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Littoral Associations

1. Bostrychia and Gelidium Associations.

These two associations will be considered together, as they occur in very similar habitats and sometimes become mixed. At Rocky Point, however, each association forms a distinct zone, the *Gelidium* below the *Bostrychia*. Both algae form dark reddish-brown dense mats, up to 1 cm. thick, covering the rock from about mid to just below high water level of spring tides. They are restricted to shaded areas of rock (see pl. xiii, fig. 2, and fig. 5). With continual shade, the mats retain sufficient water during the periods of exposure. Rock not shaded in this zone is usually bare of macroscopic algae.

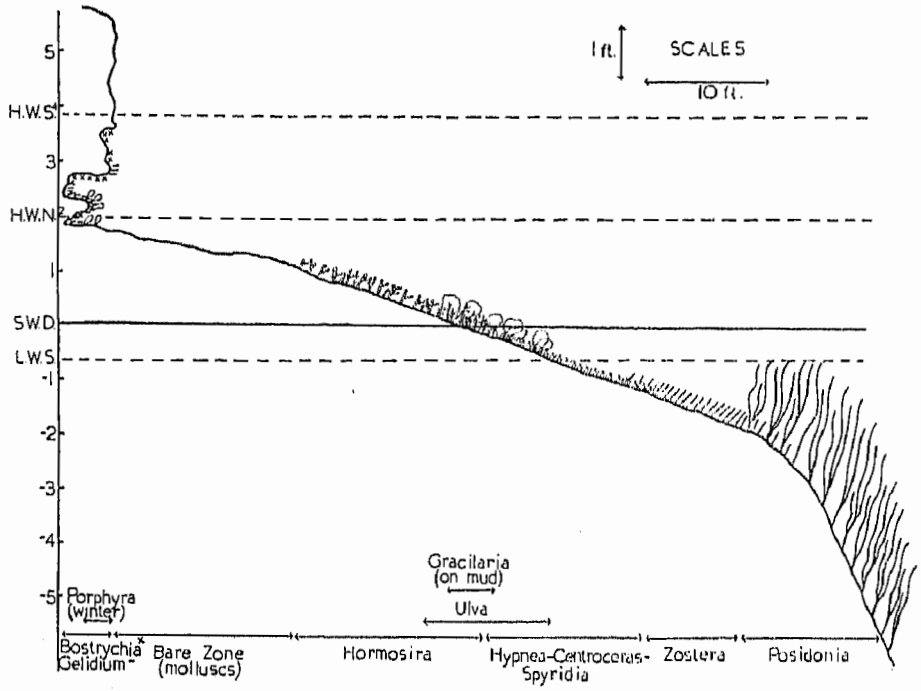

Fig. 5

Typical algal zonation on Pig Island, Pelican Lagoon. The relation of each zone to tide levels is approximately true; but in many areas the tidal flats are much wider and the *Hormosira*, *Zostera* and *Posidonia* associations occupy far greater areas than indicated. H.W.S., high water springs; L.W.S., low water springs; H.W.N., high water neaps; S.W.D., stationary water dodges.

As a general rule, *Gelidium pusillum* covers lower and more exposed rock than *Bostrychia* (*B. simpliciuscula*, with some *B. mixta* H. & H.). The roof and sides of small wave-cut caves are the most suitable habitat for *Bostrychia*.

During winter a community of *Porphyra umbilicalis* (L.) J. Ag. occurs in the lower *Gelidium* zone, but on more exposed rocks. The red-purple fronds reach a length of only 8 to 12 cm., and lie as flat sheets on the rock at low tide.

From the base of the low cliffs to the start of the *Hormosira* association (a distance of up to 20 yards) is a zone bare of macroscopic algal growth. The area is left quite dry and fully exposed to the sun at low tide. Such conditions are too severe for any alga, but the molluscs *Bembicium melanostoma* and *Modiolus areolatus* are common.

2. Hormosira Association.

Hormosira banksii forms an extensive and conspicuous association in the low littoral, from about 1 foot above the dodge low to an inch or two below. Each plant grows either on the rock, or, if the substrate is sandy or muddy, on the partially buried bivalve *Brachyodontes erosus*. The spherical water containing receptacles of *Hormosira* enable it to grow where it is always exposed at low tide (pl. xiii, fig. 4).

