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The Intertidal Ecology of the Eaglehawk Neck Area

By

ERIC R. GUILER

Department of Zoology, University of Tasmania

WITH 5 PLATES AND 4 TEXT FIGURES

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SUMMARY

The Eaglehawk Neck area is one of the most important yet seen in Tasmania. All the indicator species of algae are arranged in a linear series according to their toleration for wave action. All degrees of wave exposure are found in the Pirates Bay Area. There is extremely severe wave action on the eastern side of Fossil Island while the western shore of Fossil Island is sheltered and experiences very little wave action.

INTRODUCTION

This paper is the fifth of a series on the various features of the intertidal ecology of Tasmania. The first four papers have appeared in this journal and are listed in the references.

Eaglehawk Neck is a very narrow strip of land connecting the Tasman Peninsula with the Forestier Peninsula. It is about sixty miles from Hobart and is on the eastern seaboard of Tasmania.

The area considered at Eaglehawk Neck lies on the eastern side of the neck at Fossil Island and the Blow Hole. (Fig. 1). The shore was examined at various other places where the wave action is modified, including the *Pyura* reefs in Pirates Bay.

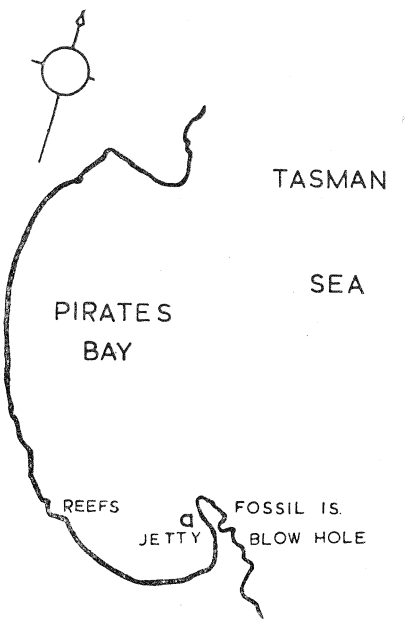

FIG. 1.—Outline map of the Eaglehawk Neck area.
Scale—1 inch = 1⅛ miles.

Preliminary visits were made several times between December, 1949 and January, 1951. Detailed examinations were made in February and late March, 1951.

(1) Topography

Pirates Bay is composed of sand with the exception of some reefs at various places as shown on Figure 4. The bay is exposed to fairly severe wave action, but at the eastern side of the bay the wave action is reduced by the presence of Fossil Island.

The wave exposed shore, both on the mainland and Fossil Island, has been cut into a horizontal rock platform of varying width. At the Blow Hole this lower platform extends out about one hundred feet from the base of high cliffs. At the base of the cliffs is a narrow ledge about five feet in height. Between the mainland and Fossil Island this latter ledge enlarges to become a wide shelf. This is the upper platform. Between Fossil Island and the mainland is a narrow shelf which is at the same level as, and continuous with, the lower expanse of rock on the wave exposed coast. On Fossil Island there is only the low level area which is up to one hundred and fifty feet in width. It has large boulders lying on it at the base of the cliffs.

On the wave sheltered side of Fossil Island the wave platform is narrow and becomes less wide the greater the distance from the north end of Fossil Island. Towards the Old Jetty it is absent altogether, the shore being composed of loose rounded stones.

At the northern wave-exposed end of Fossil Island the platform is strewn with large boulders, some of which are 10 feet in height.

(2) Physical Environment

(*a*) *Tides.* There are no tidal records available for Eaglehawk Neck, but the tides are of approximately the same magnitude as at Freycinet Peninsula and Hobart.

(*b*) *Climatic Factors.* The maximum and minimum temperatures at Eaglehawk Neck are shown in Fig. 2. The temperatures are intermediate between those of Swansea and Hobart. There is no temperature recording station maintained at Eaglehawk Neck and these results have been obtained from the Weather Bureau and are based on the interpolation of Swansea and Hobart figures.

The rainfall (Fig. 3) is appreciably higher than that encountered at either Swansea or Hobart. The rain is spread irregularly throughout the year with a maximum in June. June is also a month in which downpours are likely to occur. These range from a sub-normal 0·94″ to 12·55″. Average annual rainfall for 21 years . . . . 34·43 inches.

Although the rainfall at Eaglehawk Neck is higher than that at other places on the East Coast I do not think that has any appreciable effect on the organisms living on the shore.

There are no sea temperature figures available for Eaglehawk Neck, but it is possible that they are closely similar to those found at Freycinet Peninsula, as the major current systems are the same.

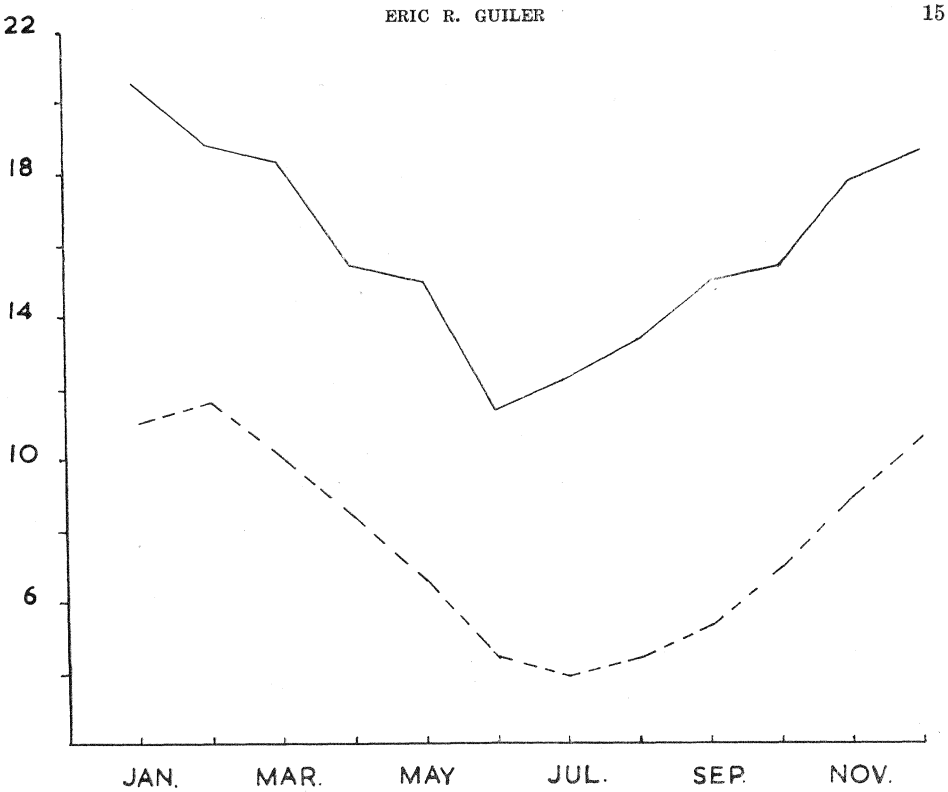

FIG. 2.—Mean maximum and minimum temperatures (°C.) at Eaglehawk Neck.

