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The Algal Vegetation of Port Arthur, Tasmania

By

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WITH 10 PLATES AND 2 TEXT FIGURES

SUMMARY

An account is given of the algal vegetation of Port Arthur, Tasmania. The rocky shore is divided into three categories, "sheltered", "semi-exposed" and "exposed", each characterized by the presence in the lower littoral or sub-littoral fringe of a particular member of the Phaeophyta. These species are respectively *Hormosira banksii* (Turn.) Dcne. *Xiphophora billardieri* Mont. and *Sarcophycus potatorum* (Labill.) Kuetz.

Associations of *Zostera muelleri* Irmisch and of *Zostera tasmanica* Mart. characterize respectively the lower littoral and sub-littoral sand-mud flats in sheltered localities.

A comparison is made with the algal vegetation in other parts of Australia, the Subantarctic and Northern Hemisphere and the comparative paucity of the littoral vegetation in the Southern Hemisphere is noted.

I. INTRODUCTION AND DESCRIPTION OF THE AREA

Description of the area and environmental factors

Port Arthur, lat. 43·15° S., long. 147·9° E., opening on to the southern coast of the Tasman Peninsula in south-eastern Tasmania, is a comparatively narrow inlet averaging about one mile in width and extending northwards for approximately five miles, broken in places, particularly on the western shores, by several bays of varying size. The greatest depth recorded on Admiralty charts is 29 fathoms.

The area is a most interesting one from the point of view of algal ecology, offering as it does a considerable variety of algal habitats ranging from very exposed cliffs and surf swept rock platforms, the home of *Sarcophycus potatorum*, to extremely well protected bays where *Zostera* flourishes on gently shelving sand-mud flats. Rock surfaces of both dolerite and mudstone present widely varied slopes for algal colonization.

The exposed eastern shore of smooth dolerite is of varying steepness but for the most part descends precipitously into deep water. Above this shore the steep wind-swept slopes rising to Arthur's Peak and its subsidiary ridges are densely covered with a low scrub of *Leptospermum* sp., other small shrubs and somewhat stunted Eucalypts.

Passing north from Denman's Bay, known locally by the more picturesque name of Deadman's Bay, the rocky shore soon gives way to one of large dolerite boulders gradually decreasing in size towards Stinking Beach, a stretch of clean white fine sand, where after storms, large quantities of decaying algae justify the unusual name. The shore of dolerite boulders then extends round Evidence Point to the northern end of Long Bay, where it is replaced by a low sand-mud beach, sometimes with emergent rocks. Continuing along the western side of Long Bay, the bouldery shore is resumed to the north-west corner of Opossum Bay, broken only by clean sandy beaches at Stingray Bay and Stewarts Bay, by small outcrops of rocky shore at Garden Point and Frying Pan Point, and by a low mudstone outcrop in Stingray Bay.

Opossum Bay is bordered on the north-west by a sandy beach broken here and there towards the south by low outcrops of mudstone. Towards the south-west, with increasing shelter, the sand gains an increasing proportion of mud.

The north-west corner of Point Puer provides a small area of mudstone boulders and along the eastern shore of Point Puer stretch the distinctive laminated mudstone cliffs up to 100 feet high, from the base of which extend the horizontal or gently shelving mudstone platforms, (see Plates 5 and 9). After the wide sandy beach of Safety Cove which replaces the mudstone of Point Puer, there appears again the bouldery dolerite shore soon giving way to a rocky shore of variable slope which is finally replaced by the white sandy beach of Half Moon Bay.

II. Environmental Factors

1. TIDES. There are no tidal data available for Port Arthur but the behaviour of the tides seems to be similar to that described for Hobart by Guiler (1950) being of the semi-diurnal type in which a " high high " tide is followed respectively by a " low low ", " low high ", and " high low ". The extreme tidal range at Port Arthur appears to be approximately 6 feet.

2. SEA TEMPERATURE. Surface water temperatures were recorded by E. J. Wenck for the summer months of 1950-51 and 1951-52 and are given in Table I. The figures are the averages of weekly readings at 10 a.m., 12 noon and 3 p.m. The highest reading recorded was 18·5° C. during February, 1951.

TABLE I

Sea temperatures at Port Arthur

	Temperature (°C.)		Temperature (°C.)
October, 1950	13·8	October, 1951	14·0
November, 1950	14·7	November, 1951	14·5
December, 1950	15·6	December, 1951	14·5
January, 1951	17·3	January, 1952	16·3
February, 1951	17·3	February, 1952	17·8
March, 1951	16·9		

3. AIR TEMPERATURE. The station nearest to Port Arthur for which air temperature records are available is Cape Bruni, lat. 43° 29′ S. Here the highest monthly mean maximum temperature is 64·1° F, occurring during February. The lowest monthly mean minimum is 42·9°F, occurring during July.

4. RAINFALL. Figures made available by the Weather Bureau, Hobart, reveal that for the 30-year period 1911-1940 the average annual rainfall at Port Arthur was 40·42 inches and rain fell on an average of 197 days during the year. Table II shows the average monthly rainfall and the number of days in each month in which rain fell for the period 1911-1940.

TABLE II

Average monthly rainfall at Port Arthur for the period 1911-1940

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Rainfall (inches)	2·62	2·38	3·10	3·96	3·22	4·54	3·78	3·68	2·88	3·75	3·04	3·47
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept,	Oct,	Nov,	Dec,
Days in which rain fell	13	11	15	16	18	19	19	18	18	18	16	15

5. WINDS. The prevailing wind over southern Tasmania is between north and north-west, with frequent south-easterlies in summer and early autumn. South to south-west winds are fewer and usually of lower velocity than the north and north-west winds.

6. SALINITY. No figures are available for salinity, but as no large fresh-water streams enter the area the variation is probably slight.

7. ILLUMINATION. No measurements of light penetration at various depths have been made but the water appears very clear and the amount of sediment introduced by the few very small streams probably has a negligible effect on light penetration.

III. TERMINOLOGY

The meanings of terms applied to the various horizontal divisions of the shore are those advocated by Womersley and Edmonds (1952). The littoral zone is regarded as that part of the shore between extreme high water mark of spring tides and mean low water mark of neap tides. This zone may be divided into upper, mid-, and lower littoral. Above the littoral is the supra-littoral zone and below is the sub-littoral fringe occupying the range between mean low water mark of neap tides and extreme low water mark of spring tides. Below this is the upper sub-littoral zone.

Following Cotton (1912), the algal associations are assigned to either the " rocky shore formation " or " sand and sand-mud formation ", the other formations recognised by Cotton at Clare Island being unrepresented at Port Arthur.

It has been found convenient to divide the rocky shores on the basis of degree of exposure, into three groups, each characterized by particular associations, mainly of the larger brown algae.

These three categories have been designated:—

Sheltered
Semi-exposed
Exposed

These terms are entirely relative and are designed only to distinguish between the degrees of exposure occurring within Port Arthur. Of course, the characteristic vegetation of each category grades gradually or suddenly into that of the next and many points on the shore can be found where the vegetation is of an intermediate nature. Also, along a comparatively short length of shore two or occasionally three of the vegetation types may be found as local variations in topography modify the degree of exposure, the seaward face of a boulder perhaps falling into one category while the landward face fits more easily into another.

However, on the whole, this division of the shore, made on the basis of degree of exposure, has been found to be convenient for Port Arthur, and there is generally little doubt as to the category into which a stretch of shore should be placed.

In this paper the abbreviations " E.H.W.S." and " E.L.W.S." are used for " extreme high water mark of spring tides " and " extreme low water mark of spring tides " respectively.

IV. Vegetation of the Shore

A. Rocky Shore Formation

1. *Sheltered Shore*

Belonging to this sheltered category are the shores of Opossum Bay, Stewart's Bay (with the exception of parts of its northern and south-eastern shores), most of Long Bay, and Stingray Bay.

With the exception of the mudstone pavements in western and southern Opossum Bay, most of the shore in these areas is of dolerite boulders of varying size interrupted in a few places by sand or sand-mud beaches.

In nearly all places the Eucalypt forest approaches close to the shore and is associated with a shrubby under-story which includes *Bedfordia linearis* DC., *Exocarpus cupressiformis* Lab., *Goodenia ovata* Sm., *Ozothamnus gunnii* (Hook. f.), F. Muell. ex Benth., O. sp., and other species, together with a ground cover which commonly includes *Lomandra* sp. (cutting grass) and *Stipa teretifolia* Stend.

(*a*) *Supra-littoral*

The encrusting lichens of the supra-littoral are a conspicuous feature of the rocky shore at Port Arthur, as elsewhere in Tasmania, and though by no means restricted to the areas designated in this account as " sheltered " they may conveniently be described here. They show a fairly constant and distinct zonation which, however, may be considerably modified by change in aspect.

(1) *Parmelia* association (grey-green Lichen association).

Highest on the shore is the grey-green lichen association consisting of *Parmelia perforata* (Wulf.) Ach., *P. conspersa* (Ehrl.) Ach. and other species rarely with patches of the dark-green more gelatinous thalli of *Collema* sp., and often mingling in its upper part with mosses such as *Ptychomitrium mittenii* Jaeg. and occasional plants of *Arthrocnemum australasicum* Moq. or tufts of *Stipa teretifolia* the two Phanerogams which venture farthest down the rocky shore and may be partly submerged at E.H.W.S. The lichen species of this association do not appear to be restricted to the shore and possibly reach a satisfactory development here mainly because freed from the restricting shade of the Eucalypt forest.

(2) *Ochrolichina* association (white lichen association).

The *Parmelias* are followed by the striking association of white lichens. This consists mainly of *Ochrolichina parella* (Linn.) Massal, with white or pale apothecia, together with some *Patellaria rimosa* M. Arg. with its contrasting black apothecia. Both form a hard, close, white or silvery grey encrustation and together may almost completely cover the substrate giving the rocks the appearance of being heavily whitewashed, and standing out quite distinctly from a distance of a mile or more (see Plate 1).

In the most sheltered localities this band may be only 2 feet 6 inches in height with its sharply marked lower limit slightly below the level of E.H.W.S., but it responds readily to change in exposure as is evidenced by the marked elevation and extension of the band with increasing spray. In exposed positions the association may have a vertical extent of 20 feet and its lower limit be elevated 15 feet or more above the E.H.W.S. in calm weather. When observing from a distance a shore along which the degree of exposure is changing, this gradually narrowing bright white band can be seen to drop lower and lower on the shore as degree of exposure decreases.

The upper part of the band mingles with the *Parmelia* association, and there is some evidence that in places, competition with this association may prevent the white association's attaining its full range.

The association shows a striking preference for southern exposures and on a shore with a northerly aspect is almost or entirely absent.

(b) Upper littoral

(3) *Candelariella* association (orange-yellow lichen association).

Overlapping the lower margin of the white lichen association are colonies of orange-yellow lichens which comprise the next downshore band. This association consists mainly of *Candelariella vitellina* (Ehrh.) Muell. Arg. and *Teloschistes parietinus* (L.) Norm. generally with the former predominating but sometimes with the *Teloschistes* locally dominant. A few flecks of the orange-red *Gasparinnia murorum* (Hoffm.) Dodge & Baker may occasionally appear, but it is a relatively unimportant species at Port Arthur. Some small light or dark-grey encrusting species also occur in the association but being similar in colour to the rock surface they are inconspicuous.

Though the highly coloured constituent species may in places form an almost complete cover within the band, such dense covers tend to be local in occurrence, and the association at Port Arthur never reaches the development found in some other parts of Tasmania, as for instance at Low Head, Bicheno, and Southport.

As in the case of *Ochrolichina* the position and extent of the band which the association forms alter with changing exposure, and though in sheltered localities it occupies a band in the upper littoral approximately 1 foot in vertical extent, when subject to exposed conditions the range is considerably increased and the lower limit appears several feet above E.H.W.M. in calm weather.

In contrast to the *Ochrolichina* and *Patellaria,* the constituent species of the orange-yellow association seems to show some preference for a northerly aspect. This preference for the north is not so marked or exclusive as that shown by the *Ochrolichina* association for the south, and though in places all the lichen associations may be seen distinctly banded in downshore succession, in general, at any point where either the white or orange-yellow association approaches optimum development the banding is likely to be less marked than at positions where neither association finds conditions entirely favourable.

(4) *Verrucaria* association (black lichen association).

The orange-yellow association is succeeded by a foot-wide band of *Verrucaria microsporoides* Nyl. often forming a complete hard black coating over the rock surface, though since the rock itself is often of a dark colour this association from a distance is not so conspicuous as the white and orange-yellow associations above it. The upper limit of the *Verrucaria* association like the lower limit of the *Ochrolichina* association is often sharply marked and it is within the clearly defined band of shore, often 6-9 inches in height, between these two association, that the orange-yellow species find their maximum development, though there may be some mingling with the bounding associations, particularly with the *Verrucaria* below.

The *Verrucaria* does not seem to respond very markedly to change in aspect, but it favours the more protected areas and is generally not found on exposed shores.

(5) *Lichina* association.

Following the *Verrucaria* is the lowest lichen band constituted by the Pyrenolichen *Lichina confinis* (Muell.) Ag. This remarkable species, submerged regularly at high tide, extends downwards from the lower limit of the *Verrucaria* for a distance of about one foot, forming firm cartilaginous colonies, rounded, lobed or irregular, generally one quarter to two inches in diameter and not more than one quarter inch high. Older colonies sometimes decay at the centre leaving rather characteristic black rings, and more rarely a colony may be in the form of two concentric rings. (see Plate 2.) When dry they are quite black and rather brittle, but after immersion change to a dull greenblack and become more fleshy. The *Lichina* often forms quite a distinct band, but it is an association of scattered colonies and only in localised areas where very

exceptional development has taken place is there anything even approaching a complete cover. Generally, though not invariably, the colonies shelter no animals. The association may at times tend to be intermittent and sometimes rocks within the band are quite uncolonised, the reasons for these fluctuations often being not readily apparent. There seems to be a slight preference for southern exposure, but the species is certainly not confined to this aspect.

The common littorinid, *Melaraphe unifasciata* (Gray), generally finds its lower limit among the *Lichina,* though its upper level is very variable depending mainly on degree of shade and amount of spray. In very sheltered localities it usually does not extend higher than the lower limit of the *Ochrolichina* association.

(6) *Bostrychia* association.

The first band of macroscopic algae to appear on the shore is formed by the *Bostrychia* association which thrives only where considerable shade and shelter are available. It may sometimes appear at the upper *Verrucaria* limit, but finds its optimum development below this association, occupying roughly the same vertical range as *Lichina.* Since it prefers the shaded boulder faces and crevices it is generally found somewhat to the rear of *Lichina* and the two rarely intermingle. Ideal conditions occur along the bouldery north-eastern shore of Long Bay, and here the association reaches maximum development forming a thick woolly felt on the shaded surfaces. Where overhanging rock ledges provide particularly moist and shaded conditions, the *Bostrychia* may hang in matted untidy festoons of densely tangled filaments. In very shaded situations the colour is almost black, and though typically it is a dark dull purple, the margins of more exposed colonies, where conditions presumably are far from optimum, sometimes appear a yellowish-brown. This association is composed of a mixture of two species, *Bostrychia mixta* Hook. and Harv. and *Bostrychia simpliciuscula* Harv., generally with the former predominating. Glistening patches of *Caloglossa leprieurii* (Mont.) J. Ag. sometimes occur on the mat of *Bostrychia,* small colonies of *Enteromorpha* are found occasionally, and in particularly shaded situations a bright green felt of *Rhizoclonium riparium* (Roth) Harv. or a blue-green scum of *Hydrocoleum glutinosum* (Ag.) Gom. may overlie the colonies.

Frequently associated with the *Bostrychia* is *Hildenbrandtia* sp. forming a very thin dull blood-red crust over the rock surface. The position and extent of this encrustation is dependent upon the presence of the deep very shaded crevices found along a shore of large boulders and in such a position it may appear at about the upper limit of *Verrucaria* and extend downwards for perhaps two feet to positions where the light intensity may be extremely low. *Bostrychia* colonies are frequently developed over the better illuminated parts of the crust which, however, is able to penetrate well beyond the limit of shade tolerance of *Bostrychia.*

(c) Mid-littoral

The strip of shore, generally 12 to 18 inches in vertical extent, between the lower limit of *Lichina* and upper limit of *Galeolaria caespitosa* (Lam.) is often floristically very bare, and though damp chinks and crevices sometimes facilitate algal invasion from the associations below,

it is predominantly an animal zone dominated by limpets and often carrying barnacles, mussels and gastropods. But within this band there may occur in various localities, several well marked algal communities.

Three limpet species are almost universally present at Port Arthur though other species also occur. The uppermost species is *Siphonaria zonata* (Teneson-Woods), a small species, dull white and indistinctly zoned with bands of blue-grey. The individuals occupy a narrow band, perhaps three inches in vertical extent at about the lower *Lichina* limit, and though fairly constantly present are nearly always sparse and inconspicuous.

