

A CONTRIBUTION TO OUR



KNOWLEDGE OF THE SOUTH AFRICAN

INTERTIDAL ZONE.

Thesis presented for

the degree of Ph.D.

by

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INTRODUCTION.

The two papers presented herewith as a thesis for the degree of Ph.D. are two items from a series which is being issued from the Zoological Department of the University of Cape Town. In a sense each paper is complete in itself; but as the papers are also parts of a larger whole, it is necessary to give some indication of their position in that whole, and of the aims and results of the entire series.

In 1932 Prof. T. A. Stephenson initiated a general survey of the South African Intertidal zone, which was intended to describe the occurrence of the commoner plants and animals, and to relate this to the arrangement of warm and cold ocean currents round the coast. The aims of the investigation were described by Prof. Stephenson in the Transactions of the Royal Society of South Africa, vol. 24, pp. 342-4. From his description the following extracts are taken:

"The investigation comprises the following parts;

- (1) A general ecological study of the South African intertidal belt at a series of localities extending from Durban on the east coast to Port Nolloth on the west.
- (2) A second branch of the work consists in choosing, from among the organisms studied in the course of the general survey, a limited number of unrelated plant and animal species, which seem from their distribution to be particularly sensitive to the effects of temperature, and in following out the distribution of these forms in more detail A variation of the same procedure is the selection of a particular group of animals or plants, the study of which seems likely to produce a significant result, and to investigate the distribution and bionomics of these intensively.
- (3) It is proposed, as the field-work advances, to conduct experiments on the reactions of specific animals, their

eggs and larvae, to temperature variations, with a view to interpreting their observed distribution in terms of their reactions to controlled conditions of temperature in the laboratory."

In other words, the investigation begins as a study in geographical distribution, and becomes transformed later into experimental work.

The two papers constituting the present thesis are contributions to the general survey mentioned under (1) above. Each one gives an account of a particular area on the west coast of the Union, and is to that extent complete. On the other hand, these two localities were studied in the early days of the survey, before its completion in 1938 made generalisation possible. Since, therefore, the discussion on pp. 80-83 could not go very far (it was written long before the date of publication), notes are added here which are based on later surveys.

It may be noted that this survey of the South African coast breaks virgin ground, and that the whole of the information contained in these papers is new. So far as I am aware there exist no papers on the ecology of the South African seashore, previous to this series, apart from some notes on algae by E. M. Delf (S.A. Journ. Nat. Hist., vol. III, pp. 53-64, 1921), W. E. Isaac (Brit. Assn. Adv. Sci., Rept. for 1935, p. 455), and M. R. Levyns (S.A. Journ. Sci., vol. 21, pp. 265-269, 1924). There are, of course, a great many systematic papers which describe collections made in the Cape, and some of these discuss the geographical distribution of the species recorded; but these papers offer little of ecological interest, and as a rule give no idea which of the organisms are common and which are rare, or of their habitats and interrelations.

The oceanographical conditions which make this survey

* In this Introduction the coasts of the Union are delimited as follows:
West Coast. From the Orange River to Cape Point.
South Coast. From Cape Point to Cape Padrone.
East Coast. From Cape Padrone to Durban.

particularly interesting are as follows. The submarine shelf surrounding South Africa to a depth of 100 fms., is narrow along the ^{East} coast, becoming much wider off the south coast, where it forms the well-known Agulhas Bank; and becoming narrower again on the west coast, though still considerably broader than in the east. The Agulhas Current, a southward-flowing continuation of the Mozambique current, sweeps fairly close inshore along the east coast, leaving the coast in the neighbourhood of Cape Padrone and flowing out to sea and round the edge of the Agulhas Bank. To southward of Cape Agulhas it divides into two principal branches, one of which turns sharply on its course and returns towards the Indian Ocean, while the other turns north westward and enters the South Atlantic off the southern part of the west coast, not very close inshore. The exact course and temperature of the several parts of the current naturally vary from one time of the year to another, and even from day to day; but according to Dietrich (Veröff. Inst. Meeresk. Univ. Berlin, A.27, 1935) the temperature of the central part of the current, as far west as about 20°E, exceeds 20°C in early summer. The current has a very marked influence on the coastal water of Natal, which it renders sub-tropical. This influence wanes on the southern part of the east coast, and remains decidedly less along the south coast than in Natal. It appears to affect the west coast comparatively little, except in the southern part of the Cape Peninsula. The west coast, in the main, is influenced by the upwelling of a body of cold water described by Deacon (1933), in the Discovery Reports, as Antarctic Intermediate Water. The effect of this cold upwelling is most marked, apparently, along the northern part of the west coast.

Speaking approximately, and allowing for overlaps, the Natal coast has distinctly warm (sub-tropical) inshore water, the west coast decidedly cold (sub-antarctic) water, while the conditions along much of the south coast may be described as warm-temperate. It must be understood that the position is much complicated locally by configuration of the land, by counter-currents inshore, and by

wind-effects. The temperature-conditions are particularly interesting in the region of the Cape Peninsula, which lies near the meeting of warmer and colder water-masses, since we find here a narrow tongue of land, on the average about 5 miles wide, separating bodies of water which, during the summer, may differ from each other in temperature by as much as 8°C.

A much more detailed account of the currents involved has recently been given by W. E. Isaac (Geographical Review, vol. 27, 1937, pp. 651-664). From this paper the following figures are taken, showing the actual mean annual surface temperatures at various places on the coast; these temperatures being dependant upon the arrangement of currents described above, together with other factors.

<u>West Coast</u>	<u>South Coast</u>	<u>East Coast.</u>
Walvis Bay 16.1°C	Simons Bay 15.3°C.	East London 17.6°C.
Saldanha Bay 14.8°C	Muizenberg 16.6°C.	Port St. Johns 19.3°C.
Dassen Island 13.45°C	Hermanus 14.6°C.	Durban 21.8°C.
Robben Island 14.2°C.	Danger Point 15.6°C.	
Cape Town Pier 12.8°C.	Cape Agulhas 17.7°C.	
	Struys Bay 17.4°C	
	Knysna Heads 16.8°C.	
	Cape St. Francis 17.25°C.	
	Bird Island 18.2°C.	

The influence of the currents is brought out very clearly by the fact that Durban, considerably south of the tropics, has a mean temperature of 21.8°C, while Walvis Bay, in the tropics far north of Durban, has a mean temperature of only 16.1°C. The average temperatures for the three coasts (omitting Walvis Bay) are 13.8, 16.6 and 19.6°C, respectively. It is hardly possible to understand the significance of the annual mean for any one locality, however, without reference to Isaac's paper.

The general survey of several coastal stations, mentioned above, has brought out clearly the effect which the currents have upon the distribution of seashore organisms. In a paper at present in the press (Annals of the Natal Museum, vol. IX, p. 16) it is

pointed out by Prof. T. A. Stephenson that the South African coastline supports three principal series of organisms, which he characterises as follows:

- "(1) A population of cold-loving organisms, which inhabits the west coast and extends in full force not farther south than the Cape of Good Hope, although many of its constituent species pass that point on to the south coast, along which they are to be found for a greater or lesser distance.
- (2) A series of organisms which flourish in warm-temperate conditions, and which are characteristic of the south coast. Many members of this series continue on to one or both of the other coasts, some for shorter and others for longer distances.
- (3) A population of tropical species which is strongly represented in the Durban district (mixed with south-coast forms), but which disappears, apart from isolated species, between Durban and East London. Certain tropical species continue along the south coast, but the impressive assemblage of them found near Durban has disappeared. The population of the southern part of the east coast is similar to that of the south coast."

To this it may be added (although the results of the survey in this connection are as yet incompletely worked out), that in the Natal fauna and flora a high proportion of the species are outlyers of the great tropical Indo-West-Pacific group of organisms, as defined by Ekman (*Tiergeographie des Meeres*, 1935). In the population of the west coast, on the other hand, there appear to be a number of Atlantic and sub-antarctic forms. A portion of the population on any of the coasts consists of endemic species, but so far as we have been able to determine, this proportion is highest on the south coast.

It is now possible to explain how the two papers submitted

herewith, contribute to the general conclusions outlined above. They describe the occurrence of the most significant organisms, from an ecological or zoogeographical point of view, in two districts affected by the cold water of the west coast; they provide the foundation of our knowledge of the intertidal belt of the west coast as a whole. Since the time when they were written, further west coast surveys have been carried out, most of them between Oudekraal and Port Nolloth, and it is now becoming possible to generalise about the west coast.

Generally speaking the later surveys have confirmed the statements made in these papers, but have brought out the essential points more clearly. We can now state that a Laminarian zone is an almost universal feature of the west coast, and that of the three giant Laminarians which inhabit it, Macrocystis pyrifera inhabits only sheltered places in the southern part of the coast, whereas Ecklonia buccinalis and Laminaria pallida occur throughout. As one proceeds northward, however, the amount of Laminaria increases, relative to the Ecklonia. Above the Laminarian zone there is universally, in the more exposed habitats, a zone thickly populated by Patella argenvillei and/or P.cochlear, whose distribution is co-extensive with that of the great bulk of the intertidal lithothamnion. A second visit to Port Nolloth has confirmed the complete absence of P.cochlear there, P. argenvillei being paramount. From Lamberts Bay southward both are important, but P.cochlear never overshadows P.argenvillei, on the west coast, to the extent which it does on the south coast. Perhaps the most important alga in the Cochlear-Argenvillei zone is Champia lumbricalis, which frequently occupies all but the highest parts of the zone.

Above the Cochlear-Argenvillei zone there is typically a zone of very bare rock, populated primarily by Patella granularis, and often by barnacles. This zone is referred to in the attached papers as the Balanoid zone, to bring the usage into conformity with our usage for the south and east coasts. On the two latter coasts, however, barnacles are abundant throughout this zone, so that the

name is thoroughly appropriate. On the west coast we have the curious feature that, although barnacles are fairly abundant in the southern parts of the coast, they seem to become scarcer and scarcer as one proceeds northward, until at Port Nolloth the two most widespread species, Octomeris angulosa and Tetraclita serrata, are almost rare. Patella granularis, on the other hand, is abundant throughout the coast, and in the northern part at least, the zone in question is more a Granularis zone than a Balanoid zone. This, however, is only a matter of terminology. Throughout the coast there is, above this zone, a Littorina zone, inhabited by Littorina knysnaënsis but by no other species of that genus. Algae are few above the lower part of the Balanoid zone, the most conspicuous being Porphyra capensis, which inhabits both the Balanoid zone and the lower Littorina zone.

Other distinguishing features of the west coast are the following:

- (i) A number of organisms find optimal conditions on this coast. The polychaet Gunnarea capensis, for instance, occurs round the whole South African coast, but it reaches by far its greatest abundance in the cold water, commonly forming immense masses and fields, which may be more than an acre in extent. The limpets Patella argenvillei, P. granatina and P. compressa, and the mussels Mytilus crenatus and M. meridionalis, attain by far their best development on this coast. A large number of algae, in particular, are characteristic west coast forms, and disappear sooner or later along the south coast.
- (ii) The converse also applies. Thus certain species which are particularly characteristic of the south coast, such as Patella oculus, P. longicosta and P. cochlear, Oxystele tigrina and O. variegata, Turbo sarmaticus, Mytilus perna, species of Sargassum, Caulerpa, Hypnea and other genera, disappear sooner or later on the west coast, although some of them are evidently much more sensitive to the

lower temperature than others, and die out more rapidly.

In addition to the species belonging to the two categories mentioned, there are a number which appear to be peculiarly eurythermic, since they are plentiful round the whole coast from Port Nolloth to Durban. Examples belonging to this class are Patella granularis and P. barbara, both of which, however, attain a larger size in the cold water than in the warm.

To this introduction it is perhaps fair to add, that the two papers submitted for the degree, amounting only to 38 printed pages, give very little idea of the amount of work which is involved in carrying out one of the surveys. The smallest item in this work, from the point of view of the time expended, is the actual observation and collection in the field. When the field-work is finished and the plants and animals suitably preserved, the collection is sorted and re-bottled, and a catalogue of the material is made, in which is recorded, opposite the reference-number given to each species, the degree of its rarity or abundance at the locality surveyed, and its habitat on the shore. After the collection has been properly labelled and catalogued, the material is divided into two parts, some specimens of each species being retained for further reference, others being sent to various specialists for identification. In the case of difficult animals such as sponges or compound ascidians, the individual colonies are cut in half to ensure that the material kept consists of true duplicates. It is unfortunate that we have in South Africa only a limited number of specialists able to give authoritative determinations of marine invertebrates, so that the bulk of our material has to be elaborately packed up and sent overseas. Finally, the working-up of the field notes into a connected account, suitable for publication, takes longer than any other phase of the work; and cannot be completed until identifications of the material have been received from the specialists, sometimes a matter of years.

A BRIEF SUMMARY OF THE CONTENTS OF THE THESIS PRESENTED

FOR THE DEGREE OF PH.D. BY K. M. F. BRIGHT.

The thesis consists of two papers, published in the Transactions of the Royal Society of South Africa, vol. 26, pp. 49-66, and 67-88, 1938, accompanied by a typewritten Introduction. The first paper describes the shore ^{at} ~~of~~ Oudekraal (west coast of the Cape Peninsula), and the occurrence of the common plants and animals there. The second gives a similar account of the coast in the Port Nolloth district, and discusses some of the more important points revealed by the work. In both papers the arrangement of the principal organisms in zones is described, the zones being named, from above downwards, the Littorina, Balanoid and Cochlear (or Argenvillei) Zones, and the Sublittoral Fringe. In the typewritten Introduction an outline is given of the aims, scope and results of the extensive Ecological Survey of the South African coasts, conducted from the Departments of Botany and Zoology of the University of Cape Town, of which these papers form a part. The relationship of the parts to the whole is there explained.

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PART I

Papers on the Ecology of the South African Coast,
from the Zoological Department, University of Cape Town.

Nos. 2 and 3

THE SOUTH AFRICAN INTERTIDAL ZONE AND
ITS RELATION TO OCEAN CURRENTS

II. AN AREA ON THE SOUTHERN PART OF THE WEST COAST
III. AN AREA ON THE NORTHERN PART OF THE WEST COAST

BY

K. M. F. BRIGHT, M.Sc.

CAPE TOWN
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THE SOUTH AFRICAN INTERTIDAL ZONE AND ITS
RELATION TO OCEAN CURRENTS.

II.—AN AREA ON THE SOUTHERN PART OF THE WEST COAST.

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(Department of Zoology, University of Cape Town.)

(With Plates IV–VI, and one Text-figure.)

(Read May 19, 1937.)

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INTRODUCTION.