The form of *Hormosira banksii* at American River is *labillardieri* Harv. It differs from the south coast form in being more branched, and having larger and more spherical vesicles. In both localities it grows only where it is exposed for a period each day; this exposure must in some way be essential to the growth of the alga.

During winter *Ectocarpus confervoides* (Roth.) Le Jol. is a common epiphyte on *Hormosira* at American River.

3. Ulva Association.

Ulva lactuca is always prominent at about low tide level, in the lower *Hormosira* and upper *Hypnea - Centroceras - Spyridia* associations. On the flats north of the American River jetty it forms a green band along the shore, superimposed on the *Zostera* association. In other areas it frequently becomes dominant to form a distinct association.

Forms of *Enteromorpha prolifera* J. Ag., *E. clathrata* Roth. and *E. bulbosa* Kütz. are common in the lower littoral and upper sublittoral, sometimes forming communities.

Sublittoral Associations

4. Hypnea - Centroceras - Spyridia Association.

This association extends from about low dodge level to 1 foot or slightly more below. The dominant algae are brown-coloured Rhodophyceae, and where dense give the zone an even brown appearance. *Hypnea musciformis* (Wulf.) Lamour., *Centroceras clavulatum* Ag. and *Spyridia biannulata* J. Ag. occur in varying but often about equal proportions. They are all slender forms, rarely more than 25 cm. long, and are just exposed at very low tides. In some places *Gracilaria confervoides* (L.) Grev. is common; on muddy patches around the small islands in Pelican Lagoon it forms dense but localised communities. The base of each plant is buried in mud but actually attached to a mollusc.

Other algae occur in the lower part of this association, and in somewhat deeper water. The distinctive feature, however, is the virtual absence of any species of *Cystophora* or other large brown alga. (The one exception is *Sargassum biforme*, which occasionally grows on rock on the sides of the channel where there is more water movement, but rarely in the upper sublittoral.) The commonest species are: *Caulerpa remotifolia* Sonder; *C. simpliciuscula; Codium muelleri* Kütz., a lithothamnion forming spherical nodules to 5 cm. across; *Corallina* sp. (hemispherical tufts 20 cm. across), and more rarely *Cystophyllum muricatum*.

5. Zostera muelleri Association.

Zostera muelleri forms a pure and dense association over large areas of the tidal flats (pl. xiii, fig. 3), from low water level to 2 feet below, in some places to as much as 6 feet below. This angiosperm spreads almost entirely by means of runners which anchor the plant in the mud and produce narrow leaves (to 25 cm. long). It seems to prefer a muddy substratum. Epiphytes on the leaves are common (pl. xiii, fig. 3), especially *Centroceras clavulatum*,

Cladophora ceratina Kütz., *Ceramium* sp., and *Rivularia polyotis* (Ag.) B. & F. Amongst the *Zostera*, on small sandy patches, *Chondria dasyphila* (Grev.) C. Ag., *Spyridia biannulata*, *Polysiphonia patersonis* Sonder and *Graciliaria confervoides* occur. Very rarely plants of *Cystophyllum muricatum* and *Cystophora cephalornithus* (Lab.) J. Ag. may be found.

6. Posidonia australis Association.

Posidonia australis colonises deeper parts of the tidal flats and the channel edges, from 1 to 10 feet below extreme low water, with occasional plants to 14 feet. In Eastern Cove it extends to about 7 fathoms. The long strap-like leaves have a distinctive appearance as they just reach the water surface on the flats at low tide.

The association is dense and pure, but the rough leaves bear a wealth of epiphytes. On small pieces of leaf 10 species are often present. The most important ones are: *Rivularia polyotis*, *Ectocarpus* sp., *Asperococcus bullosus* Lamour., *Colpomenia sinuosa* (Roth.) D. & Sol., *Jania micrarthrodia* Lamour., *Centroceras clavulatum*, *Ceramium puberulum*, *Spyridia biannulata*, *Polysiphonia succulenta* Harv., *P. fuscescens* Harv., *P. davyae* Reinb. Many of these attain their maximum development during winter months.