The small, ribbed *Siphonaria diemenensis* (Quoy & Gaimard) which extends downwards from just within the region of *S. zonata* is by far the most common limpet on the shore and reaches the *Galeolaria* band still in considerable numbers. When this species occurs on the fallen tree trunks which lie here and there partly submerged along very sheltered shores, the limpet home is marked by a green ring-shaped stain caused by some microscopic green or blue green alga. Individuals on such wooden substrata are particularly likely to carry colonies of a species of *Hildenbrandtia* apparently different from the species occurring on shaded rocks in the upper littoral. These colonies fleck or sometimes completely envelop the shell with a dull red crust.

The third species of limpet is a large *Cellana* sp., the number of individuals quite small compared with *Siphonaria diemenensis,* but their dull white shells up to one and one-half inches in basal diameter standing out very clearly where they do occur. They may be found anywhere between the associations of *Lichina* and *Galeolaria,* but generally prefer positions nearer the *Galeolaria,* though at high tide their migration may take them within the *Lichina association.* The shells may sometimes carry colonies of various algae such as *Ulva lactuca* L., *Ceramium paniculatum* Okamura or *Gelidium pusillum* (Stackh.) Le Jol. and where *Bostrychia* is common may bear a dense spongy felt of *B. mixta* which they may carry below the normal limit of this species.

The uppermost inhabitants of the mid-littoral are usually the small barnacle *Elminius* sp. and the conical gastropod *Bembicium melanostoma* (Gmelin) both of which find only the lower part of their range here, and extend well into and sometimes above the *Lichina* association, the *Bembicium* generally extending a little above and below the *Elminius.*

The barnacle *Chamaesipho columna* (Spengler), typically an inhabitant of the exposed shores, may sometimes occur below the *Elminius,* but if present at all, is usually poorly developed.

A barnacle far more constantly present though not usually in any great numbers, is *Tetraclita purpurascens* (Wood), a large low species with a light-grey rugose shell. The presence of this species is dependent upon a certain amount of shade and it is usually found in crevices, on the shaded sides of boulders, or under rock ledges, so that although it may be quite common it is sometimes not so readily noticed as other species. Where its conditions of shade and shelter are fulfilled it may occur anywhere within this band, generally with its greatest development 6-9 inches above the *Galeolaria.* The mudstone pavements being particularly bare of such localised shady habits are almost devoid of this species.

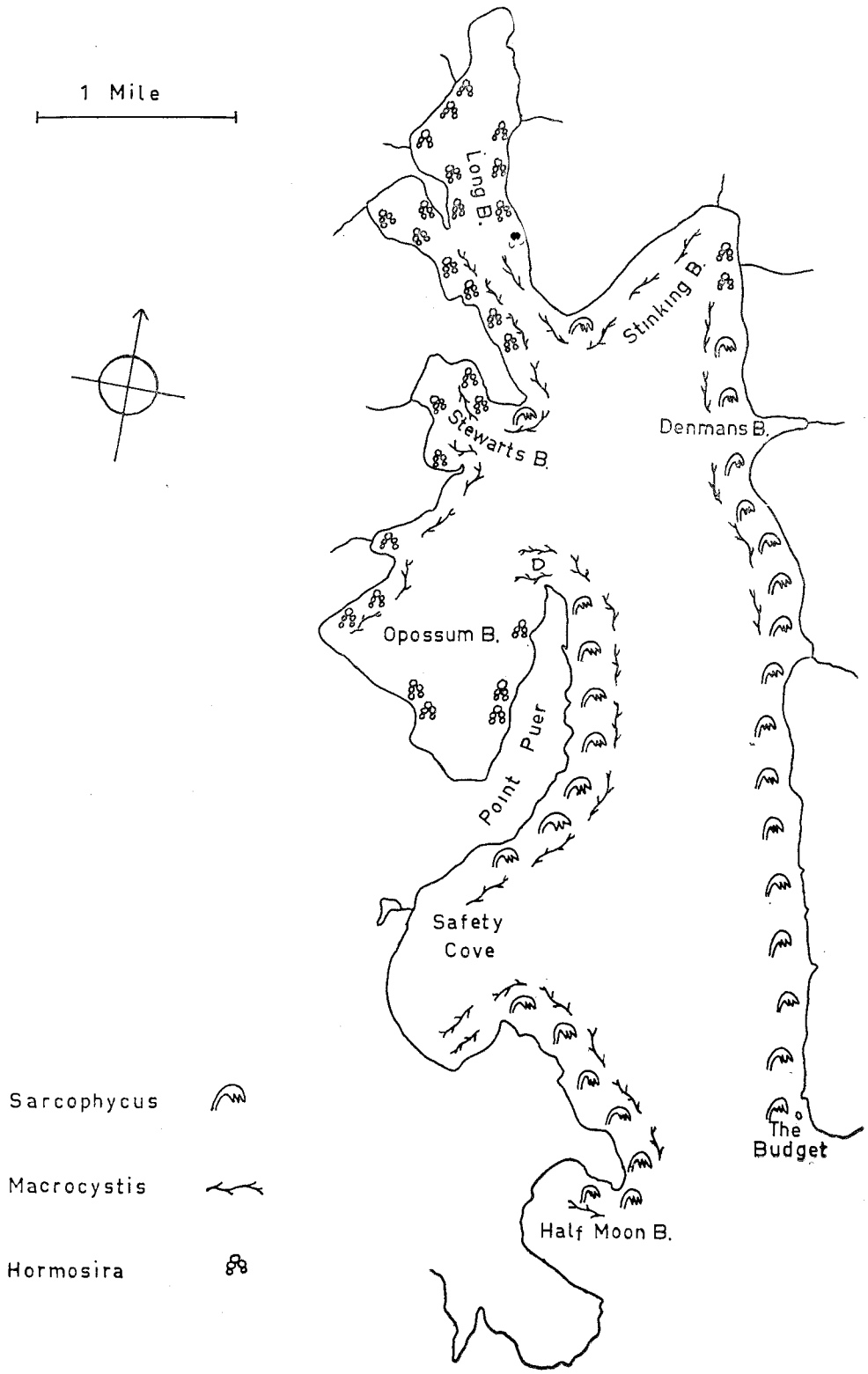

FIG. 1.—Map of Port Arthur showing the main distribution of *Sarcophycus Macrocystis* and *Hormosira*.

The small mussel *Brachyodontes rostratus* (Dunker) may also be important in the animal band. It appears to be incapable of colonising directly a smooth rock surface and on a bouldery dolerite shore the colonies are initiated in the crevices between boulders and extend outwards over the smooth rock surface by marginal increase, frequently accumulating sand and shell grit between the densely packed purple-black shells. On the mudstone pavements, the cracks and fissures at suitable levels are generally marked by black lines of these densely crowded mussels, and pock marks and small depressions in the rock surface each bears a black cluster. Where a change from the pockmarked rock to smooth surface occurs within the *Brachyodontes* region, the sudden disappearance of the species is most striking. Where the necessary cracks or pitted surfaces are available its range may extend from within the lower *Lichina* to within the upper *Galeolaria,* though the best development is generally reached a little above the upper limit of *Galeolaria.*

Two algae are commonly, though not invariably, associated with the *Brachyodontes.* During winter, *Callithamnion* sp. forms short red plumose tufts up to one inch high and is not, as a rule, found on adjacent rock surfaces. The other species is *Gelidium pusillum* its branches densely entangled between the shells and sometimes forming a firm spongy tuft over the surface of the *Brachyodontes* colonies. Both species occur mainly in the lower part of the *Brachyodontes* range.

At times an algal species commonly present on this strip of shore is the blue-green *Rivularia australis* Harv. Its soft rubbery thalli form irregularly rounded inflated hollow colonies often about one half inch in diameter, generally bottle green after recent submersion, but sometimes drying to a black crust when exposed for a considerable time. The colonies are often rather widely scattered so that the species may not form a conspicuous band. Though occasionally it has been found growing on colonies of *Lichina* the best development is found in the lower part of the band nearer the *Galeolaria.* The species is seasonal in its occurrence being mainly a summer form, found only very rarely during winter months. The young colonies generally start to appear about October.

During winter, *Porphyra umbilicalis* (L.) J. Ag. may occur here and there within this band, generally as isolated individuals or small communities, but along these shores it never forms the dense association found on some of the more exposed shores of Port Arthur.

Scytosiphon lomentarius (Lyngb.) J. Ag. also mainly a winter form, is, like *Porphyra,* very sporadic in its occurrence along these shores.

Some species seem to be mainly restricted to positions of extreme shelter often where the rocks emerge from a sandy-muddy shore. Among these are *Chordaria dictyosiphon* (Harv.) Kuetz., *Hildenbrandtia* sp., *Enteromorpha* sp. and *Monostroma* sp.

Scattered clumps of the *Chordaria* are found on rocks and particularly on logs in the lower part of this band and may extend downwards into the *Hormosira* association.

The *Hildenbrandtia* forms small rounded or oval red-brown crusts often not more than one quarter or one half inch in diameter, and

occasionally in extreme cases may occur so thickly that the confluent colonies completely cover the small boulders. It differs from the species found in the upper littoral in its thicker crust and usually definite colonies.

Sometimes the rock surfaces in these exceptionally sheltered positions develop a dark slippery coating of *Calothrix* sp. and on this may occur occasional colonies of *Enteromorpha* sp. and a few delicate pale-green plants of *Monostroma* sp., generally not more than two inches in length. *Enteromorpha* does not usually form a distinct band in any part of the shore though a bright-green mat may mark the position of fresh-water seepage on the shore. In one place, shallow upper littoral pools frequently polluted by the cleaning of fish in the vicinity carried a dense growth of *Enteromorpha intestinalis* (L.) Link during winter. The hot weather often proves fatal to the *Enteromorpha* communities and the plants quickly become bleached during summer.

Most of these species seem able to extend the upper limit of their range when growing on fallen tree trunks, and *Enteromorpha* often appears quite densely on this substratum though absent on adjacent rock surfaces, while *Bostrychia mixta* is often able to survive here without the usually necessary degree of shade. These logs sometimes carry a variety of blue-green algae which are generally absent on the rocky shore, and among these may be mentioned *Calothrix pilosa* Harv. forming a dark olive-green pilose-velvety stratum generally in the upper littoral region.

(7) *Galeolaria-Gelidium* association.

One of the most distinctive associations on the shore is provided by the *Galeolaria caespitosa-Gelidium pusillum* association generally with its fairly sharply defined upper margin. (see Plate 3.) The *Galeolaria* does not reach the excessive development found in the Sydney district of New South Wales, where the mass may be several inches thick, and at Port Arthur the bright white layer of interwined calcareous tubes is seldom more than one tube in depth. Vertically the tubes may extend for about 18 inches, but this range is frequently not realised because of the heavy competition with algae in the lower part of the association, so that the vertical extent of the band is more often in the vicinity of ten inches. The upper part of the association can be regarded as being in the mid-littoral, but the lower part of the *Galeolaria* penetrates well into the lower littoral.

Nearly always associated with the *Galeolaria* is the small alga *Gelidium pusillum,* the decumbent dark red-black richly branched cartilaginous thalli contrasting with the white of the intricate mass of tubes which provided so suitable a substrate for this creeping species. The *Gelidium* prefers the upper part of the *Galeolaria* range and occurs only to a very limited extent on adjacent rock surfaces, though, as already mentioned, its range may be extended above the *Galeolaria* in the presence of *Brachyodontes.* Though generally intimately mixed with and difficult to separate from its substrate, it may, when shelter is extreme, occasionally form rounded cushion-like clumps which can be removed from the substrate with comparative ease.

Occasionally a yellow-green sponge *Hymeniacidon perlevis* (Montagu) is found growing over the *Galeolaria* particularly in shaded localities and in the rare cases where the tubes do locally form a layer perhaps an inch thick, the barnacle *Ibla quadrivalvis* Cuvier may be found imbedded in the mass.

The congregation at low tide of individuals of *Siphonaria diemenensis* immediately above a sharp upper limit of a dense band of *Galeolaria* suggests that the uneven surface of the tube worms may hinder the further downward migration of these small limpets.

(8) *Ulva* association.

An association which is to some extent seasonal in its occurrence is constituted by *Ulva lactuca,* sometimes with other Chlorophycean genera, which generally forms the first conspicuous band of macroscopic algae on the shore. In some places old plants may occur infrequently throughout the mid-littoral but maximum development is generally reached just above and below the upper limit of *Galeolaria* though plants frequently extend in considerable numbers into the *Hormosira* association and sometimes very sparsely into the upper sub-littoral. There is a decided preference for shores of small boulders and here the bright-green sheets plastering the rocks at low tide may form a complete cover for a vertical distance of 9-12 inches. On rocky shores the preference is for gently sloping surfaces rather than vertical faces.

By November there is generally some attenuation of the association, particularly in the upper parts, and during the hotter months it is frequently represented only by scattered individuals in the *Hormosira* association.

Plants are sometimes heavily parasitised by *Myrionema strangulans* Grev. flecking the thalli with numerous rounded brown spots 2-5 mm. in diameter.

Associated with the *Ulva* in some places are a few plants of *Cladophora flexuosa* Harv. forming rather dense basal clumps from which may be emitted a tuft of long sparsely branched filaments. The species has a narrow vertical range, often no more than 3 inches, its exact position depending upon degree of exposure but usually occurring just above the *Galeolaria,* and marking the upper limit of the dense band of *Ulva* where this is present.

Another species sometimes found in the association though more usually found at lower levels, is *Bryopsis australis* Sonder, the soft heavy dark-green clumps scattered here and there amongst the *Ulva* on bouldery shores, while a species of *Ralfsia* sometimes forms chocolate-brown crusts over small boulders and stones particularly where there is some localised shading from adjacent boulders.

(d) Lower littoral

(9) *Hormosira* association.

The presence of a yellow-brown band of *Hormosira banksii* is a conspicuous feature of most rocky and bouldery shores in sheltered localities at Port Arthur (see Plates 3 and 4) and the distribution of this

species is shown in Figure 1. The position and sharpness of the association's upper limit varies with the habitat being most distinct on rocky shores with a slope of 30°-45° where it is bounded above by a well marked white band of *Galeolaria*. On vertical faces the cover, generally developed on the calcareous tubes, is sparse and the irregular upper boundary 3-6 inches below upper *Galeolaria*. Where the slope is very gentle the association ascends a little higher, the uppermost plants taking advantage of any small chinks or pock marks in the rock surface. The extreme vertical range of the association is in the vicinity of 18 inches.

Being in the main bouldery and fairly steep, the dolerite shore carries, for the most part, only a narrow band of *Hormosira*, and it is on the mudstone pavements of Opossum Bay that the association is seen at its best. Here it spreads out horizontally, often for several yards, densely covering the platform with the lax chains of fleshy yellow-brown beads.

In such positions the dense cover may almost completely exclude *Galeolaria* which on vertical faces extends well into the association.

Frequently associated with the *Hormosira* is an understory of several species chief of which is *Corallina pilulifera* Post. and Rupr. This species sometimes with *Jania* sp. forms a low dense coralline carpet providing an ideal substrate for the other small constituents of the association. *Corallina*, when associated with *Hormosira*, ascends considerably higher than on bare rock surfaces probably because the sheltering *Hormosira* prevents excessive desiccation. In the mid and lower parts of the association *Lithothamnion incisum* Fosl. sometimes consolidates the carpet with its rounded encrusting plates. *Corallina* is not invariably present with *Hormosira*, and its intolerance of muddy conditions forces it in some places to leave the association.

Apart from the *Corallina*, the understory usually is not dense, and though several species have been collected mainly in the mid and lower parts of the association, most of them are somewhat sporadic in occurrence. Species which do appear fairly regularly are *Laurencia botryoides* (Turn.) Gail. and a small procumbent species of *Gigartina*. Where *Hormosira* is sparse, gelatinous light-brown colonies of *Leathesia difformis* (L.) Aresch. and of the inflated *Colpomenia sinuosa* (Roth) Derbes and Solier have been found on occasions particularly in the more exposed localities.

A species entering the association in some places on the bouldery shore though seldom on the platforms is *Codium fragile* (Suringar) Heriot. Within the "Sheltered" localities it appears to enjoy the more exposed positions, and in extremely sheltered localities, if present at all, is poorly developed and covered with a muddy sediment. Typically, the robust dark-green dichotomously branched plants, generally densely tomentose, are fairly scattered, but just occasionally in a very limited area may form an almost complete cover. The plants commonly carry an epiphytic growth species of *Ceramium* including *C. paniculatum* which sometimes forms a dense red fringe almost completely obscuring the frond. Less frequently *Acrochaetium codicola* Boergs. may form a similar, but shorter and finer fringe.