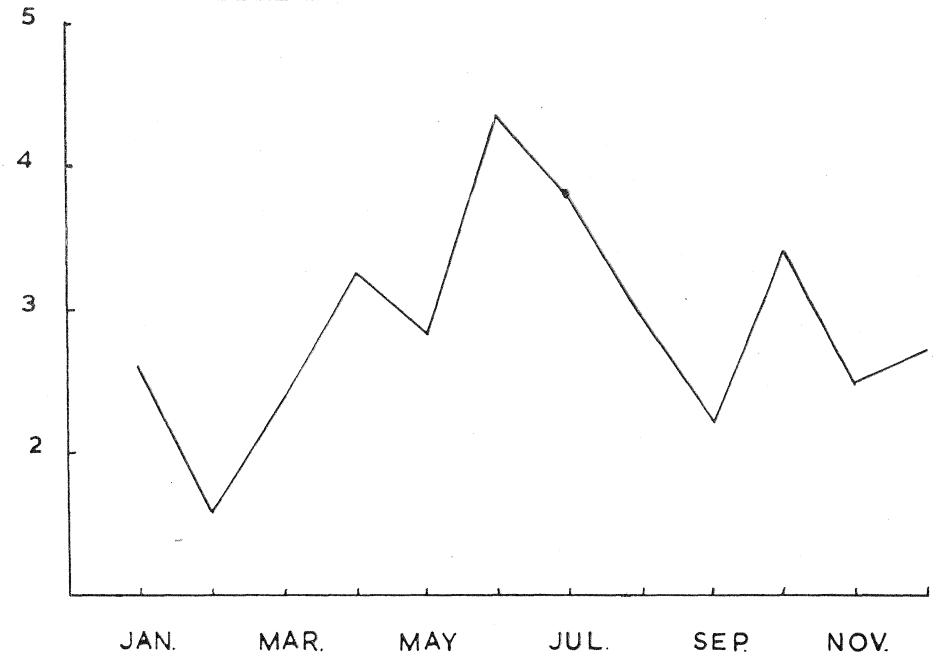

FIG. 3.—Mean monthly rainfall in inches at Eaglehawk Neck.

(*c*) *Geology.* The platforms at both the Blow Hole and Fossil Island are composed of siltstones and sandstones, with some glacial erratics. The bedding is nearly horizontal. There are no major igneous formations.

(3) Zonation

(*a*) *On the wave platform at the Blow Hole*

The intensity of the wave action is a very important factor on the eastern shore of the mainland. The effect of this factor has already been seen at Sleepy Bay. The sedimentary rocks have been eroded into platforms and for this reason it is difficult to obtain a true picture of the vertical zonation as there is a horizontal zonation superimposed on the vertical.

The zonation is:—

Supralittoral	Lichens
Supralittoral Fringe	*Melaraphe unifasciata* and/or *M. praetermissa* (May).
	Chamaesipho columna
Midlittoral Zone	Patelloids
	Corallines
Infralittoral Fringe	*Sarcophycus*

(*a*) Supralittoral

The Supralittoral is populated by a band of orange lichens which in turn are replaced by grey lichens. In some sheltered places a few small and rather stunted *Salicornia* plants are found.

(*b*) *Supralittoral Fringe*

The gastropod *Melaraphe unifasciata* inhabits this area of the shore. On those parts of the cliffs that receive the full effect of the seas this species is either absent or rare. The species is common on the high level platform beside Fossil Island where it lives in hollows and clefts in the rock. During rainy weather these hollows become filled with fresh or brackish water, but this does not appear to cause any serious harm to the Littorinids. Some small scale experiments on the dessication toleration of this species have been carried out and have been described elsewhere (Guiler, 1950).

Another small Littorinid, *Melaraphe praetermissa* (May) is also found in the Supralittoral Fringe. This species is not common at Sleepy Bay but at several places at the Blow Hole where there is intense spray the gastropod is very numerous. It appears to like vertical rock faces about 20 feet or more above M.S.L. where it is drenched with spray. It was not possible to find an area where density counts could be undertaken, but based on eye judgement the number of individuals per square foot must exceed 100. In some areas both this species and *M. unifasciata* occur together. The vertical cliffs favoured by *M. praetermissa* are usually devoid of the other species.

(*c*) *Midlittoral Zone*

All of the Midlittoral region falls on the horizontal platform. The salient feature of this region is the absence of barnacles as the dominant form over part of its area. The barnacles are only found in small numbers

at the top of the Midlittoral on the vertical rock face between the upper and lower platforms. Over most of the lower platform the limpet-like *Siphonarias* are the dominant form. The surface of the platform is irregular and there are many pools of shallow depth. In these pools is a *Jania* turf (Plate I). The presence of so much *Corallina* material obscures the zonation and a detailed examination has to be carried out in order to identify the zones. The almost constant swell causes waves to break across the platform and pools are nearly always filled with water and often the platform is covered with about 1 inch of water so that it is difficult to define the limits of the ponds. It is sufficient to say that they are very numerous and in places, continuous.

The barnacle *Chamaesipho columna* (Spengler) is found on the vertical rock as noted above and also in small patches at the landward end of the lower platform. The barnacle is not numerous and is only dominant for about 15 feet of the platform.

The barnacles are soon replaced by Patelloids. Most of the area of the platform is occupied by these organisms, of which the most numerous species are *Siphonaria diemenensis* and *S. zonata.* These species are gregarious in nature and form patches of up to 100 individuals. In the lower part of the Patelloid belt the large limpet, *Cellana limbata* (*Philippi*), is found. Also occurring in the Patelloid belt are *Patelloida marmorata* (Ten-Woods) and *Patelloida cantharus* (Reeve). The barnacle *Chamaesipho columna* is found in this belt. The lower part of the Patelloid zone is invaded by *Catophragmus polymerus* and the calcareous algae.

It is interesting to speculate what the fauna of such a platform as this would be if the water were calmer. The continual inundation of the platform by heavy waves probably assists the limpets by permitting the growth of their algal food, and so extending their range much further up the platform than would normally be the case. The presence of small groups of *Chamaesipho* over a large part of the Patelloid belt points to the fact that this species would probably be the dominant species under conditions of less wave action. These barnacles do not occur in such numerous clusters in the Patelloid belt in other parts of Tasmania. It seems that the great extension of the Patelloid belt is a local feature made possible by the wave action keeping the platform wet at nearly all phases of the tide.

The Patelloid belt is replaced by the calcareous algae. This belt extends up to 20 feet from the seaward edge of the platform. The upper part of the *Corallina* belt is occupied by the coral-like *Lithothamnion* sp. referred to in a previous paper (Guiler, 1951*b*). This species is *Lithophyllum hyperellum* Foslie and has been identified for me by Dr. H. B. S. Womersley. This alga forms a thin strip around the edge of the belt. Both the dome shaped and encrusting forms are found but neither are as large as at Sleepy Bay or, as will be seen later, Port Arthur.

The dominant alga in the lower *Corallina* belt is a *Jania* sp. with *Corallina cuvieri.* These species from a close turf which prevents other forms from colonizing the rock. Living among the algae are Sphaeromid isopods, *Lasaea australis* and errant Polychaetes. The *Corallina belt* ends at the Infralittoral Fringe where it is replaced by *Sarcophycus potatorum* (Labill.) Kütz.

