cystoseira trinode (Forsk.) C.Ag., Sargassum spp., Turbinaria conoides (J.Ag.) Kuetz., T. ornata J.Ag., Dictyota adnata, Cymodocea ciliata Ehrenb. ex Aschers., and Thalassia hemprichii (Ehrenb.) Aschers occur in pools, which are often fringed by Gracilaria crassa (Harv.) J.Ag.

The vegetation of the upper platform is much richer on the seaward sides of Kibirijini (between Turtle Bay and Blue Lagoon) and Watamu Point (north of Kibirijini). On Kibirijini most of the surface of the upper platform is covered by a dense, crisp turf of coralline Amphiroa spp., mainly A. fragilissima (L.) Lamour., mixed with Boodlea composita (Harv.) Brand, Dictyosphaeria cavernosa (Forsk.) Boergs., Dictyota ceylanica, Gelidiella acerosa (Forsk.) Feldm. & Hamel, Valoniopsis pachynema (Mart.) Boergs., Colpomenia sinuosa (Roth) Derb. & Sol., and some Actinotrichia fragilis (Forsk.) Boergs.; the spongy algal turf retains sea water and so does not dry out like the bare surface of the inshore upper platform. Conspicuous green patches of filamentous Chlorodesmis sp. grow here and there. Pools are less well developed than on the inshore platform, but are still fairly abundant and are again fringed by Gracilaria crassa, with scattered plants of a superficially similar Codium sp.. An interesting feature of these pools is the occurrence of rounded living "pebbles" of Lithothamnion spp., unattached and evidently able to grow in size and even able to multiply when they are broken up by wave action; they probably originate from the attached Lithothamnion spp. of the outer reef slope (see below). Cystoseira myrica and Padina commersonii grow both in the pools and in the turf; Sargassum cf. latifolium (Turn.) C.Ag., S. cf. polycystum C.Ag., Hormophysa triquetra (L.) Kuetz., Dictyota adnata, and stunted Cymodocea ciliata grow in the pools. The upper platform on Watamu Point, 400 m. north of Kibirijini, is very similar to that of Kibirijini, and differs mainly in the occurrence of raised bare areas, rising a few centimetres above the level of the Amphiroa turf, apparently formed by the growth of an unidentified encrusting calcereous red alga (probably Lithophyllum sp.) and often crowned by conspicuous tufts of the Cladonia-like Liagora caenomyce Decne.

At both Watamu Point and Kibirijini the upper platform is at a level of 75-90 cm. above MLWS; at Watamu Point is reaches a maximum width of c.30 m, and then slopes down to the lower platform which is at a level of c.30 cm. above MLWS fairly abruptly; a terraced slope c. 1 m. wide, with irregular terraces fringed by raised Amphiroa turf, forms the transition between the two levels. At Kibirijini the upper platform is fringed by a similar terraced slope, but is almost completely separated from the lower platform by a zone of shallow lagoons 30-40 cm. below LWMS; these lagoons contain dense beds of Cymodocea ciliata.

The lower platform at Watamu Point is c. 60 m. wide and slopes gradually down into the sub-littoral zone. It is characterised by abundant Vanvoorstia spectabilis Harv., Hydroclathrus clathratus (Bory) Howe, Boodlea composita, Laurencia obtusa (Hud.) Lamour., Caulerpa racemosa Forsk., and Gelidiella acerosa, all of which are more abundant here than on the lower platform at Kibirijini. Dictyosphaeria cavernosa and Chlorodesmis sp. are also abundant. Fleshy Turbinaria ornata increases as the surf zone is approached, and Sargassum spp. (S. cf. ilicifolium, S. cf. latifolium, and much S. cf. polycystum) grow in less exposed areas; Jania capillacea Harv. is a common epiphyte on T. ornata and the Sargassum spp.. The large siphonaceous algae Halimeda discoidea Decne and H. renschii (= H. stuposa Taylor) also occur. Hormophysa triquetra and Cymodocea ciliata are abundant in shallow pools and the shallow sub-littoral areas of the platform, and a number of encrusting red algae grow under C. ciliata. Many species grow in occasional deep pools, including Actinotrichia fragilis, Cheilosporium jungermannoides Rupr., Galaxaura squalida Kjellm., G. tenera Kjellm., and Scinaia indica Boergs, (found growing attached both here and at Kibirijini; previously known in Kenya only from a single specimen found cast up at Watamu). The sub-littoral zone at Watamu Point, which is very exposed, was not investigated beyond wading depth.

The lower platform at the southern end of Kibirijini slopes from a height of c. 30 cm. above MLWS to c. 30 cm. below MLWS in a distance of 25 m., a considerably steeper gradient than was observed on Watamu Point. Four successive zones (belts) are clearly defined here. Most of the lower platform, which is 80-150 m. wide, is in the highest of the four zones, 20-30 cm. above MLWS, and dries for $1\frac{1}{2}$ - 2 hours during spring low tides. The underlying "rock" here, as in other zones, is sand-rock, cemented with lime and mixed with larger pieces of coral and coralline alga. In the highest zone (Zone I) this rock is covered by a mixed mat of small and stunted algae, protected by a layer of sand 0.5 - 2 cm. thick through which they grow. Most of the species of algae appear to be severely damaged by desiccation if they project from the sand. The following species were observed in Zone I :

Amphiroa fragilissima	f	Eucheuma cottonii	r
Anadyomene wrightii Gray	o	Gelidiella acerosa	f
Boodlea composita	f	Jania sp.	f
Caulerpa pickeringii Harv & Bail	o	Laurencia obtusa	o
Colpomenia sinuosa	o	Padina commersonii	f
Dictyosphaeria cavernosa	f	Turbinaria ornata	o (scorched)
Dictyota cf. ceylanica	f	Valoniopsis pachynema	f
		Vanvoorstia spectabilis	f

The next zone (Zone II) is a narrow belt 4-5(-8) m. wide, between c. 5 and c. 20 cm. above MLWS, dominated by Turbinaria cf. ornata, and washed by occasional waves even during spring low tides. The Turbinaria is morphologically variable, and may consist of a hybrid swarm between T. ornata and a related species. It grows in dense stands separated by open spaces in which most of the species of Zone I grow; the overall cover of Turbinaria averages 40% and locally reaches 70-100%, and the stands reach a height of 10-15 cm. A few large plants of Halimeda discoidea, resembling the Turbinaria plants in size and height, occur both in the Turbinaria stands and in the intervening open spaces. Several species that were not observed in Zone I grow in the shelter of the Turbinaria stands; the following species were observed:

Actinotrichia fragilis	f	Halimeda renschii	f
Amanzia glomerata C. Ag.	f	Lithophyllum sp.	la
Galaxaura squalida	f	Sargassum duplicatum (Turn.) C.Ag.	o
Galaxaura tenera	r		

At a height of c.5 cm. above LWMS, the Turbinaria of Zone II is abruptly replaced by a belt dominated by Sargassum cf. polycystum (Zone III), extending to c.10 cm. below LWMS. This zone does not dry out during spring low tides, and is more open in appearance than the Turbinaria zone, with plenty of sand showing. In August 1969 the Sargassum plants were battered and abraded, with the upper fronds worn down to the midribs; new fronds were growing from the bases of most plants. A number of species of open sandy areas that occur in Zones I and II also occur in Zone III; the following species were observed:

Anadyomene wrightii	Dictyota cf. ceylanica
Boodlea composita	Gelidiella acerosa
Dictyosphaeria cavernosa	Laurencia obtusa

The species that occur in Zone III but not in Zones II and I are mostly species that are intolerant of desiccation; the following species of this type were noted:

Caulerpa racemosa	Hormophysa triquetra
C. scalpelliformis (R.Br.) C.Ag.	Ulva sp. (cf. rigida)
Chondrococcus harveyi (J.Ag.) De Toni	

At a depth of about 10 cm. below MLWS, the Sargassum zone (Zone III) gives way abruptly to a zone dominated by Cymodocea ciliata (Zone IV). This zone is floristically different to the three upper zones and, apart from Halimeda spp., few of the species of the three upper zones occur except on rocky outcrops. This sharp floristic difference possibly results from the combined effects of the fairly deep but unconsolidated layer of sand held by the rhizomes of C. ciliata, which does not provide a suitable substratum for the attachment of algal holdfasts, and the relatively dense shade cast by the canopy of C. ciliata and its epiphytes. The Halimeda spp. are apparently both shade-tolerant and able to attach into unconsolidated sand with their massive holdfasts. The following epiphytes were observed to grow on the stems of C. ciliata:

Corallina subulata	va	Liagora mauritiana Boergs	r
Dictyopteris delicatula	f	Lithophyllum sp.	f
Dictyota bartraysiana	f		

b) The outer reef slope

The slope of the reef-platform on Kibirijini steepens to c.10^{o} at a depth of about 0.3 m. below MLWS (in Zone IV) and steepens again to 30^{o}-35^{o} at a depth of 1.8 m. In the part of the sub-littoral slope that was observed, the dense stand of Cymodocea ciliata extends to the second break in the slope at -1.8 m., and then thins out rapidly, reaching a maximum depth of -2.5 m.. The rocky outer slope, from -1.8 to -10.5 m., is predominantly an algal zone here, with relatively few corals. It is exposed to fairly strong wave action, and strong surge effects are noticeable even with a moderate swell right down to the foot of the slope at -10.5 m., where it ends in a strongly ridged sandy bottom. The most interesting features of the vegetation of the slope are the occurrence of banks of a reef-forming species of Lithothamnion between -3 and -6 m., and the occurrence of Stypopodium zonale, as scattered plants growing on projecting rocks, between -3 and -10 m; attached plants of S. zonale were not observed anywhere else, although cast-up plants were found on the beach on several occasions. The following species were observed on the rocky outer slope:

Amanzia glomerata		f	(-3 to -10 m.)
Amphiroa beauvoisii Lamour.		o-f	(-3 to -10 m.)
Halimeda renschii		o-f	(-1.8 to -10.5 m.)
Hormophysa triquetra		r	(-3 m.)
Galaxaura breviarticulata		f-a	(-5 to -10.5 m.)
Neurymenia fraxinifolia (Mert.) J.Ag.		f	(-6 to -10-5 m.)
Lithothamnion sp.		la	(-3 to -6 m.)
Pocockiella variegata (Lamour) Papenf.		r	(-10 m.)
Sargassum sp.	(c)	f-a	(-1.8 to -10 m.)
Stypopodium zonale (Lamour.) Papenf.		o	(-3 to -10 m.)

c) Isolated coral heads on the reef flat

The irregular row of isolated coral heads in the deeper part of the Watamu reef flat, the "Coral Gardens" about 3 km south of Kibirijini (See Figure 7), provides a range of sub-littoral habitats for algae of rocky substrata. Algae are with few exceptions absent from living coral; the most conspicuous exception is the presence of occasional plants of Turbinaria decurrens (= T. murrayana) on the current-swept tops of projecting heads, up to a depth of 0.8 m. below LWMS. There is, however, much dead coral rock; the relief is extremely varied and there are many vertical faces, shaded overhangs, and small caves. The maximum depth is about 6 m. below LWMS. Halimeda spp. are conspicuous in open sites; H. opuntia, usually heavily overgrown with epiphytes, is most abundant in shallower water, H. renschii is abundant in deeper water, and H. tuna, H. discoidea, and H. incrassata also occur. Dictyota spp. are very common in open sites (D. adnata was one of the first colonisers of brick in this area). Neurymenia fraxinifolia, typically dirty in appearance, is locally abundant on the tops of dead coral heads at depths of 0.8 - 2 m. below MLWS, often associated with Turbinaria decurrens. Occasional depauperate plants of Sargassum (c) grow on steep rock-faces at about 3 m. below MLWS. A conspicuous and attractive red alga (cf. Gelidium rumpii) is locally frequent in moderately shaded sites at the base of the coral heads, near the sandy bottom, in depths of 3.5 to 4 m. below MLWS, and Galaxaura tenera is locally abundant in similar but less shaded sites.

One of the most interesting features of the coral heads is the well-developed algal vegetation of shaded sites. Amanzia glomerata, a red alga provisionally identified as Vidalia fimbriata (R.Br.) C.Ag., and a Dictyota sp. grow in shaded crevices where water circulates freely. Thalloid species, including exceptionally large plants of Tenaciphyllum lobatum Boergs., Pocockiella variegata, and Peyssonellia sp., grow on shaded vertical rock-faces in depths of 2 to 6 m., and Lithophyllum spp. and Porolithon sp. (tentative identifications) encrust the rock thickly in the most shaded sites.

d) Exposed shallow sub-littoral reef flat

In the more exposed part of the Watamu rock platform near the entrance to Mida Creek, large areas of the shallow sub-littoral flat (0.8 to 3 m. below ELWS) are occupied by a mixed community of large fucoid algae growing on an uneven rock and cemented sand substratum. Sargassum cf. polycystum and S. cf. ilicifolium are dominant, with some Sargassum (c), Cystoseira trinodis, and Turbinaria ornata, and a little Sargassum cf. latifolium. Padina commersonii is locally very common. Stoechospermum marginatum is a minor but characteristic member of the community, and Spathoglossum asperum J.Ag. also occurs, infrequently. Dictyota divaricata is a conspicuous epiphyte on the Sargassum spp.. This Sargassum community is replaced by Cymodocea ciliata in more sheltered areas.

The Vegetation of Sandy and Silty Substrata

The marine vegetation of sandy and silty substrata on the lower shore and in the sub-littoral zone is, in the Watamu area, dominated by marine monocotyledons, the so-called "sea-grasses"; the following eleven species occur in the area:

Cymodocea ciliata Ehrenb. ex Aschers.

C. serrulata (R.Br.) Aschers.

C. rotundata Aschers. et Schweinf.

Syringodium isoetifolium (Aschers.) Dandy

Halodule uninervis (Forsk.) Aschers.

H. wrightii Aschers.

Halophila ovalis (R.Br.) Hook.f.

H. minor (Zoll.) Hartog.

H. balfourii Solered.

Thalassia hemprichii (Ehrenb.) Aschers.

Enhalus acoroides (L.f.) Rich. ex Steud.