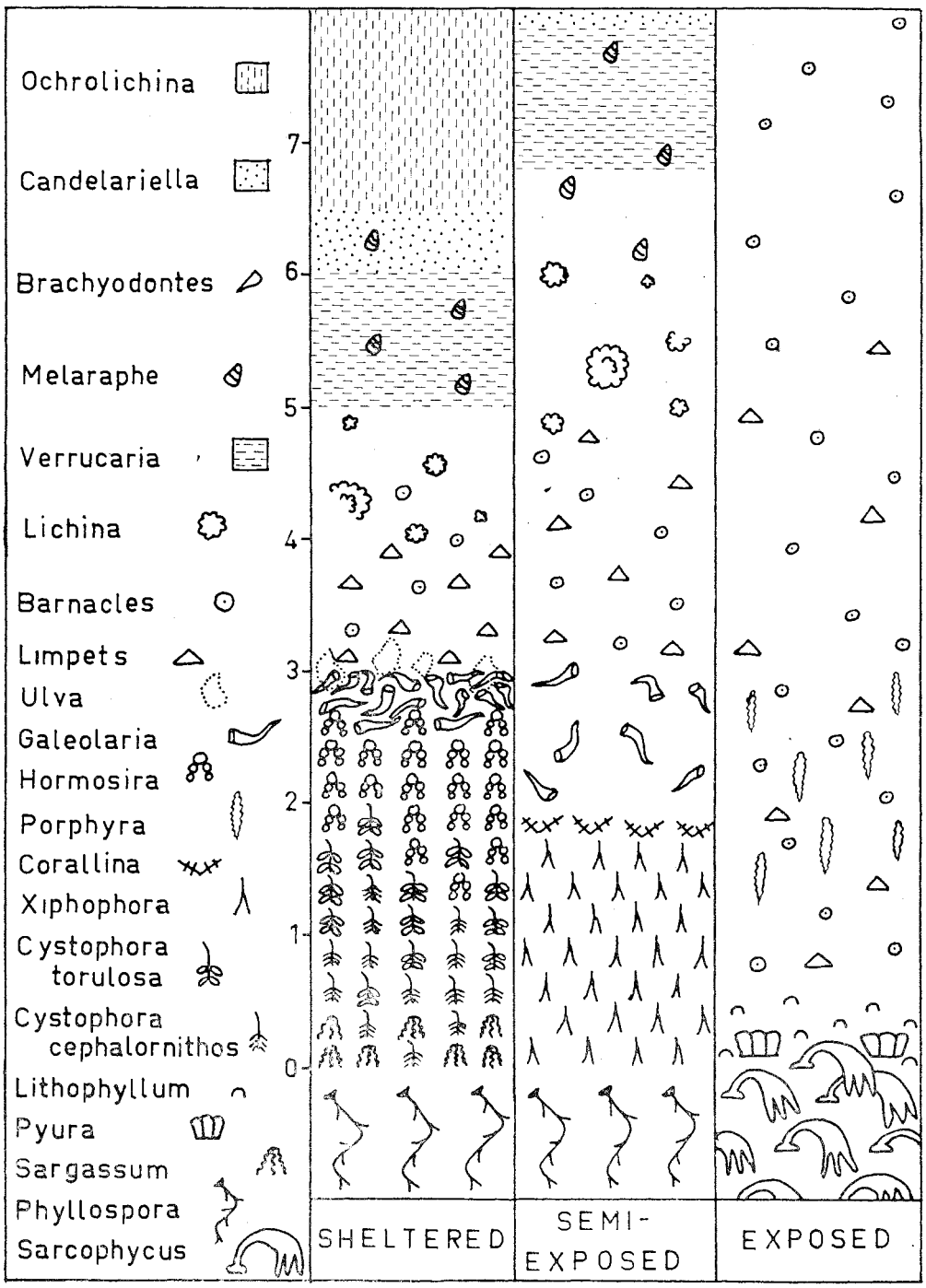

FIG. 2.—A generalized representation of the zonation of the more prominent floral and faunal bands on rocky shores of moderate slope. Zero is the approximate position of E.L.W.S. and the measurements are given in feet.

As already mentioned, *Ulva lactuca* sometimes joins the association and where a vigorous growth of *Codium* has also developed, the *Hormosira* may have to share its dominant position with these two species.

The form of *Hormosira* shows some variation depending mainly upon the degree of exposure to which the plants are subjected, those from the most sheltered positions being densely branched with large soft pale-yellow spherical internodes occasionally up to one inch in diameter, while in more exposed positions the plants are more sparingly branched and the smaller, firmer and more oval or cylindrical internodes may take on a darker colour. *Hormosira* does not seem to be intolerant of muddy conditions and at Boomer marsh, some miles from Port Arthur, large areas are covered with healthy plants attached to mussels half buried in the soft mud.

Plants of the parasitic *Notheia anomala* Bail. and Harv. are sometimes found issuing from the conceptacles of *Hormosira*, and at times various epiphytes are present. The blue-green *Symploca hydnoides* Kuetz. may form gelatinous olive-green collars at the nodes, *Polysiphonia fuscescens* Harv. appears epiphytically in somewhat muddy localities, and on various occasions *Ulva lactuca*, *Punctaria plantaginea* (Roth.) Grev., *Griffithsia monilis* Harv., *Ceramium paniculatum* and *Ectocarpus mitchellae* Harv. have all been found on *Hormosira*. In general, however, the plants do not carry a heavy burden of epiphytes.

Mytilus planulatus (Lam.) is by no means restricted to the "Sheltered" areas and its main requisite seems to be a horizontal or gently sloping surface at a suitable level. Since the bouldery dolerite shore provides this only occasionally in very localised positions, the occurrence of *Mytilus* on this type of shore is sporadic, and it is generally more common on the mudstone platforms where it occupies roughly the same vertical range as the *Hormosira* among which it often occurs when the latter is not too dense. But neither its upper nor lower limit is sharply defined, and it may extend in both directions for a short distance beyond the *Hormosira* (see Plate 4). As a rule, dense mussel beds are not found, the species occurring only as scattered individuals or small groups. Its vigorous development on wharf piles seems at variance with the preference shown on rocky shores for the more nearly horizontal surfaces, and in Long Bay the wooden piles of an old wharf carry a dense band of mussels sometimes with a vertical extent of 3 feet. In this position the upper shells often support a bright-green growth of *Enteromorpha* sp. which is replaced further down by *Ulva*. In the lowest part of the *Mytilus* range there is some mingling with sponges before *Ecklonia radiata* (Ag.) J. Ag. takes over in the sub-littoral. *Hormosira* is absent from these piles and is seldom found attached to wooden surfaces.

The *Hormosira* is gradually replaced downwards by a series of associations each passing insensibly into the one above or below, but each in turn reaching maximum development about the middle of its range where for a short distance the dominant may occur as an almost pure stand (see Plate 4).

Though general appearance of a species is often no reliable indication of drought resistance the four species of this series do show a gradation in fleshiness from the stout water-filled internodes of the upper-most *Hormosira* to the somewhat membranous blades of the lowermost *Sargassum,* and this diminution in fleshiness could reasonably be correlated with the increasing intolerance to exposure in the plants of this downshore succession.

(10) *Cystophora torulosa* association.

The first of these species to compete with the *Hormosira* is the fleshy bright-yellow *Cystophora torulosa* (R. Br.) J. Ag. The uppermost plants appear about 9 inches below the upper limit of the *Hormosira* association and gradually increase in numbers downwards till at a point approximately 9-12 inches below the upper *Hormosira* it assumes a position of dominance which it retains for perhaps 5-6 inches.

In common with *Hormosira,* it may overlie the same Coralline carpet with the scattered plants of *Laurencia* and *Gigartina. Corallina cuvieri* Lamx. which is rare among the *Hormosira* becomes more common here.

Though frequent on the bouldery dolerite shore, this *Cystophora* is, like *Hormosira,* best developed on the platforms when the association spreads out horizontally displaying the zonation of the species to much better advantage.

The luxuriance of the association varies considerably within the "Sheltered" category and with increasing exposure it is usually the first of these four species to disappear.

(e) Sub-littoral fringe

(11) *Cystophora cephalornithos* association.

Cystophora cephalornithos (Labill.) J. Ag. is confined to the lowermost part of the littoral zone and to the sub-littoral fringe. It first appears among the lowermost plants of the *Hormosira* association gradually increasing in numbers till it ousts *Cystophora torulosa* from its dominant position and forms a band of variable purity in the sub-littoral fringe. The simple or sparingly branched stems, generally 1-2 feet long, are clothed towards the apex with densely placed slender ramuli, but the lower part of the rachis is quite denuded and, if not encased by a bright pink encrusting coralline, usually carries a number of small epiphytes, including *Sphacelaria biradiata* Askenasy.

(12) *Sargassum laevigatum* association.

The final algal association before the sub-littoral proper is constituted by the densely bushy plants of *Sargassum laevigatum* J. Ag. These occur in a very narrow band at a slightly lower level than the main band of *Cystophora cephalornithos,* but in company with this species can be regarded as occupying the sub-littoral fringe. Its preference is for positions slightly more exposed than those favoured by *Cystophora torulosa,* and though the two are often found on the same shore, in localities where it shows optimum development the *Hormosira* may pass almost directly into the *Cystophora cephalormithos* and *Sargassum* associations without an intervening band of *Cystophora torulosa.* In such positions other

species may enter the sub-littoral fringe though usually in small numbers. *Cystophora spartioides* (Turn.) J. Ag. and *Sargassum muriculatum* J. Ag. are two of the larger species found sporadically while stunted plants of smaller species such as *Zonaria subarticulata* (Lamx.) Papenfuss and *Cladostephus verticillatus* (Lightf.) Ag. may occur quite commonly though typically both belong to the sub-littoral. The *Cladostephus* seems to show a preference for positions where sand overlies the rocks.

The coralline understory constituted by *Corallina pilulifera* and *Jania fastigiata* Harv. may descend into the *Sargassum* association but this usually marks its lower limit. However, *Corallina curvieri* which first appears in the lowermost part of the littoral and in the sub-littoral fringe may extend into the sub-littoral though it is not a common species at Port Arthur.

(f) Sub-littoral

(13) *Phyllospora* association.

An extensive and well developed sub-littoral vegetation is present on most rock surfaces at Port Arthur, the uppermost association of this region generally being formed by *Phyllospora comosa* (Labill.) C. Ag. The strap shaped stems often 6-9 feet long closely beset with coarsely toothed leaf-like processes are buoyed up by numerous large oval vesicles and form a dense band often 6-12 feet wide clearly marked by the numerous sharply pointed " leaves " projecting above the surface of water. The uppermost holdfasts may occasionally be just exposed at E.L.W.S. but the association here is definitely one of the sub-littoral and not the sub-littoral fringe. In these " sheltered " localities the plants usually extend no deeper than a point about 6 feet below E.L.W.S.

This dark semi-floating mass is often so dense that the light intensity beneath it must be very considerably reduced, and this is borne out by the fact that the understory in these positions is often very sparse, the main vegetation consisting of the bright pink encrusting corallines which here are exceptionally well developed and cover a large proportion of the rock surface.

A few epiphytes may be present chief among which is generally *Polysiphona cancellata* Harv., and the leaves may sometimes carry a fine, light-pink granular coating of *Melobesia* (?).

(14) *Cystophora retroflexa* association.

The heavy development of *Cystophora retroflexa* (Labill.) J. Ag. which often occurs in a band just below the *Phyllospora* seems to warrant the rank of association. Densely branched plants of a pale straw colour when fresh are, like the *Phyllospora,* buoyed up by numerous rounded or oval vessicles about the size of a pea, and the association is marked by the numerous slender terete pinnules protruding above the surface of the water. Though the band is dense, it has not the same light excluding properties as the *Phyllospora* association and consequently does not noticeably reduce the density of the understory.

(15) *Macrocystis* association.

The third of these semi-floating associations is constituted by *Macrocystis pyrifera* (L.) Ag. Certainly it does not show maximum development in these very sheltered localities but nevertheless where a rocky bottom is present it does frequently form a fringing bed of variable density and width. There may be some mingling with the *Phyllospora* and *Cystophora retroflexa* but in the main the beds are found beyond these bands. In calm weather portions of the blades project above the surface in graceful arcs marking the extent of the bed, a beautiful sight with the sun shining through the projecting golden laminae. Like the *Phyllospora* a dense cover may considerably reduce the light intensity on the floor below and the understory suffers a corresponding attenuation.

The epiphytes of *Macrocystis* show their best development in these very sheltered localities and the blades sometimes carry numerous plants of *Polysiphonia frutex* Harv. Other epiphytes occur sparingly particularly on old and decaying blades, and include *Ectocarpus confervoides* (Roth) Le Jol., *Ceramium* sp. and *Polysiphonia* sp. On some plants the small parasitic *Myrionema densum* Skottsberg forms numerous rounded or oval brown spots 0·5-2 mm., in diameter, over blades, bladders and stipes.

(16) *Ecklonia* association.

Covering a great deal of the bouldery floor in the sub-littoral is a fairly dense vegetation of variable composition and density, dominated by members of the *Phaeophyta*. The most important of these is usually *Ecklonia radiata* with its broad pinnatifid lamina 1-2 feet in diameter borne on a tough cylindrical stipe the whole plant generally 2-4 feet in length. This species may occur in the sub-littoral anywhere from E.L.W.S. and the uppermost plants are occasionally just uncovered by extremely low tides. Generally, however, competition with *Phyllospora* reduces its numbers in the upper part of the sub-littoral and it is beyond the *Phyllospora* association that more optimum development is exhibited. Sponges, bryozoans and other animals are frequently sheltered by the much branched holdfast, and the lamina, particularly in older plants may carry a few epiphytes though it is usually not heavily burdened.

The sub-littoral has not been studied in detail, but, observed from a boat in calm weather, the *Ecklonia* appears to be accompanied by a rich flora of sub-littoral species, most prominent among which are members of the *Phaeophyta*. These larger forms no doubt shelter a variety of smaller Rhodophytes which are sometimes cast up after rough weather. Of the accompanying larger Phaeophycean species perhaps the most common is *Zonaria subarticulata*, the densely crowded flabellata fronds forming regularly hemispherical cushion like masses on boulders among the *Ecklonia*. Other frequently occurring species are *Cystophora paniculata* (Turn.) J. Ag., *Carpoglossum confluens* (R. Br.) Kuetz., *Dictyopteris muelleri* (Sonder) Schmidt, and *Sargassum verruculosum* (Mert.) J. Ag. with its slender axis often several feet long, buoyed up by exceptionally large vesicles. *Sargassum grande* J. Ag., probably the largest species of the genus in these waters, may also be an important constituent in

places, sometimes reaching such density that the bottom is completely obscured by the great plants which ascend to the surface from a depth of at least 12 feet.

Bright patches of pink encrusting corallines and other encrusting red algae sometimes show through the cover of larger brown algae, and here and there are spread out horizontally brackets of the dull red *Ethelia australis* (Sonder) W. v. Bosse sometimes reaching 9 inches in diameter. Amongst other red species often seen in the sub-littoral are *Plocamium telfairiae* Harv., and *Polysiphonia cancellata.*

The Chlorophyta are sometimes represented by brilliant green pure patches of *Caulerpa hypnoides* (R. Br.) Ag. and more rarely by *Caulerpa brownii* Endl. and the smaller *Caulerpa sedoides* (R. Br.) C. Ag. Scattered filaments of the inconspicuous *Chaetomorpha aerea* (Dillw.) Kuetz., occur on the rocks and occasionally a tuft of the beautiful plumose *Cladophora feredayae* Harv. or the finer *C. gracilis* (Griff.) Kuetz. makes a bright green splash of colour.

Sponges are common in the crevices between the boulders and the large flattened shells of the inconspicuous, *Haliotus noevosa* Martyn often cling tightly to the rock faces.

2. *SEMI-EXPOSED SHORE*

The shores of this division are characterised by the appearance of the brown alga *Xiphophora billardieri* unaccompanied by either *Hormosira banksii* or *Sarcophycus potatorum,* the species characterising the "Sheltered" and "Exposed" shores respectively.

(*a*) *Supra- and upper-littoral*

The associations of this region have already been discussed when dealing with "Sheltered" shores though with the increased exposure they suffer some modification.

When the aspect is favourable encrusting lichen associations are again present though the bands are extended and elevated as compared with their representatives in "Sheltered" situations. *Lichina confinis* also is often well developed.

Bostrychia, on the other hand, cannot tolerate the more exposed conditions and is found only rarely, and then only as very poorly developed tufts in narrow crevices between the boulders.

Bembicium does not extend beyond the "Sheltered" shores, but *Melaraphe unifasciata* remains with an increased vertical range.

(*b*) *Mid-littoral*

The limpets are again well represented, other species sometimes joining the *Cellana* and species of *Siphonaria* mentioned previously. *Elminius* sp. is usually absent except very locally where it receives extra shelter, and its place is taken by *Chamaesipho columna,* another small species with a far greater vertical range extending from the lower *Lichina* to upper *Galeolaria.* With the increasing lack of locally sheltered

situations the numbers of *Tetraclita purpurascens* dwindle but in addition, in the more exposed parts, the large surf barnacle *Catophragmus polymerus* Darwin, occurs. This, though more characteristic of " Exposed " shores, is sparsely developed in some places in this division.

Rivularia australis occurs seasonally in much the same position as on " Sheltered " shores, but here is often less well developed.