This paper is the second of a series dealing with the effects of cold and warm currents on the intertidal fauna and flora of the shores of the Union of South Africa. The work is being carried out from the Department of Zoology of the University of Cape Town, under the direction of Prof. T. A. Stephenson. The general plan of the investigation, and the methods employed, have already been explained in the first paper of the series, which describes a general ecological survey of the intertidal region carried out at Still Bay (Stephenson, Stephenson and du Toit, 1937). The present account embodies the results of a similar survey of the neighbourhood of Oudekraal, on the Atlantic coast of the Cape Peninsula, an area influenced by the cold Antarctic intermediate water which upwells along the west coast of the Union.

The survey of Oudekraal extended over a considerable period. It was carried out principally in 1934, during which year most of the available tides were utilised for field-work. Supplementary observations were made in October and November 1936.

In the first paper of this series, an annotated list was provided, giving the names of all the species collected during the survey (of Still Bay) for

which identifications had been received at the time of publication. It has been decided that in the remaining papers similar lists will not be included; but these will be presented as a comparative table in a later paper devoted to the consideration of the geographical relations of the intertidal biota of the Union as a whole.

I wish to convey my thanks to E. J. Eyre, M.Sc., to whom I am much indebted for assistance in carrying out the field-work of the survey; to Dr. G. J. Broekhuysen for the photographs reproduced in Plates IV and V; and to Prof. Stephenson for guidance throughout the investigation. The material collected has been identified by the specialists whose names appear on p. 349 of the Still Bay paper, to all of whom sincere thanks are offered for their invaluable assistance. To the names formerly given must be added those mentioned below. Systematic papers dealing with Oudekraal material have been published by Burton (1936), Carlgren (1935), and O'Donoghue and de Watteville (1937).

Alcyonaria. Prof. S. J. Hickson (Cambridge); Mrs. L. M. I. McFadyen (British Museum).

Nemertinea. Dr. J. F. G. Wheeler (Bermuda).

Gephyrea. Dr. A. C. Stephen (Royal Scottish Museum).

Mollusca. R. Winckworth, Esq. (Royal Society, London).

Algae. Prof. H. Kylin (Lund); Dr. A. V. Manza (California).

DESCRIPTION OF THE LOCALITY.

Oudekraal (Lat. 33° 59' S., Long. 18° 22' E.) is situated near Cape Town, on the Atlantic coast of the Cape Peninsula. The locality derives its name from a farmhouse lying close to the shore at a distance of about 2½ miles (4 km.) in a south-westerly direction from the village of Camps Bay.

The land in this region slopes very abruptly into the sea, forming a steep incline which descends from the mountains (the Twelve Apostles) into the waters of the Atlantic. The mountains and upper talus slopes are composed of grey quartzitic sandstones of the Table Mountain Series, resting unconformably on coarse-grained porphyritic biotite-granite (A. L. du Toit, 1926). Outcrops of the underlying granite constitute the greater part of the coastline and weather into smooth rounded expanses and boulders, often of enormous size, which form promontories at irregular intervals along the coast. Three such granite masses are included in the region studied at Oudekraal. Of these the most northerly is much the largest, and contains an island and several outlying blocks or islets, known as the "Geld Kist" (fig. 1), in addition to the usual boulder-strewn promontory. From the Geld Kist a rocky beach stretches some 150 yards (140 metres) to the south-west; it is a tumbled chaos of large angular

fragments of sandstone (often 10 feet—3 metres—in diameter) which have fallen from the talus slopes above. This terminates in a clump of granite boulders of considerable size, on which the main work of the survey was carried out, and which will be called the "Homestead Rocks" in this paper,

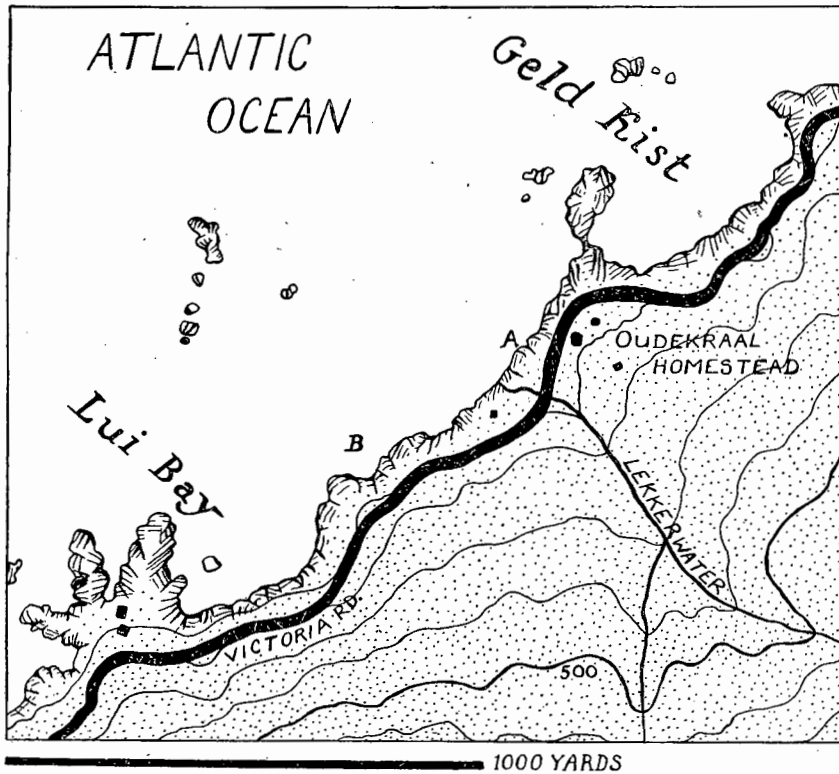


FIG. 1.—A plan of the area studied at Oudekraal. Based on a photographic enlargement of a portion of Sheet I of the map of the Cape Peninsula published by the Department of Lands Survey Board (1933). Contours at 100-foot vertical intervals.

since they lie almost directly below the farmhouse (fig. 1, A). Beyond these boulders the beach continues as a pebble-ridge some 200 yards (180 metres) in length, composed of rounded stones and shingle, and bounded at the far end by a granite wall which forms the side of the third of the small promontories. The last-named granite outcrop will be termed "Lui Bay Rocks," as the inlet known as Lui Bay lies immediately beyond it (fig. 1, B). There are no expanses of sand except at the Geld Kist, where small quantities of coarse sand and gravel occur between the rocks, and floor the channel between island and mainland.

A stream of fresh water, the Lekkerwater, flows down the mountain

side and across the beach to the sea. It is, however, so small as scarcely to affect the surrounding population of the shore.

This part of the coast is to some extent protected by fields of kelp* which mitigate the force of the waves except in stormy weather, when the seas rush up the shore almost to the edge of the bushes and grass, considerably altering the configuration of the banks of shingle and tossing up large quantities of seaweed and other debris beyond the normal high-water mark. The outer boulders of the promontories are, however, very little sheltered by the kelp, and are nearly always splashed by the surf or by the heavy swells which break over them even in calm weather.

In addition to the main survey of the Homestead Rocks, with which were included the adjacent parts of the shingle and rocky beaches, a less detailed examination was made of the Geld Kist and of the Lui Bay Rocks. As these observations cover a comparatively small area, visits were paid to other parts of the shore in the same neighbourhood, but conditions there were found to resemble so closely those already described that it was not considered necessary for the purposes of this work to investigate them further.

THE HOMESTEAD ROCKS.

(Plate IV.)

These rocks are large outcrops of weathered granite, scattered amongst which lie a few smaller blocks of sandstone. The granite forms high rounded boulders with almost perpendicular sides; the outer ones are separated by deep water-filled channels into which the waves surge even at low water, while the channels between those nearer the land are shallower and wider. These channels are all sublittoral, but at low water the landward ones remain so calm and undisturbed, with hardly a current flowing through them, that they may almost be described as pools. A surprising profusion and diversity of animals dwell in these channels, particularly in the outer ones, which constitute one of the most densely populated types of habitat on the South African shore.

On account of the steep gradient of the coast, the intertidal area is not of great extent. On the shingle beach, where it is at its widest, the distance from the edge of the sea at low water of springs to the line of decaying kelp which marks the limit reached by the waves at high water is some 35 feet (11 metres). Above that the rocks and shingle continue for a further 60 feet (18 metres), up to the margin of the bushes and grass. In this upper supralittoral region the rocks are bare but for incrustations of lichens of various colours.

The intertidal area may be subdivided for description into four main

* The term "kelp" is used in this paper to denote the large brown algae which belong to the order Laminariales.

zones, which are easily distinguished on the boulders, though on vertical faces they tend to become much compressed, and in such places certain of the communities which characterise them may even be entirely lacking. On the shingle beach the division is less obvious owing to the presence of both horizontal and vertical differentiation.

I. *The sublittoral fringe.** The sublittoral region of the shore is dominated by Laminarians. The edges of this region may be examined among the outermost boulders, for although the greater part remains perpetually submerged, the upper margin is uncovered at low water when maximal tides coincide with calm weather, and may then lie in the splash-zone for some time. In this sublittoral fringe one of the most typical animal species on open rock is the limpet *Patella argenvillei*, which is present in fairly large numbers. Tufted and leafy red algae (*Champia lumbricalis* and species of *Gigartina*) are present in varying quantity amongst the limpets, flourishing especially in places where the rock is subjected to much wave-action, and there constituting a dense carpet which obscures the other animals of the region. Where more shelter is available, and on vertical faces, the algal growth tends to be very poor, apart from a variety of encrusting forms. Lower down kelp plants become common, and a few gigantic simple Ascidians (*Pyura stolonifera*) are to be seen; these may form large clusters in clefts, but on the open rock are usually isolated. Rich growths of red algae and sheets of brightly coloured sponges (*Fibulia ramosa*, *Tedania brondstedii*, *Myxilla simplex*, etc.) are also to be seen between the holdfasts of the kelp, their luxuriance depending on the amount of shelter provided by neighbouring rocks. Beside the sponges and limpets few animals are to be found apart from the epizoic fauna of the kelp. The foregoing remarks apply to the outer regions of the rock, but the sublittoral fringe extends for some distance inshore in channels; first in the deep outer clefts, and then in the shallower channel-pools among the rocks close to the beach.

II. *The zone of Patella cochlear.* This lies immediately above the sublittoral fringe. It remains submerged at minimal tides, but is exposed for a considerable time during maximal tides, throughout which period, however, it is usually intermittently splashed or washed by the surf. In very calm weather large expanses of limpet-covered rock in this zone may dry off completely and remain isolated for some time; but this is an unusual occurrence. Exposed rock surfaces in the zone are covered by a mosaic of *Patella cochlear*. These limpets are invariably associated with several

* In this series of papers the term "sublittoral fringe," introduced in the paper on Still Bay (this Journal, vol. xxiv, p. 360), is used throughout to denote the zone constituting the boundary between the sublittoral and littoral belts, the zone uncovered for a limited period when maximal tides coincide with calm weather.

types of lithothamnion,* which encrust both the shells of the limpets and the intervening rock, imparting to the whole area a monotonous greyish-buff colour frequently unrelieved by other algae, which are typically scarce in this community. The individuals of *P. cochlear* are on the whole of small size, but are exceedingly numerous, covering the rocks so densely that some become deformed owing to contact with neighbouring limpets.† This Cochlear community occupies large stretches of flat or gently sloping rock, the tops of stones, and to a lesser extent the seaward faces of the higher boulders. It is typically completely absent from the landward aspect of these boulders, and even on the seaward side rapidly dwindles and disappears as the rocks approach the shore. The upper margin of the zone is often clearly marked by a narrow fringe of a buff-coloured coral-like lithothamnion which is one of the types commonly occurring amongst the limpets.

III. *The Balanoid zone.* The distribution of barnacles along this part

* The word "lithothamnion" (not italicised and without a capital) is used throughout this series to denote the encrusting Corallinaceae; the word "corallines" to designate the jointed forms.

† A count was made of the population inhabiting one square yard (ca. 0.84 sq. m.) of rock, part of a low flat-topped granite boulder in the Cochlear zone, and the results obtained are tabulated below. The total number of limpets occupying this small area is remarkable, for the place selected was in no way unusual and was chosen as being typical of the Cochlear zone in this locality. All the specimens of *P. cochlear*, however, were not situated directly on the rock, for as a rule each of the larger individuals bore one or more younger ones on its shell.

Animals.	Number found.	
<i>Patella cochlear</i> {	Larger specimens (average length 2 inches)	386
	Specimens under 1 inch long	929
	Total number	1315
	Percentage of above seated on rock	42
	Percentage on shells of others	58
<i>Mytilus crenatus</i>	29	
<i>Bunodactis reynaudi</i>	8	
<i>Patella argenvillei</i> (small)	1	
<i>P. granularis</i> (small)	10	
<i>P. granatina</i> (small)	1	
<i>Siphonaria capensis</i>	2	
Algae (excluding lithothamnion).	Plants found.	
<i>Splachnidium rugosum</i>	3	
<i>Iridaea capensis</i>	5	
<i>Porphyra capensis</i>	5	

of the coast is somewhat variable, but two species (*Octomeris angulosa* and *Tetraclita serrata*) form a sufficiently constant element in the fauna of the region above the Cochlear zone to justify the use of the term Balanoid zone. Another typical, and less erratic, inhabitant of the zone is the limpet *Patella granularis*, which is notably common at this level.

The Balanoid zone falls naturally into two subdivisions, of which the lower is by far the more densely populated, and contains the majority of the barnacles. Both barnacles and rock are here frequently thickly encrusted with a greyish lithothamnion which whitens on exposure to the atmosphere, rendering them very conspicuous. Rock surfaces in the upper sub-zone appear very bare, since lithothamnia are absent, and animals inconspicuous and relatively scarce. For the most part bushy algae exist only as stunted plants sparsely scattered through the zone; but here and there occur in greater quantity.

The entire zone emerges at low water of springs, when it may become dry and remain so for long periods in calm weather. During tides of lesser amplitude the lower parts are not uncovered, though the upper portion may be exposed for some time.

IV. *The Littorina zone.* This is the uppermost of the intertidal zones, and extends above the level of high water of ordinary spring tides, so overlapping into the supralittoral region. The rocks on first examination appear to be almost uninhabited, for though a small snail, *Littorina knysnaënsis*, is typical of this zone and is found in myriads in the tiny crevices of the granite, it is difficult to distinguish from the black mica-crystals in the rock. The snails are quite conspicuous in hollows or fissures in the sandstone. Other animal species are rarely to be found in the zone, apart from the amphipods (such as *Hyale saldanha*) which haunt patches of algae, and a very small blue-black collembolan (*Anurida maritima*) which creeps about the stones.

Some of the boulders are covered with a thick cap of a ragged yellowish brown alga (*Porphyra capensis*), apart from which a microscopic species, *Calothrix crustacea*, is the principal alga found on the open rock; the latter stains the tops of many of the boulders to a greenish-black tint.