Halophila balfourii is regarded by many authors as conspecific with the closely similar H. stipulacea (Forsk.) Aschers. of the Red Sea and eastern Mediterranean. One other species of marine monocotyledon, Zostera capensis Setchell, grows on the coast of Kenya, but has not yet been found in the Watamu area; the nearest site from which it is known is Kilifi Creek, where it was discovered to be locally abundant just below MLWS by D.A. Jones in August 1969. Several species of

Caulerpa, green algae with an angiosperm-like habit of growth, are associated with the angiosperms in the sub-littoral zone.

Cymodocea ciliata is easily the most important species in the Watamu district, both in the area that it occupies and in its provision of a habitat for many epiphytic plants and associated animals. In its distribution, ecological importance and even appearance, C. ciliata somewhat resembles a smaller version of Laminaria hyperborea. However, it can grow both in suitable rocky substrata and on sandy substrata, unlike L. hyperborea which is limited to rocky substrata. Its rhizomes and roots accumulate and stabilise sediment, and the tangled mass of living and dead roots and rhizomes can reach a thickness of 20-30 cm..

i) Intertidal flats

On sheltered sandy flats on the lower shore, Halodule wrightii is the most frequent species, and is often associated with Halophila ovalis or (in parts of Mida Creek) with Halophila minor. Halophila balfourii (in the north-west corner of Turtle Bay) and Thalassia hemprichii grow in the lowest part of this zone and are just exposed during the lowest spring tides. The plants of all species are normally partly buried in the sand, and leaves or stems that are fully exposed are usually severely damaged by desiccation, overheating or osmotic shock; Halodule wrightii appears to be less sensitive than the other species. Shallow sandy pools are common in this zone, and all the species grow to a much larger size in the pools. They are, however, often restricted to the margins of the pools by competition from larger species - Syringodium isoetifolium, Cymodocea rotundata, C. serrulata, and C. ciliata - that are locally abundant in the pools. A species of Hypnaea occurs, with Halodule wrightii and Halophila minor, on intertidal flats in parts of Mida Creek.

ii) Sheltered sub-littoral reef flat

Cymodocea ciliata beds cover several hundred hectares in the sheltered waters of the reef flat between Kibirijini and the entrance to Mida Creek (Figure 7). A typical transect made at right angles to the beach midway between Kibirijini and Mida Creek shows the following zonation:

A belt of ridged, mobile sand 10-15 m. wide and covered by 0.5 - 1.5 m. of water at LWMS separates the foot of the beach from a dense, pure stand of Cymodocea ciliata, fringed on the landward side by a narrow belt of depauperate plants and occasional strips of C. serrulata and C. rotundata, c. 1.5 m. below MLWS. The stand of C. ciliata extends to 400 m. from the beach, in depths of 0.8 - 3 m. below MLWS, and ends at a slightly deeper (4-5 m.) sandy channel of varying width. This inshore bed of C. ciliata resembles the inshore beds of Thalassia hemprichii at Mahé in the Seychelles, described by Taylor (1968). Beds of C. ciliata also occur further out, down to a depth of c. 6 m.; C. ciliata is often associated with Halodule uninervis in these deeper beds.

Up to a distance of 80 - 120 m. from the beach, the C. ciliata plants have few epiphytes, and the uniform stand is broken only by occasional rocky outcrops, and by a few small sandy clearings in which Thalassia hemprichii often grows. From a distance of 80 - 120 m. from the beach out to the edge of the inshore bed 400 m. from the beach, the C. ciliata plants have more epiphytes, the stand is more open, and there are frequent sandy and rocky dips eroded to 0.5 - 1 m. below the level of the C. ciliata rhizomes, and also sandy banks rising above the general level of the bottom to depths of 0.3 m. below MLWS. The rocky dips have a varied algal flora, often including Cystoseira trinode, Sargassum spp., Halimeda discoidea and other Halimeda spp., and Padina commersonii; Udotea indica A & E.S. Gepp and Neomeris van-bosseae Howe are locally abundant. The sandy dips are usually either plantless or colonised by pioneer Thalassia hemprichii. The often rather mobile sandy banks have a varied flora of marine angiosperms; Syringodium isoetifolium is common, and often forms dense stands towards the edge of the bank; Thalassia hemprichii is equally common, and is apparently an important binder of sand; Cymodocea rotundata occurs in the areas where the sand is most mobile, and occasionally forms pure swards; Halodule spp. are common, intermingled with the other species; Halophila balfourii is locally common, and occasionally co-dominant; H. ovalis is rather less common; and the siphonaceous green algae Caulerpa cupressoides and C. pickeringii also occur.

iii) Mida Creek

In the narrow entrance to Mida Creek the sandy and gravelly bottom, with occasional rocky outcrops, slopes steeply down to the central channel from the shore, and zonation of marine angiosperms is very clear on the slope. Tidal currents are very strong here and the water is consequently rather turbid. A typical transect at right angles to the northern shore shows the following zonation:

The lowest mangroves (usually Rhizophora mucronata Lam.) extend almost to MLWS, or even slightly below; Halodule wrightii, Halophila ovalis, and (in the inner parts of the creek) Halophila minor grow on the silty flats beyond the mangroves that are exposed at MLWS. In shallow, sheltered water just below MLWS, before the main slope is reached, there is a mixed community of angiosperms on a sandy or silty bottom; Halodule uninervis dominates near the mangroves, and Thalassia hemprichii is the most abundant species further out, associated with increasing quantities of stunted Enhalus acoroides as the edge of the slope is approached in 0.3 - 0.5 m. of water at MLWS. Cymodocea serrulata is locally dominant, but usually grows as scattered plants. Cymodocea rotundata, Syringodium isoetifolium Halodule wrightii (apparently intergrading with H. uninervis), Caulerpa sertularioides (Gmel.) Howe and C. mexicana (Sond.) J.Ag. also occur. At the edge of this shallow area, there is a steep slope (c. 45°) down to a depth of 2 - 3 m., covered by large, vigorous Enhalus acoroides; at 2 - 3 m. there is a flat sandy or gravelly platform 10 - 20 m. wide, with much Cymodocea serrulata, some Thalassia hemprichii, and a little Halophila ovalis and (surprisingly) H. minor; more Enhalus grows on occasional rises on this platform, and both Turbinaria ornata and T. decurrens (= murrayana) grow with Sargassum spp. on rocky outcrops. Dense stands of Cymodocea ciliata, which is exceptionally tall here, grow on the outer edge of the platform and on the slopes beyond down to a depth of 6 - 7 m; C. ciliata is absent from deeper water. Scattered plants of Halodule uninervis, Caulerpa sertularioides, and C. mexicana were found in the centre of the channel on a level silty bottom in c. 10 m. of water at MLWS.

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FAUNA OF THE PARK

Porifera

A collection of sponges was made from the Watamu Park. Notes were made on the distribution, growth forms and colours of the specimens collected; for further records photographs were taken of the majority of the live specimens.

Identification will be carried out with the help of Miss S. Stone at the British Museum.

Corals

Collections were made of the corals found in the two Parks. A preliminary identification of the more common species was made and photographs taken to show the great variety of growth forms and when possible the structure of the expanded polyps.

From general observations and comparisons with Casuarina, Horn's Bay and Shimoni (Figure 1), coral in the Watamu Park is not typical of the coast; it is poorer both in numbers and species.

In Turtle Bay there is a line of coral heads which runs in a north-south direction (Figure 7) and the richest coral in the Bay is to the south. The heads are mainly large blocks of *Porites* which may be as high as 5 m. These support other species of corals eg. *Acropora*, *Pocillopora*, *Favia*, various Brain Corals and *Fungia*. Other species found here have not yet been identified. The majority of tourists visiting the Park come to this area and there is evidence of damage by anchors. This is disturbing as the coral is by no means extensive. Towards the northern end of the line of coral heads the *Porites* heads are smaller and much is dead. There is far less *Acropora* and *Pocillopora*, with relatively more *Favia* sp.

Approximately 30 m. off shore and running parallel to it is a line of coral platforms, broken at intervals by sandy pockets and Cymodocea beds. The platform is just exposed on a 1 m. tide. It is covered by an algal turf and is poor in live coral; *Favia* and *Tubipora* being the commonest species.

To the south of Whale Island, just outside the Park boundary, there is an area richer in corals. There is much *Acropora* and *Fungia*, the *Porites* heads are more extensive and there is considerably more live and varied coral here.

Mida channel is an area particularly interesting for its corals, especially around the Big Three Cave. One species (*Dendrophyllia* sp.) is peculiar to the roof of the cave. The growth forms of the corals are small and their colours, together with those of the soft corals and the sponges which also grow on the roof of the cave, give the impression of a magnificent miniature garden.

The Malindi Park is far richer in both number and species of corals than the Watamu Park. Only a brief survey was possible as we were only able to work there on two occasions. The area known as the Coral Garden is very beautiful indeed.

Collection at Horn's Bay and Shimoni was not possible but many photographs were taken to record the general appearance of the coral growth and the common species found in both locations. The corals were rich and varied and particularly impressive at Shimoni where all life was "bigger and better" than anywhere else that we visited.

Polychaeta

Polychaetes were collected from many different substrates and habitats within the park, including beach sand, intertidal rocks and pools, subtidal grass-beds and sand, sponges, coral rock and as commensals on echinoderms. Several dozen species were identified at the time and photographed. A collection of sipunculids from mud and rocks was made.

Mollusca

Molluscs were collected from all major habitats in the park and from several other parts of the coast. Most of them were photographed both live and relaxed in order to record the natural colouration of the soft parts. Many provisional identifications were made on the spot and I was greatly assisted in this by well informed local shell collectors, who also supplied me with a great deal of information on the distribution and abundance of many species and the changes which have occurred in these. Whenever possible, the rarer species were identified, photographed and replaced and no specimens were kept. A special effort was made to collect and photograph the many beautiful species of opisthobranchs (mainly nudibranchs) which occur at Watamu. In all about 45 species were collected.

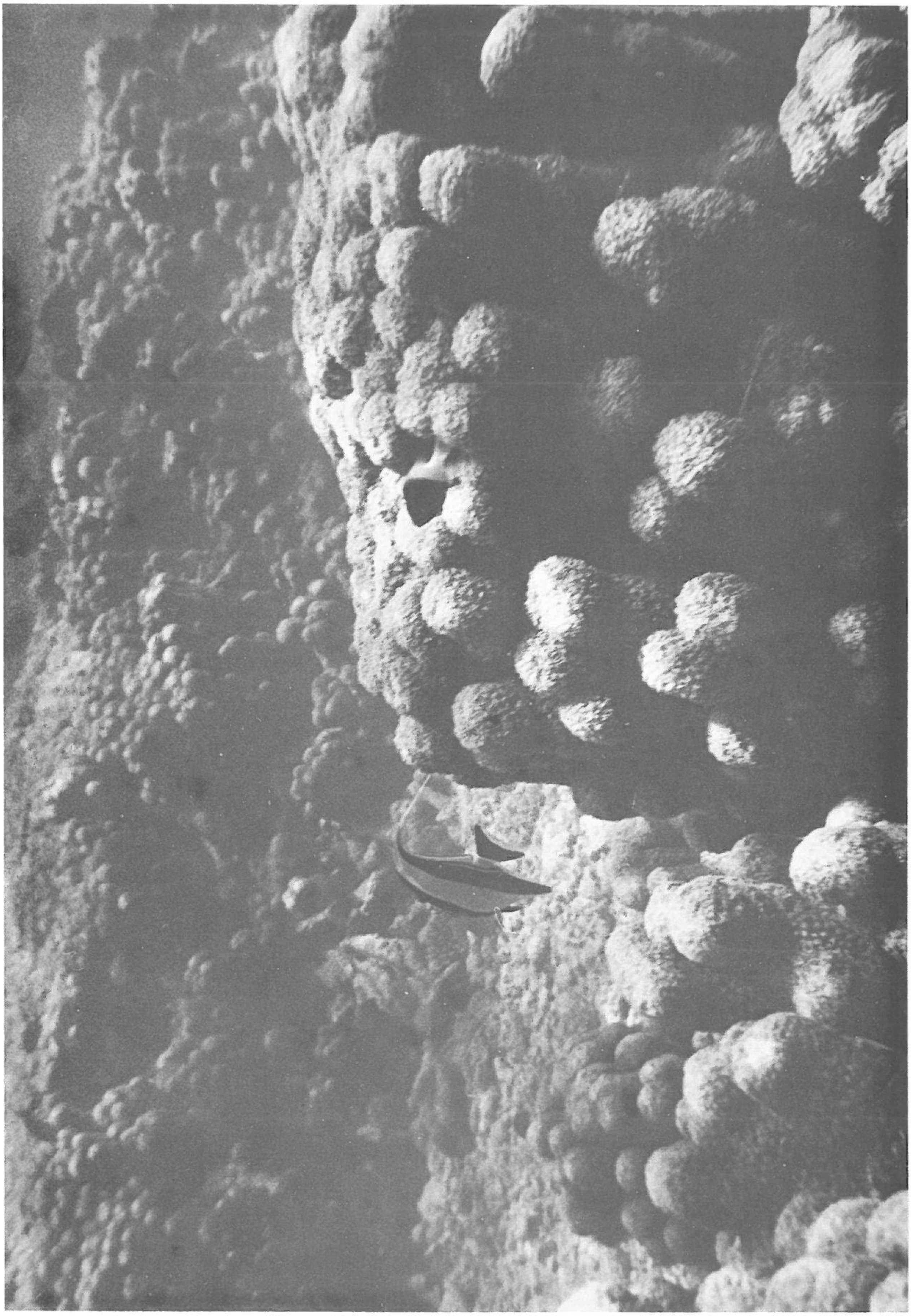
The mollusca fauna of the Park is not particularly rich, compared with other parts of the coast. According to local shell collectors it was never very rich, but has been greatly impoverished by large scale collecting in the years before the area became a park. Mida channel is one of the richest areas for molluscs and this may be partly due to the difficulty of collecting there.

Crustacea

The crustacea form an important part of the invertebrate fauna of the Watamu Park, with the Decapoda; including the Brachyura (Crabs), Anomura (Hermit crabs), Palinura (Crawfish) and Natantia (Shrimps and Prawns) together with the separate group Stomatopoda, forming the most obvious component due to their relatively large size and mobility. However, many of the habitats on closer examination revealed large numbers of smaller crustaceans including Isopoda, Amphipoda, Tanaidacea, and rocky surfaces were encrusted with Cirripedia. Other groups such as the Copepoda, Mysidacea and Cumacea were common in the plankton and in benthic samples.