Due to the steep drop off the edge of the platform into deep water it was not found possible to examine the Infralittoral Fringe in detail. The swell prevents the use of a boat. Around the holdfasts of the alga the encrusting algae form a thin incrustation on the rocks.

The ascidian *Pyura praeputialis* (Heller) occurs at the seaward end of the platform among the holdfasts of the kelp. This is the first place examined on a wave exposed coast where this species has been encountered in quantity. The tunicate does not form a continuous sheet but is found in clusters of up to 12 to 20 individuals.

At the entrance to the Blow Hole the macroscopic algae show an interesting zonation. The force of the waves sharply diminishes the greater the distance up the tunnel from the sea. Thus, there is a horizontal zonation of the algae starting with *Sarcophycus* on the exposed shelf. Following the *Sarcophycus* belt with little intermixing is *Lessonia corrugata* which in turn is replaced by *Xiphophora billardieri* Mont. A similar zoning is to be seen on the mainland side of Fossil Island, where the wave action is reduced.

On the lower platform there are two deep ponds. One of these is particularly interesting as it contains algae which are characteristic of more sheltered places. The dominant alga in the pond is *Phyllospora comosa* but there are also several large masses of *Lessonia corrugata*. *Cystophora spartioides* (Turn) J. Ag. is also found in the pool as well as one plant of *C. torulosa* (R. Br.) J. Ag. The presence of this latter plant is of especial interest in view of the fact that the species is usually found in sheltered places. The bottom of the pond is thickly carpeted with *Ulva lactuca* L.

Parts of the coralline zone are thickly colonized by *Ulva lactuca*. This species is most common at the seaward edge of the platform. Also found in the coralline belt is the finger-like alga, *Adenocystis lessonii* Hooker and Harvey.

The exposed platforms on Fossil Island were examined but differed only in minor detail from the above description. The Fossil Island platform is wider than that at the Blow Hole and consequently there is a wider *Chamaesipho* belt on Fossil Island. The limpet *Cellana limbata* extends further up the shore on Fossil Island, being found at the base of some large boulders which are scattered on the landward end of the platform.

(*b*) *On the sheltered side of Fossil Island*

There are two separate forms of zonation to be considered under this heading. The most important form is the horizontal zoning of the algae of the Infralittoral Fringe as seen on the Pirates Bay side of Fossil Island from the Old Jetty to the northern end of the island. The second series of zones is the ordinary vertical zonation found on various parts of the shore.

The Horizontal Zonation

The northern point of Fossil Island is exposed to the full effect of wave action. The shore is composed of large boulders with numerous ponds. The dominant alga in this area is *Sarcophycus potatorum* and the Infralittoral Fringe is similar in constitution to that seen at the Blow Hole. In places where the wave action is slightly reduced, *Phyllospora*

comosa is found associated with the *Sarcophycus*. With further reduction in wave action *Lessonia corrugata* appears. This species does not form a particularly well defined belt on the shore, but it is very common. The conditions suitable for this species do not appear to be present over a sufficient area to allow *Lessonia* to form a belt.

Xiphophora billardieri forms quite a long belt where the wave action is reduced. It forms the dominant alga over a large part of the sheltered side of Fossil Island. It is frequently mixed with *X. chondrophylla* (R. Br.) Mont. The latter species is more common where the wave action is slightly less than the maximum tolerated by *X. billardieri*. *Phyllospora* is found with both of these species. At one place in the *Xiphophora* belt there is a patch of *Sarcophycus*, but there are only a few *Lessonia* plants.

The *Xiphophora* sps. give way to *Cystophora spartioides*. There is considerable mixing of the three species and the *Cystophora* never becomes a pure belt. *C. spartioides* is replaced by *C. uvifera*. These two algae form a belt over most of the western end of the Infralittoral Fringe on Fossil Island. At the Old Jetty the algae are partially replaced by *Ecklonia radiata* (Turn) J. Ag. and *Phyllospora*. The two *Cystophora* species as well as *C. torulosa* are found among these larger algae.

In some restricted localities *Zostera nana* forms a thick carpet. This plant occurs in the Infralittoral as the beds are not exposed at low water.

In general, this area may be considered to be the most important yet examined on a rocky coast in Tasmania. All of the indicator species of algae are present in a continuous series and it is possible to build up a picture of the horizontal zonation of the algae as controlled by wave action. At Port Arthur all of the species are represented but not in a continuous series. The distribution of the algae is shown on Figure 4.

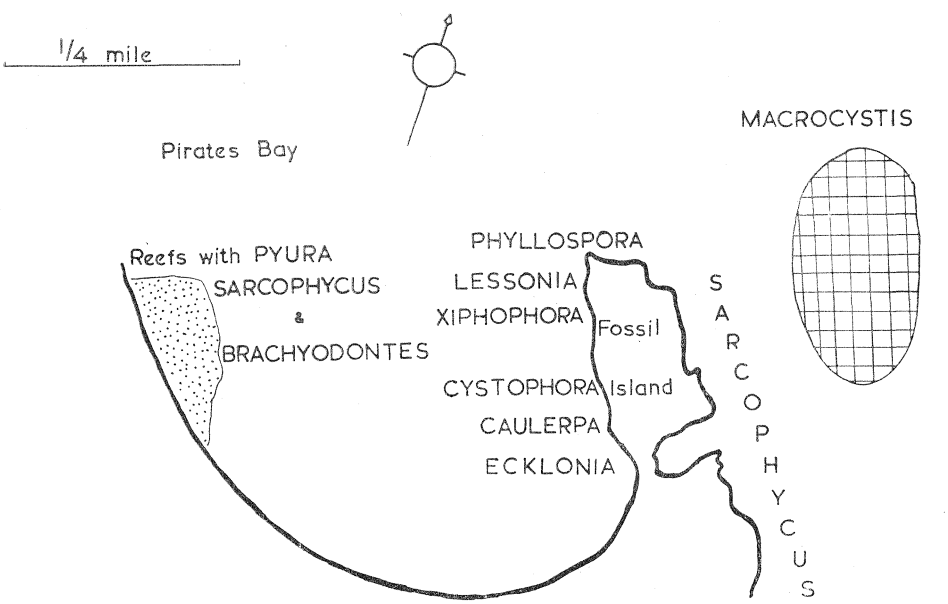

FIG. 4.—Map showing the distribution of the important wave action indicator algae at Eaglehawk Neck and Fossil Island.

The zoning of the algae of the Infralittoral Fringe and their relation to wave action may be summed up as below in Table 1. The figures for the intensity of wave action are only approximate and apply only to the Eaglehawk Neck area.

TABLE 1

The relation of Infralittoral Fringe algae to wave action at Eaglehawk Neck.

Algae.	Wave Action Range
Sarcophycus (neglecting the patch on the western shore of Fossil Island)	o. (0-11). 4. a, 3 to o. (0-11) 2. a,2.
Lessonia	o. (0-11). 4. a, 2 to s. (1-8) 2. b,3.
Xiphophora sp.	s. (0-11). o. a, 2 to s. (1-8) 2. b,3.
Cystophora spartioides	s. (1-8). 1. b, 3 to s. (1-8) 0. b,3.
Cystophora torulosa	s. (1-8). 0. b,3.
Cystophora uvifera	s. (1-8). 0. b,3.