Chordaria dictyosiphon, Hildenbrandtia sp. and *Monostroma* sp., are all plants of the " Sheltered " shores and have not been found here.

(1) *Galeolaria-Gelidium* association.

The *Galeolaria* approaches its limit of tolerance to exposure in the more exposed parts of these " Semi-exposed " areas and in such places is very sparsely developed. With the accompanying *Gelidium* which shows a similar or slightly reduced exposure tolerance, it is present in a well developed band along most of these shores though it certainly shows maximum development in less exposed positions. There being no competing band of *Hormosira* it extends almost to the upper boundary of the *Xiphophora* association. Other algae do occur, however, over the tubes; *Ulva* is often present somewhat seasonally though usually not as thickly as in the " Sheltered " localities, and perhaps the species most commonly present is *Bryocladia ericoides* (Harv.) Schmitz a small setaceous Rhodophyte forming black mat-like patches particularly in the lower part of the *Galeolaria* band which provides such an excellent substrate. Also in the lower part of this band are often a few plants of *Laurencia botryoides*. Where slope is very gentle *Ceramium fastigiatum* Harv. may occur both above and within the *Galeolaria* forming extensive soft dull red, velvet-like colonies often 6-12 inches in diameter. Other small species at times form low colonies, and compact tufts of *Cladophora flexuosa* in some places occur in the upper part of the *Galeolaria*.

(c) Lower littoral

(2) *Corallina* fringe.

Bounding the *Xiphophora* association along its upper margin is a narrow fringe of low shrubby *Corallina officinalis* L. occupying a narrow strip of shore generally no more than 1-3 inches in vertical extent. In the absence of the protecting *Hormosira,* this species seems unable to ascend any higher into the littoral and bounds the *Xiphophora* association much as the narrow strip of white *Galeolaria* bounds the *Hormosira* on very sheltered shores. Depending upon the density of the *Xiphophora* it may penetrate for 1 foot or sometimes more below this narrow band, but a dense cover of *Xiphophora* may exclude it almost completely. On vertical faces, particularly where shaded, the rigid *Corallina officinalis* is often replaced by the more lax *C. gracilis.*

Bryocladia ericoides sometimes mingles with the fringe and another small species often associated with it is *Lophurella hookeriana* (J. Ag.) Falk., its tufts of terete black branches being much the same height as the *Corallina.* Stunted *Laurencia botryoides* occurs occasionally.

The fringe often suffers from excessive exposure and insolation during summer and the calcareous tufts may then be bleached to a bright white.

(d) Sub-littoral fringe

(3) *Xiphophora* association.

The limit of tolerance of *Xiphophora* for shelter and of *Hormosira* for exposure correspond fairly closely so that there is very little overlapping of the two associations. Where both are found on the same shore the limits of neither association are well defined but on the whole, the *Xiphophora* seems to appear about 1 foot below the upper limit of *Hormosira*.

Where well developed, the narrow strap-shaped thalli form a practically pure association with a sharply defined upper margin bounded by the *Corallina* fringe. As already mentioned the *Corallina* may extend some distance into the association but is generally soon replaced by the encrusting corallines. The vertical extent of the association varies as a rule between 1 and 3 feet generally thinning out before reaching the *Phyllospora* association, and this region between the main part of the *Xiphophora* association and the upper part of the *Phyllospora* is often a rich collecting ground for the larger red algae. This is so particularly on bouldery shores where in this sub-littoral fringe together with numerous other species there have been collected *Plocamium costatum* (J. Ag.) Hook. and Harv., *P. telfairiae, Laurencia elata* (C. Ag.) Harv., *Gelidium australe* J. Ag., *Chondria* sp., and *Champia tasmanica* Harv. On these bouldery shores *Codium fragile* may also be present in the lower part of the *Xiphophora* band, and *Ulva lactuca* excluded from the denser parts of the *Xiphophora* association may sometimes reappear here. The grey-green tufts of the bristle-like *Chaetomorpha aerea* often occur particularly on shaded rocks where they are frequently developed on the coating of encrusting corallines, and the beautiful *Chaetomorpha darwinii* (Hook.) Kuetz. with its filaments of large glistening turgid cells like a string of green beads often occurs attached to other algae. Brown algae including *Cystophora* spp., *Zonaria subarticulata* and *Ecklonia radiata* may also be present in the lower parts of the association though the latter two are typically plants of deeper water.

(e) Sub-littoral

(4) *Phyllospora* association.

The *Phyllospora* association seems to reach its maximum development along these shores and is almost invariably present as a dense fringing bed of variable width depending on the steepness of the shore. Here the tall plants penetrate to somewhat deeper levels than along " Sheltered " shores.

Cystophora retroflexa is unable to withstand the increased exposure and is for the most part absent.

(5) *Macrocystis* association.

Macrocystis pyrifera again forms fringing beds often better developed than in " Sheltered " localities, and the vegetation of the sub-littoral seems in the main to be dominated by *Ecklonia radiata*.

3. *EXPOSED SHORE*

Included in this category are the eastern shores of Port Arthur from The Budget to a little north of Denman's Bay, the eastern and south-eastern shores of Point Puer and most of the rocky shore extending from Safety Cove to Half Moon Bay.

Though the prevailing wind is north-east, south-westerlies are frequent and it is these which bring into Port Arthur the big seas from outside which, crashing against the eastern shore often send spray to a height of 100 feet or more and make this stretch of shore one of the most exposed in Port Arthur.

Point Puer escapes the greatest force of these south-westerlies, and north-easterlies do not as a rule build up such large seas within Port Arthur. As a result of this escape from the most intense wave action coupled with the presentation of roughly horizontal and vertical rather than sloping faces, the vegetation here presents some differences from that of the eastern shore. However, all these shores have one species in common, the massive "Bull Kelp", *Sarcophycus potatorum*.

3A. *EXPOSED SHORE OF POINT PUER*

At Point Puer there appear the shaly mudstone cliffs, up to 100 feet high, of laminated mudstone ranging in colour from cream to light-brown and grey (see Plate 9). In general there is a gradual increase in the hardness of the strata from top to bottom of the cliffs, the upper layers being easily dug out with a pocket knife and frequently showing signs of falling away in small sections while in the littoral zone the severe buffeting of the waves causes no such rapid and noticeable erosion though falls occur occasionally at the junction of platform and cliff face where there is sometimes a certain amount of undercutting. These wave-cut platforms have been mentioned by Newton and Cribb (1951).

In places, a series of platforms each dropping to the next by a step of 2-8 feet has been formed but where this happens the platforms are generally comparatively narrow and often no wider than 6-8 feet. Elsewhere however platforms may reach a width of 40 feet or more.

Along the eastern exposure of the point the strata in the southern half dip gently to the south-west and along the northern half to the north-west so that in several places a platform tilted gently landwards may gradually emerge from the sub-littoral and at various points occupy different positions in the sub-littoral and littoral zones so that each algal association is in turn spread out horizontally over the platform surface. Along the south-eastern shore there is apparently less variation in the resistance of the strata continually exposed to the eroding action of the waves and the cliffs often drop sheer into the sea or occasionally by a series of very narrow platforms or ledges each separated by a step of 6 feet or more.

Along this shore also there have been eroded several caverns the largest about 30 feet wide and 20 feet high at the mouth and approximately 100 feet long. Unfortunately, little description can be given of the flora of these caves as they are quite inaccessible from land and being situated on the most exposed part of Point Puer, to take a boat inside is

hazardous even in the calmest weather. But from observation made near the entrance it appears that quite close to the mouth all the larger and shrubby species disappear leaving only the encrusting corallines which give way further in to the more shade tolerant *Hildenbrandtia* which forms a smooth dull-red covering over the rock surface.

(a) Supra-littoral

(1) Lichen associations.

The lichen associations of the supra-littoral differ from those already described for the dolerite shore, and though where a southerly aspect is locally available *Ochrolichina parella* and *Patellaria rimosa* may appear, particularly on the harder strata, these species never form the distinct bands formed on the dolerite. The softer substrate seems unsuitable for their growth and even where present the colonies are not readily detected against a pale-cream background of mudstone. However, these cliffs do support quite a rich though inconspicuous lichen flora, one of the most common members being a species of *Buellia*. On the south-eastern shore at a point where a landing was made there is some development of the orange-yellow lichen association extending upwards for about 70 feet from a point 10-12 feet above the *Sarcophycus*. A species of *Collema* appears about 3 feet above the lower limit of this association and occupies a band 30-40 feet wide which must frequently be drenched with salt spray.

Lichina confinis appears on Point Puer only rarely.

(2) Supra-littoral pools.

There occur occasionally on the supra-littoral platforms a few wide shallow pools fed by spray from heavy seas. One of these which received a certain amount of freshwater seepage and which during heavy rain must become nearly fresh, was almost entirely covered with a carpet of *Enteromorpha* sp., while another smaller pool less likely to be affected by seepage was lined with a dense olive-green fur up to 3 inches long of *Lyngbya confervoides* Ag.

(3) *Prasiola* community.

At two point on the south-eastern exposure of Point Puer a species of *Prasiola* occurs on the cliff face below the roosts of shags and gulls and in one case extends as a prominent green stain from almost the top of the cliffs to approximately H.W.M. *Prasiola* is a genus which has commonly been reported from cool temperate and polar regions particularly in areas enriched by nitrogenous matter. The shaded aspect of these cliffs particularly during winter when they receive hardly any direct sunlight probably favours the development of the species and during January and February only a trace of the community can be found in the lower part of its range.

(b) Upper littoral and mid-littoral

The littorinid *Melaraphe unifasciata* may enter the upper part of this region but is more usually found in the lower part of the supra-littoral which often receives considerable spray. However, a smaller and usually less common species *M. praetermissa* (May) may sometimes be found throughout the upper littoral. But as in sheltered and semi-

exposed localities this part of the shore is frequently bare of algae and is dominated by the small barnacle *Chamaesipho columna*. This is a species with a very definite preference for horizontal or gently sloping surfaces and though a few individuals do occur on the vertical steps it is on the platform surface that it reaches maximum development. Here the tall narrow shells up to three-quarters of an inch high are very densely crowded and spread as a spiny grey sheet over the smooth platform surface.

In a few places a species of *Verrucaria* forms a close black intermittent crust on the rock surface between the barnacles and sometimes on the lower part of the shell.

Brachyodontes rostratus sometimes appears densely in the lower parts of the *Chamaesipho* range, the narrow spaces between the barnacles providing an excellent alternative to the cracks and pits of the rock surface to which this small mussel is usually restricted.

In the lower part of the mid-littoral below the *Brachyodontes*, *Mytilus planulatus* is often conspicuous, occurring singly, in small groups or dense patches several feet across. The colonies occur particularly, though not necessarily, in very slight depressions and in such positions *Corallina officinalis* may mingle with the shells where not too densely placed.

Ulva is common on the *Mytilus* and it is at about this level that there sometimes appear a few plants of the fleshy brown *Splachnidium rugosum* (L.) Grev. and of *Adenocystis utricularis* (Bory) Skottsberg, a small brown species in the form of a tough velvety elongate-pyriform vesicle 1-2 inches long and usually filled with water. Though it extends into the lower littoral, the surf barnacle *Catophragmus polymerus* is often common at this level and frequently grows on the shells of *Mytilus*. Like *Chamaesipho* it shows a decided preference for horizontal and gently sloping surfaces and in such a position where the foaming surf races across the platform the large scaly white shells may be very closely placed.

(4) *Porphyra* and *Scytosiphon* associations.

During winter and spring months there is developed on parts of Point Puer, two seasonal algal associations constituted by *Porphyra umbilicalis* and *Scytosiphon lomentarius* respectively. These associations occupy the mid littoral and sometimes the lower part of the upper littoral but on Point Puer they tend to be rather sporadic in occurrence and the reasons for their presence and absence is not always readily apparent. It is even difficult to determine the relative positions of the two species, sometimes one appearing to occupy the higher level and sometimes the other, but whatever their relative positions both are almost entirely pure associations and there is hardly any mingling of the two species.

The lower plants of *Scytosiphon* are generally constricted tubulose and semi-fleshy while the upper ones are lax, thin, flattened tubes which densely plaster the rocks as the waves recede and after prolonged exposure may become almost brittle dry.

(c) *Lower littoral*

(5) Encrusting coralline association.

The uppermost algal association of the lower littoral is the encrusting coralline association characterized by two species either of which may be present alone though generally occurring together.

The first of these two is a pale-pink encrusting species which on the very greatly sloping platform surface appears generally in the lower part of the *Catophragmus* range. At first it is restricted to the very shallow depressions and cracks, but lower down it forms a complete dull fine cover over the rock surface. Over this coating there generally occur a number of algal species which vary considerably with the level, degree of shade, distance from the platform edge and other factors. *Mytilus* and *Catophragmus* are generally present at least in the upper parts and the limpets *Siphonaria diemenensis, Patellorida marmorata* (Ten.-Woods), and *Cellana* sp. are nearly always common and often associated with an occasional chiton. A few tubes of *Galeolaria caespitosa* may be scattered here and there, where the exposure is not maximal, but in these positions, where it is very close to its limit of tolerance of exposure, it never forms the distinct band found on more sheltered shores and is without the usually accompanying *Gelidium pusillum.* Green tufts of *Ulva* are scattered here and there, and *Corallina officinalis* often colonizes small shallow pools or depressions. Succulent-spongy clumps of *Polysiphonia macrarthra* Zan. are widely scattered and *Adenocystis utricularis* sometimes appears in small numbers. One of the most noticeable species is a small semi-prostrate *Ceramium* which forms large velvety dull-red colonies at first circular but later ring shaped and up to 9 inches in diameter.

The other species characterising the association is *Lithophyllum hyperellum f. fastigiata* Fosl. a species nearly always found on shores supporting *Sarcophycus,* and like it, always indicative of very exposed conditions. It is a most striking species forming pinkish to biscuit-brown cushion- or dome-shaped colonies up to 3 inches in diameter (see Plate 8.) The colonies are firmly attached to the rock surface and the densely placed erect and radiating branches which become partly fused form a dense coralloid mass with a beautifully rounded outer surface. Both vertical and horizontal faces support the colonies but it is near the seaward margin of the platform surface that the most symmetrical and well developed colonies are found. But even here, injury, an uneven surface or contact with other species may result in some distortion of the colonies. When broken from the substrate they are seen to be sheltering a large number of the small bivalves *Lasaea australis* Lam. The branches in the mid part of the colony often show a dull blue-green colour and this is caused by the perforating alga *Entophysalis deusta* (Meneghini) Drouet and Daily.

On the vertical margins of the platforms these encrusting species form a fairly distinct band. The width of this band averages 3-6 inches but is very responsive to variation in degree of light intensity, a low intensity resulting in an increase in the width while greater insolation may cause its almost complete disappearance. In the more shaded positions favouring an increased development, *Ralfsia* sp. frequently appears as sharply contrasting black encrusting colonies at first circular but later often ring shaped and up to one foot in diameter. The lowermost part of the crust on vertical faces often carries tufts of *Corallina gracilis,* a lax species with pendulous branches arising from a dense basal disc, and this too is favoured by increasing shade.

(6) *Laurencia* association.

The vertical faces along parts of Point Puer provide some of the best examples of sharp banding available at Port Arthur, and the coralline crust is replaced below with remarkable suddenness by a dense dark band of red algae with a particularly sharp though somewhat irregular upper margin (see Plate 5). During the colder months the dominant species in positions of average illumination is *Laurencia botryoides*, the low bushy plants forming a dense dull-red scrub seldom over two inches high. Associated with the *Laurencia* are nearly always a number of other small Rhodophytes generally of a dark-red or almost black colour. These include *Bryocladia ericoides, Lophurella hookeriana, Gigartina ancistroclada* Mont., *Ballia scoparia* Harv., and most important, *Lophurella periclados* (Sonder) Schmitz, with erect branches each bearing towards the apex a dense club shaped mass of finer lateral branches. Where a platform occurs at a suitable level this association is spread out over the platform surface as a close low turf varying in composition as shelter increases slightly away from the platform margin. Other species may also join the association and these include *Gigartina* sp., *Codium fragile* and occasionally stunted plants of *Hormosira*. *Lophurella periclados* is rather more tolerant of shady conditions than the *Laurencia* and may be the main constituent of the band when reduced light intensity has removed the *Laurencia*. In these positions the dull grey-green tufts of the bristle-like *Chaetomorpha aerea* may be a common though inconspicuous constituent of the association. Unlike the *Lophurella*, *Laurencia* is markedly seasonal and during January and February only the basal parts of the plants sometimes with a few bleached and decaying branches can be found. However, the other constituent species seem to make good the loss and there is no very noticeable reduction in the density of the band. Where gaps appear in the association the encrusting corallines generally occupy the uncolonised surface and *Corallina gracilis* also penetrates the band where it becomes sparse particularly as a result of shading. A few tufts of *Chaetomorpha darwinii* sometimes occur among the *Laurencia* and short scrubby clumps of *Ulva* may appear epiphytically, but these form only a very small proportion of the algal cover and the association is predominantly a Rhodophycean one. The width of the band generally varies between 3 and 6 inches, and like that of the lithothamnion association above it is influenced by variation in light intensity, reduced insolation often resulting in extension.