7. Halophila ovalis Association.

Another marine angiosperm, *Halophila ovalis* (R. Br.) Hook. forms dense patches between 2 and 12 feet below low water. The ovate leaves, produced from runners, reach a height of 15 cm., but epiphytic growth on them is much less than on the *Zostera* or *Posidonia*.

The three marine angiosperms all spread largely by runners. This ensures for the most part a pure association, but in shallow water all three have been observed growing together.

ACKNOWLEDGMENTS

The author is indebted to Professor J. G. Wood for advice during the progress of this work and criticism of the manuscript.

In much of the field work the author has been fortunate in having the assistance of members of the staff and senior students of the Botany School, University of Adelaide. Mr. S. J. Edmonds, of the Zoology Department, has also been studying the animal communities of the Kangaroo Island coasts, and most of the hydrological data were taken jointly by Mr. Edmonds and the author. The following have also rendered invaluable assistance in determinations of certain algal groups: Dr. Francis Drouet, Chicago Natural History Museum, U.S.A. (Myxophyceae, excluding Rivularia); Dr. H. K. Phinney, Chicago Natural History Museum (Cladophoraceae); Miss L. B. Moore, Botany Division, D. S. & I. R., New Zealand (*Stypocaulaceae*); Miss V. May, Fisheries Division, C. S. & I. R., Cronulla, N.S.W. (species mentioned in census and confirmation of others). The Directors of the Melbourne and Sydney National Herbaria have given most valuable assistance in the loan of named material. Mr. D. J. Rocheford, of the Fisheries Division, C. S. & I. R., Cronulla, has carried out phosphate and nitrate analyses of sea water samples from Kangaroo Island. To all these my thanks are extended.

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Fig. 1 Conditions at Pennington Bay on the South Coast of the Island with a heavy swell. The large breaker is 8-10 feet high. The figures are about half-way out on one of the rock-platform reefs.

Fig. 2 Rocks off the eastern edge of the main reef at Pennington Bay, exposed between waves at low tide. On these rocks the very dense sub-littoral fringe association, dominated by *Cystophora intermedia*, is developed.

Fig. 3 Typical rock-platform reefs at Pennington Bay exposed during low tide on a calm day.

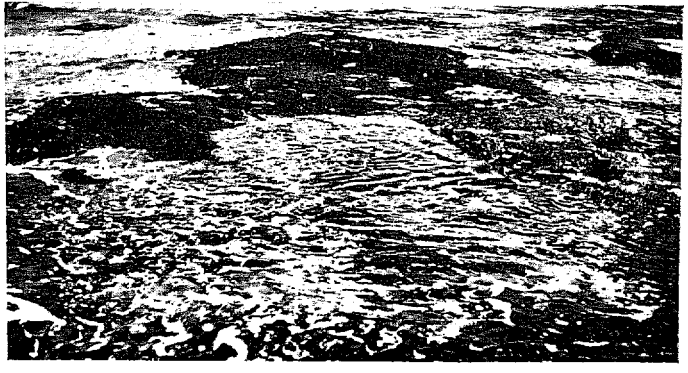

Fig. 4 The *Hormosira banksii* association at Pennington Bay. Slightly higher areas of rock on the reefs are densely covered with *Hormosira*, as is shown in the photo.

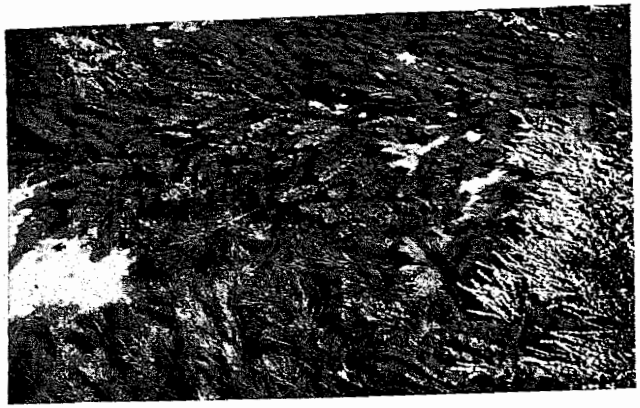

Fig. 1 The mixed *Cystophora* association at Pennington Bay. *Hormosira* occurs on higher rock on the right, with *Cystophora subfarcinata* fringing one side of a small pool (upper in the photo) and *C. siliquosa* fringing the other (deeper) side.