Extensive collections were made from as wide a variety of habitats as was possible within the Park, Mr. McLeod concentrating on the Decapoda and Stomatopoda, whilst Dr. Jones concentrated on the other groups. Many common species of Decapod have already been identified by Mr. McLeod and these are included in the relevant sections of this report. However, due to the prolific numbers and large diversity of species of crustacea present in these collections, much of the material remains to be identified.

The Isopoda collections will be retained by Dr. Jones for identification



and identification of Amphipoda has been undertaken by Dr. Myers who includes a preliminary account of this order below, whilst Mr. McLeod holds the collections of Decapoda. Other groups will be passed on to various specialists who have already volunteered their assistance in this work.

Amphipoda

Initial sorting of the amphipod samples has been carried out, with preliminary identification to genus level. Inferences of habitat preferences, associations etc., based on the genus taxon might well be erroneous, since a genus may well be ubiquitous, whilst its component species may be specific. Nevertheless some general comments can be made, and the major amphipod habitats can be enumerated as follows:

1. Branching corals (living or dead) e.g. *Acropora* spp., *Pocillopora* spp.
2. Lobate, poorly branched corals (living or dead) e.g. *Meandrina* spp., *Porites* spp., coral rock and coraline algae.
3. Marine grass-like angiosperms e.g. *Cymodocea* spp., *Thalassia* spp., *Syringodium* spp.
4. Fucoid algae e.g. *Sargassum* spp., *Hormophysa* spp., *Turbinaria* spp.
5. Mud. (Mangrove)
6. Sand.

The habitats

1. Branching corals: This habitat is characterised by a very rich and varied amphipod fauna, with almost twice the number of species present in a given sample, than in samples from any other investigated habitat. It is probable that the density of individuals per unit area sampled is lower than in many other of the enumerated habitats, but this is speculative since the samples were not quantitative. The samples from this habitat are dominated by species of *Gammaropsis* (= *Eurystheus*), this genus generally representing about one half of the total amphipod population in any given sample. Also well in evidence are species of *Elasmopus* and *Maera* and tubicolous forms of the genera *Lembos*, *Paragrubia* and *Erichthonius*.

2. Lobate, poorly branched corals: This habitat has a much lower 'species diversity index' than the preceding. The dominant genera are *Elasmopus*, *Gammaropsis* and *Maera*. The faunistic impoverishment of this habitat is doubtless due to the lack of crevices and spaces for affording concealment to the epifauna, as compared to the former habitat.

3. Marine grass-like angiosperms: The samples, taken variously from the roots and leaves of living, rooted weeds and of dead floating weed, exhibit a somewhat variable and inconsistent complement of associated forms. Further samples and more precise data are required before an accurate assessment of the factors influencing the distribution of amphipods in these angiosperm beds can be

ascertained. Samples were variously dominated by Pontogeneia, Atylus, Cymadusa, Elasmopus/Maera and Lembos. The occurrence of the last named genus is probably influenced by detritus accumulation.

4. Fucoid algae: This habitat has a very characteristic fauna, dominated by the genus Hyale which is about five times more abundant in these samples than any other genus. The next most abundant genera are Gammaropsis and Elasmopus in that order, while the Ampithoidae (Paragrubia and Ampithoe) are also well represented.

Mud: Grandidierella bonnieroides Steph. (see Myers 1970) is the characteristic amphipod of the mangrove mud, as it is everywhere on the East African coast. It occurs at a high density and is almost the only amphipod of this habitat.

Sand: A Urothoe sp. was collected in considerable numbers in night plankton hauls over sandy bottoms in 3-5 m depth.
N.B. Night plankton samples taken over Cymodocea beds collected forms already recorded under habitat 3. In particular, fast-swimming forms such as Pontogeneia and Atylus which characteristically leave the benthos and join the plankton at night. The genus Synopia was represented in all the plankton samples.

General considerations

The most abundant genus in the samples was Hyale which was very habitat specific, occurring almost exclusively in the fucoid algae. The genera Gammaropsis and Elasmopus both of which constitute a number of different species, were, by contrast, ubiquitous occurring in almost all habitats sampled. (Individual species may prove to be more habitat specific).

Little can be said at present regarding the relationships of the amphipod fauna to that of other regions. It will be of considerable interest to ascertain the relationships of this, and East African amphipod fauna in general, with that of the Red Sea, North East Africa, South Africa and other regions of the Indo-Pacific. It is clear that all these regions are represented in the present samples, but quantitative relationships have yet to be studied.

Plankton

Plankton samples were taken both intertidally and sub-littorally within the Park using coarse (340 mpi) and medium (190 mpi) nets. In conjunction with these net hauls which were taken both at night and during the day, collections were made using a light at night. Although these hauls have yet to be analysied in detail, preliminary observations show these samples have several features in common.

At certain times Pleuston (plankton living on the sea surface) was very common close inshore, presumably blown in by the onshore winds. This plankton was characterised by the possession of blue pigments rendering dorsal surfaces bright blue, and also often possessed gas filled floats. Common members of the pleuston included the siphonophores Porpita and Velella together with Physalia, which, although of a small size (1-2 cm), was still capable of giving a painful sting. The delicate pelagic nudibranch Glaucus sp. was another common member of this surface plankton.

The plankton samples contained a large epi-benthic component including

Amphipoda, which formed 80% of most samples, together with Cumacea, Mysidacea, and cirolanid Isopoda. Very few holo-planktonic forms were taken, the Copepoda, normally abundant, forming only a very small percentage of the catches, reflecting the relatively enclosed nature of the reef lagoon.

During the period July - September only two forms, stomatopod larvae and brachyuran megalopa and zoea, showed a marked dominance in the meroplankton. The stomatopod larvae were particularly numerous at light in Blue Lagoon and as they were not found by day in the plankton it seems possible that they spent much of their time among the grass beds. The Stomatopoda have a relatively long larval existence and the poverty of other larvae in the plankton is possibly due to the time of year when most benthic invertebrates were not breeding.

The Echinoderms

The echinoderms are divided into five living classes; Asteroidea (starfish), Echinoidea (sea urchins), Holothuroidea (sea cucumbers or beche de mer), Crinoidea (feather stars and sea lilies), Ophiuroidea (brittle stars or serpent stars).

The plankton contains just under 6000 living species of which about 230 species have been found in the Western Indian Ocean compared with 70 species known to occur in the well studied British waters.

The echinoderms form a prominent component of the fauna of the marine park and are comparable with the molluscs by virtue of their striking coloration and considerable size attained. They do, however, preserve badly and in consequence rarely arouse the interest of commercial collectors, unlike the molluscs.

Work conducted: The echinoderms were extensively collected together with the other phyla from throughout the park. Animals were collected individually or extracted from samples of the substrate taken back to the laboratory. A species list will be drawn up and the distribution of the species within the park and between the "habitats" established. Counts were conducted on the larger species occurring within the marine grass beds and the nature and frequency of commensal and predator-prey relationships established.

In work of this nature very little of the material can be identified in the field and in consequence it has to be preserved and returned to Britain where identified material will be offered to the British Museum (Natural History) and the Marine Science Laboratories, Menai Bridge, after a full collection has been returned to the National Museum of Kenya, Nairobi.

The large starfish Acanthaster planci (crown of thorns) has received much attention recently due to its destructive activity on the Great Barrier Reef of Australia; this starfish grazes on coral polyps, killing the coral. However, no A. planci were found in the Watamu-Casuarina Park area by members of the expedition although one individual was photographed by Mr. P. Saul earlier in the year at Casuarina. Local people, however, reported that it was widespread although uncommon. Members of the expedition saw two specimens at Shimoni in late September.

Various authors consider that the unrestricted collecting of large predatory molluscs which feed on A. planci especially the giant Triton, Chaeronia tritonis, may contribute to the increase of the starfish populations. If any plague centres develop on the East African fringing reefs it will be imperative that their spread is carefully examined and controlled if possible for such a plague would destroy the tourist appeal of the present National Park and of those in the planning stage. The urgency of the problem is such that the U.S. government has initiated a $4\frac{1}{2}$ million dollar project to investigate A. planci.

In the following section the more conspicuous Echinoderms within the different habitats will be briefly described.

The marine Angiosperm beds :

Tripneustes gratilla: A large brown regular urchin up to 10 cm in diameter with short yellow to white spines. Extremely abundant often aggregated in groups of up to 70 individuals, sometimes 2 or 3 deep. Often climbs the fronds of the grasses, especially at night. Normally covers the test with detached grass leaves or coral rubble if no leaves are available. It is predated in large numbers by the mollusc Cypraecassis rufa and by an unknown fish.

Toxopneustes pileolus; a large pink regular urchin, slightly compressed in the oral-aboral axis. Covers itself with coral debris. Most abundant immediately inshore of the surf zone but widespread; possesses huge toxic pedicellariae - (pincer-like structures found between the spines).

Culcita schmideliana; a large massive pentagonal cushion star. Ventral side pale with orange green or blue tubercles; the dorsal side is variable in colour with normally purple to black tubercles.

Protoreaster lincki; a large massive five armed grey and red starfish - 5 Prominent tubercles around the margin of the 'disc' and laterally at the arm tips. Widespread but not common.

Echinometra mathaei; a medium sized, (up to 5 cm), ovoid urchin. Colour very variable - green, mauve, purple and black. Abundant amongst the grass roots but well hidden. Patchy distribution.

Rock Platforms :

Stomopneustes variolaris; a large green to black urchin living in crevices and often making deep grooves in the rock. Characteristic of exposed shores where it maintains a tenacious grip using its tube feet and lodging its spines against the sides of the crevice. Most abundant around mean low water.

Ophiocoma scolopendrina; a large variegated to black ophiuroid with pale under-surface. Abundant, living in holes and crevices around mean low water and below. This species extrudes two or three arms to filter the water for food; often conspicuous when the tide is rising as the arms are turned over to feed on material trapped in the surface layers of the water thus exposing the white undersurface. In common with many ophiuroids the arms autotomise (are shed) if trapped.

Coral Heads :

Ophiocoma erinaceus; a large ophiuroid black with red tube feet; lives in holes in massive coral heads; protrudes arms from holes in the same manner as O. scolopendrina but normally sub-littoral in distribution.

Diadema setosum; a large black echinoid with extremely long-spined free living in groups or in crevices; bristles spines when approached. Spines covered by black 'skin' causing numbing if they penetrate ones skin. Often with five blue or white spots on test. Occasionally parasitised by Eulimid molluscs, singly or in clusters.

Linckia laevigata; a large blue starfish with narrow arms and a very small disc. Locally abundant in the coral heads. Able to enclose tube feet entirely in ambulacral groove. Virtually inflexible when handled but capable of great mobility.

Mida Channel :

Linckia multifora; a green to brown asteroid normally with 5 unequal arms and two madreporties. Animal autotomises at the disc and the missing arms regenerate producing 'comets' and eventually typical adults. Locally abundant and often in the same area as Nardoa variolata.

Theleonota ananus; a large shaggy brown holothurian with orange and yellow ventral surface and orange oral tentacles. Occurs in flowing water.

Synapta maculata; a long snake like (up to 2 m) brown to variegated holothurian with no tube feet. Moves by muscular contraction of the body wall maintaining purchase on substrate by means of large anchor shaped calcareous spicules which form part of the exoskeleton. Not uncommon along sides of the channel. A similar but much smaller species, Ophiodesoma sp., also occurs.

Biological Relationships of Watamu Echinoderms :

Echinoderms, with their calcareous skeletons and often spiny armour would appear rather formidable prey despite their sedentary existence. They are, however, readily eaten by fish on leaving shelter and many of the larger members of the phylum have more specialist predators. Commensal relationships are common. Commensalism means 'feeding at the same table' and is used to describe a range of animals which may, at one extreme, use the host animal as shelter and at the other extreme rely on the host tissue for food and are consequently parasitic.

Ophiuroidea: the polynoid Harmathoe sp. was found on the arms of several species of ophiuroids. The genus is widespread and abundant and the relationship is probably one of chance. A small white ophiuroid (unidentified) was on several occasions found on various holothurian species.

Echinoidea: Ophiuroids are occasionally found amongst echinoid spines - probably a chance occurrence. A small Alpheid shrimp Athanas sp. was found on T. gratilla, T. pileolus and E. mathaei. Diadema setosum is occasionally heavily parasitised by a large Eulimid mollusc.

Asteroidea: Both Culcita schmideliana and Protoreaster lincki frequently were found to have up to two Pearl fish (Carapidae) living in their stomachs. These rather eel like fish enter through the mouth backwards and emerge at night to feed in the neighbourhood of the host to which it retreats if alarmed. Two small, as yet unidentified, shrimps are commonly found living on the underside of these two starfish during the day and moving freely about the host at night. They retreat to the ambulacral groove if disturbed. Another medium sized shrimp Hymenocera sp. was found by Mrs. Tauber of Kikambala. This shrimp sits on an arm of the host and eats the end, eventually reducing it to a stump. It feeds on numerous species including Linckia laevigata, Protoreaster lincki, P. nodosus but preferably moves to Nardoa variolata.

Small fish sheltering beneath Protoreaster lincki may be trapped by the starfish and eaten. This was observed in aquaria with the Sargassum fish, Histrio histrio and the Trigger Fish Rhinecanthus sp. when deprived of alternative shelter.

Holothuroidea: Wide range of small Eulimid mollusc parasites up to 100 per animal. The black and white crab Lissocarcinus orbicularis is commonly found on a wide range of holothurians - up to 3 per host. The scaleworm (polynoid) Gastrolepidia clavigera with a full range of intermediate colours from white to dark brown lives on the surface of holothurians and has a negative reaction to light. Pearl fish live in the respiratory trees of cucumbers entering through the cloaca.

Holothurians are widely reported to be toxic. If Holothuria (Halodima) atra is placed in the same tank as small fish the latter often die. Reports state that the intestines of holothurians are very toxic, however, Moray eels eat eviscerates of Theleonata sp., Synapta sp. and Stichopus chloronotus and appear to suffer no ill effects.

Certain sea cucumbers eject Cuvierian organs if handled. Their long white sticky filaments are believed to entangle possible predators and result in the name cotton-spinner being applied to such animals.