In ponds at the seaward end of Fossil Island there is an algal flora which differs with the degree of wave action experienced by the ponds. In the pools at the outer edge of the boulder patch the flora and fauna is not modified from that seen in the Infralittoral Fringe. These ponds are always being filled by large waves and may be considered as upward extensions of the Infralittoral Fringe. *Lessonia* appears in ponds further away from the heavy waves, but it is soon replaced by *Xiphophora* which in turn is replaced by *Hormosira banksii*. The cryptofauna and flora of the ponds is composed of encrusting forms. *Lithothamnia* are very common and also sponges such as *Sycon gelatinosum* (Blainville), *Hymeniacidon perlevis* (Montagu) and *Tethya diploderma* (Schmidt). Many of the species found in the cryptofauna are not found in the Infralittoral Fringe but are confined to the less disturbed Infralittoral.

Chapman (1941) notes that algae found in ponds are of two types, those found in the Sublittoral and those which are characteristic of ponds. Evans (1949) noted that the intertidal cryptofauna is an extension of the *Laminarian* zone. Both of these remarks are only partly true for the ponds at the northern end of Fossil Island. The dominant algae of the ponds on Fossil Island are not truly Infralittoral in origin but reflect the conditions found in the Infralittoral Fringe. As the wave action experienced by the ponds decreases, either in severity or period of endurance, so do the dominant algae become more characteristic of sheltered conditions on the shore, until ultimately *Hormosira,* found in the lower Midlittoral of sheltered shores, is the dominant pond alga.

It must be stressed that there is little difference in the heights of the ponds on the shore. In a distance of 20 yards at the northern end of the island we find in the ponds a picture of the horizontal algal zonation on the Pirates Bay shore of Fossil Island.

Chaetomorpha darwinii (Hook). Kütz is found in most of the ponds at the end of Fossil Island. The smaller *Chaetomorpha aerea* (Dillw.). Kütz forms dark green tufts in pools, especially those with more than one foot of water. Both these species are found on more sheltered parts of the coast.

Caulerpa brownii Endl. is present in some of the ponds at Fossil Island. It favours the more sheltered places and is quite plentiful in the *Cystophora uvifera* belt near the old jetty. It lives in the upper limits of the Infralittoral and forms dark green ' bushes '.

The Vertical Zonation

At the place marked A on Figure 1 the vertical zonation on the shore is indicated as follows:—

Melaraphe unifasciata	Supralittoral
Chamaesipho columna	Midlittoral
Cellana limbata + *Actinia tenebrosa*	
Patelloida marmorata + *Siphonaria diemenensis*	
Ulva lactuca + *Corallina* + *Jania*	
Cystophora spartioides	
Xiphophora billardieri, *X. chrondrophylla* + *Sarcophycus* and *Phyllospora*	Infralittoral Fringe

The Infralittoral Fringe is of interest as the transect is at one of the critical places on the shore where the change-over from one dominant species to another takes place. Thus we find algae of both exposed and sheltered coasts. In such a situation the algae which are characteristic of the less exposed situations tend to occur higher on the shore than their normal position. Thus, *Cystophora* forms a thin strip above the Infralittoral Fringe. The other species occurring on exposed shores are found at a slightly lower level than usual. This feature will be seen at the Old Jetty, where *Ecklonia* occurs much further down the shore than normal.

The zones seen in the Midlittoral are different from those previously seen anywhere in Tasmania. *Ulva* forms a definite band with the corallines at the lower limit of the zone. This species illustrates the influence of seasonal changes on the distribution and density on the shore. At other seasons of the year this belt may be dominated by the corallines. The corallines are *Jania* sp. and *Corallina cuvieri*. The corallines form a more open turf than that found on the exposed shore. This is especially noticeable in ponds. (Plate I).

The Patelloid belt is well developed, but the dominant species are different from the usual type found on this nature of shore. *Patelloida marmorata*, found in the lower part of the belt, is usually characteristic of more exposed coasts but here it is a co-dominant with *Siphonaria diemenensis*. The lower part of the Patelloid belt is not strikingly different from the general condition of the belt as found on any semi-exposed or exposed shore, but the upper Patelloid belt is very different from anything yet seen. The large limpet *Cellana limbata*, becomes dominant in this region. The red anemone, *Actinia tenebrosa*, is extremely plentiful in the same area and ranks as a co-dominant. Both these species are found in parts of the shore where water is retained at low tide or else on sun sheltered faces. The topography of the platform is such that they are permitted to form a belt. Plate II shows a typical concentration of the anemones. The usual habitat of anemones is in cryptic or semi-cryptic places and the limpet favours similar situations or else is found bordering ponds (Plate II).

The barnacle *Chamaesipho columna* is the only barnacle found on the upper part of the shore. The species is not numerous but forms fairly large groups of individuals in various places on the shore.

As at most other transects the littorinid *Melaraphe unifasciata* is the only macroscopic organism in the Infralittoral Fringe. The Supralitoral is composed of bare rock.

In some places a bunodactid anemone forms carpets on the rocks. These carpets are usually found in the middle of the Midlittoral (Plate II) but in some instances the carpets are found in the Infralittoral Fringe. Cracks in the rocks are also occupied by this species. The anemone is dark chocolate in colour and when densely packed in cracks it has the appearance of an alga.

The mussel *Brachyodontes rostratus* inhabits the clefts in the rocks as well as forming isolated patches. Due to the density of colonization of cracks by both species, *Brachyodontes* and the anemone do not inhabit the same cracks.

The 'limpets', *Patelloida diemenensis, Siphonaria diemenensis* and *S. zonata,* all migrate in search of food, each returning at low water to their 'homes' (Plate III).

At the northern end of Fossil Island the vertical zonation is obscured by the broken shoreline of large boulders, and also by the superimposed diminishing wave effect as the distance from the Infralittoral Fringe increases. Examination of a transect yields peculiar results with *Sarcophycus* and *Hormosira* dominant at the same level but different places on the shore. However, the basic zonation is much the same as that seen at the Blow Hole, with the important exception that in the upper Patelloid belt there is a band of *Rivularia* sp. This dark green, button-like alga does not like heavy surf. It is found on stones which get some spray but not a lot of wave action. The alga does not form a continuous band but when it occurs it is usually very plentiful.

Towards the Old Jetty near the end of the platform on Fossil Island (A on Fig. 1) the lower Midlittoral is dominated by *Hormosira banksii* with a few *Galeolaria* tubes. The Infralittoral Fringe is composed of the *Cystophoras* noted above and *Caulerpa brownii.* The anemone carpets are not as well developed here as at further along the platform towards the northern end of the island. The anemones probably demand a certain amount of broken water such as is obtained from the backwash of waves sweeping round the point of Fossil Island. The other anemone, *Actinia tenebrosa* and the large *Cellana* limpets also seem to have the same requirements as they are not so numerous here as at A.