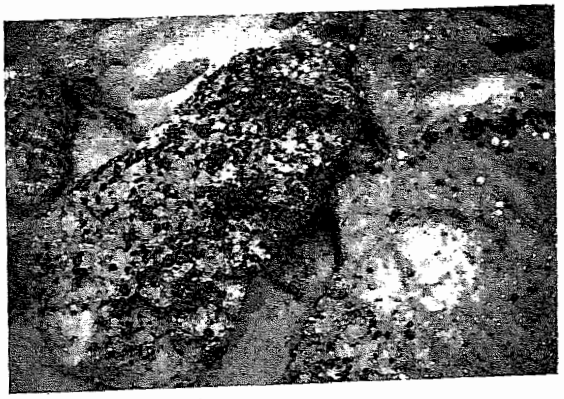

Fig. 2 *Rivularia firma* on rocks at the rear of the main Reef at Pennington Bay, during winter. The hemispherical blobs of *Rivularia firma* are usually more scattered than shown here.

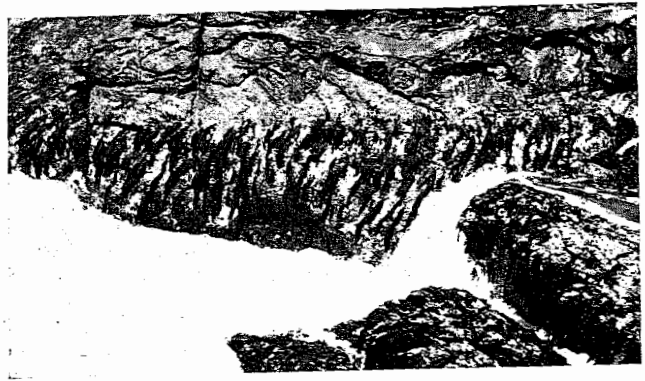

Fig. 3 The sub-littoral fringe association of *Cystophora intermedia* on the south side of Ellen Point, Vivonne Bay. Here the upper edge of the association is sharply limited, due partly to waves passing along the rock rather than breaking against it; for the same reason the coralline-mat association is almost absent here.

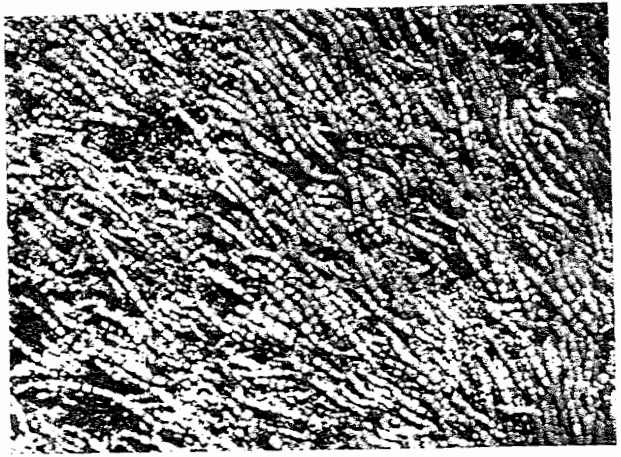

Fig. 4 Close up view of the *Hormosira banksii* association at Pennington Bay. The *Hormosira* here is pure and dense, with a few epiphytes.

Fig. 1 Rock pools on the south side of Ellen Point, Vivonne Bay. The pool in the foreground contains a community of *Laurencia heteroclada* and a lithothamnion; in the rear pool localised communities occur in shaded areas. Waves enter these pools only at high tide.

Fig. 3 *Splachnidium rugosum* occurring as short tufted plants on granite rocks in the upper littoral at Cape Willoughby.