On the shingle beach small crustaceans are to be found throughout the uppermost regions. Ordinarily hidden, they appear in countless myriads when the stones are littered with decaying kelp after a storm. The chief species collected were *Ligia glabrata*, *Deto echinata*, and *Talorchestia capensis*.

Tide levels. In order to obtain some indication of the respective periods during which the different zones are exposed to the air at Oudekraal, the movements of the tide were observed throughout a period of eight hours, on 1st December 1936 (three days after full moon). The times

thus procured are as accurate as can be expected from such a method, for the sea was unusually calm, with no breaking waves, on the day chosen, and boulders exhibiting well-defined zonation were available. There was hardly any actual splashing at any time during the day, though slight swells kept the rocks wetted for a couple of feet above the actual level of the water.

Cochlear zone. Parts of this zone remained dry for some time, but the rest, though uncovered for a considerable period, was kept moist by occasional surges. The zone was dry for a time ranging between 0 per cent. and 25 per cent. of the tidal period,* according to position.

Balanoid zone. The lower subzone was left unwetted for a considerably shorter time than the upper. The time during which the whole zone remained dry amounted to 25 per cent. of the tidal period, but parts were exposed for as long as 50 per cent. of this period.

Littorina zone. Many of the specimens of *Littorina* were quite dry even at high water, as were the patches of *Porphyra capensis* on some of the rocks. This was probably due in part to the unusual lack of splashing. The exposure of the zone varied between 50 per cent. and 100 per cent. of the tidal period.

Further Notes on the occurrence of particular Animals.

1. *Barnacles.* Occasional barnacles (*Octomeris angulosa* and *Tetraclita serrata*) make their appearance among the upper individuals of *P. cochlear*, but their typical habitat lies at a somewhat higher level. On the outermost boulders they are not remarkably common, few *O. angulosa* occurring on the open rock, though crevices fringed with *T. serrata* often accommodate large numbers. On rocks nearer to the beach the *O. angulosa* become very plentiful, thickly populating a definite belt in the lower Balanoid zone, while still farther inshore they are almost completely replaced by *T. serrata*, which becomes abundant in angles between rocks and in other well-sheltered situations. Three other species belong to the fauna of Oudekraal. *Balanus trigonus* and *B. algicola* are small pallid barnacles commonly found at low levels on the shore, particularly on rock-surfaces in the sublittoral fringe and encrusting the shells of *Mytilus crenatus* and of the large *Balanus maxillaris* which often lives just above the margins of the sublittoral channels.

2. *Limpets.* The Patellids form an important section of the fauna, and comprise ten species of *Patella* and two of *Helcion*. *Patella granularis* extends highest on the shore; the animals are large and well-formed, reaching their greatest size on the shingle beach. Small specimens are often found

* By the "tidal period" is meant the interval between one high water and the next.

amongst *P. cochlear*, and frequent the lower parts of the Balanoid zone, while the upper Balanoid zone chiefly accommodates the larger individuals. *P. granatina* is uncommon on the outer boulders, but is notably plentiful on the shingle and rocky beaches, where its habitat extends down into the Cochlear zone. *P. oculus* * is comparatively rare, but when present is often of large size; it lives in the same region as *P. granatina*, though its zone of distribution is not so wide. *P. cochlear* † is so numerous in the zone it characterises as almost to obscure the rock within certain areas. *P. barbara* and *P. miniata* are widespread on rocks low down on the shore in the sublittoral fringe, where they are almost permanently submerged. *P. barbara* is the more abundant of the two species, and often attains a large size, the shell in many cases becoming overgrown with grey lithothamnion and worm-tubes (*Spirorbis borealis*), or infested with algae. Only one specimen of *P. longicosta* was found during the whole course of the survey, in spite of careful search. *P. argenvillei* occupies the upper margin of the sublittoral fringe, where it is fairly common and is conspicuous on account of its large size; and occasional examples are also found amongst *P. cochlear*. *P. compressa* and *P. patriarcha* belong to the sublittoral. The former almost exclusively confines itself to the stipes of the kelp, and is fairly numerous though not easily accessible. *P. patriarcha* is rarely seen, being as a rule limited to fairly deep water. Large numbers of *Helcion pectunculus* are to be found in the Balanoid zone, particularly on the shingle beach where they occur both on and under the stones; on the boulders they prefer crevices and hollows. *H. pruinosa* is moderately common on stones near the water's edge, and in the shallower sublittoral channels. *Siphonaria capensis* occurs in small pools in the higher zones, as well as lower down.

3. *Mussels.* *Mytilus crenatus* is the only species of the genus abundant at Oudekraal. Its principal habitat is the ridge of *Vermetus* (see § 4) in the Cochlear zone. Here numbers of mussels live partially embedded in the *Vermetus* tubes, many of them encrusted with barnacles. Small clusters of the mussels are also to be seen filling cracks in the Cochlear zone, and living in the fringe of coral-like lithothamnion which often forms its upper boundary. On the outer rocks the mussels are small and squat, but in more sheltered places they are often very large and completely hidden by small white barnacles. In many places they extend up into the Balanoid zone for some distance.

4. *Other molluscs.* An interesting gastropod at Oudekraal is a species

* Each *P. oculus* as a rule shelters one or more commensal flatworms (*Notoplana ovalis*) between mantle and foot.

† Many of the individuals of *P. cochlear* possess "gardens" consisting of a fine fringe of short *Gelidium* (*G. reptans*?) or of other short algae.

of *Vermetus*, which builds sheets of calcareous tubes along the margin of the sublittoral fringe and in the Cochlear zone. The thickest growth of these tubes occurs about a foot above the level of low water of springs, where it forms a lithothamnion-encrusted ridge along the rocks. On low outer boulders such a ridge forms a rim surrounding the expanses of cochlear mosaic; on higher boulders it marks the upper limit of the Cochlear zone, and forms one of the most outstanding features of the shore, since it persists much nearer inshore than do the *cochlears*, making a conspicuous narrow ridge on rocks and stones (Pl. V). Where the *Vermetus* extends into the mosaic of *P. cochlear* it forms low walls separating the limpets, and gives a very curious appearance to such areas (Pl. VI).

Whelks and periwinkles form a considerable section of the fauna. The large *Argobuccinum argus* is a sublittoral form; *Thais dubia* is typical of the Balanoid zone; *Cominella limbosa* is widely distributed in the damper places; and a smaller whelk (*Pollia lacertina*) inhabits the lower margin of the Littorina zone on the shingle beach. Higher up on the pebble-ridge countless reddish-brown snails (*Marinula tristanensis*) live deep down under the stones. *Littorina knysnaënsis* is present in myriads in the appropriate region, and is often of unusually large size. The most striking of the periwinkles is *Oxystele variegata*, of which large numbers swell the population of the beaches. Although the optimum level of this species is the Balanoid zone, many specimens climb up among the *Littorina* as the tide rises. A curious shell-less pulmonate, *Onchidiella capensis*, forms a constant member of the fauna, and congregates in small fissures and under stones near low-water line. Several species of chiton are abundant on the beaches. *Acanthochiton garnoti* prefers damp positions round the edges of pools, as does *Chiton nigrovirescens*, which, however, can also be found in considerable quantities beneath stones with *Ischnochiton tigrinus* and *Chiton tulipa*.

5. *Tubicolous polychaets*. These form a less important part of the fauna at Oudekraal than in many other parts of the South African coast. *Gunnarea capensis* is the most conspicuous colonial tube-dweller, and is sometimes found cementing together stones in the shallow sublittoral pools. The sandy tubes occur isolated or in small clumps, and do not form large masses as in some other localities. *Spirorbis borealis* is very common in these pools, where its small white tubes are scattered over many of the stones.

6. *Spiders and flies*. Small greyish-black flies, *Telmatogeton minor*, are a familiar sight hovering over the rocks low down on the shore. A grey and red maritime spider, *Desis tubicola*, is also to be seen on damp rocks.

7. *Other common invertebrates; and fishes*. Sea-anemones are particularly conspicuous in the Cochlear and lower Balanoid zones, where

cracks and depressions are often filled with small specimens of the many-coloured *Bunodactis reynaudi*; these also form sheets among limpets or barnacles in places subjected to a considerable amount of splashing, or where water tends to collect. Cracks higher up are the habitat of a smooth dark red species of *Actinia*. Caves and sublittoral channels shelter a variety of brightly coloured forms (*Bunodosoma capensis*, *Pseudactinia flagellifera* and species of *Anthopleura*). Numerous anemones are also found beneath the stones of the shingle beach, where *Anthothoë stimpsonii* and *Halianthella annularis*, among others, live deep down in damp places. Brittle-stars are the most abundant of the echinoderms, for they form an important item in the crypto-fauna; of asteroids, *Asterina exigua* is the most worthy of note, and is very common in the Balanoid zone of the shingle beach and in shallow channels and pools, though it is inconspicuous on account of its small size and uniform greenish-yellow colouring. The orange *Parasterina bellula* and *Echinaster ornatus* are to be seen in various habitats at low levels, but are never present in quantity. An urchin, *Parechinus angulosus*, inhabits crannies in rock pools; it is usually pinkish in colour in this locality. Sipunculids are commonly to be found buried in the substratum of coarse sand and pebbles beneath the shingle, and nemertines are fairly numerous both on and beneath the stones. Of crabs the large *Plagusia chabrus* is almost ubiquitous, while the smaller *Cyclograpsus punctatus* occurs commonly under damp stones at fairly high levels. *Dromidia hirsutissima*, a large hairy pink crab inhabiting the deepest channels, is more rarely seen. The algae harbour multitudes of small crustaceans, many of which are the exact colour of the plants on which they live. Common among the larger species are the isopods *Glyptidotea lichtensteini* and *Paridotea rubra*. Small fish shelter under stones and seaweed in all the pools, and include *Clinus dorsalis* and *C. superciliosus*, a handsome spotted species, *Marcgravia apiatus*, and the sucker-fish *Chorisochismus dentex*.

Notes on the occurrence of Algae.

The most prominent feature of the shore in this locality is the presence of giant brown algae of the order Laminariales. These seaweeds form extensive fields and forests in the sublittoral area, both off-shore and along the margins of the outer rocks. They extend far inshore in sublittoral channels, in which, however, they are of small size, whereas in deeper water they frequently reach a length of 20 feet (6 metres) or more. The kelp consists principally of *Ecklonia buccinalis*, interspersed in places with palm-like clumps of the smaller *Laminaria pallida*. The latter rarely projects above the surface at low water as does the *Ecklonia*, and

so is less conspicuous. On the outer boulders the rock between the holdfasts of the kelp supports varying quantities of other algae, chiefly small fields of red species such as *Epymenia obtusa* and *Botryoglossum platycarpum*, with tufts of *Gelidium cartilagineum*, *Neuroglossum Binderianum* and *Botryocarpa prolifera*, and fronds of the larger *Pachymenia carnososa*. Smaller species, such as *Pterosiphonia cloiophylla*, *Apoglossum ruscifolium* and *Gymnogongrus glomeratus*, are also to be found, particularly towards the upper limits of the region. In sheltered positions the algae are often less dense.

The algae in the margin of the sublittoral fringe where kelp is sparse or absent, vary greatly in amount. In many places *Champia lumbricalis* and *Gigartina stiriata* * flourish, together with smaller amounts of *G. radula*. Higher up the rocks the *Champia* gradually thins out, while the *Gigartina* becomes more plentiful, and dense patches of *Plocamium cornutum* appear in places. The *Champia* and *Gigartina* thus occur in parts of the Cochlear zone as well as below it.

Where the ridge of mussels and *Vermetus* is found, it is typically accompanied by a thin and scanty growth of extremely stunted *Gelidium* (*G. reptans* ?), which sometimes extends on to adjacent rock surfaces. The Cochlear mosaic is in many places remarkably free from algae; occasional small patches of *Caulacanthus ustulatus* occur, with tufts of *Cladophora flagelliformis* and *Iridaea capensis*. The last-named is usually small and dwarfed in this position, but in other habitats the plants become large and very luxuriant. *Caulacanthus ustulatus* has a wide range; patches of it are found as high as the upper parts of the Balanoid zone. *Porphyra capensis* also has an extremely wide range. Its fronds are often small and poor in the upper Cochlear zone, but become larger and more abundant higher up the shore, and are most conspicuous in the Littorina zone, where they form a thick cap on some of the boulders. In most cases these sheets of seaweed consist entirely of a broad-bladed form of *P. capensis*; but when found in the Balanoid zone, they may be composed of a ribbon-like variant of the species. *Splachnidium rugosum* is never common, but isolated plants may attain a considerable length in the Balanoid zone. Two other species typical of this zone are the fringed *Chaetangium ornatum* and the vesicular *C. saccatum*, both of which occur sporadically in the upper parts, forming luxuriant patches on certain rocks and entirely absent from others.

* It is possible that the plants referred to here as *Gigartina radula* and *G. stiriata* may belong, not to two species, but to complexes of related forms (see Setchell and Gardner, 1933). A revision of the South African algae is at present being conducted by G. F. Papenfuss, but he has not yet had the opportunity of comparing our plants with the type specimens, and until his revision is completed, is following De Toni (1897) in treating the plants involved provisionally as belonging to two species; and the same usage has been adopted here.

Two species of encrusting non-calcareous algae are a constant feature of the flora. *Lepadoderma africanum* forms extensive greenish-brown sheets on the rock surfaces in the sublittoral fringe, and is often associated with reddish patches of *Hildenbrandtia pachythallos* and with various pink and mauve lithothamnia. Both these species when found higher up the shore tend to be confined to moist positions and rock pools. Corallines are poorly represented along this part of the coast; small tufts occur in the sublittoral fringe and the Cochlear zone, or sometimes in pools at slightly higher levels; but they are neither plentiful nor varied.

The following account gives some indication of the dense community of algae which lines the shallower sublittoral channels and pools. The floors of these pools consist of small stones and sand which support very few seaweeds. The lower parts of their rocky sides are thinly carpeted with red algae, including *Polyopes constrictus*, *Champia compressa*, *Pleonosporium Harveyanum* and *Dicurella flabellata*, together with some of the species typical of the outer parts of the sublittoral fringe. Higher up the walls are hung with a dense curtain of great fronds of *Gigartina stiriata* and *G. radula*, of which the latter is here by far the commoner of the two species. *G. fastigiata* is also a member of this community, though it is not very plentiful. *Iridaea capensis* reaches its maximum size in this position, where great undulating expanses of it cover the tops of many of the rocks and form a thick fringe just above the curtain of *Gigartina*. Another typical species is *Porphyra capensis*, which grows to considerable size though the fronds are often ragged, and small plants of *Ecklonia buccinalis* are often to be seen.