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Species list to date

	Environment			
	Grass beds and sand channels	Reef Platforms	Coral heads	Mida Channel
Asteroidea				
Culcita schmideliana	x			
Protoreaster lincki	x			
P. nodosus	x			x
Asterina burtoni		x	x	
Gomophia sp.		x		
Linckia laevigata	x		x	x

Species list (contd.)	Environment			
	Grass beds and sand channels	Reef Platforms	Coral Heads	Mida Channel
Leiaster coriaceus				x
L. glaber				x
Linckia guildingii				x
Ophidiaster hemprichi				x
Echinaster purpureus				x
Astropecten sp.				x
Echinoidea				
Toxopneustes pileolus	x			
Tripneustes gratilla	x		x	
Echinometra mathaei	x	x		x
Prionocidaris verticillata	x			
Stomopneustes variolaris	x	x		
Laganum depressum	x			
Diadema setosum	x	x	x	x
Echinothrix diadema		x		x
E. calamaris		x		x
Echinoneus cyclostomus			x	
Eucidaris metularia				x
Astropyga radiata				x
Clypeaster sp.	x			x
Meretia sp.	x			x
Holothuroidea				
Actinopyga mauritiana				x
Bohadschia kollikeri				x
Microthele nobilis				x
Stichopus variegatus				x
Theleonota ananus				x
Synapta maculata				x
Afrocucumis africana		x		
Halodiema sp.		x		
Actinopyga spp.	x			x
Bohadschia marmorata				x
Ophiodesoma sp.				x
Ophiuroidea				
Ophiocoma scolopendrina	x	x		x
O. erinaceus		x	x	x
O. dentata		x		
Ophiocoma brevipas		x		
Ophiarthrum elegans		x.		x
Ophiarachna sp.		x		
Ophiopeza fallax		x		
Ophiarachnella septemspinosa		x		
Ophioplocus imbricatus			x	

Species list (contd.)

	Environment			
	Grass beds and sand channels	Reef Platforms	Coral Heads	Mida Channel
Ophiolepis superba			x	
Ophiactis savignyi			x	x
Ophiothrix echinotecta				x
O. trilineata				x
O. (Keystonea) nereidina				x
O. (K) propinqua				x
Ophiomestix spp.				x
O. venosa			x	x
Ophiarachnella gorgonia				x

No crinoids were identified in the field.

Fish

A general survey of the species of fish found in the Marine National Park and neighbouring inshore waters was undertaken.

A collection of intertidal and other fish was made, while notes on habitat, distribution, behaviour, size, colour variations etc., were recorded.

Fish were caught using several methods.

1) Capturing fish from the intertidal pools was facilitated by the use of the anaesthetic quinaldine (Gibson 1967).

2) Large hand nets were used in the park.

3) Surround nets were used in lagoon areas and over mud and sand areas in Mida Creek.

4) Small gill nets of varying mesh size were staked out from the shore and across mangrove drainage channels and visited at consecutive low tides.

By catching and observing fish in the intertidal, lagoon and Mida Creek environments an indication of the distribution of different species was obtained. Their distribution illustrates a need to define the term "coral fish". For the majority of so called "coral fishes" the degree and type of dependence on living coral is not known, and until more is known, the term "coral fish", unless supported by a definition, is often misleading "Reef fish" is a little better and has been used here.

The intertidal platforms embrace deep pools often with a particularly rich flora and containing a variety of fish. Distribution of fish over the platforms depends more upon the dimensions of the pools than their distance above MLW. The size of the pool determines the species present. Pools are characterised by the following, probably permanent species: Apogon taeniatus, Bathygobius fuscus, Abudefduf biocellatus, Exallias brevis, Halichoeres sp., and Halmablennius sp.

Pomancentrus annulatus is common, but is also seen elsewhere about the reefs. Where the medium energy cliffs of N.E. Kibirijini curve down to meet the reef platform, large groups of small Rockhoppers like Alticops periophthalmus (Cuvier), may be found basking in the sun often 40-50 cms away from water. When approached, there is a moment of panic as they leap into the water, while the reverse happens if one disturbs the water, all fish struggling to seek cover in rock crevices which provide protection from the fury of breaking waves during high tide.

The protection afforded to fish by the complex shelter of the littoral reef platform appears to be utilised by a variety of species for certain stages of juvenile growth. The most common of these, found in the intertidal pools in small schools, is Dules taeniurus; other examples include Canthigaster ambionensis, Thalassoma purpureum, Grammistes sexlineatus, Abudefduf saxatilis and Abudefduf sordidus. Small tightly packed schools of young Plotosus anguillaris are found in weedy pools, and the small colour variant of Amphiprion ephippium (Bloch, 1790) is also common. The pools of the reef platforms and the quieter cave pools under the sheltering cliffs of Kibirijini that face Ocean Sports, frequently contain schools of many hundred tiny juvenile fish. (These were impossible to identify in the field). Furthermore, it was observed that pools often contained numbers of fish of the same species grouped in clearly different size classes. If some reef fish are using the intertidal reef platforms and associated pools as "nursery grounds", then the reef platforms at Watamu are playing an important role in the ecology of the whole area. Direct recruitment from the intertidal platforms to other sub-littoral areas may occur. The northern park boundary divides Blue Lagoon across its centre along a NW/SE axis and thereby excludes the area of littoral reef platform that extends northward into Watamu Bay. More information is needed to know whether or not further protection of this area would be worthwhile.

At LWS, Blue Lagoon is left dry except for very shallow pools which, with their sand/mud bottom and usually thin covering of seagrass, do not provide much cover for fish. At high tide, however, members of the following genera may be seen: Acanthopagurus, Callyodon, Diplodus, Tylosaurus, Hemirhamphus, and Sardinella. Small sharks were sometimes caught by the gill nets and large members of the Carangidae have been reported entering the lagoon on the flood tide at night.

The reef platforms extending out from the beach and surrounding the large champignon outcrops in Turtle Bay are more sheltered than the reef platforms around Kibirijini, their flora is not so rich and the pools are covered by sand. Consequently the total number of fish and fish species found here is less than at Kibirijini, although many species are common to both areas, such as Abudefduf biocellatus, which is most common in Turtle Bay. There are notable exceptions such as Alticops periophthalmus. In the quieter pools of Turtle Bay Canthigaster margaritatus is common, and juvenile forms of Gaterin gaterinus are often found amidst the protective spines of Diadema setosum. Where the coral platforms are undercut, the caves so produced often shelter large serranids of up to about 40 lbs, probably Epinephalus tauvina. Labroides dimidiatus is often seen scurrying around the crevices at the break in the reef platforms, feeding on small crustaceans etc., and probably attending some of the larger fish, although this was only observed in the Coral Gardens. In the deeper waters of Turtle Bay sedate groups of Platax pinnatus are seen in both colour forms, while large schools of young fast moving Lutianus fulviflamma are seen feeding over the dense Cymodocea/ Thalassia grass beds. Syngnathus spp. and Histrio sp. are adapted to life in the beds of seagrass, but are not common in the park. A beautiful sea snake Myrichthys colubrinus was found on a sand covered reef platform extending out into the Bay.

By far the greatest density of fish in the park is found around the coral heads in the Coral Gardens, where many families are represented, often in great numbers. On passing into the Coral Gardens the first fish the tourist is likely to see are the teems of Abudefduf sexfasciatus that cluster underneath the goggle boats. Other common members of the Pomacentridae are Abudefduf saxatilis and Abudefduf sordidus; Amphiprion ephippium is common here also, but the large colour variant was not seen; Amphiprion (Phalerebus) akallopisos (Blkr 1953) was common where a large, lemon coloured Stoichactis sp. spread over large heads of "brain" coral; the small black Dascyllus trimaculatus was rarely observed. Chaetodontidae are commonly represented by Chaetodon lunula and Chaetodon auriga; Heniochus acuminatus is also quite common. Amongst the Labridae the strange shaped Gomphosus caeruleus is often seen; the small colour variant of Cheilinus trilobatus is quite common; the brilliant green Cheilio inermus is found around the coral heads in the dense sea grass; beautiful members of the genus Coris are quite common, but again often only seen as the small colour variants of the adults. The cleaner fish Labroides dimidiatus is very common, and its remarkable mimic Aspidontus tractus (Blennidae) is also present. Probably the most common Parrotfish of all is Callyodon guttatus, others include Leptoscarus vaigiensis and Leptoscarus caeruleo-punctatus. Members of the Gaternidae are apparently far more common now than they were before protection. Gaterin gaterinus and G. reticulatus are most common, G. flavomaculatus is less common, and G. orientalis is only seen very occasionally. Amongst the Acanthuridae, Acanthurus leucosternon and Acanthurus triostegus are very common; Zebrasoma veliferum is a rather beautiful rarity. Pterois volitans is the most common Scorpaenid; Pterois antennata being much less abundant. Pomacanthus semicirculatus and P. striatus are both common, although the adult colour forms of the two species appear less common than the juvenile forms. Members of the Balistidae, the Zanclidae (Zanclus cornutus), the Monacanthidae (Oxymonocanthus longirostris), the Platacidae (Platax pinnatus), the Diodontidae (Diodon hystrix), the Tetradontidae (Arothron hispidus), the Ostracionidae, the Serranidae, the Mugilidae and the Holocentridae, may all be seen at some time around the Coral Gardens. On several occasions a species of Platycephalus was observed lying over the sand at the base of the coral heads, but since they are rare no attempt was made to catch them.

Synanceichthys verrucosa (Stonefish) was not seen at the Coral Gardens. The preferred habitat of this fish is amongst coral rubble on the reef; however, it is a feeble swimmer and if dislodged can come to rest in any location. It is therefore a constant threat.

Until Mida Channel broadens into the Creek, much of the limestone rock on the north side is unusually exposed and rugged. The fauna and flora of these exposed parts is sparse and although there are many pools few fish are able to live here. The genus Abudefduf appears to be exceptionally robust and A. saxatilis, A. sordidus and A. glaucus are found, as well as an occasional and beautiful specimen of a juvenile Cephalopholis argus. Some of the highest pools along this shore may only be replenished with sea water during spring tides. They are often inhabited by large numbers of small fish similar to Istiblennius bellus impudens (Smith 1959b) and Alticops periophthalmus (Cuvier). Although able to move from pool to pool by powerful leaps covering a distance of up to 6', these fish are remarkable in their tolerance to extremes in temperature and salinity.

As Mida Channel widens the mangroves of the Creek begin. Their root-prop system, encrusted by invertebrate organisms, oysters usually predominating, and by algae, supports a population of small fish characterised by Monodactylus falciformis.

Although far less numerous, Monodactylus argenteus is also present and both species have been seen schooling together. Abudefduf saxatilis is common. Two members of the Apogonidae, Apogon orbicularis and A. novemfasciatus also characterise the root-prop system but tend to be more common closer inshore, particularly where limestone rock and mud meet and form pools. Along the muddy littoral shore the strange Mudskipper Periophthalmus sp. can be found.

In the open Creek schools of Parrotfish move rapidly in certain directions with seeming purpose; similarly silvery flashes from the sea surface may indicate large schools of young Agriosphyraena barracuda, while schools of Pseudopeneus barberinus feed over the bed of the Creek, and where over sandy areas large rays, 3' - 4' across are common. As these fish move extraordinarily fast in a direct line when frightened, they were never identified. Small pelagic game fish are also caught in the open Creek, such as Elegatis bipinnatulus. Pelagic game fish were never observed actually in the Watamu Marine Park, although if Mida Creek is used as a spawning ground or a "nursery ground" or both, large numbers probably pass through the southern end of the park at certain times of the year.

INSHORE FISHERIES The following aspects were surveyed briefly:

1. Fishermen's methods
2. Local fishing grounds
3. Fish marketing
4. Fisheries development
5. The confrontation between the Marine Parks organisation and the local fishermen's unions.

Several trips were made in local fishing boats from Malindi and Watamu and fishermen were observed working Ozio traps, Maema traps, Shark nets, Tata traps and other methods.

Several days were spent in the Malindi fish market identifying fish and observing the "catch" being landed, auctioned, cleaned, sorted, dried etc. At present 60-70% of the total weight of fish landed at Malindi and Watamu by the inshore fishing industry is demersal fish (in some months 80%). The Rabbitfish Siganus oramin, alone, may sometimes constitute up to about 30% of this figure, while the remainder is made up by a variety of species. The more important families are the Serranidae e.g. Epinephelus tauvina; the Lutianidae e.g. Lutinus argentimaculatus; the Lethrinidae e.g. Lethrinus nebulosus; the Gaterinidae e.g. Gaterin gaterinus; the Mugilidae in which three genera are all well represented Mugil spp., Upeneus spp. and Pseudo-peneus spp; the Callyodontidae e.g. Callyodon guttatus; and many others such as the Tigerfish Therapon jarbus. No fish is "trash" (Morgans 1964, p. 33) at Malindi (except locally toxic species) and fish such as Chaetodon lunula, Chaetodon auriga, Acanthurus triostegus, Zebrasoma veliferum, Naso unicornis, and others, are caught and landed, which is an unnecessary waste and should be avoided if possible.

Many of even the largest reef fishes seen in the Coral Gardens at Watamu frequently do not attain the size of many of the same species brought into the Malindi fish market. To see a 3' Callyodon guttatus or a 20" Naso unicornis in the Watamu Marine Park would be quite a shock. Furthermore it seems commonly to be the case that the small colour variant of a particular species may be abundant in the Watamu Park whereas the adult colour variant is rare if present at all e.g. Cheilinus trilobatus. Finally, amongst the larger species found in the Watamu Park, it is rare to find a species that attains the figure for size quoted in Smith (1949, 1963), when it is described. It seems likely that some of the larger species found in the Coral Gardens at Watamu may begin a move into deeper water as they reach a certain size and possibly before they are mature; an important point when considering the degree of protection afforded to these fish by the park.

Beyond any crude statement of relative abundance, it was not possible in the time available to obtain any bionomic assessment of individual fish populations.

In this Preliminary Report all identification was carried out using "The Sea Fishes of South Africa" (Smith 1949) and "The Fishes of the Seychelles" (Smith and Smith 1963). Material has still to be identified. Fish caught were preserved and bottled when possible, and it is hoped to enlarge the collection in the future. Duplicate specimens will be sent to the Nairobi Natural History Museum, which at present is devoid of marine fish specimens.