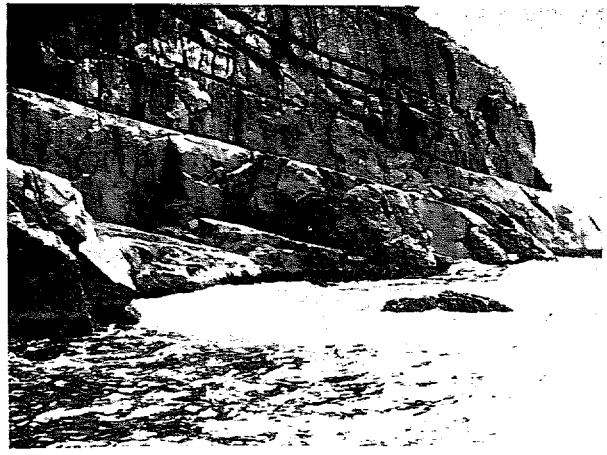

Fig. 2 The coast on the south side of Cape Willoughby. The dark band of *Cystophora intermedia*, with a sharply limited upper edge, is shown passing along the rock just above the water level. The photograph was taken between waves at low tide.

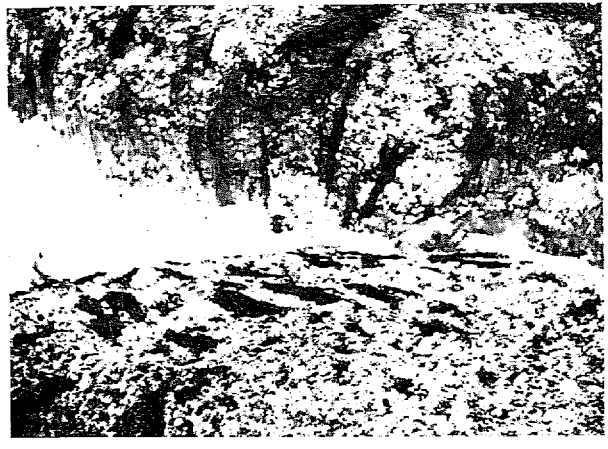

Fig. 4 The coralline-mat association in the lower littoral at Cape Willoughby. In very rough places *Cystophora intermedia* spreads into the dense mat of corallines (mainly *Jania*), as is shown here.

Fig. 1 The coast on the south side of Ellen Point, Vivonne Bay, looking west. This type of coast is typical of the south coast of Kangaroo Island where Pre-Cambrian rocks occur.

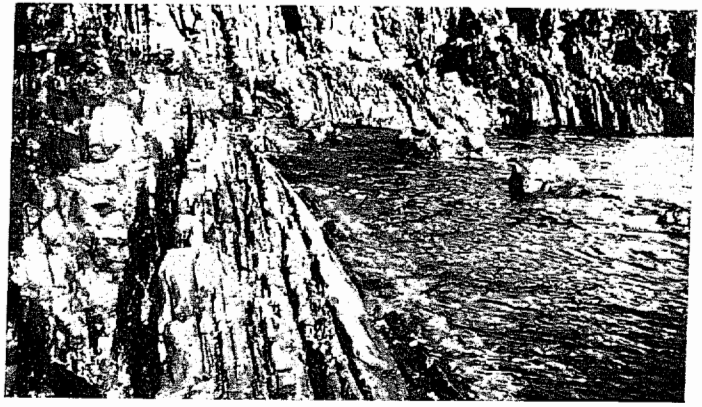

Fig. 2 The coast east of Middle River. Such conditions are typical of this area of coast on a calm day.

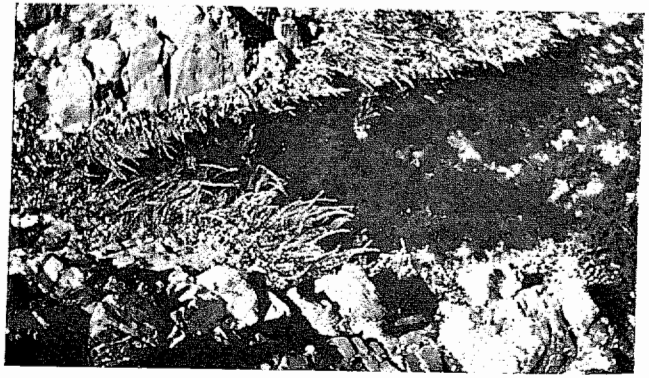

Fig. 3 *Hormosira banksii* fringing a pool at Middle River. Below the water surface species of *Cystophora* occur, forming *the Hormosira-Cystophora* pool association.