In the foregoing account of the algae very few green algae have been mentioned, for these are curiously infrequent at Oudekraal. On the open rock *Cladophora flagelliformis* is found in the lower zones, where its green tufts are hardly noticeable amongst the limpets. It also grows in pools at higher levels. *Ulva Lactuca* and species of *Enteromorpha* and *Codium* are to be found, and may be abundant in the shallower channels, but the two former are of very variable occurrence, a profuse growth appearing at times and then disappearing again. Pools high up on the rocks sometimes support large amounts of a light green species of *Enteromorpha*.

Fauna of the lower parts of the Shore.

1. *Deep sublittoral channels and caves.* These clefts lie between the outermost boulders and are always in communication with the open sea. They are often very deep, are in most places difficult of access, and frequently so filled with kelp that it is almost impossible to determine their population. Certain of the channels, however, are so overshadowed

by rocks that they contain little or no kelp, while others are more of the nature of caves.

One such long narrow cleft on examination proved to be fairly typical of the region, and is described below. It is a crevice * lying between two granite boulders and is partially blocked at either end by fallen slabs of rock. The fauna is remarkable for the vivid coloration of many of its members. The stones forming the floor are mottled with purple lithothamnia, and often bear solitary stony corals (*Balanophyllia bonae spei*), orange in colour. The walls are clothed with small red algae (chiefly *Epymenia obtusa*) amongst which live innumerable animals, of which the commonest and most conspicuous are the sponges, which abound near the bottom of these deep channels and often form masses a couple of feet in diameter. These sponges are very seldom exposed to the air even during maximal tides. The largest is *Stelletta agulhana*, which forms grey balls resembling pieces of granite. Others among the more plentiful species are the orange *Lissodendoryx stephensoni*, the brownish yellow *Guitarra fimbriata*, the creamy *Haliclona anonyma*, and a beautiful lilac-blue finger-like sponge, *Callyspongia tubulosa*. Many of these sponges and the surrounding rock surfaces are overgrown with hydroids such as *Sertularella arbuscula* and species of *Eudendrium* and *Tubularia*. At the shoreward end of the pool the rock is patterned with small pink corals (*Corynactis annulata*) and patches of the vivid magenta *Alcyonium fallax*, while throughout the crevice are scattered small corals, variously coloured anemones, white or scarlet gorgonians (*Eunicella papillosa* and *Wrightella coccinea*) and small colonies of ascidians. Errant species, particularly near the water-line, include numbers of hermit crabs (*Paguristes*) and whelks (*Cominella limbosa*, *C. papyracea*, *Argobuccinum argus*, *Fasciolaria lugubris* and *Thais wahlbergi*).

Many of the channels resemble the one just described, but those more completely overshadowed by the surrounding boulders contain a typical cave fauna. In them an even greater profusion of animal life is found, the diversity of corals, gorgonians, anemones, alcyonarians and molluscs being supplemented by many other species of sponges, and by compound ascidians and polyzoa of many kinds, the whole population forming a brilliantly coloured carpet which almost completely hides the rocky walls. The polyzoa are of several different habits. *Emballotheca capensis* and *E. nivea* are encrusting forms; *Retepora tessellata*, *Costazia costazii* and *Chaperia galeata* build coral-like or fan-like colonies; and bushes of softer species, such as *Cellularia infantae*, *C. triseriata* and *Menipea cirrata*, are also commonly seen. Other inhabitants of

* Dimensions: Length 10 feet (3 m.); width 1 foot (0.3 m.); depth 2-3 feet (0.6-0.9 m.).

these caves are crabs of various species, crayfish (*Jasus lalandii*), nudibranchs and starfish.

2. *Shallow sublittoral channels.* These channel-pools lie between the main groups of boulders and the beach, and are fairly shallow, seldom being more than a foot (0.3 m.) in depth at low water of springs. They are of considerable extent, with a substratum composed of rounded stones resting on coarse sand, and are all interconnected, communicating with the deeper channels and the open sea even during maximal tides. During tides of exceptional amplitude some of them become almost drained of water for a time.

All these channel-pools support a great profusion of algae, which has already been described. The smaller stones which floor the pools are free from such growths of leafy algae, but are largely covered with pink or purple lithothamnion or with a green slimy coat of lichens and diatoms, and in many cases are also sprinkled with the small white tubes of *Spirorbis borealis*. The animals living on the upper surfaces of the stones and rocks are chiefly molluscs, of which the limpets *Patella granatina*, *P. miniata*, *P. oculus* and *Helcion pruinosa* form the greater proportion. Other animals frequently encountered here are *Mytilus crenatus*, nudibranchs, starfish, crabs, and in the deeper parts *Corynactis annulata*. Near the water's edge *Acanthochiton garnoti* and an orange-red ascidian (*Aplidium schultzei*) are commonly found.

It is, however, beneath the stones that the greater part of the animal life of these pools is to be discovered, for they harbour a cryptofauna which is both abundant and varied, and of which the following list gives but an outline. Small molluscs, worms and echinoderms are all exceedingly common, while the stones themselves are in many cases encrusted with polyzoa (*Mucronella contorta*, *Cribrilina inermis*), with pink, fawn, or orange sponges (*Aplysilla rosea*, *Haliclona ciocalyptioides*, *H. anonyma*, *Hymeniacion sanguinea*) and with colonies of compound ascidians, and are overrun by small isopods (*Exosphaeroma kraussii*, *Parisocladius perforatus*) and other crustaceans. The molluscs include *Oxystele zonata*, *Gibbula rosea*, *G. capensis*, *Marginella biannulata*, *Turbo cidaris*, *Ischnochiton tigrinus*, *Chiton tulipa*, the fissurellid *Diodora mutabilis* and the ormer *Haliotis sanguinea*. The commoner polychaets are *Euphrosyne capensis*, *Audouinia filigera*, *Cirratulus chrysoderma*, *Nicolea macrobranchia* and the polynoid *Lepidonotus semitectus*. Small brittle-stars (*Amphiura capensis*, *Ophiothrix triglochis*, *Amphipholis squamata*) are remarkably plentiful, and may often be picked up by the handful when stones are overturned. The pink urchin *Parechinus angulosus* is common, and holothurians (*Thyone serrata*, *Cucumaria insolens* and *C. discolor*) are also to be found. Other species are pink and white brachiopods

(*Kraussina pisum*), pycnogonids (*Discoarachne brevipes*) and crabs of several species.

3. *The epiphytes and epizoa of the kelp.* The giant Laminarians, in particular *Ecklonia buccinalis*, form a place of attachment for many animals and algae. The stipes of the older kelp plants are often infested with epiphytic algae, from which young plants are usually free. Mossy growths of species of *Ectocarpus* and *Enteromorpha* form a green coating over many of the stipes, to which are also attached bushes of the red epiphytes *Suhria vittata*, *Carpoblepharis flaccida* and *Polysiphonia virgata*, which may in their turn bear soft feathery tufts of *Pleonosporium purpuriferum*. Colonies of vivid pink hydroids (a species of *Tubularia*) clothe the lower parts of many stipes, and the limpet *Patella compressa* is sometimes to be seen, especially on the subterminal expansions of the stipes. The long fronds are in many cases covered with a delicate tracery of small colourless hydroids (*Plumularia setacea* and *Obelia geniculata*). It is, however, the holdfasts of the plant which yield the most interesting section of the population; they form an ideal habitat for a large community of animals since they give adequate protection and yet permit currents of water to circulate freely through them. The tubicolous polychaet *Spirorbis borealis*, encrusting polyzoa, as well as hydroids, are attached to the holdfasts, while within the shelters formed by their interlocking subdivisions live countless small animals of which examples must suffice. The sponges include soft diffuse forms and sycons (*Iophon proximum*, *Oscarella lobularis*, *Leuconia crambessa*), and these together with compound ascidians line the small hollows among the subdivisions; these hollows also afford protection to various nemertines, such polychaets as *Eulalia viridis*, *Platynereis dumerilii*, *Syllis variegata* and other smaller species; and small crustaceans (*Ceradocus rubromaculatus*, *Maera inaequipes*, *Aora typica*, *Dynamenella ovalis*, *Polycheria atolli*, etc.). Small molluscs include *Helcion pruinosa*, small bivalves and minute whelks. In addition mats of encrusting polyzoans (*Holoporella capensis*, *Mucronella contorta* and others) are often to be found, while pycnogonids, alcyonarians, brittle-stars and sea-anemones also avail themselves of this refuge.

THE ROCKS AT LUI BAY AND GELD KIST.

The examination of these rocks served to confirm the account of the population and its arrangement in zones which has been given for Homestead Rocks. Local variations were, of course, apparent, but these were on the whole of minor importance. Perhaps the most noteworthy difference at Lui Bay was a stronger development of *Gunnarea capensis* than at Homestead Rocks. At Geld Kist the granite island is separated from the

shore by a fairly wide and sheltered channel, in which there is a considerable growth of the Laminarian *Macrocystis pyrifera*, with fronds up to 15 or 20 feet (5 or 6 m.) long, in addition to *Laminaria* and *Ecklonia*. The *Macrocystis* along this coast tends to appear in the more sheltered parts of the sublittoral zone. Another feature of the Geld Kist rocks is that the fauna of the sublittoral pools and channels is on the whole less rich in species than at Homestead Rocks.

DISCUSSION.

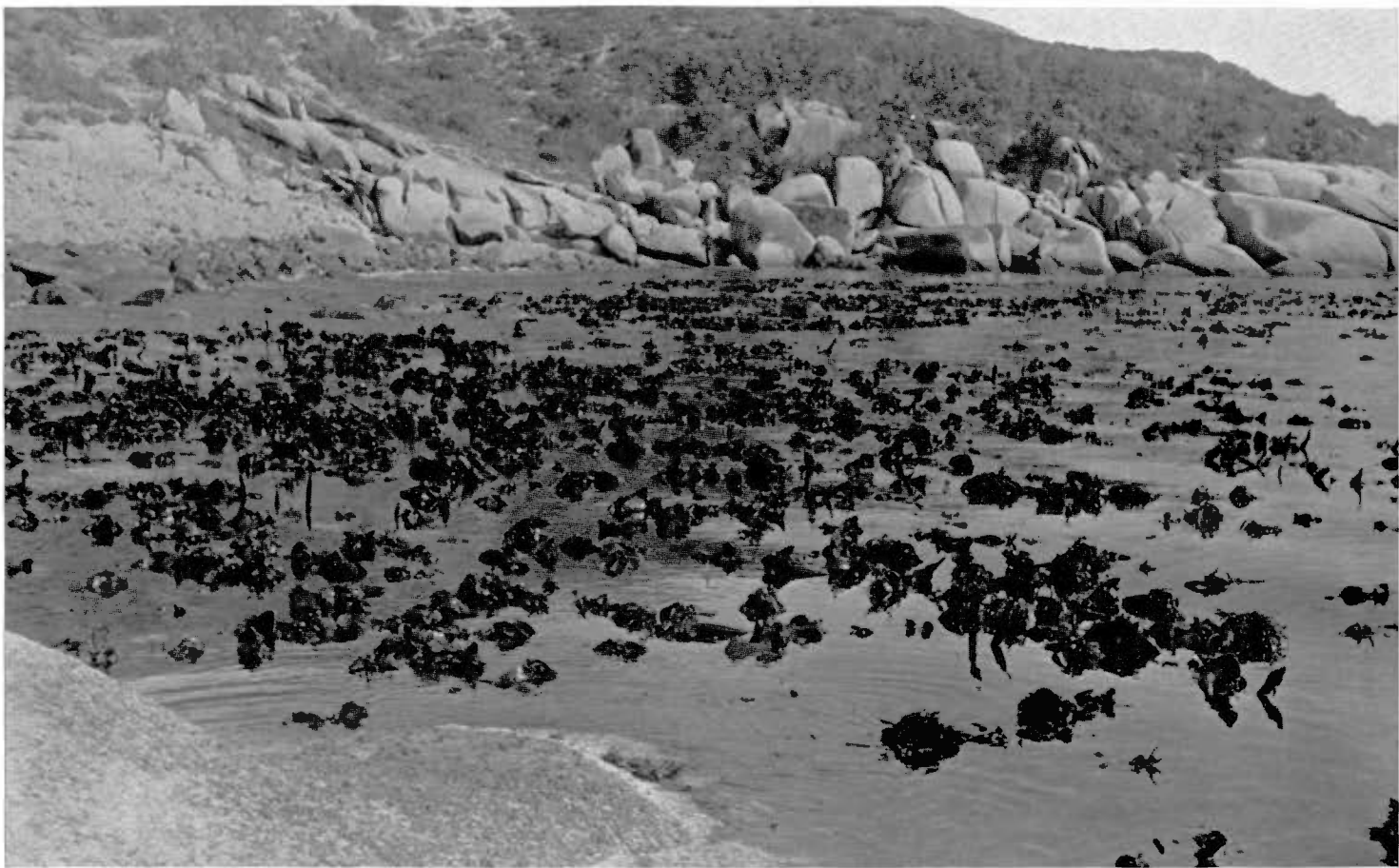
The points of general importance which are brought out by this paper can be emphasised much more profitably after a second area on the west coast has been described. An account will shortly be completed of the intertidal region in the Port Nolloth district, near the northern extremity of the west coast of the Union, and after this has been presented some of the leading features of the biota of the two localities will be discussed.

SUMMARY.

A description is given of rocky areas in the intertidal region in the neighbourhood of Oudekraal, a locality situated on the northern part of the west coast of the Cape Peninsula, and affected by cold inshore water. The intertidal belt here is subdivided for descriptive purposes into four zones, from above downwards the Littorina, Balanoid and Cochlear zones, and the sublittoral fringe. The sublittoral region is characterised by the presence of a strongly developed Laminarian belt, dominated by *Ecklonia buccinalis*.

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The shore at Oudekraal, looking southward from Homestead Rocks; showing granite boulders and a field of *Ecklonia buccinalis*.
From a photograph by G. J. Broekhuysen.



Oudekraal. A granite boulder, showing the position of the *Vermetus* zone, following the waterline.
From a photograph by G. J. Broekhuysen.



The Cochlear zone, Kommetje (Atlantic coast of the Cape Peninsula, south of Oudekraal); specimens of *Patella cochlear* situated in crater-like depressions. The ridges bounding the craters are formed by *Vermetus* tubes and lithothamnion, and the floor of each crater represents the habitual browsing-area of the limpet, on which the formation of the tubes is inhibited. There are small limpets on the backs of the larger ones, a feature characteristic of crowded parts of this zone. From a photograph by T. A. Stephenson.

THE SOUTH AFRICAN INTERTIDAL ZONE AND ITS
RELATION TO OCEAN CURRENTS.

III.—AN AREA ON THE NORTHERN PART OF THE WEST COAST.

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(With Plates VII-IX, and two Text-figures.)