RESEARCH PROJECTS

In conjunction with the main work of the expedition various research projects were conducted by expedition members, either individually or in groups. Although the expedition's stay at Watamu was limited to a relatively short period it enabled members to make studies and observations on several species of tropical marine animals and plants about which little is known, and it was also possible for other members to continue research initiated on the Royal Society Expedition to Aldabra. A brief review of these projects is given below by the individuals concerned and it is hoped that they will form the basis of a series of scientific publications arising from the expedition.

Ecological studies on the genus Ocypode (D.A. Jones)

Although the genus *Ocypode* is widespread in the tropics, there appears to be few detailed observations on the behaviour and ecology of these crabs, (Tweedie, 1950). Studies were carried out on two species *Ocypode kuhlii* and *O.ceratophthalmus* which were abundant in the Watamu Park.

Distribution: An ecological survey was made of population densities of both species of crab which confirmed the observations of Macnae and Kalk (1962) who suggest that *O. kuhlii* has a preference for exposed beaches whilst *O.ceratophthalmus* is restricted to sheltered shores. These counts also revealed that although both species may occur at any level on the beach they reach their maximum densities in the supra-littoral zone at the top of the beach.

Observations on feeding behaviour in the field were conducted in addition to analysis of gut contents of both species. Preliminary results show that whilst both species are omnivorous, *O. kuhlii* shows marked herbivorous tendencies, feeding largely on *Cymodocea* and other vegetable refuse left stranded by the tide. *O. ceratophthalmus* appears to prefer small crustacea or dead crabs and was observed to catch and eat ants.

It has been reported that whereas *O. kuhlii* is predominantly diurnal, *O. ceratophthalmus* has a more nocturnal habit (Macnae and Kalk, 1962). Experiments were carried out using a tipping box aktograph (Naylor, 1958) recording on a clock-work drum using pressure sensitive paper. Crabs were kept in a constant-dark environment for periods of 4-6 days and activity recorded on the drum. Results have not yet been analysed.

Burrowing and feeding behaviour were recorded using still photography and cine-film in the field during a full tidal cycle.

It is hoped that the results of these studies will be fully analysed in the near future and presented in the form of a paper.

Studies on Eurydicid Isopoda of the Sand beach

Whilst the Eurydicid group of isopods form a characteristic part of the sand beach fauna in many areas of the world (Dahl, 1952; Bacesco, 1948; Monod, 1954;), it has been shown that individual species usually have fairly well defined ecological preferences both for a certain type of beach and for certain zones on a beach (Jones and Naylor, 1967; Jones, 1969;).

Quantitative samples of the beaches in the Watamu area have revealed 8 species of Eurydicid isopod, all possibly new to science. Analysis has shown these species show distinct preferences, one species, Pontegeloides sp. for sheltered beaches, others, Excirolana sp., for exposed beaches.

British species of Eurydice show a complex cycle of activity incorporating a tidal rhythm, animals swimming free of the sand during the high tide period, (Jones and Naylor, 1970). A series of quantitative plankton hauls taken at hourly intervals over a full tidal cycle at Watamu revealed a similar pattern of activity in African species. This work was supplemented with observations on isopods kept in a constant environment away from the sea, and data collected will be analysed for signs of a persistent tidal rhythm.

Descriptions of these isopods are in preparation and it is hoped that these will be published together with details on ecological and behavioural studies completed.

An investigation into the internal volume of coral rock.

(P. Fraser and K. Brander)

That organisms contribute to the processes of coastal erosion is well established. During the expedition a quantitative survey of the organisms that inhabit hard substrates was made. As a corollary to this work experiments were carried out to determine the extent to which boring organisms penetrate rocks. Measurements were made on the internal volumes of samples of Porites taken from coral heads in the Watamu Park.

Similar sized samples of live coral were taken from one very large Porites head. The samples were selected as small out-growths from the main head and so may be regarded as individual units. The samples were broken up into small pieces and the infauna extracted and recorded. The rocks were bleached, dried, weighed and volumed. The internal holes were filled with vaseline and the rocks reweighed. The results of this experiment will be worked up.

Hard substrate studies (K. Brander, A. McLeod, W. Humphreys)

Studies of marine benthic diversity have concentrated on the soft substrates which can be sampled by dredge or grab (Sanders, 1960, 1968; Parker, 1963; Thorson, 1957). Although a great deal has been written about the theoretical aspects of species diversity in tropical marine communities (Dunbar, 1960; Connell and Orias, 1964; Paine, 1966) very few studies have been carried out on shallow water and intertidal habitats.

Kohn's work on environmental complexity and species diversity on Indo-West Pacific reef platforms (Kohn, 1967) was restricted to the genus Conus. The three habitats which he compares are "sand substratum of shallow bays", "smooth intertidal limestone platforms" and "subtidal coral platforms" and the criteria of habitat complexity which he adopts a priori are heterogeneity and topographic relief of the substratum.

Our study was confined to an analysis of the species composition and diversity of molluscs, echinoderms, polychaetes and crustacea from hard substrates in the intertidal and subtidal reef platforms near Settlement, Aldabra, where the work was begun, and from subtidal coral areas at Watamu. The aim is to show how far the data from this type of substrate can be used to support or contradict the type of habitat classification which Kohn uses and the criteria on which such a classification is based. In addition, details of the distribution of the fauna within this type of substrate are given and samples from similar "habitats" on Aldabra and at Watamu are compared.

Classification of artificial substrates and coral rock

(K. Brander)

This was a continuation of an experiment started on Aldabra the previous year. A dozen rocks of coral origin were collected from the subtidal grass beds and left on the beach for two weeks to kill off the existing flora and fauna. They were marked with red paint and replaced on the bottom of the sandy channel running beside the Coral Heads, at a depth of about 15' below MTL. In addition eight large building blocks were put down in the same place to see what would colonise them. Rocks and bricks were removed at regular intervals, smashed up and the animals extracted by the dilute formalin method.

The object was to study recolonisation of these substrates and physical changes which take place over short periods (e.g. being covered with sand). The study is also relevant to our work on the infauna of hard substrates and provides data on colonisation and succession of infauna in coral, on motile elements of the infauna and on the relative importance of biotic and abiotic factors in determining species diversity.

About half way through the experiment an incident occurred which, although interesting in itself, badly damaged the experimental design. The colonisation experiment had been set out beneath a very large *Porites* head, which sheared off at its base and crushed or covered a large portion of the experiment. Luckily no divers were present at the time.

Decapod and Stomatopod larval culture and development

(A. McLeod)

Although the adult stages of many tropical Decapoda and Stomatopoda are relatively well known, little information is available as yet on stages in their development and dispersal. Study of the growth of several Crustacean larval forms was attempted at Watamu utilising both young larvae just released from a berried female, and later larval stages caught in a plankton net. The former by virtue of their origin are the more interesting since the parent species is known. The same culture techniques were used for both newly released and adult planktonic forms, but unfortunately with little success, partially due to lack of experience, partially due to lack of correct diets.

Live, freshly hatched larvae of the brine shrimp (*Artemia*) were used as food, cultured from a stock of dried shrimp eggs. The recently released larvae under study tended to be of a similar size to the *Artemia* larvae and thus could not handle the food with their raptorial and masticatory appendages and all died. The later stage larvae derived from the plankton fared better since they were large enough to utilise the *Artemia* larvae. Though only a pilot experiment was run the results obtained were spectacular, one transparent larval stomatopod ecdysing after a few days to give a rapidly pigmenting adult. However, although it was not possible to rear any brachyuran larvae through to the megalopa stage, several species of crab produced 1st stage zoeas in the laboratory, and these have been preserved for detailed examination. Collections of stomatopod larvae at various stages were also taken from plankton samples and it is hoped that it may be possible to use these in conjunction with the successful rearing experiments to piece together the developmental stages for at least one species of Mantis shrimp.

Botanical projects (Q.O.M. Kay)

Chromosome number counts: Chromosome number counts were made on marine angiosperms. The following numbers were found:

Enhalus acoroides	(Mida Creek)	2n = 18
Thalassia hemprichii	(Turtle Bay)	2n = 18
Halophila ovalis	(Turtle Bay)	2n = c.20
H. balfourii	(Turtle Bay)	2n = c.20

Frequency of flowering and flowering structure of Cymodocea serrulata: No flowers or remains of flowers were found on C. serrulata from Turtle Bay and the Watamu reef flat, but 43% of the sample of 183 plants from the entrance to Mida Creek bore female flowers, or the remains of female flowers. The structure of these flowers differs from that described by Isaac (1968) for the only previously known example, a single female flower found in drift at Diani Beach in 1967. The Mida Creek plants have female flowers which are terminal in position, with a gynaecium resembling that of C. ciliata as described by Isaac, but the gynaecium is subtended by a single leaf-like bract (not four bracts resembling those of C. ciliata as described by Isaac) and the growth of the stem is continued by a shoot arising in the axil of the leaf below the bract, so that the flower becomes apparently lateral in position; flowers arise both on short shoots and on long shoots (and do not terminate the growth of short shoots).

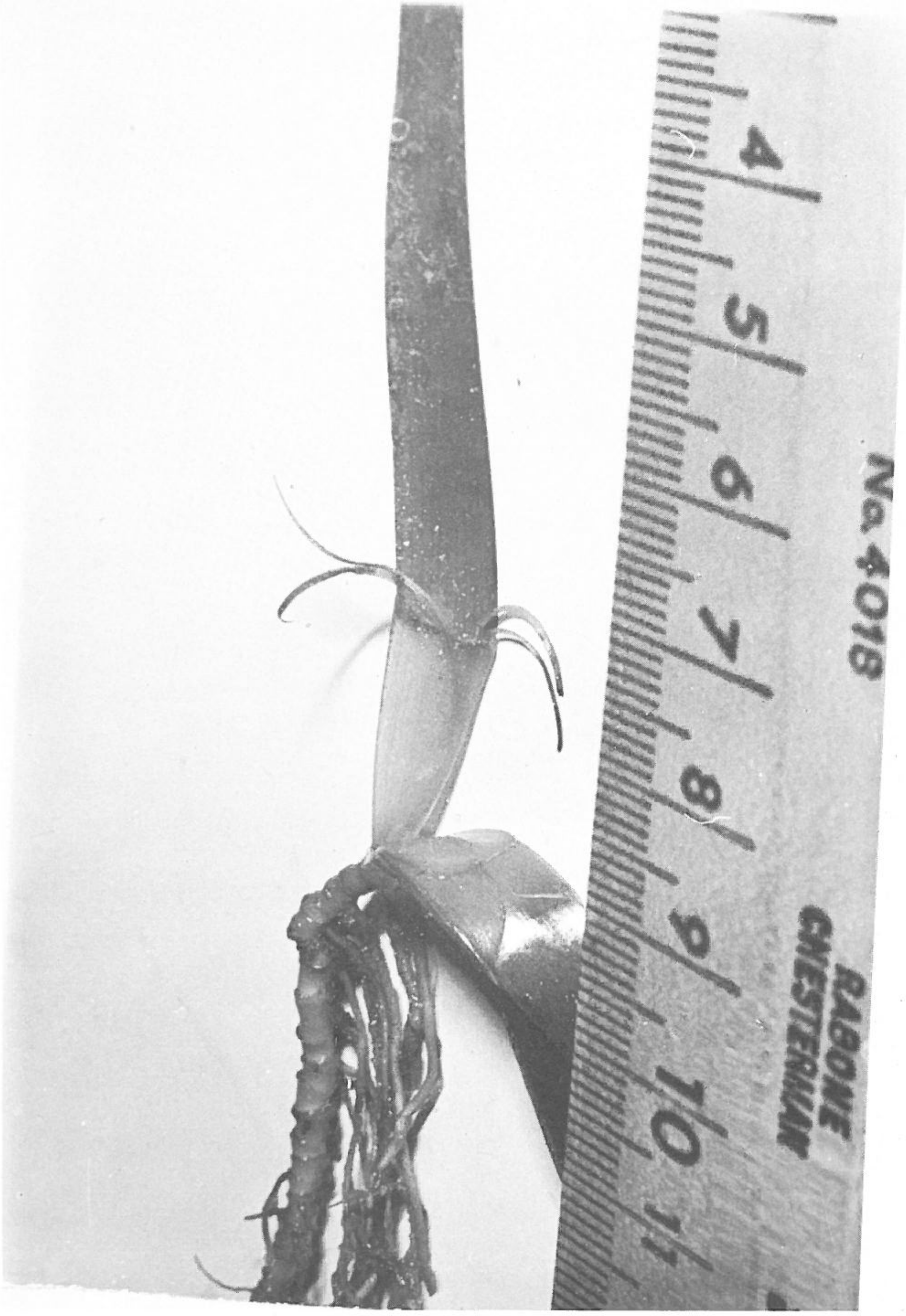
Fish project (R. Thompson Coon)

From experience gained during the expedition a research programme has been planned, entitled - "An investigation into the life-histories and ecology of several commercially important demersal fish species found in the Marine National Parks of Kenya."

The programme was instigated by the Director, Kenya National Parks and has been approved by the Trustee Committee, Kenya National Parks. The programme has been screened by the Scientific and Technical Advisory Committee of the East African Wildlife Society and has been approved for funding by the Council of the Society, subject to the availability of supervision by a recognised expert.

The research will provide valuable data on certain selected species from the following families: Siganoidea; Callyodontidae; Lethrinidae; Lutianidae; Mugilidae; and the Serranidae.

Within the park at Malindi, Maema traps will be put down beside pre-set markers; in the vicinity of the park a Fisheries Department Ozio trap will be set; and other methods such as the Butterfly trap will be employed. All fish caught will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weighed, measured and marked or tagged before release, certain fish will be retained for dissection and further study.

Furthermore the project will :

1. Help to increase co-operation between inshore fisheries and Marine Parks by:
    a) Establishing a laboratory at Malindi.
    b) Acquiring a suitable inshore research boat.
    c) Bringing understanding to the local fishermen of the ways in which the Marine Parks, (although preventing them from fishing some traditional fishing grounds) can be of benefit to them.

2. Bring greater understanding to Marine Parks management, by the continuous measurement of standard physical parameters, of changing physical conditions and therefore biotic conditions (R.E. Subsidiary Project, below).

3. Assist in the training of Marine Park Rangers, who will assist in project work on a rotational basis.

4. Include a Subsidiary Project entitled: "An investigation during the course of the main project into the effects of silt and fresh water from the Sabaki river upon the Marine Park at Malindi and the surrounding marine environment. To report on the real possibility of extensive destruction in the future."