The *Cellana-Actinia* belt is absent. The zonation here is indicated below—

Melaraphe unifasciata
Barnacles
Patelloid
Hormosira banksii
Corallines
Cystophora

At the Old Jetty the shore is composed of rounded stones up to one foot in diameter embedded in a gritty mud. This type of substratum renders the vertical zonation more difficult to determine due to the abundance of semi-cryptic places.

The *Melaraphe* belt is not well developed in this area. There is probably insufficient spray to support a large littorinid fauna. Barnacles are local in distribution but all are *Chamaesipho.* The Patelloid belt is the most well developed on the shore and it is separated from the algae of the Infralittoral Fringe by a coralline turf with a few *Hormosira* plants.

One conspicuous feature of the shore at the Old Jetty is the presence of a broad band in the upper barnacle belt which is populated by the gastropod *Austrocochlea obtusa* (Dillwyn). The variety found here has strong ribs round the shell and was formerly named *A. constricta*. The species is particularly plentiful in the neighbourhood of decaying plant matter and numbers as many as 12 per square foot.

The zonation here is indicated as follows—

Melaraphe unifasciata
Austrocochlea obtusa
Barnacles
Patelloids
Corallines
Cystophora-Xiphophora-Phyllospora-Ecklonia.

The algae of the Infralittoral Fringe fall into five dominant species. *Phyllospora comosa, Cystophora spartioides, C. uvifera, Xiphophora chrondrophylla,* and *Ecklonia radiata. Cystophora spartioides* is dominant inshore and is mixed with *C. uvifera.* The *Phyllospora* and *Ecklonia* form a mixed association at the lower limits of the fringe beside the Old Jetty. Between the *Ecklonia* and the *Cystophora* is a wide strip of weed dominated by *Xiphophora chondrophylla.* These weed belts are not sharply differentiated from each other as there is much mixing of the species. *Cystophora uvifera* occurs with *Phyllospora* and other algae but *Ecklonia* does not occur in the *Xiphophora* and *Cystophora* belts. Other generally distributed algae are *Lithothamnia, Corallina cuvieri, Jania* sps., *Caulerpa brownii, Caulerpa sedoides* (R. Br.) Ag., *Colpomenia sinuosa* (Roth.) Derby & Sol., *Codium tomentosum, Ulva lactuca* and a few *Hormosira* plants. The latter are found in the upper part of the Infralittoral Fringe and the lower part of the Midlittoral.

The boulders do not form a suitable substratum for animals, but in places the anemone *Actinia tenebrosa* is very numerous. *Cellana* is also found. The common crab on the upper part of the shore is *Cyclograpsus punctatus* (M-Ed.) while at lower levels such species as *Lomis hirta* and *Naxia spinosa* are found. The encrusting sponges listed as occurring at Fossil Island are all found here. One species which is scarce at other places on the western shore of Fossil Island is very numerous in this area, namely, the serpulid *Galeolaria caespitosa.* Its tubes form a white band around the lower part of the boulders and stones found on the shore. Some mussels, *Mytilus planulatus,* are found but they do not form beds and are not sufficiently numerous to form a zone.

Several algae species occur scattered along the sheltered shore of Fossil Island. These species are found in the lower Midlittoral or the Infralittoral Fringe. The species are *Caulerpa brownii, Chaetomorpha darwinii, C. aerea* and *Codium tomentosum. Hormosira banksii* is also found at various places on the shore, but this species is restricted to the Midlittoral except at the Old Jetty.

(*c*) *On the Reefs in Pirates Bay*

About a mile along the shore from the Blow Hole towards Eaglehawk Neck there is a series of low reefs which extend out for a short distance into the bay.

These reefs are of considerable importance as they throw some light on the distribution of two intertidal species. In particular, they give an index of the wave action toleration of the ascidian *Pyura praeputialis* and the mussel *Brachyodontes rostratus*.

The dominant form over nearly all of the reefs is *Brachyodontes rostratus*. The parts of the reef nearest the top of the shore are populated by *Melaraphe unifasciata*. The gastropod is replaced by a poor barnacle population. The latter is replaced by an open *Galeolaria-Brachyodontes* belt (Plate III). The mussels soon become the dominant species and cover the rocks in a densely packed sheet. In lower parts of the reef *Catophragmus polymerus* uses the mussels as a substratum, but the mussels do not offer a habitat to other forms.

At the end of the reef the mussels are replaced by *Pyura*. (Plate IV). In some places there is a thin band of *Laurencia* sps. separating these two species. The water at the edge of the reef is shallow and at low tide on a calm day it is probable that the ascidians are completely exposed. Another ascidian found on these reefs is the stalked ascidian *Boltenia pachydermatina* (Herdman). The presence of sand all round these reefs does not seem to reduce the mussel population. In many places on the reef, mussels living in cracks are embedded in sand and during gales considerable quantities of detritus, weed and sand must be deposited on the reef. The presence of moving sand probably accounts for the poor *Galeolaria* population.

At some places on the reefs *Sarcophycus* is found at the same level as the ascidians. (Plate IV). This is important as it enables us to state that *Pyura* occurs on these reefs in the Infralittoral Fringe, *Sarcophycus* being characteristic of that level.

It is worth noting that there are very few Patelloids, certainly not sufficient to warrant describing a Patelloid belt. *Siphonaria diemenensis* and *S. zonata* are found as well as *Patelloida alticostata*. A few *Cellana limbata* occur in clefts. Similarly, there are no coralline algae or other lower Midlittoral forms.

The zonation on these reefs is indicated as follows:—

Melaraphe unifasciata
Barnacles
Galeolaria + *Brachyodontes*
Brachyodontes
Pyura with or without *Sarcophycus*
or
Melaraphe
Barnacles
Galeolaria + *Brachyodontes*
Brachyodontes
Laurencia
Pyura

Notes on the Port Arthur Area

All types of coast are found in the Port Arthur area. The wave exposure varies from intense to slight. On the coast at Remarkable Cave and on the eastern side of the entrance to Port Arthur the wave

action is very strong. In the harbour of Port Arthur the wave action is negligible. All grades of wave action between these two extremes are found within the area of water called Port Arthur. The grades of wave action are not arranged in a linear series as at Eaglehawk Neck.

In the entrance to Port Arthur and at various places within the Port, notably Opossum Bay off Point Puer, and Frying Pan Island, the kelp, *Macrocystis pyrifera* is found in large off-shore beds. The effect of this species in modifying the wave action has already been noted. The seaweed is kept afloat at or near the surface by bladders and just below the surface of the sea is a mass of bladders and fronds. Often found with the *Macrocystis* is a *Sargassum* sp. which frequently has a vivid red encrusting bryozoan on it. This mass of weed near the surface deadens the intensity of the wave action but it is difficult to estimate its effect on the shore. It certainly reduces and often eliminates ' white horses '. *Macrocystis* is subject to considerable seasonal variations in the size of the beds. Work on this aspect of algal ecology is being carried out by Mr. Cribb, of C.S.I.R.O. It has been observed that growth takes place during the winter and spring, which would give the maximum protection to intertidal animals. In summer, judging by my own irregular observations on the Eaglehawk Neck kelp beds, the area of sea occupied by the kelp suffers considerable reduction. This would allow the maximum possible wave action which in turn would cause spray on the shore and so alleviate the effects of dessication and exposure on the shore. I consider that while the presence of *Macrocystis* reduces the amount of broken water that reaches the shore, it does not greatly reduce the effect of the ocean swell. It is not possible to measure the strength of the swell before and after the passage through the kelp beds. A lot more information is required on seasonal variation of the density per unit area of the plants and the migration of the beds.