(d) Sub-littoral fringe

(7) *Xiphophora* association.

The dark Rhodophycean band is sharply bounded below by the contrasting yellow-brown of *Xiphophora billardieri* which constitutes the succeeding band (see Plate 5). Plants in the upper inch or two of the *Xiphophora* range are often short and stumpy and here there may be some mingling with the lowermost individuals of the *Laurencia* association, though in the main the boundary between the two associations is very sharply marked.

The long narrow forked straps generally 1-2 feet long taper gradually from a width of about a quarter of an inch to a fine point, and as the waves recede the dense fringe of branches hangs laxly downwards often completely obscuring the rock surface for a distance of 2-3 feet. The

branches are quite without epiphytes and though a pink coralline crust may enter the lower part of the band, the association is in the main a fairly pure one and within the band of holdfasts, generally 12-18 inches, in width there are few other algae, at least where the association is well developed. But where for some reason the *Xiphophora* becomes sparse the *Laurencia* may often descend for another foot. Cranwell and Moore (1938) on the other hand report a varied and well developed understory to the *Xiphophora* association in New Zealand.

A conspicuous plant of the *Xiphophora* association is *Lessonia corrugata* Lucas. The massive branched holdfast is generally attached within the *Xiphophora* band and from it arise a great dark-brown mass of deeply corrugated strap shaped blades half to one inch in diameter and up to 6 feet long. These blades, often 200 or more from a single holdfast, are extremely strong, pliant and elastic, and though continually being worn away at the tip are replaced, at least for a time, by meristematic activity near the base. The blades are usually free from epiphytes though the holdfasts sometimes carry a coating of lithothamnia and a few small algae. The species forms a distinct band only in very localized positions and usually occurs scattered here and there along the *Xiphophora* band particularly in its lower parts. It is more tolerant of shade than *Xiphophora* and though probably able to withstand a greater buffeting than *Xiphophora,* it cannot survive the extreme exposure tolerated by *Sarcophycus.*

The *Xiphophora* can probably be regarded as forming a sub-littoral fringe though in the absence of *Sarcophycus* it may extend into the sub-littoral and on one occasion was seen at a depth of approximately 12 feet below E.L.W.S. However, these occurrences are exceptional, and in the main it is confined to the fringing band.

The downward extension of each of these three bands in the absence of the succeeding association suggests that each is prevented from attaining a full expression of its vertical range by competition with the association below it, though competition does not appear to be a limiting factor in the upward extension of the bands.

(e) Sub-littoral

(8) *Sarcophycus* association.

The *Xiphophora* is replaced below by an association dominated by one of the most striking algal species in Tasmanian waters, the large brown " Bull Kelp ", *Sarcophycus potatorum.*

A few plants sometimes appear near the upper limit of the *Xiphophora* association but in the main it occurs in quantity only below the *Xiphophora* band which its presence may reduce in width.

The uppermost plants may be regarded as belonging to the sub-littoral fringe, but dense submarine forests are formed at depths at least 12 feet below E.L.W.S. and it must be regarded as an association of the upper sub-littoral with its uppermost representatives entering the sub-littoral fringe.

The plant is attached by a large disc-shaped holdfast often 9 inches in diameter and from this arises a massive stipe 8-24 inches long sometimes attaining a diameter of 3 inches. This stipe though extremely

strong is of a somewhat rubbery consistency and is fairly pliant though rigid enough to remain fairly erect when the waves recede. At its upper and it becomes flattened and passes into a broad lamina. This is of the consistency of heavy leather and up to a quarter of an inch thick, and though at first an unbroken sheet up to 12 inches wide, upwards it divides in a roughly palmate manner into broad repeatedly and irregularly forked gradually tapering strap shaped segments near the apex often coarsely undulate and with a spiralled appearance. The total length in large specimens may often reach 15 feet or more. In some plants branches are borne in a pinnate manner or very short stipes along the margin of the individual portion of the main lamina and each of these in turn may be pinnately branched at the base and split into long tapering segments above. It is almost impossible to pull even a small plant from the rocks and an examination of drift specimens seems to indicate that their detachment is often due to the flaking away of the substrate rather than to any weakening of the holdfast itself.

Vertical faces will support the *Sarcophycus* but at Point Puer it reaches maximum development on or near the platform margins where the massive plants are lifted by the swell and crashed on to the pavement lashing it with a multitude of heavy laminae as it is withdrawn again by the foaming mass of water cascading off the platform (see Plate 7). During low water on a calm day the gentle swell lifts the weight of the lamina and the rhythmical movements of a stand of erect stipes near the platform margin vaguely suggest from a distance the motion of a group of black swans.

The great battering the plants receive is probably at least partly responsible for the almost complete absence of epiphytes over the whole plant. On a couple of occasions a short fur of *Ectocarpus confervoides* was found on a partly decayed lamina but apart from this the only species found is an, as yet, undescribed species of *Compsonema*, which frequently forms small rounded or ring shaped colonies up to half an inch though generally less in diameter. These do not appear to be responsible for the large holes so commonly occurring in the thallus. According to Whitting (1893) these holes are caused by the parasitic *Chlorocystis sarcophyci* Whitting but no sign of this species has been found in the Port Arthur specimens.

Durvillea antarctica (Cham.) Hariot which forms a comparable association in New Zealand appears to occupy a slightly higher level on the shore occurring, according to Oliver (1923), in the lower part of the mid-littoral. Oliver mentions that the segments of the thallus are usually broken off at the ends but this is hardly ever the case with *Sarcophycus* though the laminae do show signs of being continually worn away at the margins. *Sarcophycus* seems to be of a much more pliant consistency and the narrow laminae sometimes become tied in tight thumb knots without showing any sign of cracking.

Oliver also notes the honeycombing of the holdfast by various moluscs, but this caverning is seen only to a very limited extent in *Sarcophycus*. Certainly in an attached plant there are no visible signs of these cavities as figured by Herriott (1923) for *Durvillea antarctica*, though when a holdfast is removed from the rock a certain amount of channeling is revealed. This results from the activities of a small white amphipod,

but usually does not extend far into the tissues and seems seldom to reach a stage where the efficiency of the holdfast is seriously impaired. Oliver reports a variety of animals in the *Durvillea* holdfast but the amphipod is the only species found in the *Sarcophycus*.

The *Sarcophycus* association also differs from the *Durvillea* association in having very little understory, at least in its upper parts. Oliver reports a fairly dense growth of various smaller algae occurring among the *Durvillea* stipes but at Port Arthur this second story is very poorly developed. Often the only alga occurring in quantity is an encrusting coralline which in the mid and lower parts of the association may almost completely cover the rocks beneath the *Sarcophycus*, its bright pink crust contrasting strongly with the pale-yellow discs of the *Sarcophycus* holdfasts.

(9) *Phyllospora* association.

Phyllospora comosa can be seen in the upper sub-littoral in places along this shore. For the most part the platforms drop sharply into deep water and it is difficult to see anything but the uppermost part of the sub-littoral vegetation. However, the *Phyllospora* is fairly common sometimes reaching a length of at least 10 feet and it probably forms an indefinite association below the *Sarcophycus* at a depth somewhat greater than that in sheltered localities.

A number of Rhodophytes are found cast up only after bad storms and most of these probably come from the lower sub-littoral in these exposed positions. They include *Ballia robertiana* Harv., *B. mariana* Harv., *Plocamium coccineum var. flexuosum* Harv., *Ptilonia australasica* Harv., *Gelidium glaudulaefolium* Hook. and Harv. and several others.

(10) *Macrocystis* association.

Macrocystis fringes this shore showing very good development in water up to 45 feet deep, and when dense, has a small effect in reducing the severity of the swell reaching the shore (see Plate 9).

3B. *EXPOSED EASTERN SHORE OF PORT ARTHUR*

The eastern shore of Port Arthur is a comparatively unbroken stretch of coast about three miles in extent and subject to increasing exposure southwards. The shore is for the most part steep and dolerite slopes of 30° and often more rise often to 50 feet above the sea, while in places dolerite cliffs sometimes showing organ pipe structure fall vertically into the sea without any intervening slope. There is always considerable swell along this shore and in only a couple of places has it been possible to effect a landing. The rough nature of the country makes approach by land impracticable so most of the observations have had to be made from a boat.

The exposed shores from Safety Cove to Half-Moon Bay are likewise not readily accessible, and the algal vegetation here appears to be, in the main, similar to that occurring on the exposed eastern shore.

(*a*) *Supra-littoral*

(1) Lichen association.

Conspicuous lichen bands are for the most part lacking along this shore. The orange-yellow association is feebly developed in places while

the association of white lichens is almost entirely absent except where a southerly aspect is locally available in the gulches which interrupt the shore at intervals. Here it appears once again about 15 feet or more above the *Sarcophycus* densely covering the rocks for several feet while the opposing face of the gulch presents an apparently entirely uncolonised surface.

(*b*) *Upper littoral and mid-littoral*

The distribution of the animal inhabitants of these zones follows much the same lines as on Point Puer though the bands tend to be vertically extended and since the slopes are not broken up by platforms at various levels the banding is in most cases clearer. *Chamaesipho columna* again forms a dense cover on slopes of up to 30° but becomes sparser with increasing steepness and almost disappears on vertical faces. It appears about 6-10 feet above the *Sarcophycus* and extends upwards with a vertical range of up to 6 feet. *Melaraphe unifasciata* occurs among the uppermost individuals but its main region is above this and it has been found as high as 25 feet above the *Sarcophycus*. *Melaraphe praetermissa* occurs in the upper and mid part of the *Chamaesipho* range. *Lichina confinis* sometimes appears in the upper part of the *Chamaesipho* range particularly where exposure is not maximum but on the whole it is poorly developed along this shore. *Brachyodontes rostratus* is of common occurrence in the lower part of the *Chamaesipho* band, reaching a maximum density on slopes of less than 30°. *Catophragmus polymerus*, also favouring gentle slopes, is very well developed in the lower mid-littoral and descends well into the lower littoral. Limpets occur on the vertical faces but are not so common on the gentle slopes and it seems probable that the *Catophragmus* occur with such density that the movement of the limpets over the rock surface is impeded or prevented. Where more or less horizontal or very gently sloping surfaces are locally available these barnacles are often densely scattered over the surface of a patch of *Mytilus planulatus* which appears throughout Port Arthur from positions of extreme shelter to extreme exposure.

(2) *Porphyra* association.

During winter and spring an almost pure association of *Porphyra umbilicalis* may form a band occupying the mid-littoral. Generally, however, it is poorly developed and discontinuous on the eastern shore and the association is seen at its best on the exposed western shore between Safety Cove and Half Moon Bay. Here there occurs on both sloping and erect faces a distinct band of *Porphyra* with a vertical range of about 2 feet its lower limit is approximately 18 inches above the *Sarcophycus*, and on sloping surfaces which it favours the dense mass of crisped and ruffled fronds form a layer 2 inches deep completely covering the rocks (see Plate 6). In the lower and mid parts of its range the plants are of a deep olive green colour but near the upper margin of the band they tend to be smaller and somewhat bleached, and after emergence for some time they plaster the rocks with a close, shiny, lilac-pink crust. Above the *Porphyra* there is often a narrow indistinct band of *Bangia fuscopurpurea* (Dillw.) Lyngb. This usually does not exceed 6 inches in vertical extend and there is some mingling with the upper part of the *Porphyra* association.

(c) Lower littoral

(3) Encrusting coralline association.

Along most of this shore the encrusting coralline species seen on Point Puer are absent and they appear only locally where more sheltered conditions are available as on the vertical sides of the gulches. A coralline association is still conspicuously present, however, and is represented by the second species, *Lithophyllum hyperellum f. fastigiata* forming a distinct white band above the *Sarcophycus*. The colonies are closely placed, often confluent and depressed, and at least in the upper part of the band are often crowded by *Mytilus* and *Catophragmus* so that they are very frequently distorted and seldom present the beautifully symmetrical appearance of colonies on the platforms of Point Puer. Plate 8 shows a sloping shore, not subject to maximum exposure, where *Lithophyllum* is sparsely developed with *Catophragmus* above the *Sarcophycus*.

(4) *Laurencia* association.

On the very exposed sloping faces the association is almost entirely absent though it reappears on vertical faces particularly where exposure is slightly reduced. The association shows some preference for vertical faces, but even here extreme exposure seems able to remove it.

(d) Sub-littoral fringe

(5) *Xiphophora* association.

On the most exposed slopes the *Xiphophora* association is either quite absent or present only as a few scattered plants just above the *Sarcophycus*, though vertical faces may carry the band in some places. The reasons for the appearance and disappearance of *Xiphophora* is complicated by the fact that along this shore the more shaded south-western faces are the ones usually more exposed to heavy swell and it is in general on the north-western faces that *Xiphophora* appears. From observations in other places there seems little doubt that *Xiphophora* lacks the shade tolerance of *Sarcophycus* and *Lessonia* but it also seems likely that extreme exposure too can cause its removal though it persists longer on vertical than on sloping faces. Though it is unlikely to be the full explanation, this preference for vertical faces may perhaps in part be determined by the *Sarcophycus* which is more at home on the slopes and in these positions perhaps lashes the rock surface above it so severely as to discourage the *Xiphophora*.

(6) *Pyura* band.

On steep and vertical faces the *Sarcophycus* association is bounded above by the band of white or pale-pink encrusting corallines but on slopes of 30° and less in the most exposed positions there frequently appears an intervening band of *Pyura praeputialis* (Heller) which can be regarded as occupying the sub-littoral fringe. It has a vertical range usually not exceeding 6 inches and may mingle above with the *Lithophyllum* and below with the *Sarcophycus*. The leathery individuals are shortly cylindrical, up to 3 inches wide and 5 inches high and adjacent individuals are often fused into a very resistant firmly attached mass. A number of small Rhodophytes often occur on the *Pyura* but it has not been possible to collect specimens for determination.

Sarcophycus, Lithophyllum and *Pyura* are the three main shore inhabitants indicative of exposed conditions but with decreasing exposure *Pyura* is the first of these to leave the shore while *Sarcophycus* with a greater range of tolerance is the last.

(e) Sub-littoral

(7) *Sarcophycus* association.

At low water a dense fringe of *Sarcophycus* is exposed between swells along the whole of this shore, and, as usual, reaches greatest development on the gentle slopes while the plants are reduced in size on the vertical faces. As on Point Puer the association seems fairly pure though a clump of *Lessonia corrugata* may appear here and there. The *Sarcophycus* penetrates well into the sub-littoral and forms a dense submarine forest to depths of at least 15 feet. Beyond this depth it seems to be replaced by *Phyllospora comosa.*

(8) *Macrocystis* association.

Macrocystis pyrifera is absent along the greater part of this shore probably because of the sharp descent to depths of 13-14 fathoms which is in excess of the depths at which *Macrocystis* usually grows. If attached to the steeply sloping face at suitable depths the delicate terminal blades would be unlikely to survive long the constant friction with the rock surface which would undoubtedly occur along this shore.

Figure 2 shows a generalised representation of the zonation found on rocky shores of moderate slope and varying exposure at Port Arthur, and Section V lists the associations with their more important animal and plant constituents.

B. SAND AND SAND-MUD FORMATION

1. *SHELTERED SHORE*

The *Zostera* associations characteristic of sand-mud flats in the most sheltered positions are well developed on the extensive flats occurring in the northern end of Long Bay and the western part of Opossum Bay. Two species are involved, *Zostera muelleri* Irmisch in the lower littoral and *Z. tasmanica* Mart. in the sub-littoral.

(a) Lower littoral zone

(1) *Zostera muelleri* association.

Zostera muelleri is a small species, seldom exceeding 6 inches in length, which forms a fine sward not always completely covering the substratum. It occupies a band extending from about the level of the upper limit of the *Hormosira* association down to approximately E.L.W.S. Apart from algae from lower levels which are deposited on the association and apparently survive for some time there are comparativly few macroscopic algal associates. Where stones occur *Hormosira* frequently appears, and clumps of *Gracilaria confervoides* (L.) Grev. *Polysiphonia fuscescens, Cladophora fascicularis* (Mert.) Kuetz. and *Enteromorpha clathrata* (Roth) J. Ag. generally attached to pebbles or shells may be widely scattered over the flat. The clumps of *Gracilaria* carry a great variety of microscopic epiphytes including *Erythrotrichia carnea* (Dillw.) J. Ag.,

E. reflexa (Crouan) Thuret several species of diatoms, including *Schizonema* sp., and a number of filamentous and unicellular blue-green algae. Colonies of the blue-green *Merismopoedium glaucum* (Ehr.) Naeg. have been found in washings from the *Gracilaria*. On the shells of dead bivalves, which often litter the flat, the black *Isactis plana* (Harv.) Thuret sometimes forms firm closely appressed flat colonies while the shells themselves are often stained a dull blue-green by the perforating alga, *Entophysalis deusta*.