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INTRODUCTION.

A paper appears in the present issue of this Journal (pp. 49-65), which describes the biota inhabiting rock surfaces in the intertidal region at Oudekraal, a locality situated on the southern part of the west coast of the Union of South Africa. The following paper presents the results of a further survey on the same coast; this was carried out in the neighbourhood of Port Nolloth, near the northern boundary of the Union. These surveys form the second and third members of a series directed by Prof. T. A. Stephenson, of the Department of Zoology, University of Cape Town, in which the influence of cold and warm currents on the biota of the South African coasts is being investigated. Port Nolloth, like Oudekraal, lies on the part of the coast affected by the cold Antarctic intermediate water.

In the survey of the Port Nolloth district the field-work was accomplished during a three-weeks visit in October and November 1935. I wish

to thank E. J. Eyre, M.Sc. and Anne Stephenson for assistance during this visit; Dr. G. J. Broekhuysen for the photographs reproduced in Plates VII and VIII; and Prof. Stephenson for his guidance throughout the work. I also wish to acknowledge my further great indebtedness to the various specialists who have identified the material collected during the survey, and whose names have appeared in the first and second papers of this series (Stephenson, Stephenson and du Toit, 1937, p. 349; Bright, 1938, p. 50). A paper referring to Port Nolloth (and other) material from our collection has been published by Monro (1937).

DESCRIPTION OF THE LOCALITY.

The village of Port Nolloth (Lat. $29^{\circ} 15' S.$, Long. $16^{\circ} 52' E.$) faces the Atlantic Ocean in the north-west corner of the Union of South Africa. It lies on the coast of Namaqualand in the Cape Province, some 55 miles (89 km.) south of the mouth of the Orange River, and 460 miles (740 km.) by road from Cape Town.* The village itself is built on and mainly surrounded by deposits of sand, but there are rocky outcrops of considerable extent on the foreshore. These outcrops, interrupted at intervals by small sandy beaches, stretch along the coast for many miles in both southerly and northerly directions. The village possesses a quay, visited by fishing-boats and small coasting steamers, but their presence does not appear to pollute the water for any appreciable distance. On calm days a small amount of oil may be seen collected along the edge of the rocks which lie nearest to the quay, but those farther off appear to be free from any trace of it.

A general survey of the shore in the neighbourhood of Port Nolloth itself was carried out, and a supplementary survey was made of the rocks at Cliff Point, a place situated approximately 15 miles (24 km.) by road to the north of Port Nolloth. A visit was also paid to the shore at Buchuberg, though a detailed examination could not be made there owing to the short time available and the state of the tides, which were of minimum amplitude. Buchuberg lies beyond Cliff Point, some 46 miles (74 km.) by road from Port Nolloth, and is the most northerly point included in our surveys of the west coast of the Union.

Fresh water has little or no influence on the parts of the Namaqualand coast which were studied in this survey. The Orange is the only river which contains water throughout the year, and this lies too far north to affect the biota of the areas investigated. Other streams are very few in number and flow only at infrequent intervals, while springs and marshes are absent owing to the dryness of the climate.

* Distances have been taken from the R.A.C. Route Book for 1936.

THE ROCKS AT PORT NOLLOTH.

In order to obtain a comprehensive picture of the animal and plant populations of the intertidal region, several different areas of rock were studied in the immediate vicinity of Port Nolloth (fig. 1). These are composed of pre-Nama quartzites and schistose rocks, and are hard, light brown

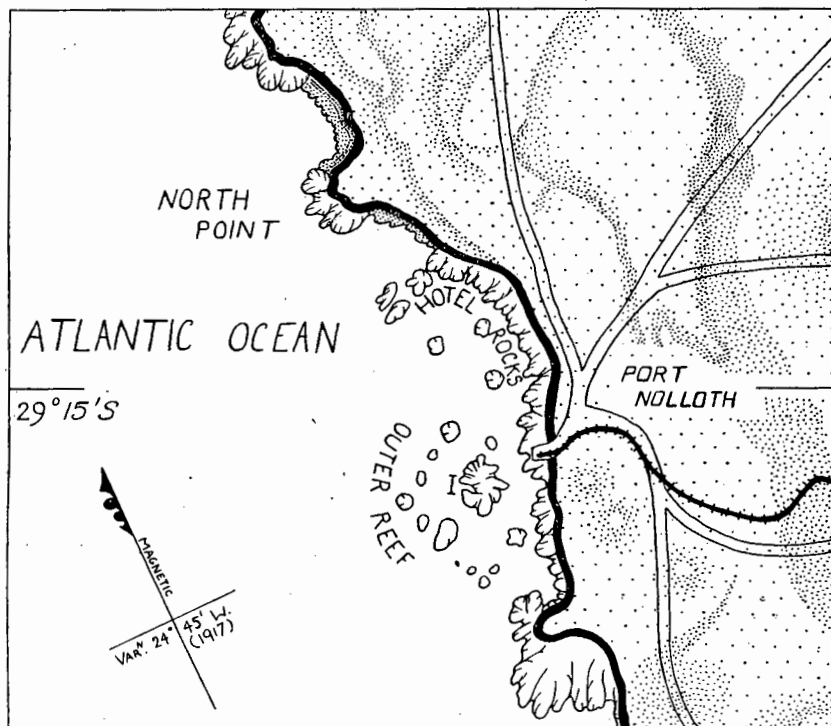


FIG. 1.—A sketch-map showing approximately the arrangement of the rocks at Port Nolloth. Based on a photographic enlargement of a part of Admiralty Chart No. 897 (1931).

in colour and fine-grained in texture.* Correlated with the hardness of the rock is a lack of caves and grottoes, and, in consequence, of a typical cave fauna; also an apparent absence of boring animals.

The foreshore below the village consists of outcrops of rock alternating with sandy beaches of greater or less extent, and succeeded to landward by a belt of sand or by low sand-dunes. One such outcrop, which will be called "Hotel Rocks," stretches northwards from the village quay to the lighthouse. In this region the shore presents a curious appearance,

* I am indebted to Dr. A. W. Rogers for this information.

consisting of long ridges of rock which run parallel to the coastline and which typically slope steeply to seaward and present a vertical or overhanging landward face.* Animals living on the landward overhang of such a ridge are therefore much better protected from the waves than those on the seaward face. The ridges are separated from one another by channels, of which those in the lower part of the shore are at all times filled with water and in communication with the open sea, whereas those higher up are dry (except for shallow isolated pools) at low water. At high water all the channels are wave-swept, while the outer ridges are completely submerged and their positions only indicated by lines of surf.

About a mile † (1.6 km.) to the north of the village, separated from the Hotel Rocks by a stretch of sand, lies an extensive rocky promontory known as North Point. The same type of rock-formation occurs in this region, but here the ridges, which often form broad high platforms, lie at right angles to the shore and are subjected to very strong wave-action.

Near the Hotel Rocks, some 300 yards (275 metres) to seaward of the quay, is situated a small island (fig. 1, I). It is easily reached by boat, and at low water appears as an acre or more of low rocky outcrops surmounted near the northern end by a large mound of sand and shell. This mound is the only part left uncovered at high water of springs. The Island and the Hotel Rocks are to some extent protected from the force of the waves by a low-lying offshore reef which extends in a broken line from a point opposite the lighthouse in the north, southwards past the Island. Over this reef (which will be referred to as the Outer Reef) the seas break continuously except in unusually calm weather. This reef partially encloses a fairly well sheltered lagoon in which, although the waves are still quite large, they are by no means as strong as those on the unprotected parts of the coast such as North Point. The lagoon has a sandy bottom on which boulders overgrown with kelp are scattered.

The area examined in most detail was the Hotel Rocks; but the observations made there were confirmed and supplemented by less extensive studies of the Island, the Outer Reef, and North Point.

As at Oudekraal, the rock surfaces in the intertidal region may be divided into three zones, each of which is characterised by the presence of certain animals and algae. At Port Nolloth, as elsewhere, these zones grade into one another, their boundaries seldom being sharply demarcated, and also vary considerably in nature according as the amount of splash and wave-action differs from place to place. The subdivision into zones

* A cross-section of the shore in this region is given in fig. 2. The measurements were made with a surveyor's tape.

† These distances are only approximate, since no facilities were available for accurate determinations:

is less obvious at the Hotel Rocks than in the other areas, owing to the configuration of the shore; certain of the zones, however, may be clearly distinguished on each ridge, so that by taking the ridges together a complete picture of the zonation may be obtained. At Hotel Rocks large pools are few in number, such small pools as occur on the ridges frequently harbouring a community which corresponds in general with that of the open rock, though often denser and more varied. Extensive pools with a very rich population are found on the Island, and interesting pools also occur at North Point.

In the course of the surveys hitherto carried out at other points on the South African coast, it has been found that from Durban along the eastern and southern coasts to False Bay, and on at least part of the west coast, it is possible to divide the intertidal belt for descriptive purposes into at least three principal zones—Littorina zone, Balanoid zone and Sublittoral Fringe; and a fourth belt, the Cochlear zone, is distinguishable along the greater part of this region. In the case of Port Nolloth a difficulty has arisen. In the first place the Cochlear zone is absent, and is replaced by a belt inhabited by *Patella argenvillei*; but since *P. argenvillei* does not, so far as we can determine, extend to as high a level as *P. cochlear* would reach if present, the correspondence between the two zones is partial and not exact. Secondly, the sublittoral fringe and the Littorina zone can be recognised at Port Nolloth as elsewhere; but between the Littorina zone and the zone of *Patella argenvillei* there remains a region for which it is not easy to find a suitable name. There is no doubt that the region in question corresponds approximately to the Balanoid zone of the major part of the South African coast, and that it can be subdivided, as elsewhere, into levels corresponding to the upper and lower Balanoid zones; the difficulty arises from the fact that only the lowest part of the zone is at all extensively populated by barnacles, which are scarce or absent at the higher levels. We think that in spite of this fact it would be confusing rather than otherwise to create a new term for this zone at Port Nolloth, and we propose consequently to refer to it as the Balanoid zone so that our terminology for the whole coast may be as uniform as possible.

I. *The sublittoral fringe.* As at Oudekraal, the sublittoral zone proper is occupied by a community of Laminarians, which invade the sublittoral fringe to a certain extent (a similar region is illustrated in Plate VIII). Along the upper edge of this zone the kelp plants are relatively small and interspersed with other algae. The tunicate *Pyura stolonifera* ("redbait") is commonly to be found in the fringe. In some places these ascidians form a narrow belt of closely packed individuals, in others only small clumps or solitary individuals are to be seen. A curious exception to the normal occurrence of *Pyura* is found on the Island, where the redbaits are present

at higher levels than usual on ledges where water tends to collect. The sublittoral fringe is only accessible at low water of maximal tides, at which time it is uncovered only between waves, unless in exceptionally calm weather. The redbaits are not easily distinguished as their tests are frequently overgrown with lithothamnion and small algae of other types.

The sublittoral region is most easily examined in the deep outer clefts of the Outer Reef and North Point, where a selection of brightly coloured sponges, sheets of compound ascidians of various species, bushy polyzoa and a variety of small red algae commonly coat the rocks between the holdfasts of the kelp. Of other animals *Dasychone natalensis*, a handsome polychaet with mauve or reddish fans, is often associated with the redbaits, while a large brown-and-white whelk (*Argobuccinum argus*) inhabits the channels, in which large crayfish are also of frequent occurrence.

II. *The zone of Patella argenvillei* (Pl. VII, fig. 2). The zone immediately above the fringe, which is exposed for a time during the stronger but not during the weaker tides, is dominated in the more seaward positions by a large limpet, *Patella argenvillei*. Great numbers of these limpets occupy a very clearly defined region which includes the lower parts of the rocks up to about the limit of the splash zone at average low water of springs; above this level they are seldom seen except in pools. The limpets often reach a great size, many of the larger individuals being overgrown with pinkish lithothamnion and clumps of small barnacles, and crowned with bushes of corallines and other algae, so that they give a curious and very characteristic appearance to the rocks. The adults commonly bear one or more younger limpets on their shells. Between the limpets the rock is often coated with lithothamnion or with non-calcareous encrusting algae; whilst corallines and tufts of leafy red algae are also of common occurrence. In the lower parts of the area, which are much splashed or over which water drains continually, these bushy algae may form a dense carpet in which the limpets are almost hidden from view.

At low water of springs on a moderately calm day most of the *P. argenvillei* are uncovered for a limited period, varying according to their position in the zone, but even during this time are washed by almost every swell. At low water of neaps the zone remains completely submerged.

III. *The Balanoid zone.* Barnacles are present in comparatively small numbers along this coast, and the zone above the *Patella argenvillei* is perhaps most distinctly characterised by the presence of the limpet *Patella granularis*, large numbers of which occur in this region all along the shore. The zone falls naturally into two subdivisions: of these the lower is the more densely and variably populated, while the upper is everywhere occupied by a sparse but relatively constant fauna.

(a) *Lower Balanoid zone.* At the Hotel Rocks open rock surfaces in this region support a singularly scanty fauna in which *P. granularis* is the most frequent species, though various other molluscs are also common, including *Mytilus* in small numbers. Algae are scarce; such species as are found are short and moss-like except at the lower margin of the zone, where a fringe of brownish algae (*Iridaea*, *Porphyra*, *Gigartina*, *Leathesia*, etc.) is a prominent feature. A population of this constitution is confined to the more sheltered areas. Increased exposure to the surf is often accompanied by a much greater development of mussels, of which an extensive community covers large expanses of rock. On the Island this community consists principally of *Mytilus crenatus*, of which large clumps almost hide the rocks. At North Point the blue-black *Mytilus meridionalis* is also to be found, though uncommon except in pools, and on the Outer Reef the extraordinarily dense carpet of mussels consists of both species. *Mytilus crenatus* commonly occupies the upper parts, while lower down it is partially ousted by masses of *Mytilus meridionalis*, which at this level becomes the commoner of the two species. Luxuriant growths of a diversity of algae frequently accompany the mussel-beds, covering them with so thick a turf as almost to obscure them from view. Among these algae *Champia lumbricalis* and species of *Gigartina* are conspicuous. Other characteristic inhabitants of the lower Balanoid zone are the tube-building polychaets *Gunnarea capensis* and *Dodecaceria fistulicola*, both present in moderate amounts. Among the mussels anemones are very plentiful, often forming many-coloured sheets in shallow pools, the principal species being *Bunodactis reynaudi* (Pl. VII, fig. 1) and a species of *Anthothoë*.

(b) *Upper Balanoid zone.* Rock surfaces in this sub-zone offer a great contrast to those lower down, for the fauna is scanty, and animals are on the whole small, soberly coloured and inconspicuous, while algae are represented by a few short moss-like species (*Caulacanthus*, *Cladophora*, etc.). *Patella granularis* reaches a large size here, and other animals which are notably plentiful are the small limpet *Helcion pectunculus* and the periwinkle *Oxysteles variegata*. In some places, as at North Point, large numbers of *Siphonaria capensis* inhabit the uppermost parts of the zone.