Point Puer

At Point Puer there are two main types of shore. The wave exposed coast is cut into three platforms. The upper platform is at the foot of high cliffs and is only a few feet in width. Most of the shore area is on the second platform. This platform is at a level equivalent to the coralline zone. The third platform is some four feet below the second and is only two or three feet in width. Because of the heavy swell it is inaccessible in all but the calmest weather.

On the edge of the lowest shelf the dominant form is *Sarcophycus potatorum*. This species likes places where there is a horizontal or near horizontal shelf offering a firm substratum. *Phyllospora comosa* occurs in the water immediately beside the *Sarcophycus*. I was unable to determine the substratum to which the *Phyllospora* was adhering. In general, the flora and fauna of the Infralittoral Fringe is very similar to that found at the northern end of Fossil Island.

At the seaward edge of the second platform there is a very rich growth of the coral-like *Lithothamnion* sp. This species appears to reach its maximum development in this part of Port Arthur. On other parts of the eastern shore of Tasmania the species is not as well developed,

either in size or in numbers. The dominant form is the dome but the encrusting variety is also present. (Plate IV). The rock is densely populated by both larger and small colonies.

The largest or second platform is covered by a coralline turf with *Patelloida marmorata, Siphonaria diemenensis, Cellana limbata* and *Plaxiphora albida.*

The second type of coast found at Point Puer is a sheltered shore on the northern side of the point. There is a nearly horizontal platform which is covered by a very considerable growth of *Hormosira banksii.* This is easily the largest area covered by this alga yet encountered in Tasmania. The *Hormosira* is of sufficient size and density to justify the use of the term Hormosiretum.

Frying Pan Island

This area shows a gradation of algae from *Xiphophora* on the exposed eastern side of the island to *Cystophora* sps. in the shelter of Lady Bay. This species is in the Infralittoral Fringe and is immediately replaced by a very dense population of the surf barnacle, *Catophragmus polymerus.* (Plate V). Separating the barnacle from the alga is a narrow strip of bare rock. This rock is kept bare of life by the constant sweeping action of the seaweed. The formation of the rock undoubtedly assists the growth of this latter species. There is some swell which comes in from the entrance to Port Arthur so that there is always some surf breaking across the rock. Living in clefts in this rock are numbers of the mussel *Mytilus planulatus.*

On rounding the corner of Frying Pan Island the *Xiphophora* + *Phyllospora* is replaced inshore by *Ecklonia radiata.* The *Ecklonia Phyllospora* junction can be picked out on the shore by a large tree lying partly in the water. The *Ecklonia* does not occupy a large area but is soon replaced by *Cystophora cephalornithes* and *C. spartioides.*

The vertical zonation in Lady Bay is shown below—

Melaraphe unifasciata
Bare rock
Lichina confinis
Barnacles
Rivularia
Galeolaria
Galeolaria + *Hormosira* + *Ulva* + *Codium fragile.*
Cystophora sps.

It is doubtful if the barnacle belt can be called a true belt. The barnacles are very few in numbers and are found in isolated patches, of ten in cryptic or semi-cryptic places. The species found are *Chamaesipho columna* and *Tetraclita purpurascens.*

At Opossum Bay

The zoning here is different from that seen at Lady Bay and Frying Pan Island. The wave action is certainly less than that encountered on the exposed shore of Frying Pan Island but it is probably more than that encountered at Lady Bay.

As at Lady Bay, the barnacle zone is greatly reduced, the barnacles being confined to cryptic places. It is better to speak of bare rock with barnacles in clefts rather than of a barnacle zone. The zoning is as follows—

Bare rock
Lichina confinis + *Melaraphe unifasciata*
Siphonaria diemenensis (in hollows in the rock)
Bare rock with *Tetraclita purpurascens* in clefts
Galeolaria caespitosa
Galeolaria + *Hormosira banksii*
Hormosira + *Cystophora torulosa*
Cystophora sps.

This zonation is shown in Plate V. Slightly to the east of the locality of Plate 5 there is a small point where there is more wave action. *Phyllospora* replaces *Cystophora* in the Infralittoral Fringe but *Hormosira* is present at higher levels of the shore. The *Hormosira* at this point is very well developed, with large strong plants. It is worth noting that there are no mussel beds on this point. Mussels, *Mytilus planulatus* are found further along the shore towards the sandy part of Opossum Bay. These mussels do not form well developed beds, but are in large clusters arranged along small escarpments caused by erosion along the bedding planes.

Remarkable Cave

The shore at Remarkable Cave lies on the oceanic coast a few miles beyond Point Puer. The area is interesting ecologically on account of the presence of packed beds of the ascidian *Pyura praeputialis*. These animals live among the holdfasts of the kelp *Sarcophycus*. It is very difficult to examine the Infralittoral Fringe on account of the heavy swell. When an examination was attempted the sea was very smooth but there was a low swell causing up to twelve feet rises of water-level on the shore.

The small mussel, *Brachyodontes rostratus*, also is found in large numbers in this area. The species does not form the dense incrustations such as seen in Pirates Bay but it is a very noticeable feature of the lower Midlittoral belts.

The Port Arthur region covers a considerable area of ground and these notes are not intended to be a survey of this area but merely to mention one of two interesting ecological features. Mr. A. Cribb of C.S.I.R.O. is carrying out a detailed survey of the area and for that reason I have not attempted any major work at Port Arthur.

Discussion

One of the most interesting features of the wave exposed coasts in Tasmania is the presence of the extensive off-shore beds of *Macrocystis*. This alga, as noted above, has a considerable effect in modifying the wave action, but this effect is difficult to evaluate.

The presence of these off-shore beds of kelp is a feature found only on Pacific and Southern coasts. On the eastern seaboard of North America there are extensive kelp beds which have been described by

Andrews (1945). At Monterey these beds are composed of two species, *Macrocystis integrifolia* Turn. and *Nereocystis luetkeana* Martens with other species of lesser importance. The same author (1925) described the kelp beds at Puget Sound. Shelford (1935) also described the Puget Sound beds.

One of the conclusions reached by Andrews at Monterey is that the weed checks currents and wave action. A most interesting feature of his conclusions is that the major numbers of the animals found on the weed are immature forms of the fauna of the adjacent sea floor. It is not beyond possibility that beds which are found close to the shore might influence the fauna of the Infralittoral Fringe.

In South-West Africa the kelp beds are composed of *Ecklonia buccinalis, Laminaria pallida* and with *Macrocystis pyrifera* important in local areas (Stephenson, 1939).

In Australia, *Ecklonia radiata* is found on the warmer coasts but this species is not as large as *Macrocystis* and occurs in either the Infralittoral Fringe or the immediate Infralittoral. This species would probably have no greater effect on the wave action than any other species. In Tasmania, *Ecklonia* is found in sheltered places, *Macrocystis pyrifera* being the kelp of exposed coasts.