A bivalve, probably *Marcia* sp. and a turret shell, *Pyrazus australis* (Quoy and Gaimard), are often common over the flat, the former partly or shallowly buried, and in some places, particularly less muddy areas, the surface is thrown into numerous small hummocks often a couple of inches high and 6-9 inches across, probably caused by a burrowing *Lutraria*-like mollusc.

(*b*) *Sub-littoral zone*

(2) *Zostera tasmanica* association.

This species appears at approximately E.L.W.S. and overlaps to a slight extent with the *Zostera muelleri* association above. It forms a very dense cover completely obscuring the bottom and extends to depths of at least 12 feet below E.L.W.S. The leaves are borne towards the top of an erect stem which increases to considerable lengths, often 4-5 feet in deeper water, and even near the upper limit of the association, the stems are frequently 2 feet long. At low tide on still summer days the uppermost layer of the mass of *Zostera* left in shallow water may partly emerge and suffer some injury from desiccation. During the late summer months the plants in general show very noticeable signs of decay and stems from which most of the leaves have rotted away frequently protrude above the surface at low tide (see Plate 10).

Unaccountably bare patches, thickly strewn with dead shells, appear here and there within the association and in deeper water large starfish and sea urchins are commonly seen. Bare patches which occur in shallow water are the favourite grounds of fishermen spearing flounder.

Associated with the *Zostera* are a considerable quantity and variety of algae. During the summer when many of the plants are decaying the partly denuded stems carry a heavy epiphytic growth of *Hydrocoleum glutinosum* and *H. lyngbyaceum* Kuetz. which form mucous—gelatinous, often vesiculate, olive-green masses, loosely attached and often matting together the decaying leaves of the *Zostera*. The small curled limy tubes of *Spirorbis* sp. often occur thickly over the surface of leaves and stems and a fine encrusting coralline, probably a *Melobesia*, is commonly present. The lower denuded parts of the stems frequently carry small sparse brown tufts of *Sphacelaria biradiata*, and *Jania micrarthrodia* Lamx. shows its best development in the more exposed parts of the association where it forms rounded clumps 1-2 inches in diameter. Brown gas-filled bladders of *Colpomenia sinuosa* are often conspicuous and a species of *Ectocarpus*, which has not been found in a fertile condition, occurs loosely attached to the *Zostera*, and, particularly in winter, forms great furry brown expanses in the upper part of the association. Sometimes a species of *Cladophora* also forms large plumose tufts, but never reaches the develop-

ment of the *Ectocarpus*. At the base of the *Zostera* plants is typically a mat of various algal species loosely attached to and entangled with the bases of the *Zostera* stems and with each other. The *Ectocarpus* occurs here also, but the main constituents of this basal mat seem to be *Chondria debilis* Harv. with its hooked branches and a small species of *Laurencia*. With these are generally found a variety of other species including *Polysiphonia fuscescens, Spyridia filamentosa* (Wulf.) Harv., and the springy curled filaments of *Chaetomorpha valida* (Hook and Harv.) Kuetz. together with various other species and a great variety of microscopic algae.

This basal algal mat appears at depths down to at least 3-4 feet below E.L.W.S., but *Zostera* growing in deeper water probably carries rather different algal associates and the following species which have not been collected in the upper part of the association have been found attached to *Zostera* drift which presumably came from deeper water:—*Hemineura frondosa* (Hook and Harv.) Harv., *Polysiphona dasyoides,* Zan., *Dictyota apiculata* J. Ag.

2. *SEMI-EXPOSED AND EXPOSED SHORE*

The exposed and semi-exposed beaches of clean white sand such as occur in Half Moon Bay, Safety Cove, and Stinking Beach support no macroscopic algae, though frequently after storms great masses of drift weed are piled up along the shore. *Macrocystis* is generally one of the main constituents of the drift, and the stipes from which blades and pneumatocysts are often broken by the pounding on the shore become rolled into great ropes, often one foot or more in diameter, partly embedded in the sand.

The beaches in places are backed by low sand dunes supporting *Pteridium aquilinum* (L.) Kuhn and other small species.

V. List of the Association with the More Important Animal and Plant Constituents

A. ROCKY SHORE FORMATION

1. *SHELTERED SHORE*

(*a*) *Supra-littoral*

(1) *Parmelia* association.
Lichens: *Parmelia perforata* (Wulf.) Ach.; *Parmelia conspersa* (Ehr.) Ach.; *Collema* sp.
Phanerograms: *Salicornia australis* Sol.; *Stipa teretifolia* Stend.

(2) *Ochrolichina* association.
Lichens: *Ochrolichina parella* (Linn.) Massal; *Patellaria rimosa* Muell. Arg.

(*b*) *Upper littoral*

(3) *Candelariella* association.
Lichens: *Candelariella vitellina* (Ehrh.) Muell. Arg.; *Teloschistes parietinus* (L.) Norm; *Gasparinia murorum* (Hoffm.) Dodge and Baker.

(4) *Verrucaria* association.
Lichens: *Verrucaria microsporoides* Nyl.

(5) *Lichina* association.
Lichens: *Lichina confinis* (Muell.) Arg.
Animals: *Melaraphe unifasciata* (Gray)

(6) *Bostrychia* association.
Algae: *Bostrychia mixta* Hook. and Harv.; *B. simpliciuscula* Harv.; *Caloglossa leprieurii* (Mont.) J. Ag.; *Hildenbrandtia* sp.; *Enteromorpha* sp.; *Rhizocolonium riparium* (Roth.) Harv.; *Hydrocoleum glutinosum* (Ag.) Gom.

(*c*) *Mid-littoral*

Animals: *Bembicium melanostoma* (Gmelin); *Elminius* sp.; *Tetraclita purpurascens* (Wood); *Siphonaria zonata* Teneson-Woods; *S. Diemenensis* (Quoy and Gaimard); *Cellana* sp.; *Brachyodontes rostratus* (Dunker).
Algae: *Gelidium pusillum* (Stackh.) Le Jol.; *Callithamnion* sp.; *Porphyra umbilicalis* (L.) J. Ag.; *Hildenbrandtia* sp.; *Scytosiphon lomentarius* (Lyngb.) J. Ag.; *Chordaria dictyosiphon* (Harv.) Kuetz.; *Enteromorpha* sp.; *Monostroma* sp.; *Rivularia australis* Harv.; *Calothrix* sp.

(7) *Galeolaria-Gelidium* association.
Animals: *Galeolaria caespitosa* (Lam.); *Hymeniacidon perlevis* (Montagu); *Ibla quadrivalvis* Cuvier.
Algae: *Gelidium pusillum* (Stackh.) Le Jol.; *Ulva lactuca* L.

(8) *Ulva* association.
Animals: *Galeolaria caespitosa* (Lam.).
Algae: *Ulva lactuca* L.; *Cladophora flexuosa* Harv.; *Bryopsis australis* Sonder; *Myrionema strangulans* Grev.; *Ralfsia* sp.

(*d*) *Lower littoral*

(9) *Hormosira* association.
Animals: *Galeolaria caespitosa* (Lam.); *Mytilus planulatus* (Lam.).
Algae: *Hormosira banksii* (Turn.) Decne.; *Corallina pilulifera* Post. and Rupr.; *Jania* sp.; *Lithothamnion incisum* Fosl.; *Gigartina* sp.; *Laurencia botryoides* (Turn.) Gail.; *Leathesia difformis* (L.) Aresch.; *Colpomenia sinuosa* (Roth) Derbes and Solier; *Notheia anomala* Bail. and Harv.; *Punctaria plantaginea* (Roth.) Grev.; *Ectocarpus mitchellae* Harv.; *Codium fragile* (Suringer) Heriot; *Ceramium paniculatum* Okamura; *Acrochaetium codicola* Boergs.; *Ulva lactuca* L.; *Polysiphonia fuscescens* Harv.; *Griffithsia monilis* Harv.; *Symploca hydnoides* Kuetz.

(10) *Cystophora torulosa* association.
Algae: *Cystophora torulosa* (R. Br.) J. Ag.; *Hormosira banksii* (Turn.) Dcene.; *Laurencia botryoides* (Turn.) Gail.; *Corallina pilulifera* Post. and Rupr.; *Jania* sp.; *Gigartina* sp.; *Corallina cuvieri* Lamx.; *Cystophora cephalornithos* (Labill.) J. Ag.

(*e*) *Sub-littoral fringe*

(11) *Cystophora cephalornithos* association.
Algae: *Cystophora cephalornithos* (Labill.) J. Ag.; *C. torulosa* (R. Br.) J. Ag.; *Sargassum laevigatum* J. Ag.; *Sphacelaria biradiata* Askenasy; *Corallina pilulifera* Post. and Rupr.; *C. cuvieri* Lamx.; *Jania fastigiata* Harv.

(12) *Sargassum laevigatum* association.
Algae: *Sargassum laevigatum* J. Ag.; *Cystophora cephalornithos* (Labill.) J. Ag.; *Cystophora spartioides* (Turn.) J. Ag.; *Sargassum muriculatum* J. Ag.; *Zonaria subarticulata* (Lamx.) Papenfuss; *Cladospephus verticillalus* (Lightf.) Ag.; *Corallina pilulifera* Post. and Rupr.; *C. cuvieri* Lamx.; *Jania fastigiata* Harv.

(*f*) *Sub-littoral*

(13) *Phyllospora* association.
Algae: *Phyllospora comosa* (Labill.) C. Ag.; *Polysiphonia cancellata* Harv.; encrusting corallines.

(14) *Cystophora retroflexa* association.
Algae: *Cystophora retroflexa* (Labill.) J. Ag.

(15) *Macrocystis* association.
Algae: *Macrocystis pyrifera* (L.) Ag.; *Polysiphonia frutex* Harv.; *P.* sp.; *Ectocarpus confervoides* (Roth) Le Jol.; *Ceramium* sp.; *Myrionema densum* Shottsberg.

(16) *Ecklonia* association.
Animals: *Haliotus noevosa* Martyn; sponges; bryozoans.
Algae: *Ecklonia radiata* (Ag.) J. Ag.; *Zonaria subarticulata* (Lamx.) Papenfuss; *Cystophora paniculata* (Turn.) J. Ag.; *Carpoglossum confluens* (R. Br.) Kuetz.; *Dictyopteris muelleri* (Sonder) Schmidt; *Sargassum verruculosum* (Mert.) J. Ag.; *S. grande* J. Ag.; *Cladophora feredayae* Harv.; *C. gracilis* (Griff.) Kuetz.; *Chaetomorpha aerea* (Dill.) Kuetz.; *Caulerpa brownii* Endl.; *C. sedoides* (R. Br.) C. Ag.; *C. hypnoides* (R. Br.) Ag.; *Polysiphonia cancellata* Harv.; *Plocamium telfariae* Harv.; *Ethelia australis* (Sonder) W. v. Bosse; encrusting corallines.

2. *SEMI-EXPOSED SHORE*

(*a*) *Supra- and upper littoral*

Animals: *Melaraphe unifasciata* (Gray).
Lichens: *Parmelia perforata* (Wulf.) Ach.; *P. conspersa* (Ehrh.) Ach.; *Ochrolichina parella* (Linn.) Massal; *Patellaria rimosa* M. Arg.; *Lichina confinis* (Muell.) Arg.

(*b*) *Mid-littoral*

Animals: *Siphonaria zonata* Teneson-Woods; *S. diemenensis* Quoy & Gaim.; *Celana* sp.; other species of limpets; *Chamaesipho columna* (Spengler); *Catophragmus polymerus* Darwin.
Algae: *Rivularia australis* Harv.

(1) *Galeolaria-Gelidium* association.
Animals: *Galeolaria caespitosa* (Lam.).
Algae: *Gelidium pusillum* (Stackh.) Le Jol.; *Ulva lactuca* L.; *Bryocladia ericoides* (Harv.) Schmitz; *Laurencia botryoides* (Turn.) Gail.; *Ceramium fastigiatum* Harv.; *Cladophora flexuosa* Harv.

(*c*) *Lower littoral*

(2) *Corallina* fringe.
Algae: *Corallina officinalis* L.; *C. gracilis* Lamx.; *Bryocladia ericoides* (Harv.) Schmitz.; *Lophurella hookeriana* (J. Ag.) Falk.; *Laurencia botryoides* (Turn.) Gail.

(*d*) *Sub-littoral fringe*

(3) *Xiphophora* association.
Algae: *Xiphophora billardieri* Mont.; *Corallina officinalis* L.; *C. gracilis* Lamx.; encrusting corallines; *Plocamium costatum* (J. Ag.) Hook. and Harv.; *P. telfairiae* Harv.; *Laurencia elata* (C. Ag.) Harv.; *Gelidium australe* J. Ag.; *Chondria* sp.; *Champia tasmanica* Harv.; *Codium fragile* (Suringar) Heriot; *Ulva lactuca* L.; *Chaetomorpha aerea* (Dillw.) Kuetz.; *C. darwinii* (Hook.) Kuetz.; *Cystophora* spp.; *Zonaria subarticulata* (Lamx.) Papenfuss; *Ecklonia radiata* (Ag.) J. Ag.

(*e*) *Sub-littoral*

(4) *Phyllospora* association.
Algae: *Phyllospora comosa* (Labill.) C. Ag.; encrusting corallines.

(5) *Macrocystis* association.
Algae: *Macrocystis pyrifera* (L.) Ag.

(6) *Ecklonia* association.
Algae: *Ecklonia radiata* (Ag.) J. Ag.; *Zonaria subarticulata* (Lamx.) Papenfuss; *Cystophora* spp.; *Carpoglossum confluens* (R. Br.) Kuetz.; *Sargassum* spp.

3. Exposed shore

3A. *EXPOSED SHORE OF POINT PUER*

(*a*) *Supra-littoral*

(1) Lichen associations.
Lichens: *Buellia* sp.; various other spp.

(2) Supra-littoral pools.
Algae: *Enteromorpha* sp.; *Lyngbya confervoides* Ag.

(3) Shaded and fertilised cliffs.
Algae: *Prasiola* sp.

(*b*) *Upper littoral and mid-littoral*

Animals: *Melaraphe unifasciata* (Gray); *M. praetermissa* (May); *Chamaesipho columna* (Spengler); *Brachyodontes rostratus* (Dunker); *Mytilus planulatus* (Lam.); *Catophragmus polymerus* Darwin.
Lichens: *Verrucaria* sp.
Algae: *Corallina officinalis* L.; *Ulva lactuca* L.; *Splachnidium rugosum* (L.) Grev.; *Adenocystis utricularis* (Bory) Skottaberg.

(4) *Porphyra* and *Scytosiphon* associations.
Algae: *Porphyra umbilicalis* (L.) J. Ag.; *Scytosiphon lomentarius* (Lyngb.) J. Ag.

(*c*) *Lower littoral*

(5) Encrusting coralline association.
Animals: *Mytilus planulatus* (Lam.); *Catophragmus polymerus* Darwin; *Siphonaria diemenensis* Quoy and Gaim.; *Patelloida marmorata* (Tcn.-Woods); *Cellana* sp.
Algae: encrusting coralline spp.; *Lithophyllum hyperellum f. fastigiata* Fosl.; *Corallina officinalis* L.; *C. gracilis* Lamx.; *Polysiphonia macrarthra* Zan.; *Ceramium* sp.; *Adenocystis utricularis* (Bory) Skottsberg; *Ralfsia* sp.

(6) *Laurencia* association.
Algae: *Laurencia botryoides* (Turn.) Gail.; *Bryocladia ericoides* (Harv.) Schmitz; *Lophyrella hookeriana* (J. Ag.) Falk.; *L. periclados* (Sonder) Schmitz; *Gigartina ancistroclada* Mont.; *G.* sp.; *Ballia scoparia* Harv.; *Corallina gracilis* Lamx.; encrusting corallines; *Chaetomorpha aerea* (Dillw.) Kuetz.; *C. darwinii* (Hooker) Kuetz.

(*d*) *Sub-littoral fringe*

(7) *Xiphophora* association.
Algae: *Xiphophora billardieri* Mont.; *Lessonia corrugata* Lucas; encrusting corallines.

(*e*) *Sub-littoral*

(8) *Sarcophycus* association.
Algae: *Sarcophycus potatorum* (Labill.) Kuetz.; encrusting corallines.

(9) *Phyllospora* association.
Algae: *Phyllospora comosa* (Labill.) C. Ag.; encrusting corallines.

(10) *Macrocystis* association.
Algae: *Macrocystis pyrifera* (L.) Ag.

3B. *EXPOSED EASTERN SHORE OF PORT ARTHUR*

(*a*) *Supra-littoral*

(1) *Lichen* associations.

(*b*) *Upper littoral and mid-littoral*

Animals: *Melaraphe unifasciata* (Gray); *M. praetermissa* (May); *Chamaesipho columna* (Spengler); *Brachyodontes rostratus* (Dunker); *Mytilus planulatus* (Lam.); *Catophragmus polymerus* Darwin.
Lichens: *Lichina confinis* (Muell.) Arg.