The Balanoid zone remains entirely exposed for some hours during maximal tides; during minimal tides the lower parts are splashed or submerged, particularly in rough weather. The entire zone is submerged for a considerable time at high water.

IV. *The Littorina zone.* The Littorina zone occupies the highest and driest parts of the intertidal belt and overlaps into the supralittoral area. This zone remains completely exposed for considerable periods during both maximal and minimal tides, and in it a small snail, *Littorina knysnaënsis*, occurs in vast numbers. The zone occupies the highest parts of

the ridges at Hotel Rocks and North Point, but is absent from the other two areas as they contain no rocks of sufficient height above the sea. Few other animals, and as a rule only one alga (*Porphyra capensis*), which is very erratic in its distribution, are found on the open rock in the *Littorina* zone, though an assortment inhabit the pools. A colourless amphipod, *Talorchestia capensis*, infests patches of sand in this region and the decaying kelp with which they are often littered.

Tide levels. An attempt was made to obtain some indication of the relative amounts of exposure to which the several zones are subjected, at Hotel Rocks, during both spring and neap tides, by noting the time and order of appearance of some of the commoner and more prominent animals during a period of 8 or 9 hours, on each of two days. The times obtained are very approximate, since the sea was never very calm, nor were vertical rock faces available for taking exact measurements. The observations made are given below for comparison with those obtained at Oudekraal and elsewhere.

28th October, 1935 (one day after new moon).

Argenvillei zone. The upper parts of this zone were splashed at low water, while the lower parts only emerged between waves. The exposure of the upper parts lasted from 16–20 per cent. of the tidal period, while the lowest parts appeared during less than 8 per cent. of that period.

Balanoid zone. The lowest animals in the zone were splashed even at low water; the rest remained dry for considerable periods. The time during which the zone was uncovered varied from 20 per cent. to 58 per cent. of the tidal period, according to level on the shore.

Littorina zone. This was completely exposed and dry at low water; at high water almost all the snails were submerged, even the topmost ones being in the splash. None remained dry. The animals were exposed for 58–83 per cent. of the tidal period.*

2nd November, 1935 (six days after new moon—tides almost minimal).

Argenvillei zone. Completely submerged even at low water.

Balanoid zone. At low water the lower part of the zone, containing *Patella granatina* and much of the *Gunnarea capensis*, was submerged or continually wave-washed. The zone remained uncovered for a time ranging between 0 per cent. and 84 per cent. of the tidal period.

Littorina zone. At low water all the individuals of *Littorina* were left dry, while at high water the zone was almost completely washed or splashed, though much of it was visible between waves. The time of exposure varied between 84 per cent. and 100 per cent. of the tidal period, for a few of the snails remained dry throughout the entire period.

* It may be noted that if the rocks at this locality had been higher, a proportion of the periwinkles would probably have been out of reach of the splash.

Further Notes on the occurrence of particular Animals.

1. *Barnacles*. These do not constitute a large proportion of the population. The only species which appears to be plentiful is *Chthamalus dentatus*, which is very unevenly distributed; when present, its chief habitat is low down on the shore either among the *Patella argenvillei*, whose shells it often encrusts, or attached to mussels in small runnels of water between them. The larger species, *Octomeris angulosa* and *Tetraclita serrata*, appear to be relatively scarce at Port Nolloth, and, so far as we were able to discover, are confined to small moist crevices and other sheltered positions. The giant barnacle *Balanus maxillaris* is sometimes to be seen in the lower zones.

2. *Limpets*. Seven species of *Patella* are found at Port Nolloth, at least six of which form a conspicuous part of the fauna. The species whose range extends farthest up the shore is *Patella granularis*; next comes *P. granatina*; then *P. barbara* and *P. miniata*, and finally *P. argenvillei*. *P. patriarcha* is rarely found, and belongs exclusively to the sublittoral, as does *P. compressa*, the latter being confined to the stipes of the kelp plants. Although the species appear in this order they do not form separate zones, but overlap to a considerable extent. *P. granularis* has a wide area of distribution which ranges from the lower fringe of the Littorina zone as far as the Argenvillei zone. *P. granatina* is extremely common all along the shore; the individuals are of large size, and most abundant in the lower Balanoid zone, occurring especially in situations such as the leeward side of rocks and the tops of stones in shallow channels, though they may inhabit pools up to high levels. *P. barbara* is plentiful all along this coast, and shows a marked tendency to live entirely submerged, seeming to flourish best in calm water. It commonly lives in sublittoral channels and pools, and more rarely on wave-washed rock faces. In such positions it outnumbers *P. granatina*, but it does not extend very far up the shore. The individuals are large, and commonly covered with lithothamnion and worm-tubes. *P. miniata* is not uncommon, living in similar situations to *P. barbara*. Besides these *Patellae*, another genus of Patellids occurs. *Helcion pectunculus* is conspicuous in the upper parts of the Balanoid zone, particularly in hollows and crevices. *Helcion dunkeri* is widely distributed in channels and damp places at most levels on the shore, but is nowhere very common. *Siphonaria capensis* (a pulmonate) is notably abundant in and around pools in the higher zones.

3. *Mussels*. *Mytilus crenatus* and *M. meridionalis* both reach their maximum density in the lower Balanoid zone, where they form tightly packed fields on many of the rocks. The typical mussel of the *Mytilus* zone along the south coast, *Mytilus perna*, was not found.

4. *Tubicolous polychaets.* Two species of tube-building worms form a prominent part of the fauna. The more abundant of the two is *Gunnarea capensis*, whose sandy tubes form clumps or thin sheets in the Argenvillei and lower Balanoid zones. This worm often builds extensive rounded masses of tubes on the isolated clumps of rock which stand up at intervals along the sandy beach between the Hotel Rocks and North Point. The other noteworthy tubicolous species is *Dodecaceria fistulicola*, which in places forms a ridge of limy tubes along the lower border of the Balanoid zone, and is also found in small mounds among the mussels. Its tubes and the adjacent rock surfaces are almost invariably encrusted with lithothamnion. *Spirorbis borealis* is also fairly common but is inconspicuous; it often covers limpet shells and stones low down on the shore.

5. *Other common invertebrates, and fishes.* Sea-anemones are abundant locally, typically belonging to the fauna of channels or pools, though considerable sheets of *Bunodactis reynaudi* occur on wave-washed ledges. Among Echinoderms, *Parechinus angulosus* is a common inhabitant of pools and channels in some of the rocky areas; and a small brittle-star (*Amphiura capensis*) is conspicuous among the animals under stones. The commonest star-fish is *Asterina exigua*, invariably of a dirty olive-green colour and especially frequent in pools high up on the shore.

The common snail-shaped gastropods of the shore include a series of species rather different from that which prevails along the southern coast of the Union, the series already described as occurring on the shore at Still Bay (Stephenson, Stephenson and du Toit, 1937). Some of the common south coast species are present and plentiful; others appear to be absent; and species possibly not represented on the south coast are present also. Among the apparent absentees the most notable are *Oxystele sinensis* and *O. tigrina*, species extremely abundant on the south coast. *Littorina knysnaënsis* and *Oxystele variegata* are very plentiful at high levels; *Thais dubia* is found at both high and low levels. *Cominella delalandii* is almost ubiquitous in damp places, and *C. papyracea* inhabits the lowest zones and is commonly encrusted with a dark purple polyzoan. *Thais cingulata* is abundant in some places, especially among mussels; and the small bluish *Tricolia kraussi* is fairly common in pools and channels.

A small chiton (*Ischnochiton elizabethensis*), varying in colour from white to greyish-black, is abundant on and under stones. Among crabs, *Plagusia chabrus* is a common species, while the smaller *Cyclograpsus punctatus* is a familiar inhabitant of the upper pools on the shore. Of fish found in pools the most common are probably the small *Clinus acuminatus*, *C. superciliosus* and *Gobius nudiceps*, whilst shoals of small fry such as *Mugil capito* are often seen in channels.

Notes on the occurrence of Algae.

The algal flora of the Port Nolloth district is characterised in the first place by the presence of a conspicuous Laminarian zone, occupied by the two giant species *Laminaria pallida* and *Ecklonia buccinalis*. So far as it was possible to determine, the *Laminaria* is by far the commoner of the two species, the specimens of *Ecklonia* being of relatively occasional occurrence.

Secondly, apart from the Laminarians the flora includes several species capable of growing into large plants. Further, the algae often completely cover the rocks in great profusion for considerable distances along the shore, frequently forming a dense and very coarse turf in the Balanoid and Argenvillei zones. Another interesting feature is the great quantity of epiphytes, particularly on the larger algae.*

In the wave-swept areas of the lowest zones the *Laminaria* may cover as well as surround the rocks, but very frequently the coarse turf mentioned hides the rock altogether. Such a turf is particularly characteristic of parts of the Argenvillei zone and of the *Mytilus* belt, and, although varying in constitution from place to place, commonly contains some or all of the following species: *Champia lumbricalis*, *Plocamium cornutum*, *Caulacanthus ustulatus*, *Gigartina fastigiata*, short plants of *G. radula* and *G. striata*, *Cladophora flagelliformis*, *Bryopsis setacea*, *Leathesia difformis*, *Iridaea capensis*, *Porphyra capensis*, *Centroceras clavulatum* and corallines.

The *Laminaria* and *Ecklonia* are the largest and most conspicuous forms, but there are also several other very striking types. *Porphyra capensis* grows to a large size, frequently entirely covering low-lying isolated rocks, and making long fringes around the edges of the deeper pools, as well as occurring at higher levels. Elsewhere the long ribbons of *Schizymenia undulata* often surround the pools. *Gymnogongrus vermicularis* sometimes covers the rocks in sheets, and *Iridaea capensis* displays its extensive folds in pools and channels. Other forms which are ubiquitous, if not so spectacular in appearance, in the lower pools and channels, are firstly *Codium fragile*, which is very often so covered by epiphytes as to be quite hidden, and secondly *Chordaria capensis*, which is also plentiful right up to the pools in the highest regions.

Amongst so many red or brown seaweeds the few green ones present are very conspicuous. In pools at high levels green hair-like species of *Cladophora* are very common, and also a fair quantity of *Enteromorpha*. A soft green hair-like weed (*Urospora media*) grows plentifully on certain inshore rocks. A little lower, *Ulva Lactuca* makes its first appearance in

* These epiphytes include *Pleonosporium purpuriferum*, *Pterosiphonia cloiophylla*, *Ceramium rubrum*, *C. cancellatum*, *Polysiphonia virgata*, *Suhria vittata*, *Ectocarpus sili-culosus*, *Porphyra capensis*, etc.

small patches, and other types of fine green weed, such as *Cladophora flagelliformis* and *Bryopsis setacea*, grow in long streamers in the deeper channels, their greatest length and abundance being reached in the lowest regions of the shore.

Corallines and lithothamnia are to be found in all the lower parts of the beach, but extend to higher levels in pools than they do on open rock. The corallines of the higher areas are short and stunted, and the lithothamnion is often pale and thin, except where it makes a petal-like formation on stones in the pools. In the lower zones it stretches in great sheets of definite colour, sometimes hidden by kelp, and here the corallines are long and feathery, and often form one of the components of the turf previously mentioned. The shells of the limpets of the lower zones are frequently crested with corallines and may be covered with lithothamnion as well.

Some idea of the types of algae occurring in the various zones of the beach is given by the following descriptions of pools in several areas at Hotel Rocks.

In the inshore regions, which are uncovered at low water of all tides, there are roughly three kinds of pool. The smallest, mere cracks in the rock, contain only lithothamnion and *Chordaria capensis*; in larger crevices corallines and the bluish-green *Cladophora flagelliformis* are also present. One large pool contained all the algae mentioned above together with *Enteromorpha*, a little *Leathesia difformis*, and a mossy species of *Cladophora* which concealed numerous specimens of *Asterina exigua*. The rocks bounding the pool were fringed with *Schizymenia undulata*.

Towards the middle of the shore, in a pool from 18 inches to 2 feet (0.5–0.6 m.) deep, the algae were both numerous and well grown. *Chordaria capensis*, long streamers of *Cladophora flagelliformis* and much epiphytised *Codium fragile* were attached to the rocks around the pool, and often floated over the entire surface of the water. Below them were shorter algae, often in tufts, such as *Plocamium rigidum*, *Gigartina fastigiata*, *Bryopsis setacea*, *Pleonosporium Harveyanum*, and a species of *Cladophora*. The stones at the bottom of the pool were often coloured pink with lithothamnion and much overgrown by corallines.

In the sublittoral pools and channels, which may reach a depth of 3 to 5 feet (0.9–1.5 m.), the algae are the most luxuriant. The marginal growth is greater, containing not only the forms fringing the pools of the middle region, but also *Porphyra capensis*, *Iridaea capensis*, *Centroceras clavulatum* and *Laminaria pallida*. The epiphytes on the *Laminaria* and *Codium* are particularly long and varied. Amongst the algae in the deeper parts are *Chaetomorpha clavata*, *Pterosiphonia cloiophylla*, *Apoglossum ruscifolium*, *Ceramium rubrum*, *Botryoglossum platycarpum* and others. The stones lying at the bottoms of such pools often bear a good growth of

corallines, the green algae *Bryopsis setacea* and *Cladophora flagelliformis*, and also a quantity of colonial diatoms. Other species fairly or very common in these channels are *Champia lumbricalis*, *Gigartina radula*, *G. stiriata*, *Grateloupia filicina*, *Suhria vittata*, *Schizymenia obovata*, *Botryocarpa prolifera*, *Leathesia difformis*, *Chordaria capensis*, *Pleonosporium Harveyanum*, and *Anisocladus congestus*.

THE ROCKS AT CLIFF POINT.

The shore at Cliff Point presents a very different aspect from that seen in the environs of Port Nolloth, since it is bounded by perpendicular rocky cliffs from 50 to 70 feet (15 to 21 metres) in height. The cliffs have been much eroded by the sea, so that they form an irregular coastline with many bays and promontories. Below them the shore varies greatly. In some places deep water may extend right up to the base of the declivity, rendering it entirely inaccessible, while in others there are wave-cut platforms and fallen rocks which can quite easily be examined. In such places deep channels and gullies run up between the rocks, whose population is continually exposed to the action of heavy seas. In some of the bays, however, conditions are very different. In the one examined the shore is almost flat, and a very wide, almost imperceptibly sloping stretch of low rocks is separated from the cliffs by a broad sandy beach. On these flats the rocks are cut up into small islands and platforms by a network of fairly deep channels. The rock formation appears very different from that at Port Nolloth, the quartzites being accompanied by a broad band of conglomerate in which large water-worn pebbles are embedded in a fine sandy matrix. The rocks forming the flats consist almost entirely of the fine-grained quartzites, and form a belt from 150 to 200 yards (140 to 180 metres) wide along a considerable part of the bay. The sandy beach between them and the base of the cliff is about 40 yards (37 metres) in width; both flats and beach are covered by the sea at high water.