Fig. 4 The coast just west of the jetty at Emu Bay. Rocks in the lower littoral are covered with the coralline-mat association, the upper edge of which is indicated by the arrow.

Wide tidal flats on the east side of the American River Inlet, exposed during low tide. The channel can be seen on the far right. Most of the area shown is colonised by *Posidonia*, with some *Zostera* and *Hormosira*.

Fig. 3 Tidal flats near the American River Jetty, colonised by *Zostera* and showing masses of epiphytes floating on the surface during low tide (summer).

Fig. 2 The coast at Pig Island in Pelican Lagoon. In the shaded region of undercut rock, associations of *Bostrychia* and *Gelidium pusillum* occur, while the flat area exposed to the sun and not under water is bare of a'gae. The tide is just covering the *Hormosira* association.

Fig. 4 Close up view of the *Hormosira* association at American River, showing its dense nature. Note the difference in form between the *Hormosira* shown here and that shown in Plate X, figure 4 (at Pennington Bay).

2.

THE MARINE ALGAE OF KANGAROO ISLAND
II. THE PENNINGTON BAY REGION

By H. B. S. Womersley

Department of Botany, University of Adelaide

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II. THE PENNINGTON BAY REGION

By H. B. S. Womersley*

[Read 8 July 1948]

Contents

* Department of Botany, University of Adelaide.

INTRODUCTION

The first paper of this series (Womersley 1947) gave a general description of the algal ecology of Kangaroo Island, together with an account of the more important environmental factors for the island as a whole, and a discussion of the terminology found most satisfactory in describing the algal ecology.

This paper deals with one of the distinctive regions of the Kangaroo Island coast, *viz.*, the horizontal rock platforms of the Pennington Bay region and other areas of the south coast of the island (see previous paper). The Pennington Bay reefs, because of their easy accessibility from the American River settlement, have been studied in some detail. The same type of rock platform has been briefly examined elsewhere along the coast—east of Vivonne Bay and at Sou'-West River—and their algal ecology appears to be similar in all cases. This is in accordance with the similarity in structure of the reefs and in the environmental conditions to which organisms inhabiting them are subject.

These rock-platform reefs are classed as a distinct section of the Exposed Rocky-coast Subformation around Kangaroo Island (Womersley 1947). They are formed by wave action from consolidated calcareous sand-dunes of Recent to Pleistocene age, and alternate with areas of Precambrian rocks along the south coast.

Pennington Bay is not well defined. The western part of the bay is formed of cliffs 80 to 100 feet high overlying Precambrian rocks. In the central and eastern parts the sand-rock cliffs are lower, usually less than 50 feet high, forming small outcrops and headlands, separated by sandy beaches backed by sand-dunes (see pl. X). Further to the east the cliffs are more continuous and tend to be higher.

From the cliff bases stretch out the horizontal wave-cut platforms, composed of the same calcareous sand rock as the cliffs. Except in a few cases where wave action has eroded small caves at the cliff base, the cliffs descend almost vertically to the flat reef surface. Rock above high water level is usually sharply pitted and ridged, that on the reef itself less so but still forming a hard and rough surface.

The characteristic feature of the reefs is their flat, horizontal surface and vertical drop off at the edge into deep water of 10 to 20 feet. Many reefs are undercut in varying degrees, with occasional tunnels and blow holes up through the reef surface.

The following account is based largely on the reefs occurring along some 1½ miles of coast at Pennington Bay and to the east. The Precambrian rocks which form the western headland of the bay are not included in the discussion. The most accessible reef is also one of the largest. It is situated some 100 yards west of the track to Pennington Bay from the American River – Hog Bay road, and almost due south from a large sand hill known as Mount Thisbe. This reef illustrates well the main features of the reefs generally, and most of the algal associations found in the region occur on it. The distribution of the algal associations on this "main reef" (pl. XI, fig. 1) will be used as a basis for the following descriptions, reference being made where necessary to other reefs.