(2) *Porphyra* association.
Algae: *Porphyra umbilicalis* (L.) J. Ag.; *Bangia fuscopurpurea* (Dillw.) Lyngb.

(*c*) *Lower littoral*

(3) Encrusting coralline association.
Animals: *Mytilus planulatus* (Lam.); *Catophragmus polymerus* Darwin.
Algae: *Lithophyllum hyperellum* f. *fastigiata* Fosl.

(4) *Laurencia* association.
Present only locally.

(*d*) *Sub-littoral fringe*

(5) *Xiphophora* association.
Poorly developed and intermittent.

(6) *Pyura* band.
Animals: *Pyura praeputialis* (Heller).

(*e*) *Sub-littoral*

(7) *Sarcophycus* association.

Algae: *Sarcophycus potatorum* (Labill.) Kuetz.; *Lessonia corrugata* Lucas.

B. SAND AND SAND-MUD FORMATION

1. *SHELTERED SHORES*

(*a*) *Lower littoral*

(1) *Zostera muelleri* association.

Animals: *Marcia* sp.; *Pyrazus australis* (Quoy and Gaimard).

Phanerogams: *Zostera muelleri* Roth.

Algae: *Gracilaria confervoides* (L.) Grev.; *Polysiphonia fuscesens* Harv.; *Erythrotrichia carnea* (Dillw.) J. Ag.; *E. reflexa* (Crouan) Thuret; *Cladophora fascicularis* (Mert.) Kuetz.; *Entermorpha clathrata* (Roth) J. Ag.; *Merismopoedium glaucum* (Ehr.) Naeg.; *Isactis plana* (Harv.) Thur.; *Entophysalis deusta* (Menegh.) Drouet and Daily.

(*b*) *Sub-littoral*

(2) *Zostera tasmanica* association.

Animals: *Spirorbis* sp.

Phanerogams: *Zostera tasmanica* Mart.

Algae: *Jania micrarthrodia* Lamx.; *Chondria debilis* Harv.; *Laurencia* sp.; *Polysiphonia fuscescens* Harv.; *P. dasyoides* Zan.; *Spyridia filamentosa* (Wulf.) Harv.; *Hemineura frondosa* (Hook. and Harv.) Harv.; *Melobesia* (?) sp.; *Colpomenia sinuosa* (Roth) Derbes and Solier; *Ectocarpus* sp.; *Dictyota apiculata* J. Ag.; *Sphacelaria biradiata* Asken.; *Cladophora* sp.; *Chaetomorpha valida* (Hook. and Harv.) Kuetz.; *Hydrocoleum glutinosum* (Ag.) Gom.; *H. lyngbyaceum* Kuetz.

2. *SEMI-EXPOSED AND EXPOSED SHORE*

(*a*) *Supra-littoral*

Phanerogams: *Pteridium aquilinum* (L.) Kuhn; other species of Phanerogams.

VI. COMPARISON WITH OTHER AREAS

From the foregoing it may be seen that one of the most important factors influencing the distribution of the marine vegetation in the region of Port Arthur is exposure.

On Kangaroo Island, South Australia, Womersley (1947) has found on steeply sloping exposed rocky coasts a *Rivularia-Isactis* association in the upper littoral and in the lower littoral a coralline-mat association sometimes with a small stout *Laurencia* and *Dasyopsis clavigera*. This passes into an association of the brown alga *Cystophora intermedia* occupying the sub-littoral fringe.

On sheltered rocky coasts there is described an upper littoral zone of blue-green algae and coralline-mat association often with other small red species and sometimes with a *Hormosira* association at a lower level. The upper sub-littoral zone is characterized by the dominance of species of *Cystophora*.

Near Sydney on the coast of New South Wales very exposed rocky shores may carry a seasonal band of *Porphyra* in the mid-littoral and the first distinct band of algae is one occurring in the lower littoral and made up of a variety of small species including *Corallina*, particularly in the upper parts, *Laurencia* sp., *Pterocladia capillacea*, *Zonaria* sp., stunted *Sargassum* sp., and other species, the composition varying with the environmental factors. This shrubby association extends into a band

of the ascidian *Pyura praeputialis* occupying the lowermost part of the littoral while in the sub-littoral fringe and upper sub-littoral there appear the large brown alga *Phyllospora comosa* often with *Ecklonia radiata* slightly lower.

On sheltered shores *Bostrychia mixta* and blue-green algae may occur in the upper littoral, particularly where shaded and the mid-littoral is frequently occupied by a band of the oyster *Saxostrea commercialis* bounded below by a dense band of *Galeolaria caespitosa* often associated with *Gelidium pusillum*. *Hormosira* appears just below the upper limit of *Galeolaria* and forms a band sometimes with *Corallina* in the lower littoral. *Ecklonia* appears densely in the sub-littoral fringe and upper sub-littoral and is often separated from the main band of *Hormosira* by a narrow strip occupied by a variety of small algae including *Corallina, Codium lucasii, Ceramium* sp., *Polysiphonia* sp., and others.

Dakin, Bennett and Pope (1948) describe the inter-tidal ecology of the New South Wales coast and give instructive diagrams showing the zonation on shores of varying exposure.

The general picture in both these localities though differing in some respects nevertheless has certain features in common with the inter-tidal picture at Port Arthur. In exposed positions both show a sparingly colonized upper and mid-littoral and the first permanent band of larger algae is a lower littoral one of small scrubby species in which *Corallina* plays an important part. The differences in this band in the various localities appear to be in the somewhat different proportions of the various constituents rather than in the essential nature of the band itself. At Kangaroo Island the *Corallina* seems to be exceptionally well developed at the expense of other species, while at Port Arthur the red species of the *Laurencia* association are developed at the expense of the *Corallina* which in the absence of competing species assumes much greater importance.

It is in the vegetation of the sub-littoral fringe that the more striking differences are seen. On Kangaroo Island *Xiphophora* is present in some places but it seems to appear below a band of Cystophora in the sub-littoral fringe and can hardly present the distinctive sharp band found at Port Arthur. Near Sydney *Xiphophora* is absent and its range is occupied by the *Pyura* and perhaps in part by the uppermost *Phyllospora*. But the really outstanding difference is in the occupation of the sub-littoral fringe near Sydney by *Phyllospora* and on Kangaroo Island by *Cystophora*, both in appearance very poor substitutes for the massive *Sarcophycus* of more southern latitudes.

Oliver (1923) describes in New Zealand associations of two small close growing algae *Bostrychia arbuscula* and *Caulacanthus spinellus* in the upper part of the intertidal belt. Associations of *Ulva rigida* and *Porphyra columbina* may occur at about half-tide mark while *Hormosira* with *Corallina*, best developed in harbours, forms an association sometimes completely covering the rocks in the lower part of the intertidal region. With it may occur also *Scytothamnus australis, Colpomenia sinuosa. Adenocystis utricularis*, and in shady places, *Codium adhaerena*. Towards low water mark the *Hormosira-Corallina* association is replaced by a thick low growth of *Stypocaulon, Ballia, Nitophyllum, Chaetomorpha* and other species.

The appearance of these sheltered shores with a lower littoral *Hormosira* band shows good agreement with the vegetation or similar shores at Port Arthur, but north of lat. 38° S. Oliver reports a well defined band of *Ostrea cucullata* centred about half-tide mark. Chapman (1950), Dellow (1950) and Carnahan (1952) all working on sheltered localities near Auckland report bands of *Saxostrea glomerata* and these bands probably give sheltered shores in the northern part of New Zealand an appearance rather more similar to sheltered shores near Sydney than to those at Port Arthur.

In exposed situations *Xiphophora* is described as occupying a belt inshore of the *Durvillea* association below which is a growth of *Marginaria boryana, Lessonia variegata, Carpophyllum maschalocarpum* and *Cystophora dumosa.* Beneath these the rock surface is completely covered with corallines and a number of small red and brown algae. Where *Durvillea* is absent *Xiphophora* seems to pass directly into a *Carpophyllum* association which occupies rocks exposed only at spring tides and extends below low tide mark for a little distance. This association is dominated by *Carpophyllum maschalocarpum* and depending on the locality there may occur also *Ecklonia richardsonia, Carpoglossum plumosum, Sargassum sinclairii, Cystophora dumosa* and *Marginaria boryana.* There is an undergrowth of smaller algae including *Pterocladia lucida, Melanthalia abscissa, Caulerpa sedoides, Zonaria turneriana* and others.

This picture presented by Oliver seems to correspond remarkably well with what is seen on semi-exposed and exposed shores at Port Arthur, and though species may differ, growth form is closely paralleled.

Cranwell and Moore (1938) give an account of the exposed shores of the Poor Knights Islands, New Zealand, and described seasonal societies of *Porphyra columbina* in the upper littoral while *Apophloea* is the dominant algal species in the mid-littoral. Algal members here are few but include *Porphyra, Nemastoma oligarthra,* N. sp., *Nemalion lubricum, Hildenbrandtia crouanii* and *Ralfsia* sp. Below this is generally a pink *Novasta* (a mollusc)—encrusting coralline association with some small red algae including *Nemalion, Laurencia virgata, Trematocarpus aciculare, Gigartina* spp., *Polysiphonia, Ceramium, Callophyllis* and *Ulva.* The region about low water neap tide is occupied by a band of *Xiphophora chondrophylla,* the junction with the *Novasta*—coralline belt appearing clear cut. *Xiphophora* is replaced by *Durvillea* in a few places on the Poor Knights where heavy surf runs, and below the *Xiphophora* is an association dominated by either *Carpoglossum elongatum* or *C. maschalocarpum.* In the sub-littoral the *Carpophyllum* is followed by a *Lessonia* association sometimes with an intervening community of red algae.

Again the picture of the exposed shore presents great similarity to the comparable shores at Port Arthur, the *Novasta*—coralline association with its small red algae in New Zealand being represented by the *Corallina* fringe, *Laurencia* association and encrusting coralline association at Port Arthur, while similar bands of *Xiphophora* in both areas are followed by *Phyllospora* in Tasmania and *Carpoglossum* in New Zealand. In the most exposed positions *Sarcophycus* and *Durvillea* form comparable associations and the main point of difference seems to be in the occurrence in the Poor Knights of a dominant algal species, *Apophyloea sinclairii,* in the mid-littoral, an association quite unrepresented at Port Arthur and elsewhere in Tasmania.

Beveridge and Chapman (1950) give an account of the intertidal communities at Piha, a locality on the west coast of the north island of New Zealand fully exposed to the full force of the prevailing westerly winds. *Bostrychia arbuscula* is dominant in the upper part of the littoral, *Porphyra columbina* occurs between mean high water springs and mean sea level, while the area between mean high water neaps and mean low water neaps seems fairly bare of algae though a number of small species including *Centroceras clavulatum, Gelidium pusillum, Apophloea sinclairii, Gigartina alveata, Gelidium caulacanthus* and others are stated to occur occasionally. Below mean sea level *Gigartina alveata, Pachymenia himantophora* and *Gigartina marginifera* each in turn become dominant, the last mentioned extending to mean low water spring tides. In exposed positions *Durvillea* may occupy the range extreme (lowest) high water mark neap tides to extreme low water springs, approximately the range occupied in positions less exposure by *Pachymenia himantophora* and *Gigartina marginifera.*

The main features of vegetation distinguishing this shore from similar areas at Port Arthur seem to be the absence of the *Xiphophora* band and the increased width of the band of scrubby red algae in the lower littoral, an increase which might be expected in the absence of *Xiphophora.*

Skottsberg (1941) describes *Hildenbrandtia* as forming thick, uneven, dark purple crusts in the uppermost littoral on exposed rocky shores in the Subantarctic. The *Bostrychietum* may extend almost as high up forming an intermediate *Hildenbrandtia-Bostrychia* association. With the *Bostrychia* may be found *Cladophora* spp., *Rhizoclonium riparium, Catenella fusiforme* and *Chaetangium fastigiatum* while in the lower part of the association *Phaeophyceae,* especially *Scytosiphon lomentaria* and *Caepidium antracticum* may become co-dominant, and a conspicuous association of *Porphyra umbilicalis* may occupy a middle littoral habitat. Species of *Iridaea* occur in the lower littoral and uppermost sub-littoral as a rule with a bottom layer of lithothamnia, while *Durvillea antarctica* and *Durvillea harveyi* belong to the lower littoral region in the most exposed places, the latter species extending to depths of 1-2 m. at low tide. The arborescent *Lessonia nigrescens* forms submarine forests from near low-water mark to a depth of several metres.

In sheltered situations also Skottsberg reports the *Bostrychia* and *Hildenbrandtia* associations but finds that *Iridaea obovata* seems to be confined to open situations. In the lower littoral regions small brown and green algae predominate and include *Adenocystis utricularis, Scytosiphon lomentaria,* species of *Cladophora* and *Monostroma,* and *Ceramium rubrum.*

Skottsberg has remarked on the resemblance between the littoral region of the subantarctic and that of New Zealand as described by Oliver and by Cranwell and Moore, and there seems also to be a clear resemblance between the regions of Port Arthur and the Subantarctic. *Bostrychia* and *Hildenbrandtia* are generally lacking on the exposed shores at Port Arthur but the *Porphyra* and *Scytosiphon* of the Subantarctic are both represented, and the *Laurencia* association may be compared with Skottsberg's band of *Iridaea* with its bottom layer of Lithothamnia. The species of *Durvillea* are clearly comparable with the *Sarcophycus* in Tasmania

but there seems to be no species in the Subantarctic representing the *Xiphophora* band in Tasmania and the range of this species is probably occupied in the Subantarctic in part by *Iridaea* and in part by *Durvillea antarctica*.

In sheltered localities the absence from the lower littoral of the *Hormosira* association so typical of Tasmanian shores must give the lower littoral region of the Subantarctic a rather different aspect.

Considering the accounts given by the various authors of the algal vegetation on the shores of Australia, New Zealand and the Subantarctic it seems that on exposed coasts the general appearance of the shore vegetation at Port Arthur has more in common with that of New Zealand and the Subantarctic than with shores near Sydney or on Kangaroo Island, the more marked resemblance to the former localities depending largely on the presence of *Xiphophora* and *Durvillea* in New Zealand and of *Durvillea* in the Subantarctic.

But in sheltered positions the common occurrence of *Hormosira* on the shores of New Zealand, Sydney and Kangaroo Island give these areas rather than the Subantarctic a considerable resemblance to Port Arthur shores. The common occurrence at Port Arthur of species of *Cystophora* in the sub-littoral fringe and upper sub-littoral heightens the affinity with Kangaroo Island.

Skottsberg has compared shores in the Subantarctic with those in the Northern Hemisphere and has been able to refer some of the Subantarctic associations to corresponding associations composed of other species in the Northern Hemisphere. He finds that *Hildenbrandtia, Bostrychia* and *Porphyra* are all represented by comparable associations on the west coast of North America and the first two also in the North Atlantic. The *Durvillea antarctica* of the Subantarctic is paralled by *Postelsia* on the west coast of North America and by *Alaria* and *Laminaria* in the North Atlantic.

The great and striking differences between these two regions become apparent on the sheltered shores which in northern Europe and to a less extent in the North Pacific are bounded from almost high to low water mark by members of the Fucaceae, and Skottsberg remarks that " It is the total absence of *Fucus* and allied genera that makes the Subantarctic littoral look to be utterly different from the Subarctic. The undergrowth of small brown, green and a few red algae is all that remains . . ." In Tasmania, *Hormosira* probably in part corresponds to *Fucus serratus* in the North Atlantic, but apart from this, Skottsberg's remarks might just as well be applied to Tasmanian shores.

Isaac (1937, 1949), working on the west and south coasts of South Africa, has found above the lower littoral zones of red algae a bare zone which is relieved only by a zone of *Porphyra* on the south coast and by zones of *Porphyra* and *Chaetanguim* on the east coast.

It thus seems that the comparative paucity of fleshy algae, particularly Phaeophyceae, in the mid- and upper littoral regions is generally characteristic of shores in the Southern Hemisphere. The bareness of the Australian intertidal region has been noted by Newton and Cribb (1951) and it has been suggested that light intensity, temperature, and desiccation may be among the factors responsible for the differences noted. The

effect of these factors would certainly be expected to increase with nearness to the Tropics, so that their effect in Queensland and New South Wales would be greater than in Tasmania. If they were the only operative factors, however, a rich littoral vegetation of Phaeophycean species would be expected to have developed in the Subantarctic. Not only is this not so, but the two uppermost bands of fleshy Phacophyceans found on the Tasmanian coast, namely, *Hormosira* and *Xiphophora*, are actually absent from Subantarctic shores and are unreplaced by any comparable species. So whatever the reasons for this littoral bareness in more southerly latitudes may be, it seems unlikely that insolation, temperature and dessication are the prime factors over the whole of the area concerned.