OTHER SITES VISITED ON EAST AFRICAN COAST

It was considered that it would be valuable during the latter part of the expedition for members to visit other coastal areas of East Africa so that comparisons could be made with the Watamu Park area. The areas referred to are indicated in Fig. 1, and notes are given in conjunction with photographs and diagrams to illustrate important features of each area.

Horns Bay

Situated about ten miles north of Kilifi with rather difficult access, this is a very interesting stretch of coast as there is a deep channel about 50 yards wide and up to 30' deep between the outer reef and the inner reef platform, which itself has several very large pools in it. Coral growth along the sides of the channel is rich, and large fish are abundant. The channel is a favourite spear fishing spot and the locals collect crayfish, octopi and shells there.

Shimoni

Unfortunately only two of us were able to visit Shimoni and then only for two days. This is undoubtedly the richest and most beautiful part of the coast we visited and fully lived up to the fabulous tales we had heard of it. We visited Kisiti, a small island beyond Wasin Island, which in turn is separated from the mainland by a channel. The area on the seaward side of Wasin, out to Kisiti and beyond, is made up of extensive intertidal coral flats with scattered small islands and channels. At Kisiti the coral forms a fairly steep slope, running from the rich intertidal flats to a sandy bottom about twenty feet below. We found a very large specimen of *Acanthaster planci*, the Crown-of-Thorns starfish (about 45 cm across) here. This was the first we had seen, although they are frequently reported at Malindi.

At Kisiti a gang of about twenty men were systematically collecting shells and coral on the island and we were told that they were Tanzanians who come over regularly. A five ton lorry load of shells and coral is shipped from Shimoni to Mombasa each week, most of it getting smashed on the way.

On our second day at Shimoni we crossed over to the intertidal flats at the south end of Wasin Island. This area is also extremely rich and we found large numbers of several species of mulluscs which were rare at Watamu and Malindi. The channel has sandy sides sloping down gently to about 14 m and supporting an extremely rich and interesting echinoderm fauna. We estimated a density of over 1 per m^2 for a large species of Protoreaster (up to 30 cm span), which occurs in well over 20 colour variants on the bottom. We also found a second smaller specimen of *Acanthaster planci*.

If shell collecting and coral gathering goes on at the present rate, this area will be severely damaged. It is an area which has enormous attractions for naturalists and tourists and could benefit greatly from the establishment of a National Park or a ban on the trade in shells.

Ras Ngomeni

This area of the coastline to the north of Malindi (Fig. 1) consists of a relatively sheltered bay bordered on the north side by a rocky promontory (see photograph).

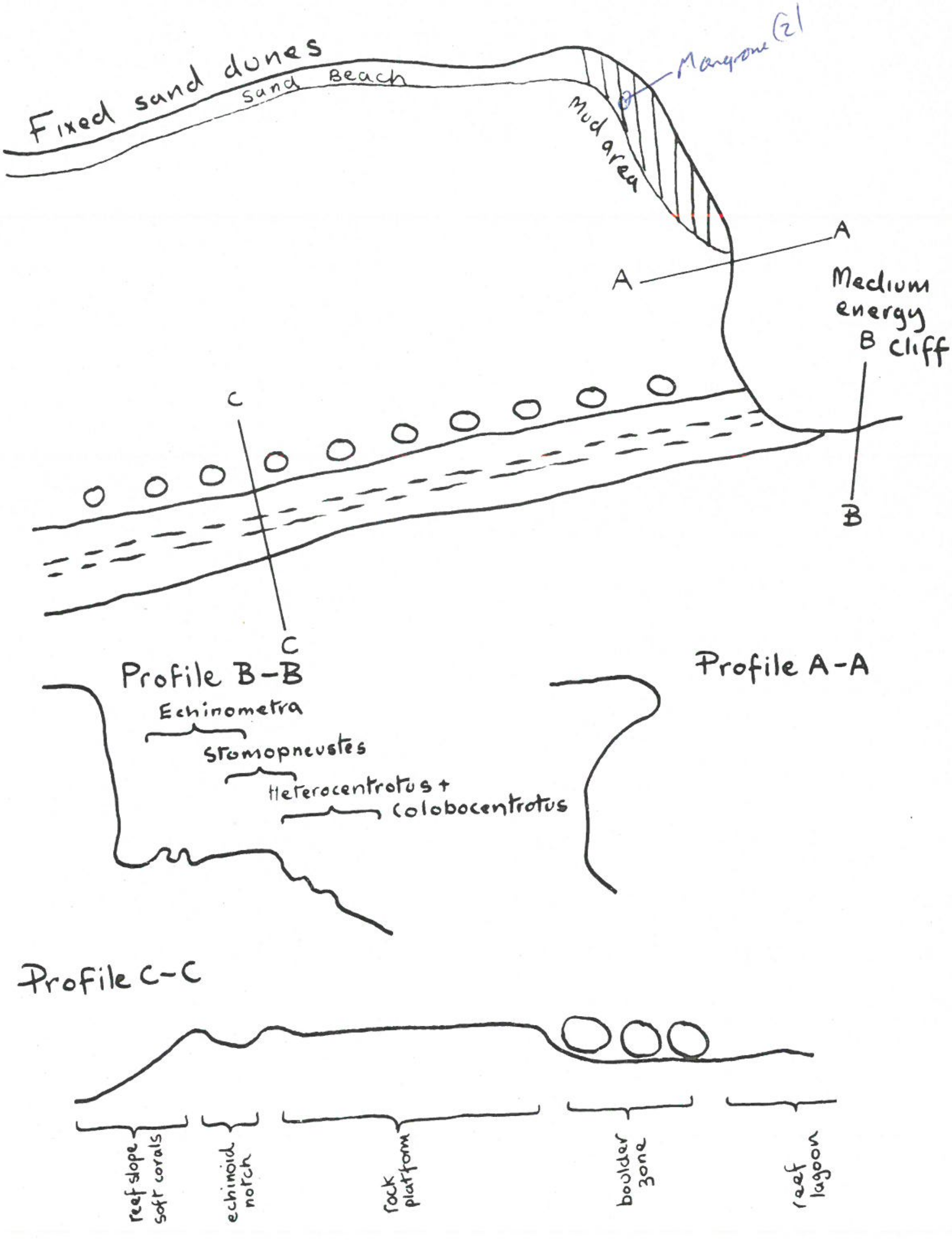

FIG. 10 Sketch map of shore at Ras Ngomeni (see Fig. 1) showing wide range of habitats present.

Sketch map Fig. 10 shows the clearly defined zone of medium energy champignon cliffs rising to 10 m in height in the exposed end of this promontory. These cliffs contrast with the hollowed profile of the low energy cliffs on the southern side of the promontory (see profiles a-a, b-b Fig. 10).

The medium energy cliffs bear large numbers of the living urchin Stomopneustes variolaris concentrated into a distinct zone (Fig. 10b), together with the slate pencil urchin Heterocentrotus trigonarius and a limpet-like urchin Colobocentrotus atratus. The common urchin Echinometra mathaei occurs above and overlaps within this zone.

Extending southward from the rocky promontory is a rock reef (Fig. 10) the seaward edge of which slopes up gently from the sub-littoral terminating in an "echinoid notch" running the length of the reef (Fig. 10 c-c). This notch is created by the urchin Stomopneustes variolaris which is concentrated in this area although they may occur in smaller numbers over much of the reef platform.

The reef platform extending landward from the echinoid notch is colonised by several echinoderms including Ophiocoma scolopendrina and Echinometra mathaei, together with the cowries Cypraea moneta, C. annularis and C. erosa and the ubiquitous shore crab Eriphea laevimanus. This reef platform gives way to a well defined boulder zone which supports a rich fauna sheltering beneath the rocks. This includes the Ophiuroids Ophiocoma scolopendrina, O. erinaceus, and O. venosa together with the highly prized gasteropod Conus geographicus and large numbers of crustacea.

The reef lagoon is about 1.5 m deep even at low tide, drainage being impeded by the rich growth of corals which occurs within the lagoon. In the sheltered north west corner of the bay a small area of mud flats occurs supporting the growth of Mangroves. Thus within a relatively small area this region of the coast provides a wide range of habitats and a varied marine fauna and flora.

Kilifi

This part of the coastline lies some 30 miles south of Malindi and the areas studied fall naturally into Kilifi south and north separated by a drowned river valley (see Fig. 1).

Kilifi south: The shores of the creek are bordered by a low line of champignon cliffs at the base of which piled rock debris occurred, occupied by a brown xanthid crab. The sandy foreshore above MTL was perforated with the burrows of small ocypodid crabs and in a more muddy area by the burrows of a large colony of Dotilla sp..

The intertidal rock platform was much smoother than that found at Watamu consequently there was a far smaller crevice-living fauna present, the dominant species present being Echinometra mathaei. The occasional boulder provided cover for mobile crustaceans, ophiuroids and dorids. At LWS fine mud is present fixed in places by areas of sea grasses supporting a dense population of strombids (gasteropods) as well as a few bivalves.

Subtidally the mud bottom slopes gently to a depth of some 3 m below LWS after which it drops off more steeply. The surface of the mud bore the marks of excavations and burrows probably produced by molluscs and crustacea and was reminiscent of some areas of Mida Creek.

The entrance to Kilifi creek is marked by a long low rock platform similar to that at Kibirijini with the exception that the platform at Kilifi is littered with loose rocks. The fauna sheltering under these rocks was similar to that of other intertidal rock habitats except that the Porcellanid crab Petrolisthes sp. is common here yet noteably absent from Watamu.

Kilifi North: The intertidal zone is again made up of a rock platform similar to that found at Kibirijini, deeply eroded by solution effects and shelving deeply into the sub-littoral zone where Cymodocea beds occurred in sand pockets. This rock platform is in general faunistically similar to that at Kibirijini, although several species of Ophiroid were collected which had not been recorded from the Park.

Cruise of R.V. Manihine (10th - 26th September)

Due to the generosity of the East African Marine Fisheries Organisation Messrs. Humphreys and McLeod were able to join in a cruise on the Organisation's research boat as scientific assistants. R.V. Manihine is a sixty year old converted Scottish trawler and is one of the few permanently stationed research boats in the Western Indian Ocean.

Cruise itinerary (see also Fig. 11)

September	10th	Humphreys and McLeod signed on, pay K1/- per month. Sail for Zanzibar 15.30 hrs.
	11th	Arrive Zanzibar 09.00 hrs. Visited EAMFRO Laboratory to collect necessary equipment and chemicals. EAMFRO scientific personnel arrive on board, including Dr. Truesdale. Sail for Mombasa 23.00 hrs.
	12th	Arrive Mombasa 13.30 hrs. Echo sounder serviced Sail for station H1 24.00 hrs.
	13th	Stations H1 - H4 note station data to be confirmed
	14th	Stations H5 - to H10
	15th	
	16th	Turn south 18.00 hrs.
	17th	Steaming south all day

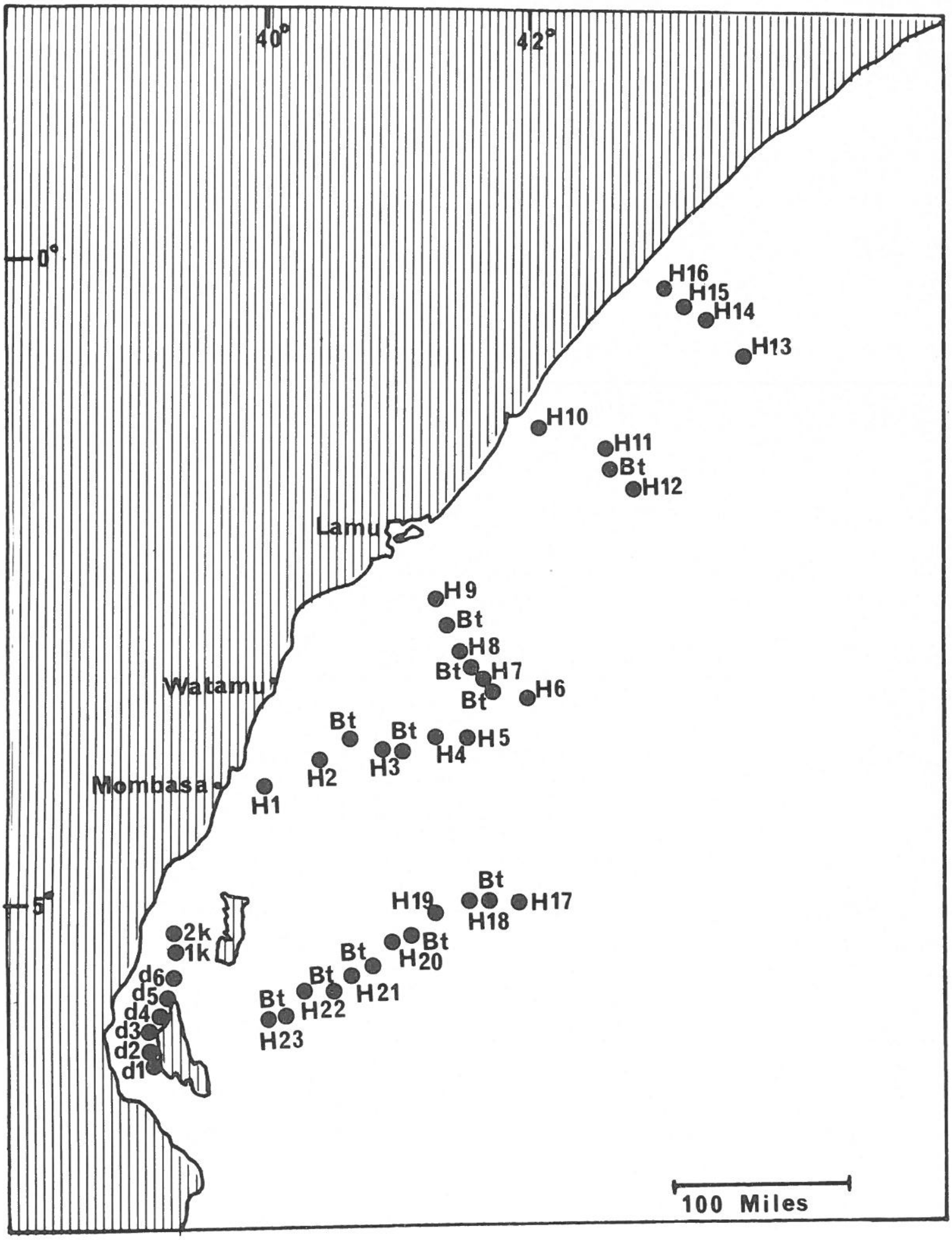

FIG. 11 Map showing position of sampling stations on cruise of R.V. Manihine 10 - 26 Sept. 1969; d, dredge station; Bt, bathy-thermograph station; H, hydrographic station.