Almost the whole surface of these rock platforms is dominated by algae, though molluscs and other animals are characteristic of many associations. In the rear littoral, on sloping and more exposed rock, several animal associations occur, often pure but sometimes co-dominant with algae in restricted areas. It has proved most satisfactory to deal with the algal associations by themselves, although mention is made in cases where algal-animal biocenoses occur. A full account of the fauna of the Pennington Bay reefs is given by Edmonds (Edmonds 1948).

ENVIRONMENTAL CONDITIONS

A general account of the environmental conditions of the Kangaroo Island coast has been given previously (Womersley 1947). The more important environmental factors at Pennington Bay are summarised below.

Tidal Range—Spring range, 2½ feet approximately; neap range, 1½ feet approximately. The effect of wind and the state of the sea greatly modify the tidal rise, often causing low or high water when least expected.

Roughness—Conditions on outer parts of the reefs are always rough, becoming calmer further in as breakers passing over the reefs gradually lose their force. Breakers are a constant feature of the Pennington Bay coastline, but with a north wind and calm sea they are only 1 to 2 feet high (pl. X and XI). Such conditions, however, are not common, and with a heavy swell breakers up to 8 or 10 feet high occur off the reefs (pl. IX, fig. 1, pt. 1).[1] During calm conditions and a low tide, most of the reefs may be exposed, or have few waves passing over them. High summer air temperatures may kill or damage large reef algae under such conditions.

At the rear of the reefs conditions are usually much calmer, but most areas of sloping rock are washed over by small waves, and pools of still water occur only at low tide.

Temperature—The following table of sea temperatures on the main reef gives some idea of the yearly range. All figures are isolated readings, but the daily or weekly variation is small owing to deep water close in shore.

TABLE I

Sea temperatures on the main reef, Pennington Bay

	Jan.	April	May	June	July	Sept.	Nov.
Temp. °C. - -	19·0	18·5	17·5	16·0	13·5	14·0	16·0

Temperatures on the main reef are usually within 1° C. of the sea temperature off the reef (warmer in summer, warmer or cooler in winter depending on the air temperature). On rock platforms above the reef surface, and usually above high water level, isolated pools may occur where water temperatures reach 30° C. during summer. Such pools bear a characteristic but sparse algal community (see later).

The yearly range in sea temperature is small (about 5·5° C.), but variation in size and seasonal occurrence of a number of reef algae can best be attributed to this.

Air temperatures—Few figures of air temperatures are available. Some for Kingscote (on the north coast of Kangaroo Island) have been given previously (Womersley 1947). The climate generally is insular and mild. Air temperatures of most importance in the algal ecology occur on hot summer days, when they may reach 37° C. If combined with a north wind and low tide exposing the

[1] Part I refers to the first paper of this series (Womersley 1947).

reef surface, this may result in considerable damage to reef algae, particularly species of *Cystophora* and *Hormosira banksii* (which occurs on higher levels of the reefs). No harmful effect of exposure during low tides in winter months has been observed, nor would be expected as air temperatures are not often higher than sea temperatures from June to September.

Winds—Southerly to westerly winds are most frequent on the south coast of Kangaroo Island. Easterlies often occur, but occasional northerlies during hot summer weather are the only winds of direct importance in the algal ecology (see under Temperatures).

Chlorinity—Isolated readings (January 1946) have given a chlorinity of 19·5-19·6‰ (salinity 35·2-35·4‰) for water on the reefs. Little annual change would be expected. Isolated pools above the reef surface are often more saline, particularly in summer (chlorinity 20·5-22·2‰), and usually lower after heavy rain.

Alkalinity—Colorimetric methods have given a pH of 8·2 to 8·3 for water on the reef.

ZONATION

The relatively small tides, and constant breakers, result in no marked horizontal zones such as described by numerous workers in regions of greater tidal range. Algal zonation does occur, however, and differences in reef levels of only 2 or 3 inches frequently cause profound changes in the algal associations (see reef section, fig. 1). The greatly dissected nature of the coastline, and the variety and grading of the habitats on the reefs, tend to obscure any obvious zonation, but over the whole area of the coastline examined there occur numerous well-marked associations, characterised by fairly distinct environmental conditions.