The parts of the coast considered in this region of Tasmania are the most important examined to date. In particular, the zoning of the algae in relation to the intensity of wave action is seen very fully at Fossil Island. All of the indicator algae of Tasmania are seen in their relative positions of wave toleration. The series is thus . . . . *Sarcophycus, Sarcophycus* + *Phyllospora, Lessonia, Xiphophora, Ecklonia, Hormosira, Cystophora.* The relative position of *Lessonia* was in considerable doubt until the Eaglehawk Neck area was examined. The latter locality shows that the species requires slightly less wave action than *Sarcophycus,* although the exact conditions are not reproduced at Fossil Island.

The area is also important as it gives a picture of the habitats of the ascidian *Pyura* and the mussel *Brachyodontes rostratus,* both of these species being found on reefs in Pirates Bay. It also gives an outline of the wave action toleration of these species.

As at Freycinet Peninsula, the upper parts of the shore are very poorly populated, but the barnacle fauna is greater than at Sleepy Bay and Coles Bay areas. The physical environment at Eaglehawk Neck is similar to that encountered at Freycinet Peninsula so there must be some other reason for the poverty of the barnacle fauna at the latter place. The distribution of barnacles in Tasmania will be discussed later.

The various zones as seen on the shore will be correlated with those seen elsewhere in a later paper.

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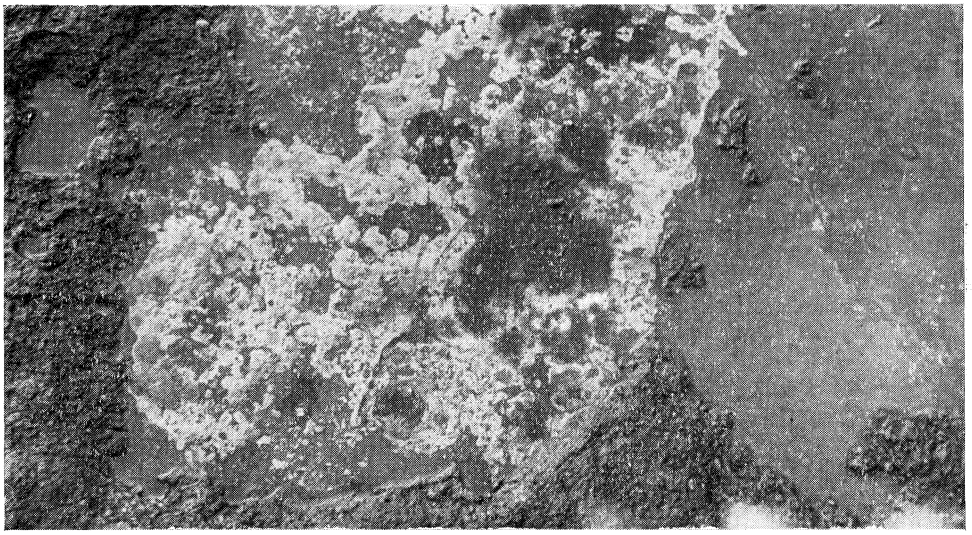

FIG. 1.—*Jania* turf of the exposed platform at the Blowhole, Eaglehawk Neck. Note the close, short nature of the alga.

FIG. 2.—The *Jania* turf on the sheltered side of Fossil Island. The alga is larger and the turf is more open. The barnacles on the overhanging rock are *Tetraclita*.

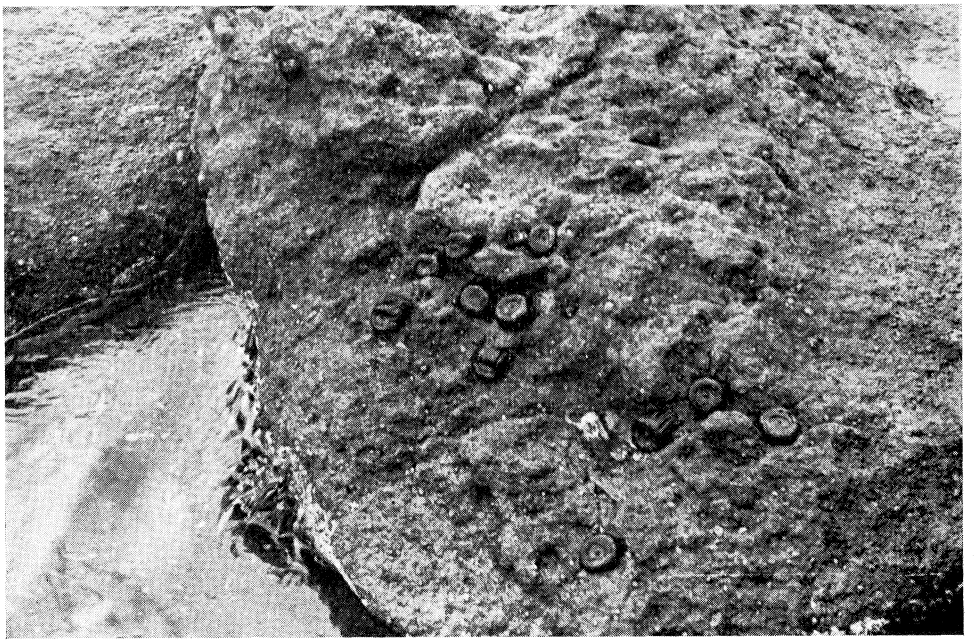

FIG. 1.—*Actinia tenebrosa* at the northern end of Fossil Island.

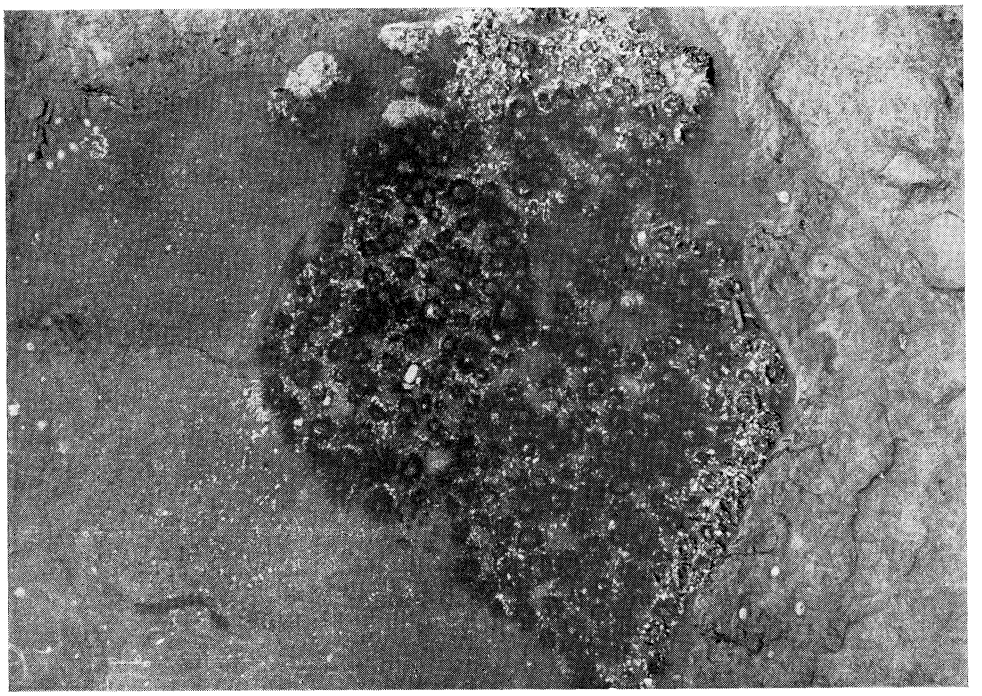

FIG. 2.—Anemone carpet on the sheltered side of Fossil Island.