September	18th	Steaming south all day
	19th	Steaming south until 13.00 hrs. Station
	20th	
		Sail for Zanzibar 18.30 hrs.
	21st	Arrive Zanzibar 03.30 hrs. Rest day Dip net station Zanzibar 24.00 hrs. to 05.30 on 22nd.
	22nd	Dredging off N.W. Coast of Zanzibar Island Stations B1 - B7.
	23rd	Rest day
	24th	Collecting and scuba trips to Pange and Funga Chawamba.
	25th	Depart Zanzibar 11.35 hrs. Stations with Isaac Kidd Mid-water trawl
	26th	Arrive Mombasa 06.00 hrs.

Research Work : The hydrographic stations were supervised by Dr. Truesdale, research scientist at EAMFRO studying the current patterns off the East African Coast. At each hydrographic station water bottle samples were taken down to 1200 m to establish oxygen content and salinity, water temperatures were also taken at these stations and at points mid way between stations using a bathy-thermograph. Data gathered will be used to construct a three dimensional model of current systems off the coast.

Usually at each bathythermograph station 100 metre vertical plankton hauls using a Hensen net were taken by McLeod and Humphreys. The analysis of the samples thus obtained may show further characteristics of the surface waters as different water types generally possess characteristic faunas. Due to the frequency at which stations had to be taken it proved impracticable to perform even a preliminary analysis on the samples.

On returning to Zanzibar on the 21st the Expedition members were able to use the ship's facilities to carry out bottom dredging along the N.W. Coast of Zanzibar Island where both muddy and hard substrate were sampled.

Later McLeod and Humphreys visited coral reefs at Pange and Funga Chawamba using Scuba to investigate sub-littoral parts of the reefs, an account of these reefs is given below. Finally during the return voyage to Mombasa the expedition members operated an Isaac-Kidd Mid-water trawl in the Pemba channel at a depth of 68 m. Two separate two hour hauls were made yielding several litres of plankton containing a wide variety of animals including some rare species.

N. W. Coast of Zanzibar Island: This area was sampled by dredging from R. V. Manihine, using a dredge fabricated from stainless steel mesh with a solid cutting edge bordering the mouth.

Station B2 (see Fig. 11) comprised a fine mud with a coarse gritty shell content giving a sharp feel to the matrix. It was of a greyish colour, and had a sulphurous smell containing only a few small crabs and shrimps and polychaetes.

Stations B2 and B4 were practically identical composed of a very fine green grey mud with very little coarse material. Extremely little was found to be living in the samples, the only animal being a tubiculous polychaete.

Station B3. The substrate was a medium coarse sand with a fine mud content and contained a rich bivalve population.

Station B5 was taken with the engines running over a hard substratum. The result was one of the most spectacular collection of sponges made by the Expedition, a considerable number of Crustacea and Echinoderms were also taken among the dead coral rocks, however there was comparatively little live coral.

Station B6 yielded both live and dead coral, coral boulders covered in encrusting algae, sponges and Polyzoa and a vast collection of Polychaetes, Crustacea and Echinoderms. Sampling efforts at Station B7, in a heavy swell, resulted in the loss of the dredge.

The wealth of material collected prevented any serious attempt at identification at the time of collection and these collections will be worked up as soon as possible.

Pange and Funga Chawamba, Zanzibar

These two sandbank and reef areas were visited during the cruise of R. V. Manihine and provided a useful comparison with similar areas at Watamu. Pange is a sandbank some three metres high, partially fringed by a narrow intertidal rock zone and completely surrounded by the coral reef. The sandbank composed of sharp well sorted clean coral sand is crested by a narrow band of a large shell and coral fragments and is inhabited by ghost crabs (Ocypode sp.). The intertidal rock was of a structure not found at Watamu. Fossilised reef deposits had become broken into horizontal sheets, the slabs on the average being the size and thickness of paving stones, supporting a rich Fauna. On the undersurface of the rocks multicoloured species of sponges encrusted and bored, the edges of the crevices being fringed by Hydrozoan and Polyzoan colonies. Polychaetes including Amphinomids, Eunicids and Phyllodocids were present in large numbers. The Crustacean fauna was dominated by Eriphia laevimanus, which reached a density of 41m^2. Smaller Crustacea included Percnon planissum, Trapezia sp., several species of Xanthidae and Paguridae, the latter often grouped in large numbers beneath rocks. Also present were Petrolisthes sp., several species of shrimp, Stomatopoda, Amphipoda, and Isopoda. Smaller Holothuria and many ophiuroid species could be found.

The reef area was divided into two zones. To the east of the bank was a large expanse of sand covered by a foot or two of water at low spring tide. This area was dotted with small coral heads each head being only a foot or two across, but often composed of a number of the commoner species of coral. The sand and coral supported an amazing variety of Echinoderms including Diadema, Linckia, Culcita and Protoreaster. Crustacea included Calappa and Matula, species of sand dollar was found here which is not present at Watamu.

The second zone of the reef also present at Funga Chawamba, a mile to the west of Pange, ranged from just sub-littoral to a depth of 60 feet, with no level sand platform and continuous coral cover. Near the surface in about 1 m of water at LWS heads of individual species of coral tended to occupy only a small area, no more than a square metre and the number of species present tended to be high in any one locality. Offshore in somewhat deeper water individual species of coral tend to occupy larger stands, and the number of species of coral became less, this becoming very marked beyond a depth of 3 m. The dominant species of coral are very different from those at Watamu or Malindi, and the relative absence of massive corals at Zanzibar was noted. Once the depth exceeded 3 m the profile became much steeper and no extensive sub-littoral ledges were observed. An unusual bright blue finger-like sponge was found supporting a large ophiuroid population but apart from this no sampling was done on the sub-littoral reef. The mud bottom of 60 feet by Fungu Chawamba supported a variety of Holothuria.

These two reefs presented a large expanse of almost undamaged coral, the only visible disturbance being due to native punting poles. The marked differences between this area and Watamu and Malindi is one of considerable ecological interest.

WATAMU PARK - PRELIMINARY CONCLUSIONS

It is of course impossible at this stage to draw any specific conclusions as to the effect protection afforded by the Marine Park will have on future repopulation and development of the fauna and flora. This will come as a result of future investigations into the productivity of the waters enclosed by the Park, using the present baseline studies as a reference. However, as a result of the present survey carried out at Watamu, and in comparison with other shores visited in East Africa, it is possible to make some general observations about the marine biology of the Park.

The area within the present boundaries of the Park contains a wide range of marine habitats both sub-littoral and littoral, ranging from mangrove fringes to exposed rock platforms. Apart from a small section of Whale Island the Park lacks only high energy shore, as seen for example at Ras Ngomeni and in consequence some of the fauna associated with such areas in particular the echinoid genera Heterocentrotus and Colobocentrotus. This is due to the shelter afforded by the fringing reef, together with the increasing southerly aspect of the shore away from Kibirijini point. The sheltered nature of the Park area together with the large areas of reef exposed at low tide are one of the most valuable assets of the Park both to the tourist and the scientist as they place the fauna and flora within easy reach throughout the year. At the same time these features also expose the fauna and flora of the Park to depletion and destruction by coral and shell collectors.

Faunistically the Watamu Park is not as rich as some other parts of the coast. Living coral is not abundant in the Park in comparison with other areas such as the Park at Casuarina and in general occurs in the form of isolated coral stands or 'heads' (see Fig. 7 and Section on coral fauna). However, these coral heads are readily accessible at all times during the year and are often quite spectacular, contrasting with the surrounding Cymodocea beds and sand. Of particular interest are areas of Mida Creek, some of which lie outside present Park boundaries, which are rich in many species of colourful soft corals, not easily found on other parts of the coast.

Although many species of mollusc are present in the Park, they again may be found more abundantly, together with rarer species apparently absent in the Park, on other parts of the coast (Shimoni). The large mollusc Cypraecassis rufa was more abundant at Watamu than at any other part of the coast visited, however it will be some time before it will be known if the invertebrates in general are re-establishing themselves.

With regard to the more mobile elements of the fauna, the picture is very encouraging for it became obvious during the survey that both the larger crustacea and fish are in many cases more abundant within the Park than in some other areas visited. The crawfish (Panulirus) with their striking coloration are common both at Casuarina and Watamu even in shallow water, and together with the coral fish, which are becoming increasingly 'tame', form a major tourist attraction. As might be expected these mobile animals are the first to take advantage of the protection afforded by the Park, moving in from other areas where they were constantly disturbed and harassed by fishing.

It appears then that the Watamu Park provides a wide and varied fauna and flora readily accessible to the public throughout the year which, given adequate protection, should become even richer in the future. We have included in this report some suggestions which we feel will assist in ensuring that both the habitats and animals and plants receive the necessary protection for their material growth and development.

SUGGESTIONS FOR THE PARK

A major difference between marine National Parks and terrestrial ones is that in the former, visitors and staff are to a large extent unfamiliar with the animals and the ecosystem to which they belong. This is one of the great difficulties and also perhaps one of the attractions of this type of park. It is of primary importance to make people aware of the great diversity and beauty of the marine fauna and flora, both in order to show the need for conservation and to attract greater interest in the park.

We feel that the establishment of a small aquarium, with some research facilities, would be the most important single step to achieve this. It would enable visitors and staff to look at and identify animals which they have seen in the park and it would be essential to a training or research programme. Because of the ideal situation of the park the initial cost of such a venture would be small and there is already a great deal of local knowledge and interest. Running costs could easily be covered by an admission fee; in fact several local people have talked of setting up a commercial aquarium. Reference books and slides for identification could be kept at the aquarium for interested visitors to consult and we have made a start to this with a collection of reference books bought for us by the East African Wildlife Society, some of which are at present in the Marine National Parks office at Malindi and others in the National Museum, Nairobi. We shall be providing a set of slides which would serve as the basis of a display and collection.

A second measure which we feel is of immediate importance is the provision of a training programme in diving and elementary biological observation and identification for the Park Rangers. We tried to make a start on this by teaching some of them how to use a snorkel and an aqualung, taking them with us on field trips, showing them the commoner species of plants and animals and inviting them to our camp to see our work and our collections, which they did frequently. They were very keen and quick to learn and were enthusiastic about having a training scheme. The difficulty would be to find someone able to carry out the training, but there are several possibilities. The University College run a series of evening classes on Marine Biology in Mombasa and many of the local people are very good naturalists, with a wide knowledge of the local flora and fauna. We gave two slide shows for the Rangers, lent them books and gave them sets of black and white photographs for identifying common animals. We intend to supply more of these.

The third measure is that the park could be extended to enclose a larger area of Mida Creek which contains its own unique Fauna and Flora and that all areas within the confines of the Park should be properly protected and the regulations aimed at conservation enforced strictly. The difficulties of patrolling and enforcement are apparent, but the violations are common and often quite blatant, such as goggle boats anchoring instead of using the buoys provided. The Reserve is not patrolled at all and so shell collecting continues. Perhaps an effective way to check it would be to legislate against all trade in shells, particularly by large dealers.

We are not in a position to make any special recommendations about the protection of particular animals or particular areas at this stage. Obviously areas heavily visited by tourists should be under constant watch for signs of excessive damage or disturbance.

Finally it must be stressed that owing to the limited time and finance available the present survey can only be of a preliminary nature and to gain a complete picture of the ecology of the Park similar studies at other seasons of the year must be completed. Future surveys will also be necessary if the effectiveness of the Park/ Reserve system in relation to the development of the fauna and flora are to be established.

FISH AND FISHERIES

The confrontation between the Marine Parks organisation and the local fishermen's unions.

After gazettement of the Marine National Parks all forms of fishing were banned within their boundaries, causing a certain amount of ill feeling amongst the local fishermen.

The Expedition is not in a position to state categorically whether or not this ban should be maintained or relaxed in certain cases. The only evidence, however, is as follows:

(a) Points in favour of the ban being maintained are :-

1. That the Malindi and Watamu Marine National Parks cover areas of only 1.5 and 3.0 square nautical miles respectively.

2. That according to all local opinion the gazettement of both Marine Park areas has resulted in a general increase in the density of fish in those areas, thereby increasing the level of attraction of the Parks to visitors.

3. That the protection afforded to fish by the Marine Parks has led to the establishment of a relatively "tame" fish population, thereby increasing again the level of attraction of the Parks to visitors.

4. That it avoids the temptation to pick up shells and pieces of coral while fishing (common practice with fishermen fishing in the Reserve).

5. That it avoids damage caused by punting poles and anchors.

(b) Factual evidence in support of the ban being relaxed in certain cases is not easy to find. The main cause of ill feeling after gazettement was at Malindi, where park boundaries enclose an area that is sheltered during "Kusi", the southerly winter monsoon, partly by Leopard Reef and partly by Sand Island. It was argued that through closure of this area, some fishermen in small boats would not be able to set their nets and put down their traps during "Kusi". Fisheries Department records, however, have not shown any appreciable decline in the weight of fish landed at Malindi and Watamu since gazettement of the Parks. Furthermore, the original arguments raised against the ban are diminishing and must continue to do so as the inshore fishing industry becomes more efficient through improved marketing techniques, the introduction of motorised boats, and improved methods of capturing fish.

It is not the responsibility of the Expedition to draw conclusions from this evidence.

Other suggestions concerning fish and fisheries:

The degree of protection afforded by present Marine Park boundaries to species of fish and other animals found inside these boundaries, may in some cases be high, in others low, and protection for some species may be virtually non-existent.

The degree of protection afforded to reef fishes (and other animals) will depend upon the permanence of their residence in the protected areas, and their spawning behaviour.

Some reef fishes live within a relatively small area or "territory", which is often fiercely defended. Strong territoriality is shown by many Chaetodontid, Acanthurid and Pomacentrid species, and together these fish constitute a large portion of the small reef fish found in the Marine Parks and are likely to be well protected by the present position of park boundaries.