The same zones are present here as at Port Nolloth, but various minor differences are noticeable. The zones may be most clearly distinguished on the flats, owing to the presence there of certain animals in overwhelming numbers, to which the unusual appearance of this region is mainly due. The description which follows refers to the conditions obtaining on such flats. The fauna of the steeper parts of the shore is of the same type, but there some of the animals are much less plentiful, so that the zones lack the dominant communities so characteristic of the flats.

A very rich growth of kelp is present in the sublittoral area, and as elsewhere at Port Nolloth it consists almost entirely of *Laminaria pallida*, though a few plants of *Ecklonia buccinalis* are to be seen. The *Pyura*

community is poorly developed, though a few redbaits are often present among the holdfasts of the kelp in the sublittoral fringe, and in shallow pools a short distance above it.

An *Argenvillei* zone of the same type as at Port Nolloth itself is found, and occupies a similar position on the shore.

Possibly owing to the width of the flats, two dominant communities of animals occupy the lower Balanoid zone. These are very extensive and exceedingly well-defined. The outermost rocks and the sides of some of those higher up the shore are entirely covered by a community of mussels very like that found on the Island Reef and at North Point. Here *Mytilus crenatus* is by far the most abundant species, though interspersed with a few *Mytilus meridionalis*.* To landward of the mussels enormous expanses of *Gunnarea capensis* cover the tops of most of the rocks. Indeed, from a distance the flats appear to consist almost exclusively of sheets and mounds of these sandy worm-tubes (similar masses from another locality are illustrated in Pl. IX).

The upper Balanoid zone is inextensive on the flats, as the rocks are low, but is present on the upper parts of those fairly near to the beach. It has much the same population as at Port Nolloth, except that sheets of *Balanus algicola* occur fringing pools and along the sides of rocks near the sandy beach.

The *Littorina* zone is represented where higher rocks are present, and on some parts of the cliff face.

THE ROCKS AT BUCHUBERG.

The part of the shore examined was that lying below the more northerly of the two Buchuberg hills, a couple of miles (3 km.) south of Peacock's Bay. Only one day was spent there, as the locality is not easily accessible. Since the tides were at their minimum, detailed observations could not be made, but such as were possible indicate that the fauna, flora, and zonation greatly resemble those of the other areas studied at Port Nolloth and Cliff Point.

DISCUSSION.†

A description of the shore at Oudekraal has been published in Part II of this series (the present issue of this Journal, pp. 49-65); but a discussion of the results was postponed until Port Nolloth had also been described, since the two places are best considered together.

1. *Zonation*. At both localities the zone immediately above the sub-

* On the steeper parts of the coast and in certain parts of the flats *M. meridionalis* greatly outnumbers *M. crenatus*.

† It should be noted that this discussion was sent to press before the appearance of the first part of W. E. Isaac's "Studies of South African Seaweed Vegetation," in 1937.

littoral fringe is typically inhabited, in the more wave-washed parts, by limpets in close-set formation. At Oudekraal this position is occupied by a *Patella cochlear* community such as has already been described for Still Bay (this Journal, vol. xxiv, p. 353), but with the difference that at Oudekraal the individuals of *P. cochlear* tend to be even more numerous per unit area than at Still Bay (as exemplified by a count of 1315 specimens on a typical square yard at Oudekraal, 256 on a comparable square yard at Still Bay). How general this difference may be it is as yet impossible to say; but the crowded condition found at Oudekraal has also been noted at several other places on the west coast.

At Port Nolloth a striking difference is apparent. Although several places in the area were studied, some of them on the open ocean and others partly sheltered, not a single specimen of *P. cochlear* could be found during the survey. Considering the amazing abundance of this species along so much of the South African coast, its apparent absence (for if it is present it must be rare) at Port Nolloth is remarkable, especially as we have confirmed its presence in abundance north of the Peninsula at Blaauwberg, Melkbosch, and Lamberts Bay. At Port Nolloth the region which would elsewhere be populated by *P. cochlear* is partly inhabited instead by a population of *P. argenvillei*. In the absence of precise instrumental determinations of levels at Port Nolloth and Oudekraal, it is difficult to compare the vertical extent of the Argenvillei zone at the one place with that of the Cochlear zone at the other; but, so far as could be determined, the zone of *P. argenvillei* has its upper limit somewhat below that of *P. cochlear*. The Argenvillei zone is seldom sufficiently exposed for drying to occur, whereas the upper part of the zone of *P. cochlear* is sometimes left dry for considerable periods. It may also be noted that in localities where *P. cochlear* and *P. argenvillei* coexist, the upper limit of the bulk of the population is at a lower level for the latter than for the former. Conversely, where *P. cochlear* is absent, the *argenvillei* community is more extensive and appears to persist to a higher level than where the two species occur together.

Above the Cochlear or Argenvillei zone, a Balanoid zone is distinguishable at both places. At Oudekraal the incrustation of barnacles in the lower part of this zone is often dense, consisting principally of two (*Octomeris angulosa* and *Tetraclita serrata*) of the three species prevalent at Still Bay and at many other places on the south coast. At Port Nolloth, on the other hand, these two species are relatively scarce, and the barnacle population of the zone in general is weakly developed, though *Chthamalus dentatus* is often characteristic not only of the lower part of this zone, but also of the region immediately below it.

A Littorina zone is recognisable above the Balanoid, at both places,

as at Still Bay; inhabited notably by vast numbers of *Littorina knysnaënsis* and by *Porphyra capensis*. The latter occurs in thick sheets on many of the rocks at Port Nolloth and Oudekraal, in occasional tufts only at Still Bay.

2. *The Algal Flora.* One of the outstanding differences between Still Bay on the one hand and Port Nolloth and Oudekraal on the other is the absence of a Laminarian zone at the former place, and its strong development at the two latter. The Laminarian community of the west coast at a given spot may include one or all of three giant species—*Ecklonia buccinalis*, *Laminaria pallida*, and *Macrocystis pyrifera*. The last mentioned appears to be confined in the main to the calmer water of more or less sheltered channels and lagoons. Of the other two, the *Ecklonia* is the predominating species at Oudekraal, though the *Laminaria* is not uncommon; whereas at Port Nolloth the position is reversed.

Apart from the Laminarians, the profusion of the algal growth at both localities is noteworthy, and the lower reaches of the intertidal region are frequently carpeted with fairly large, often leafy species, mostly brown in colour (though many belong to the Rhodophyceae). Typical constituents of this growth are species of *Gigartina*, *Champia* and *Iridea*. This particular type of growth is not present at Still Bay, the algae of comparable levels there being on the whole both smaller and of different species.

It is too soon as yet to attempt to compile lists of species characteristic of the west and south coasts, but there are a few points which should be mentioned here. Along the south coast, as far as we know it, species of *Sargassum* are a common feature; *Caulerpa* is represented by one or more common species; the corallines are present in a variety of species and genera; and *Gelidium pristoides* and *Hypnea spicifera* are ecologically important forms. At Oudekraal and Port Nolloth no *Sargassum*, *Caulerpa*, *Gelidium pristoides* or *Hypnea spicifera* were found; and the corallines appear to be represented by a much more limited number of species. It cannot yet be stated that these features are generally characteristic of the west coast (along which *Hypnea spicifera*, for instance, occurs intermittently), but they are features of probable significance worthy of further investigation. (A dwarf *Gelidium* is abundant at Oudekraal, but this is apparently not *G. pristoides*, though it may be *G. reptans*.)

3. *The Fauna.* Here, again, it is not possible at the present stage to go beyond the indication of features of probable significance.

It has been mentioned in a former paper (this Journal, vol. xxiv, p. 360) that on some parts of the South African coast, e.g. at St. James in False Bay, a dense community of ascidians (*Pyura stolonifera*) is abundant in the sublittoral fringe. At the west coast localities described these ascidians are plentiful, though nowhere forming the fields so characteristic of St.

James; they occur as isolated clumps or solitary individuals, or form a narrow belt among the marginal plants of the Laminarian zone.

At both Still Bay and the two west coast localities beds of mussels are of frequent occurrence, occupying wave-washed situations in the lower part of the Balanoid zone and overlapping into the zone below. At Still Bay these beds consist of *Mytilus perna*; at the other places of *M. meridionalis* and *M. crenata*. Our surveys so far suggest that *M. perna* is characteristic of the south coast and the other species of the colder water; but there is a considerable amount of overlapping, which will be described in a later paper.

The relative abundance of several species of limpets at Port Nolloth and Oudekraal is undoubtedly significant. At both places *Patella granatina*, *P. argenvillei* and *P. compressa* (species reaching their best development in the colder water) are abundant. *P. oculus*, a species of warm-temperate distribution, is moderately common at Oudekraal, but absent, so far as we could determine, from Port Nolloth. *P. longicosta*, another warm-temperate species, seems to disappear rapidly on the west coast. It was not found at Port Nolloth; and in the course of many visits to Oudekraal, extending over several years, only a single specimen was found there. The absence of *P. cochlear* from Port Nolloth has already been noted. Lastly, it may be observed that at both places *P. granularis* and *P. barbara* frequently attain large size, and this again is a feature of their occurrence in the colder water.

Lastly, it may be noted that the fauna of Oudekraal is interesting in itself, apart from other considerations, because of the profusion of coelenterates represented in it, both by species and individuals. This coelenterate fauna includes at least nine species of hydroids; an interesting creeping medusa (*Eleutheria vallenghini*); a new lucernarian (*Depastromorpha africana*); nine species of anemones; two corals (*Corynactis annulata* and *Balanophyllia bonae spei*); several alcyonaria (*Alcyonium fallax*, *Wrightella coccinea*, *Eunicella papillosa*, and a species of *Clavularia*); a zoanthid (*Isozoanthus capensis*); and probably others as yet undiscovered. Presumably the presence of this rich array of coelenterates is partly connected with the very favourable habitat provided by the sublittoral pools and clefts, often deep and shaded, of the shore.

SUMMARY.

A description is given of several rocky areas in the intertidal region in the district of Port Nolloth, a locality situated near the northern boundary of the west coast of the Union, and affected by cold inshore water. The intertidal belt here is subdivided for descriptive purposes into four zones,

from above downwards the Littorina, Balanoid and Argenvillei zones, and the sublittoral fringe. The Argenvillei zone approximately replaces the Cochlear zone described in Parts I and II of this series as characteristic of Still Bay and Oudekraal. The algal flora at Port Nolloth is characterised by the presence of a strongly developed Laminarian belt, dominated by *Laminaria pallida*; and by a profuse growth of other algae, many of them of considerable size. The fauna and flora undoubtedly include species which disappear sooner or later along the south coast, and lack other forms characteristic of that coast; but as yet only a preliminary indication of the identity of these species can be given.

APPENDIX.

Notes on the Population of the Pools and Channels.

1. *The fauna of the channels at Hotel Rocks.* It has already been remarked that the channels fall into two groups. Those belonging to the lower group are sublittoral (*i.e.* in communication with the sea at low water), while the others, though wave-swept at high water, remain dry, except for isolated pools, during a large part of the tidal period. The animals inhabiting these channels may be subdivided into forms which prefer the upper surfaces of rocks and stones, and forms confined to their undersurfaces. The species which fall into the former category correspond in general with those of the adjacent ridges, though in many cases animals extend to higher levels in the channels and pools than on open rock. The cryptofauna of the channels is abundant and constant though not very rich in species. A description of a typical sublittoral channel is given in the following paragraph.

This channel (fig. 2, A) varies much in width and depth. It is narrow and from 1 to 3 feet (0.3-0.9 m.) in depth at the one end, gradually widening out and becoming shallower towards the other, when it merges with the neighbouring channels. Its floor is composed of rocks and stones, between which are packed smaller pebbles embedded in sand. Most of this substratum is encrusted with pink and mauve lithothamnion on which live numbers of limpets (*Patella granularis*, *P. granatina*, *P. barbara*, and occasional specimens of *P. miniata* or of *Helcion dunkeri*), whelks (*Cominella delalandii*) and various small snails such as *Oxysteles zonata* and *Tricolia kraussi*. Vivid anemones are numerous. Many of the stones are cemented together by sandy tubes of *Gunnarea capensis* or by *Hymeniacion sanguinea*. Cirratulid worms are commonly found living in the fine muddy sand between the stones. Of these the orange variety of *Audouinia filigera* is the more abundant, though a blackish form with creamy pink cirri is also present.

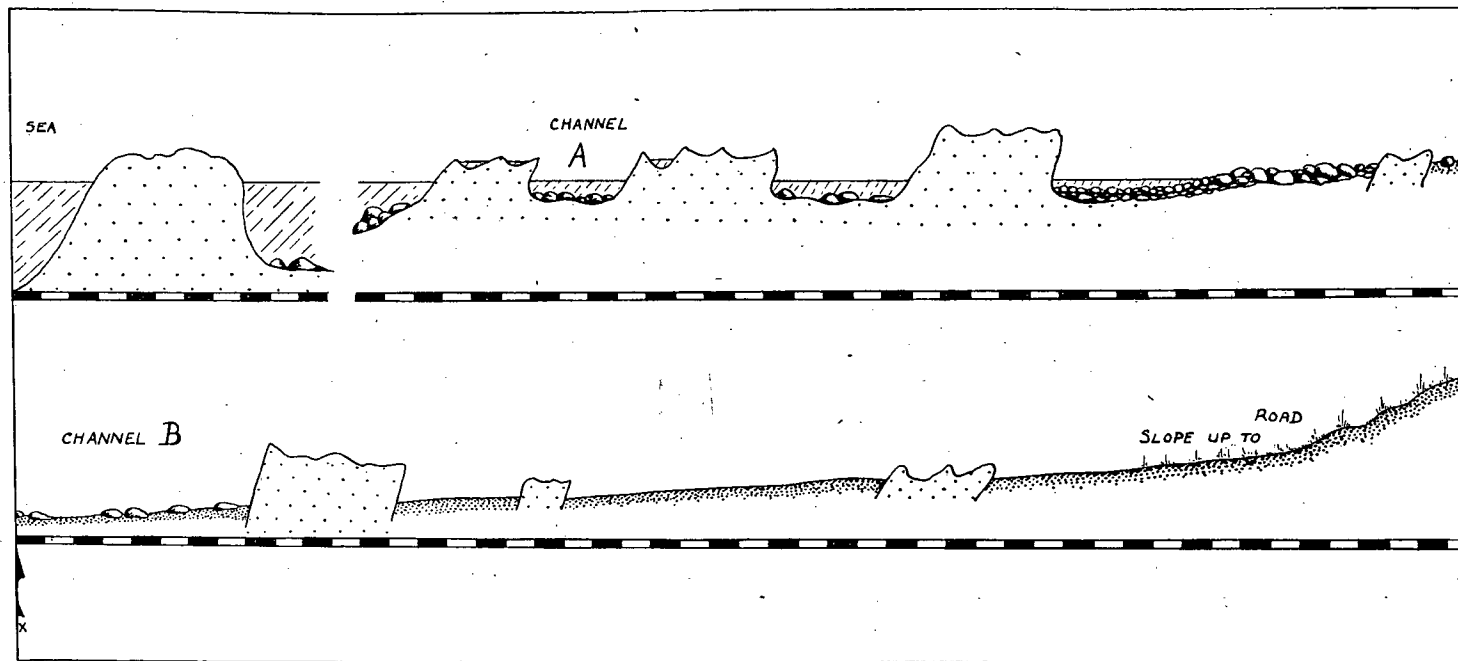


FIG. 2.—An approximate cross-section of the ridges and channels at Hotel Rocks, Port Nolloth. Based on measurements made with a surveyor's tape. Water is indicated by lines of shading; sand by dots; and rock by more widely spaced dots. Below the section the scale is indicated in yards.