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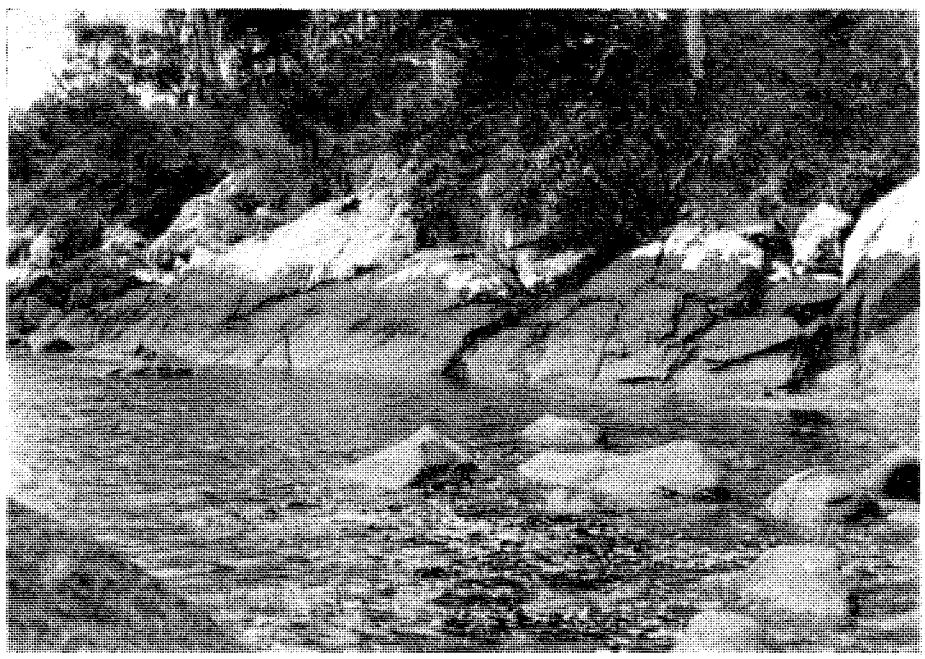

PLATE 1.—Semi-exposed to exposed rocky shore carrying a band of white lichens in the supra-littoral and a band of *Lichina confinis* in the upper littoral.

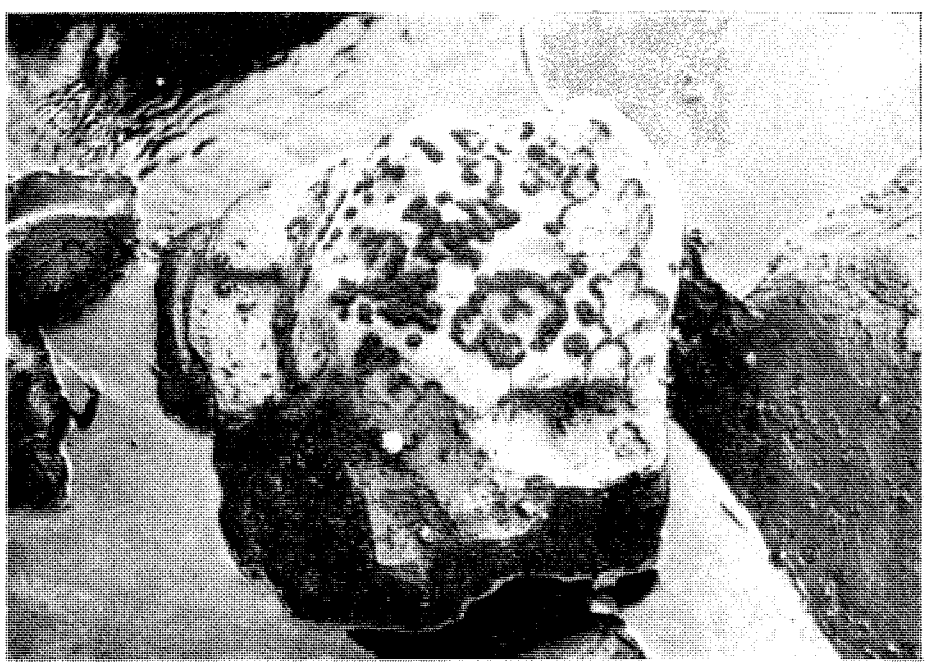

PLATE 2.—Well developed colonies of *Lichina confinis* on a sheltered boulder.

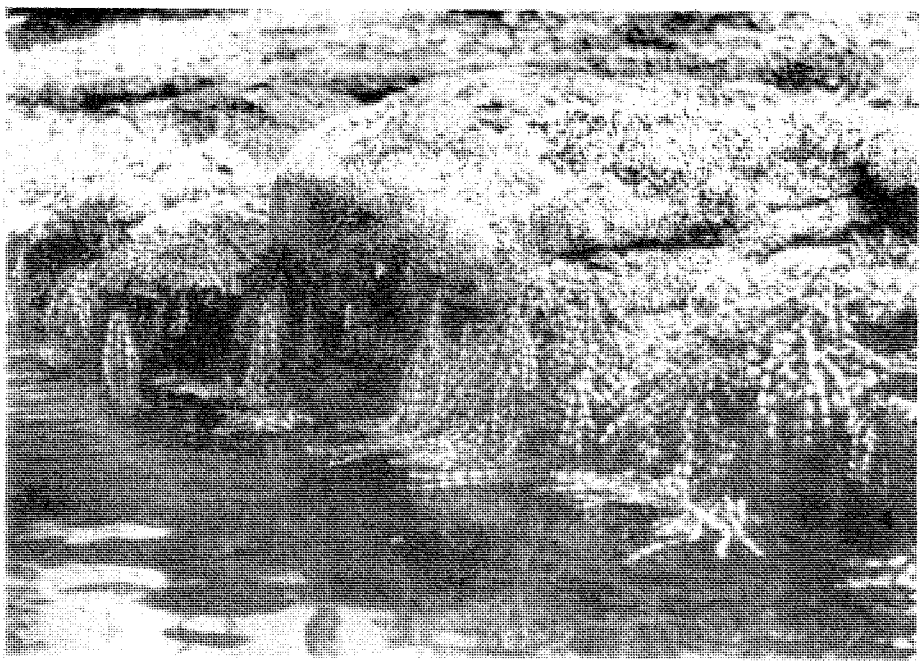

PLATE 3.—*Galeolaria caespitosa* and *Hormosira banksii* on mudstone in a sheltered locality.

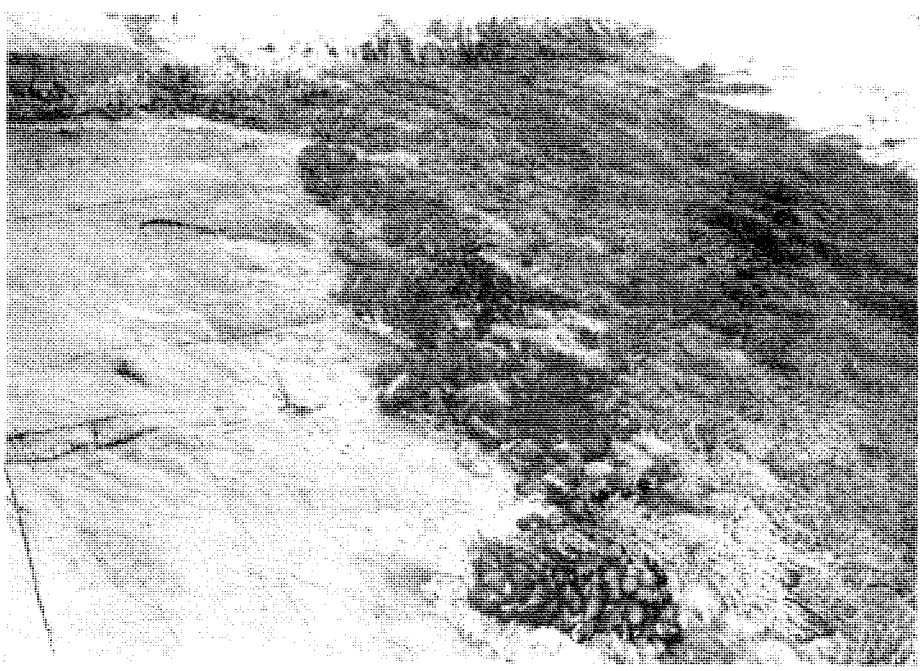

PLATE 4.—*Galeolaria caespitosa* and *Mytilus planulatus* succeeded downshore by bands of *Hormosira banksii*, *Cystophora torulosa* and *C. cephalornithos* respectively.

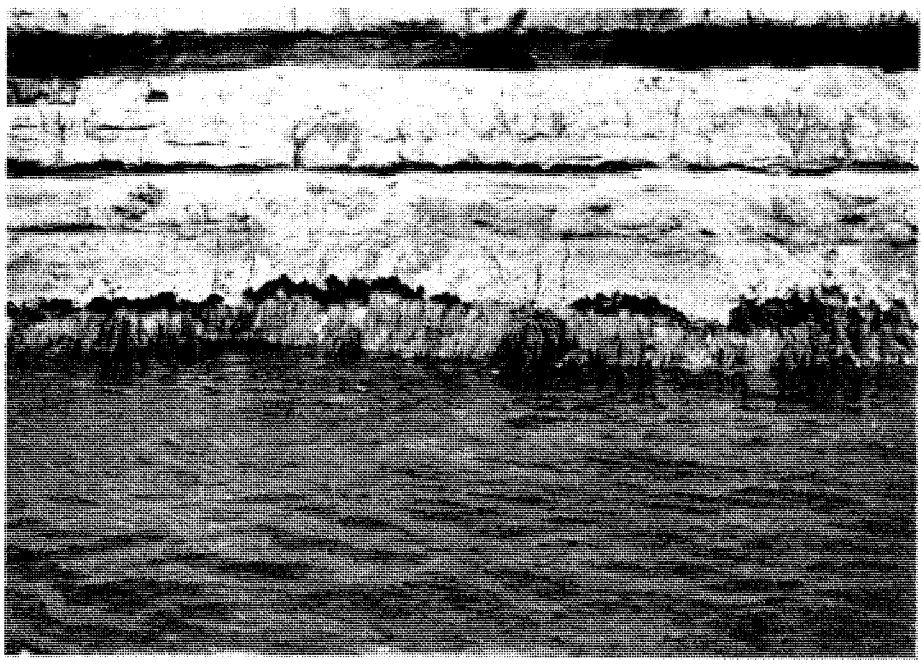

PLATE 5.—Vertical side of a mudstone platform carrying a narrow dark coloured band of *Laurencia botryoides* and other Rhodophytes above a wider band of *Xiphophora billardieri*.

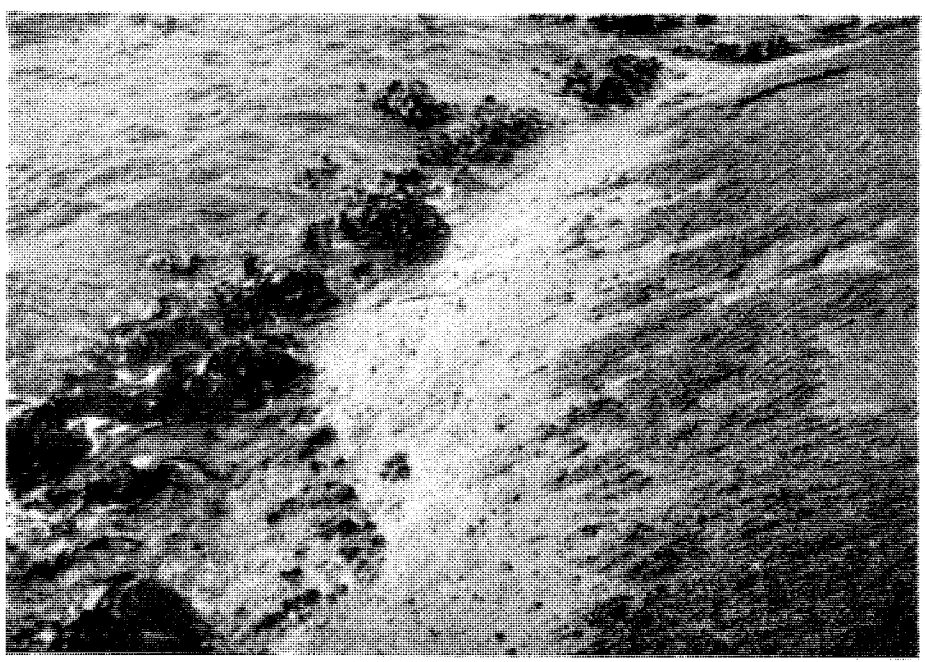

PLATE 6.—Exposed rocky shore carrying a mid-littoral band of *Porphyra umbilicalis* with *Sarcophycus potatorum* in the sub-littoral fringe.

PLATE 7.—*Sarcophycus potatorum* exposed between surges on the margin of a mudstone platform.

PLATE 8.—Cushion-shaped colonies of *Lithophyllum hyperellum f. fastigiata* mingling with barnacles and limpets above small plants of *Sarcophycus potatorum*.

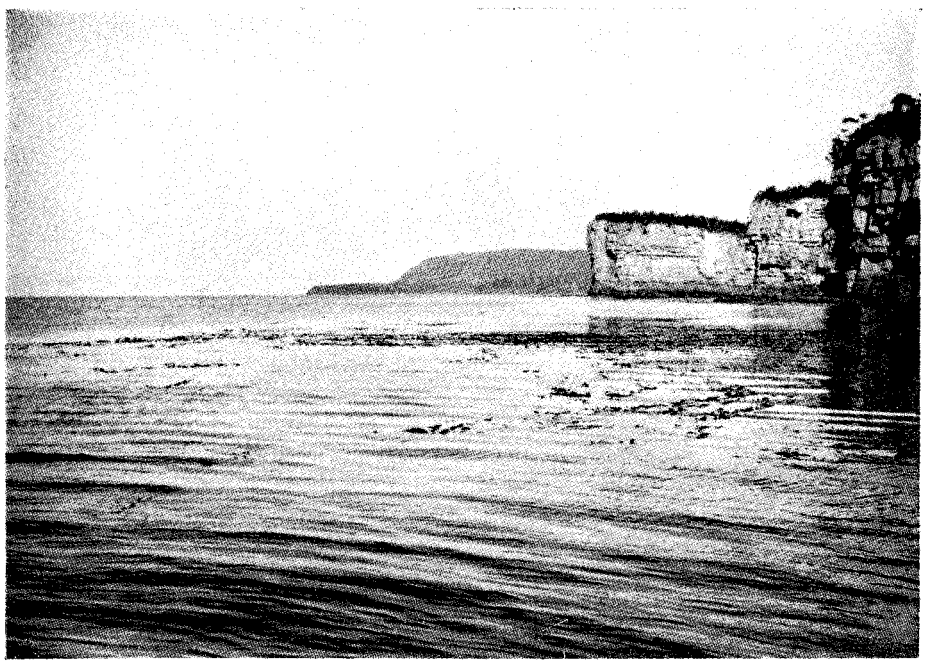

PLATE 9.—A bed of *Macrocystis pyrifera* fringing laminated mudstone cliffs and pavements.

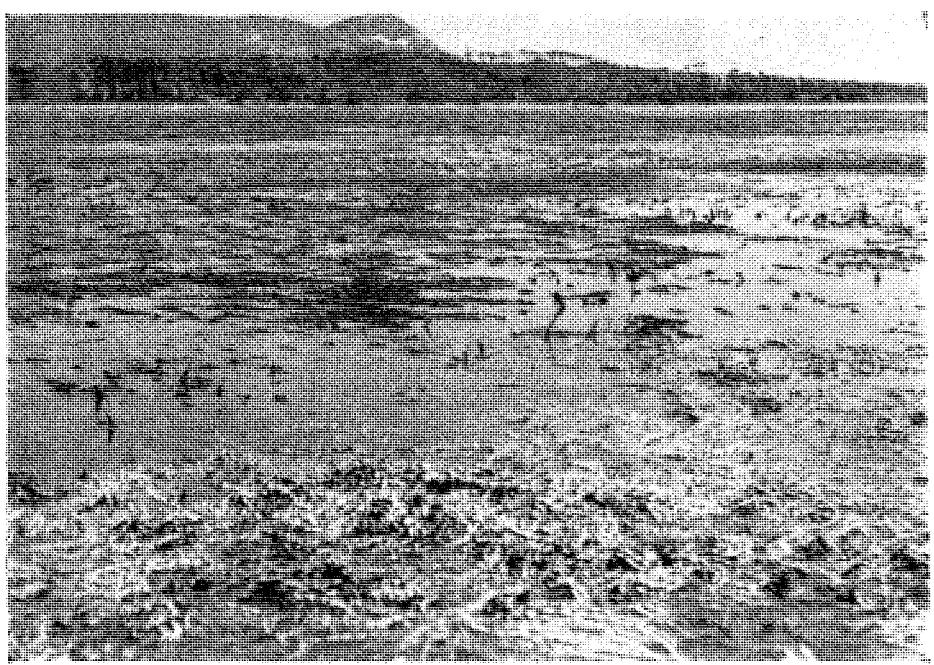

PLATE 10.—A sand-mud flat with *Zostera tasmanica* partly exposed at low tide. *Hormosira banksii* is developed on rocks in the foreground.