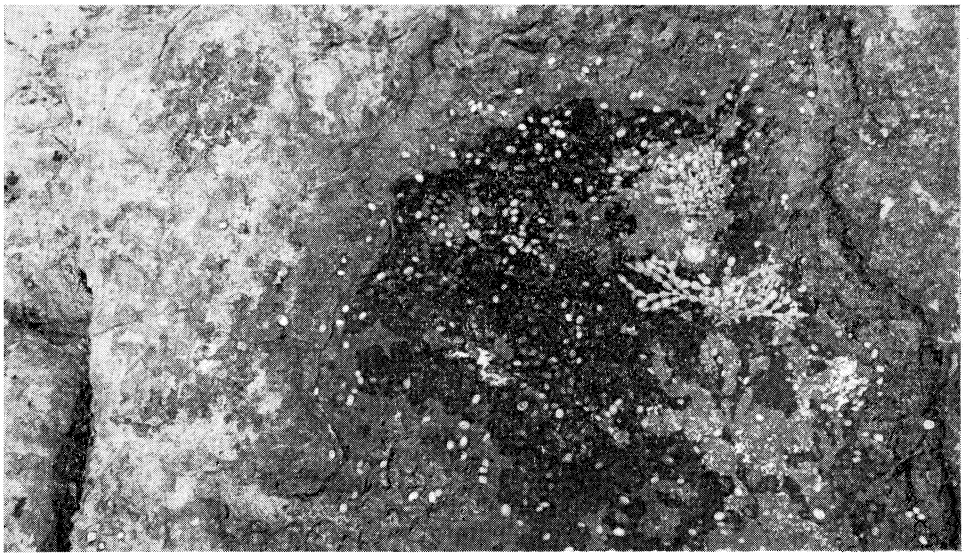

FIG. 1.—Limpet 'homes' on Fossil Island. The dark background is a blue-green alga, ? *Isactis*. The white objects are *Siphonaria diemenensis* with a few *S. zonata* also distinguishable. The grey marks on the algal background are the 'homes' to which the limpets return.

FIG. 2.—*Galeolaria-Brachyodontes* at the reef in Pirates Bay.

FIG. 1.—*Pyura* and *Sarcophycus* at the end of the reef in Pirates Bay.

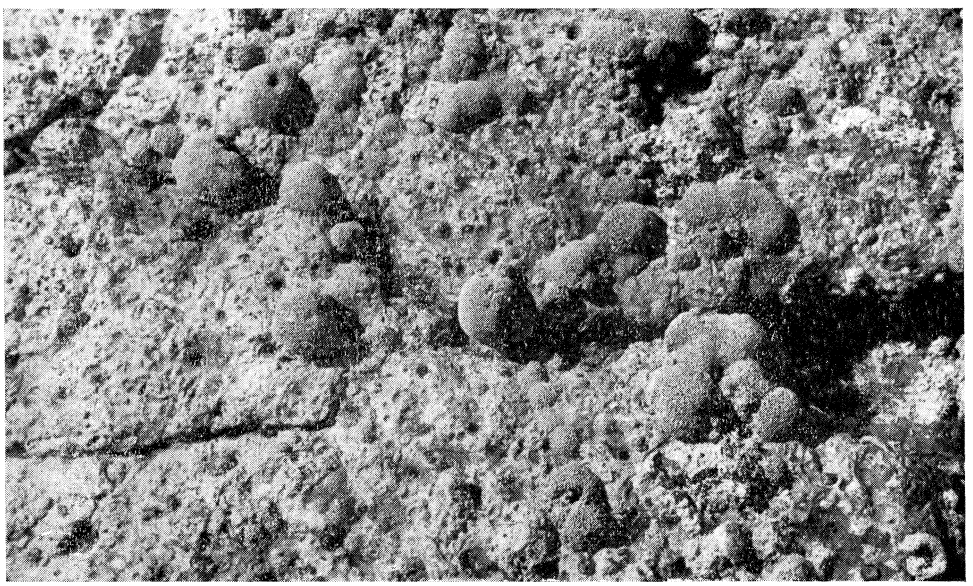

FIG. 2.—*Lithophyllum* at Point Puer, Port Arthur.

FIG. 1.—*Catophragmus polymerus* at Frying Pan Island, Port Arthur.

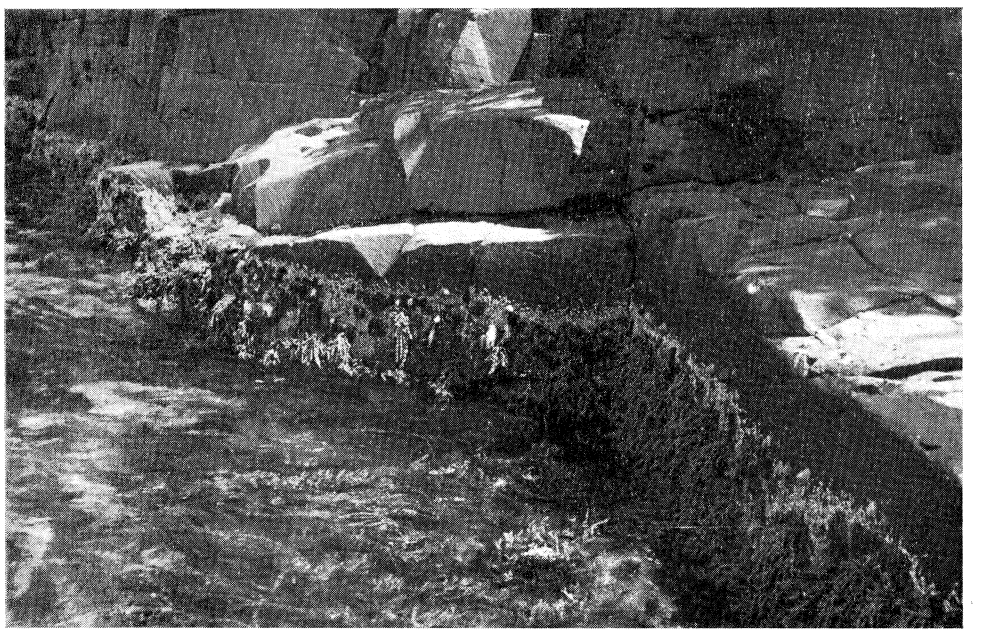

FIG. 2.—The zonation at Opossum Bay, Port Arthur. The black patches on the rocks are *Lichina*. The *Galeolaria* belt is very thin and is immediately replaced by *Hormosira*.