The situation, with regard to many of the larger reef fish, equally characteristic in the Marine Parks, is not so clear. Such fish tend to make more extensive movements than those occupying defined territories and usually move in small schools. The questions to be asked, therefore, are, do their movements take them outside park boundaries where they are immediately subject to predation by fishermen, and if so, are their movements restricted? Work done in this field indicates that many of these fish will normally move within a limited area called a "home range", in which case, by establishing the size of their ranges some indication of the degree of protection being afforded to these fish, by the Parks, can be ascertained.

It is impossible to give total protection to all the animals in the Marine Parks, because of the very nature of the sea. Many of the larger reef fish have pelagic eggs, so too do some of the smaller ones. Information on the spawning of reef fish is still fragmentary, however, even if a fish shows no migration during the breeding season and releases pelagic eggs actually in the park, recruitment of this species need bear little or no relation to the protection afforded to it by the Park in the first place.

The proposed research project described very briefly earlier on, was specifically designed to investigate the range of movement shown by some of the larger reef dwelling fishes. Until such information is available, planning Marine Park boundaries can only be done without real knowledge of whether the boundaries give maximum necessary protection or not.

Any research of this kind needs the full co-operation of the Fisheries Department, and must follow two paths. One path is to work out the biology of individual species, while the other is to monitor the catch and the catch per unit of effort within the inshore fishing industry. Both are complementary in attempting to understand the complete life-histories and ecology of fish species. It is, therefore, of primary importance that an effort be made to a) initiate proper landing figures at Malindi, since at present all demersal fish landed are "weighed in" as Demersal fish, with no attempt to break this weight down into the weights of the important individual species and b) to work out units of effort etc., for the various fishing methods employed. Without this data any research on the larger demersal species will be severely handicapped, while this kind of research is essential to the basic needs of inshore fisheries and Marine Parks management.

While shell and coral collecting continues within the Reserve, so too does spear fishing, not in a limited way, but quite extensively. It is, therefore, suggested that the Fisheries, Marine Parks and civic bodies co-operate as much as possible, but in particular that the Marine National Parks be given full support by the local judiciary.

It is suggested that a limit be set on the number of people entering the Big Three Caves at the same time, as too much disturbance causes the big rock cod found there to back away into the dark recesses where they cannot be seen. Furthermore, such disturbance may be reflected in "stress" signs developing amongst the fish in the form of flesh wounds inflicted by bumping the sides of the caves. Perhaps a Marine Park Ranger or Rangers could be taught to use an "Aquanaut" and, by previous arrangement, be on hand to supervise diving excursions to the Big Three Caves.

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The Expedition has relied very heavily for its success upon the goodwill and assistance of a large number of individuals; friends both in this country and in Kenya who have given both their time and experience, benefactors, advisers and commercial firms. We are indebted to all who are listed below for without their interest the Expedition would not have been possible. We offer them our grateful thanks and to anyone whom we have omitted our sincere apologies.

(The list is sub-divided into categories and an indication of the form of assistance has been included although this must be of necessity brief and in many cases includes a whole host of generous actions).

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Royal Society of St. George	For a generous donation
The Worshipful Co. of Drapers	For a generous donation
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Zoology Dept., U.C.N.W.	For the loan of scientific equipment

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Commercial Firms

Armour, R. Ltd. (Malindi)	For assistance with outboard engine
Arrofleet Ltd.	For assistance with supplies
Boots Pure Drug Co. Ltd.	For generous assistance with medical supplies
Brit. India Steam Ship Navigation Co. Ltd.	For advice on transport

British Universities Society of Arts	For efficient and inexpensive air travel
Cadbury Bros. Ltd.	For generous assistance with supplies
Caltex Oil (Kenya) Ltd.	For generous assistance with supplies
Chandos Intercontinental	For generous assistance with supplies
Chesterfield Tube Co. Ltd.	For generous assistance with diving equipment
CIBA (A.R.L.) Ltd.	For generous assistance with equipment
Chance Brothers Ltd.	For generous assistance with laboratory equipment
Collins and Chambers Ltd.	For assistance with diving equipment
Electrical Tools Ltd. (Menai Bridge)	For assistance with equipment
Endecotts (Test sieves) Ltd.	For generous assistance with equipment
English Numbering Machines Ltd.	" " " " "
Express Transport (Mombasa) Ltd.	For assistance with transport
Holland Africa Line	For advice on travel
International Harvester Co. of E. Africa	For advice on transport
Joyce Chemists Ltd. (Beaumaris)	For assistance with supplies
Kafetz Cameras Ltd.	For assistance with equipment
Kenya Shipping Agency Ltd.	For assistance with transport
Lillywhites Ltd.	For assistance with diving equipment
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Monks, E.T. and Co. Ltd.	For assistance with supplies and equipment
Nilestar Tours Ltd.	For advice on travel
North Sea Diving Services Ltd.	For a generous donation
North Wales Travel Agency Bangor	For a generous donation and advice
Packers and Shippers International Ltd.	For assistance with transport

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Submarine Products Ltd.	For assistance with equipment
Swann-Morton (Sales) Ltd.	For generous assistance with equipment
The British Drug Houses Ltd.	For generous assistance with chemicals
The Metal Box Co. Ltd.	For assistance with supplies
The Stockton Heatt Forge (Caldwells) Ltd.	For generous assistance with equipment
The Watamu Beach Hotel	For use of diving compressor
Victoria Supplies	For assistance with supplies
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W.C.B. Containers Ltd.	For assistance with equipment
Wiggins Teape (Merchants) Ltd.	For assistance with equipment
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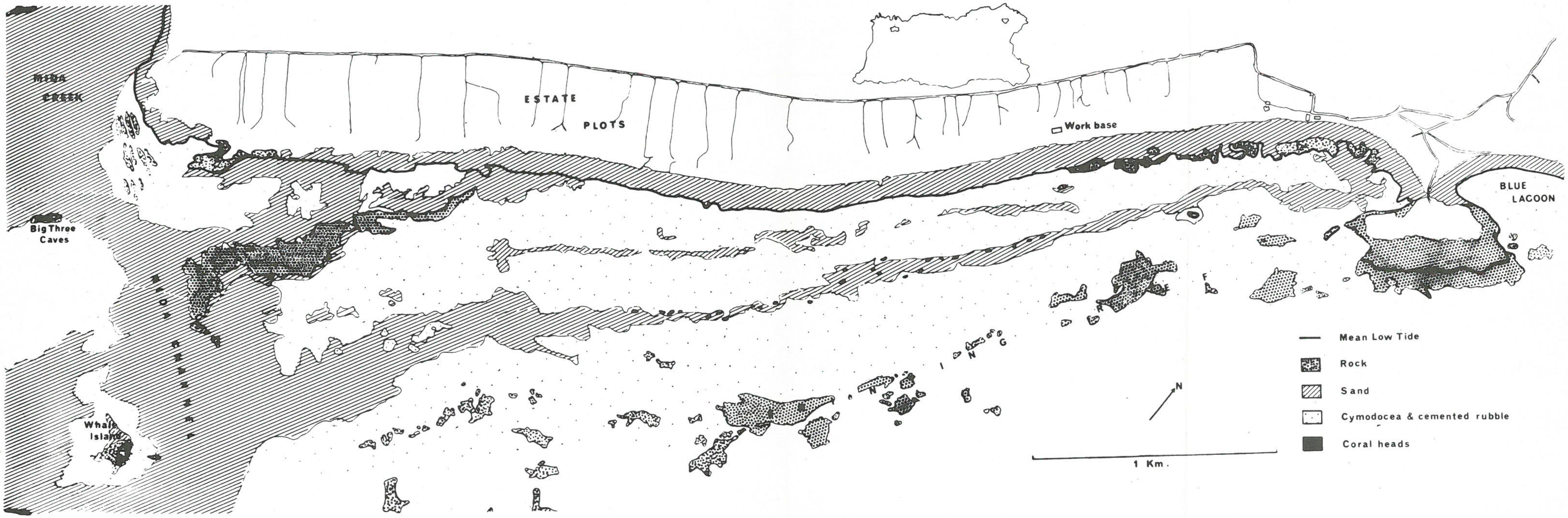
PHOTOGRAPH LEGENDS


MIDA CREEK
ESTATE PLOTS
Work base
BLUE LAGOON
Big Three Caves
Whale Island
Mean Low Tide
Rock
Sand
Cymodocea & cemented rubble
Coral heads
N
1 Km.

International development

Conservation is priceless for Kenyan forest

Preserving diversity and wealth ... Charo Ngumba, chair of Gede Community Forest Association Daniel Sitole

Tribes and government team up to defeat loggers and thieves

Daniel Sitole

The conservation of forests in Kenya has been a challenge to policy makers. The majority of the rural population rely on charcoal and firewood for domestic use. Illegal logging, land grabbing, and human encroachment are some of the challenges facing the whole country. There's one area that is an exception: Arabuko Sokoke, where the people of Kilifi County have conserved the largest indigenous coastal forest in East Africa.

Arabuko Sokoke is the remnant of the largest block of coastal indigenous dry forest on the continent, which once stretched from southern Somalia to northern Mozambique. The forest, which covers 420 sq km and measures 41,765 hectares, is in Malindi, 110km north of Mombasa. It borders the Indian Ocean.

The forest was first declared a crown land in 1934.

"The people of Kilifi value conservation," says Blessingtone Maganga, of the Kenya Forest Service (KFS). "There is no logging, charcoal burning, illegal fuel wood collection, mining or poaching." Blessingtone adds that Somalia, Tanzania and Mozambique have destroyed parts of their share of the forest due to human settlement.

The forest consists of three ecosystems: mixed forest, Brachystegia (tropical timber) forest and Gynometra forest. Arabuko is a designated Unesco Biosphere Reserve, and believed to contain titanium deposits.

"Yes there is a lot of it here. It is visible on the surface, especially in the western side of the forest," says Blessingtone, adding that many private investors have shown an interest in starting mining, but "the community and the government don't want it, because the forest is for conservation".

The name Arabuko Sokoke derives from words used by the Waata tribe that lived in the forest: *arbi* meaning elephant, *huk'o* meaning thin, and *sokoke* "short (trees)". It therefore means, a "forest of the thin elephant". The story goes that Waata men found a thin elephant in the Gynometra region of the forest, where typically trees are about 50cm in diameter and less than seven metres high.

The local community has conserved their forest despite pressure by land grabbers and loggers. "Arabuko is our heritage, and we have fought tough battles to protect it," says Hamis Juma, 46, a volunteer scout. "Sometimes we camp in this forest for months, armed with machetes and bows and arrows to flush out loggers and to protect it from land grabbers."

Arabuko has a rich biodiversity, and is home to endangered flora and fauna. It is considered the second most important area for bird conservation after the Congo rainforest, and is home to 230 bird species, of which six are globally threatened. Fifty-two mammal species have been recorded in the forest, among them three groups that are in danger as well as the golden rumpled shrew, of which 90% of the known population live in Arabuko Sokoke. There are also 150 elephants and 250 butterfly species.

"I'm a member of the Waata, the indigenous tribe of this forest," says Peter Mashauri, 53, of the Friends of Waata Association. "We were hunter-gatherers, and lived near trees and wildlife. We hunted the most aged animals, and killing of young animals was an offence under our tradition."

Together with the Waatas, the Giriama tribe make up the majority population in Kilifi County. The two tribes have conserved forest for nearly 80 years.

The community, under the Arabuko Sokoke Forest Adjacent Dwellers Association (Asfada), comprising 152,000 members from 52 villages, manages the project in collaboration with the Kenya Forest Service and Kenya Wildlife Service.

Asfada, an umbrella body of three community forest associations (CFAs) - Gede, Jilore and Sokoke - manage different parts of the forest.

The community has also set up several income generating projects. These include butterfly farming (Kipepeo Project), which exports live butterflies and other insects to Europe, the US and beyond. There are also other user groups for bee-keepers and for those who practise herbal medicine. Asfada has also set up a guesthouse, the Arabuko Jamii Villa, about 20kms from Malindi town.

The people of Kilifi have kept their forest intact despite high level of poverty. According to figures released last year by the Commission of Revenue Allocation, 71.4% of the people in Kilifi live below the poverty level (less than $1 a day). "It is true that our people are poor, but in terms of natural resources Kilifi County is an island of millionaires in a sea of poverty," says Charo Ngumba, chairman of Gede CFA.

Charo says unlike in other forests, there is no human-wildlife conflict in Arabuko Sokoke because the Community Development Trust Fund, a project of the EU and Kenyan government "funded the fencing of the forest to the tune of 14m Kenyan shillings (kes), the community contributed 4m kes ($50,000)".

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UNIVERSITY COLLEGE OF NORTH WALES - WATAMU EXPEDITION

Income and Expenditure account for the period from 21 March 1968 to 4 May 1970.

INCOME

	£ s. d.
Drapers Company of City of London	120. -. -.
National Provincial Bank	1. 1. -.
North Sea Diving	10.10. -.
Sir William Roberts	10. -. -.
Miss Jones	11.10. -.
North Wales Travel Agency	10. -. -.
Royal Society	1507. -. -.
East African Wild Life Trust	600. -. -.
Duke Of Edinburgh	50. -. -.
Gilchrist Educational Trust	50. -. -.
Percy Sladen Memorial Trust	350. -. -.
B.B.C.	500. -. -.
University College of North Wales	125. -. -.
Students' Union, U.C.N.W.	50. -. -.
Ministry of Overseas Development	500. -. -.
Personal contributions by Members of the Expedition	350. -. -.
	£4245. 1. -.

EXPENDITURE

		£ s. d.
Travel		1226. 2. 2.
Transport of Equipment	271. 5. 4.	
Less sale of crates	10.10. -.	260. 15. 4.
Accommodation and Maintenance		742. 4. 8.
Administration		114. 8. 8.
Insurance		201. -. -.
Diving Equipment	538. 5. -.	
Less equipment sold	130.12. -.	407. 13. -.
Collecting Equipment		296. 13. 7.
Photographic Equipment		440. 12.11.
Books		67. 14. 6.
Medical		67. 11. 4.
Balance at Bank		420. 4.10.
		£4245. 1. -.

I have examined this Income and Expenditure Account with the relative Books and Vouchers and find it to be in accordance therewith.

AUDITOR
(Lt.Col. O.R.Davies.MBE.)
Financial Secretary
Students' Union, U.C.N.W.