The whelks and periwinkles already mentioned are found beneath the stones, and one small gastropod, *Marginella biannulata*, is confined to that habitat. Other members of the cryptofauna are chitons (*Ischnochiton elizabethensis*); anemones; encrusting sponges, ascidians (*Didemnum lutarium*) and polyzoa (none of which are very plentiful); various polychaets (*Euphrosyne capensis*, *Spirorbis borealis* and polynoids); brittle-stars (*Amphiura capensis*); occasional *Asterina exigua* and *Mytilus crenatus*; and countless minute crustaceans of various species (*Ceradocus rubromaculatus*, *Paramoera capensis*, etc.).

The higher channels, which are only covered by the sea at high water, have a much poorer fauna than the sublittoral channels, and this fauna becomes progressively scantier towards the top of the shore. A typical pool in one of these channels (fig. 2, B) is described in the next paragraph.

Towards the southern end the bed of this channel consists at low water of dry sand and shingle, but farther along it becomes rocky. The pool described lies in the rocky part; it is fairly large and shallow and floored with stones and sand. The animals living on the stones are the limpets *Patella granularis*, *P. granatina* and *Helcion dunkeri*, a few *Siphonaria capensis* and *Asterina exigua*, and numbers of *Oxystele variegata* and *Cominella delalandii*. The cryptofauna includes the ubiquitous *Ischnochiton elizabethensis*, young specimens of *Oxystele*, and myriads of small crustaceans, the commonest of which are probably certain isopods (*Exosphaeroma laeviusculum* and *Parisocladius perforatus*), while an amphipod, *Paramoera capensis*, is also very plentiful.

2. *Pools in the ridges at Hotel Rocks.* There is, in addition to the channel pools, a fairly large number of small deep water-filled cracks and crevices in the ridges. As in the case of the channels, the fauna of these may to a large extent be correlated with that of the adjacent rock-surfaces. As an example, a crevice-pool in the upper Balanoid zone will be described. This pool is a narrow deep crack lined with greyish lithothamnion, which also fringes it. The animals are almost entirely obscured by a thick growth of algae (*Chordaria capensis* and *Bryopsis setacea*). Round the water's edge are specimens of *Bunodactis reynaudi*, and numbers of *Siphonaria capensis* and *Diodora mutabilis*. In the deeper parts, half-hidden by the algae, there are in addition *Cominella delalandii*, a few *Mytilus crenatus* and a small greenish-brown anemone (*Anthothoë*). Small crustaceans are as usual plentiful, particularly among the algae, where *Paridotea unguolata*, *Hyale saldanha*, and *Paramoera capensis* are all to be found.

3. *Rock-pools on the Island.* Towards the shoreward side of the island, where the rocky outcrops are very low, they are covered with loose stones and contain many large shallow pools. These pools contain a very rich fauna, which is denser and more varied than that found anywhere else

near Port Nolloth. Most of these very shallow pools have a substratum of large flat stones resting on fine muddy sand. The upper surfaces of the stones are coated with lithothamnia and short corallines, and also support a few plants of such algae as *Iridaea capensis* and *Leathesia difformis*. Various animals also occupy this habitat. These are principally molluscs (*Patella granatina*, *Diodora mutabilis*, *Thais squamosa*, *T. cingulata*, *Rissoa nigra* and *Mytilus crenatus*) and coelenterates (*Corynactis annulata* and anemones). A soft orange sponge (*Hymeniacidon sanguinea*) grows in crevices between the stones.

The cryptofauna is extremely rich and very constant throughout these pools. Most conspicuous are thin sheets of soft sponges, particularly a cream-coloured form (*Hymeniacidon styliferus*), and various compound ascidians of which a bright orange species is the most frequent. In addition to these encrusting forms many of the stones, and the huge *Mytilus crenatus* which live beneath them, are covered with fields of pink and red *Corynactis*. Other characteristic animals are anemones, and molluscs such as *Ischnochiton elizabethensis*, *Cominella delalandii*, *Marginella biannulata* and *Diodora mutabilis*. Most striking, however, is the great abundance of echinoderms and worms. Common echinoderms include the small pinkish urchin *Parechinus angulosus*, an ophiuroid (*Amphiura capensis*) and a vivid red sea-cucumber (*Cucumaria insolens*). Another holothurian, *Thyone serrata*, is sometimes seen. Asteroids are less frequent, but occasional specimens of *Echinaster ornatus* and *Asterina exigua* are encountered. Polychaets include *Euphrosyne capensis*, *Terebella pterochaeta*, the two varieties of *Audouinia filigera*, and the polynoids *Lepidonotus semitectus* and *Polynoe erythrotaenia*. Large sipunculids live buried in the sand beneath the stones. Of crustaceans, isopods such as *Sphaeramene polytylotos* are common, and other species such as *Paridotea rubra*, *P. fucicola* and *Glyptidotea lichtensteinii* are also to be found.

4. *Rock-pools at North Point.* Four main types of pool fauna are found at North Point.

The large shallow pools in the region of the mussel community are packed with animals of various kinds. *Mytilus meridionalis* and *Bunodactis reynaudi* form sheets covering the floors of the pools, while *Parechinus angulosus* and an assortment of molluscs (*Diodora mutabilis*, *Argobuccinum argus*, *Cominella delalandii*, *Crepidula hepatica* and *Mytilus crenatus*) are all present in large numbers. The algal growth is poor, apart from corallines and lithothamnia.

Pools towards the middle of the Balanoid zone are lined with encrusting algae (*Lepadoderma africanum* and *Hildenbrandtia pachythallos*) and contain such molluscs as *Patella granatina* and *Tricolia kraussi*, sponges (*Hymeniacidon sanguinea*) and small plants of *Splachnidium rugosum*.

Most of the pools in the higher parts of the Balanoid zone are of considerable size and are filled with algae (*Ulva Lactuca*, *Chordaria capensis* and *Cladophora flagelliformis*) in which the animal inhabitants (chiefly *Oxystele variegata*) are almost hidden.

Pools in the Littorina zone are mainly populated by *Siphonaria capensis* and *Littorina knysnaënsis*, and contain a good growth of *Enteromorpha*.

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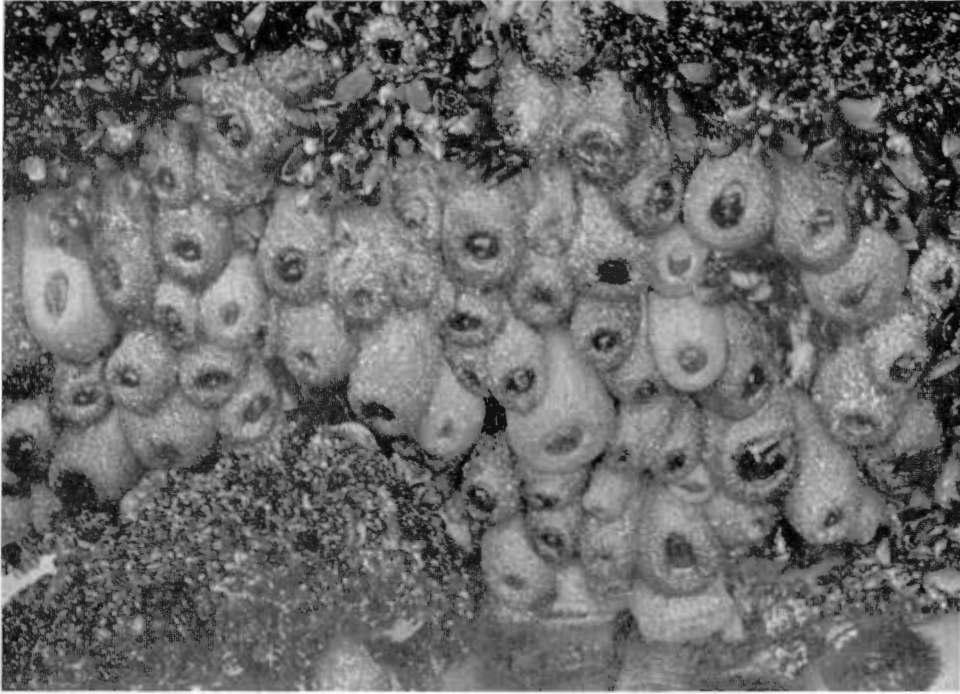


FIG. 1.—The large many-coloured anemone *Bunodactis reynaudi*, in typical dense formation, associated with *Mytilus meridionalis*, at Hout Bay (Cape Peninsula). From a photograph by G. J. Broekhuysen.

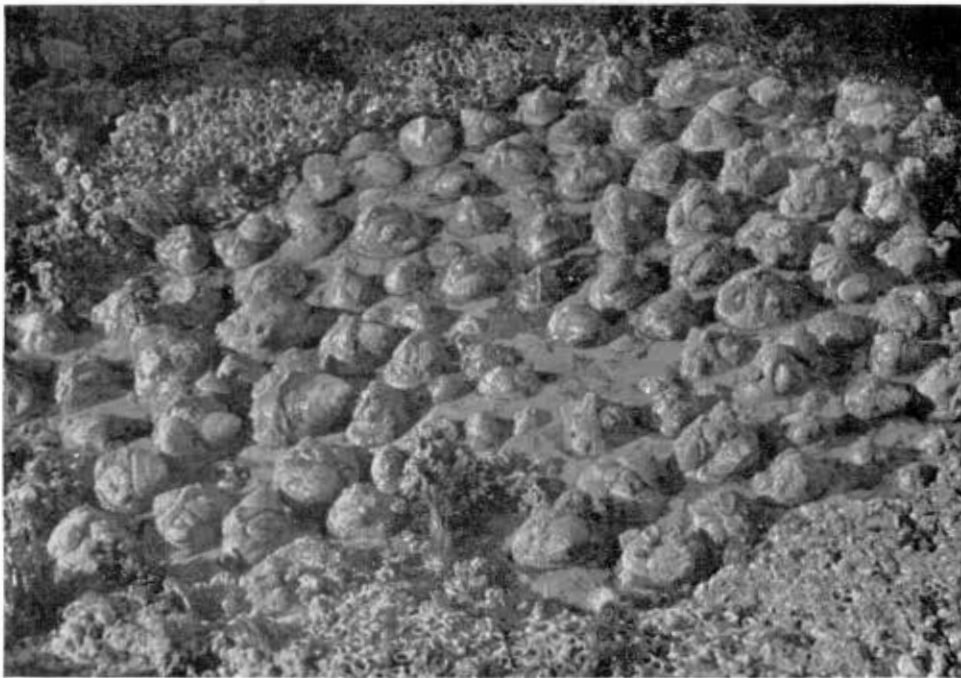


FIG. 2.—The zone of *Patella argenvillei* near Schusters Bay (Cape Peninsula); with tubes of *Gunnarea capensis* in foreground and background. From a photograph by G. J. Broekhuysen.



The Laminarian zone near Slangkop Lighthouse (Cape Peninsula). From a photograph by G. J. Broekhuysen.



FIG. 1.—A mass of tubes of *Gunnarea capensis*, at Witsands (Cape Peninsula). Such masses cover large areas of the rocks at certain localities, and attain a thickness of fifteen inches or more. From a photograph by R. T. Scott.

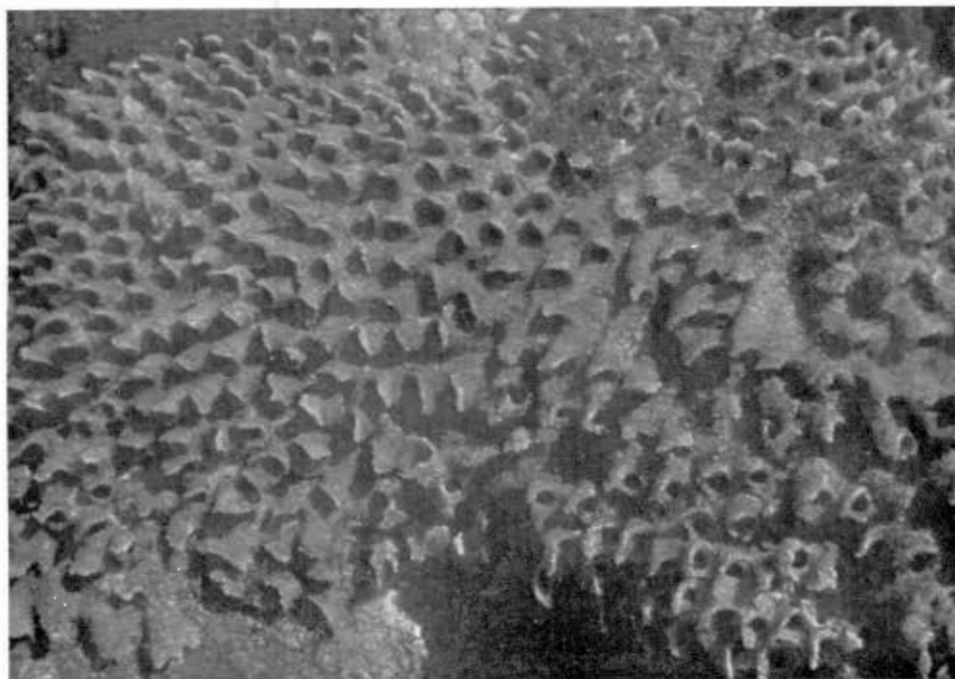


FIG. 2.—A small group of *Gunnarea* tubes, seen at close quarters. From a photograph by T. A. Stephenson.