The average horizontal level of the reefs seems to correspond fairly closely to a mean low tide level (neaps). Some areas, either on the outer edge or elsewhere on the reefs, are a few inches higher than the rest, while shallow channels and pools often occur on the reef surface. Such features are well shown on the main reef (see map and pl. XI, fig. 1).

The reef surface is therefore classed as being in the *littoral zone*.[1] However, owing to the form of the reefs, few of the algae on their flat surface are ever completely exposed; many occur in shallow pools or areas of water retained on the reef at low tide. In other slightly higher areas the growth is so dense that a considerable amount of water is retained in the masses, and such areas are washed over by occasional waves. Only at the rear of the reefs on sloping and vertical rock which is classed as the *rear littoral* are the algae exposed for any length of time at low tide (see reef section, fig. 1).

The algal associations grouped together in the littoral zone are therefore subject to a much smaller degree of exposure than are littoral associations on steeply sloping rock in calmer seas. This is a characteristic feature of horizontal rock platforms wherever they occur, in contrast to the conditions on steeply sloping coasts. Algal ecological literature contains very few accounts of similar rock platforms, which are however a distinctive feature of many parts of the southern Australian coast.

The littoral zone is considered to include all algal associations at higher elevations, subject to wave action or spray. These may occur 2 or 3 feet above actual high tide level, but this is due entirely to the effect of wave splash and, in some areas, of shade.

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[1] For discussion of terminology see Womersley 1947.

The only algal community which can truly be classed at *supralittoral* is one of *Prasiola,* which is found only where penguin colonies occur. This habitat is also subject to fine, blown spray, but is more semi-terrestrial than marine. At least one mollusc association can be best considered as supralittoral (Edmonds, this journal, p. 168).

The edge of the reef, and to 1 or 2 feet down the vertical side, is termed the sublittoral fringe (pl. XIV, fig. 4). A very distinctive association of algae occurs on this part of the reefs. The importance of the sublittoral fringe zone in the broad algal ecology of Kangaroo Island has been outlined in the first paper of this series.

Below the edge of the reef, for at least 3 or 4 feet down (as far as it is possible to investigate), zonation occurs, but the deeper sublittoral flora is known only from the assemblage found cast up and not growing on the reefs. Dredging off the shore is, unfortunately, quite impossible.

THE ALGAL ASSOCIATIONS

Description of the Main Reef

The shape and appearance of the main reef at Pennington Bay is shown in pl. XI, fig. 1 and by the map. It measures some 70 yards across and 75 yards from beach to outer edge. Other reefs at Pennington Bay are shown in pl. IX, fig. 3, pt. I.

On the north-west corner of the main reef are cliffs about 15 feet high, with a ledge 2-3 feet wide at the base. This ledge forms the western side of a sandy pool, which is about 5 feet deep in the outer corner, and has a small sandy beach at the rear. The amount of sand on the beach and in the pool varies greatly at different times. As a general tendency the beach and pool are heavily sanded up in summer (pl. XIV, fig. 1), but with considerable bare rock in winter (pl. XII, fig. 3; also see map); this allows development of *Ectocarpus* and *Enteromorpha* associations on the exposed rock in winter. The amount of sand present, however, is largely dependant on the weather over the previous few weeks. The eastern part of the reef is backed by rocks which have fallen from the cliffs—the "fallen rock region" (pl. XII, fig. 1 and 2). At the north-east corner of the reef is a small rock platform which contains several rock pools on the top, about 5 feet above the reef surface.

A noticeable feature of the reef is the absence of loose rocks on the surface; a few which occur in the fallen rock region are almost dry at low tide and too large to be removed by wave action. This results in the virtual absence of the characteristic fauna, and to a lesser extent the flora, which inhabits the undersurface of loose rocks (see Pope 1943).

An important structural feature of the main reef is a ledge forming a drop of 6-12 inches, running in a curve through the centre of the reef to the south-east corner (pl. XI, fig. 1; pl. XIV, fig. 1 and 2, and map). This ledge, due to the almost continual streaming of water over it, even at low tide, bears a distinct algal association.

The areas colonised densely by *Hormosira* on the outer part of the reefs are slightly higher than the rest. Between the main area of *Hormosira* and the ledge is a shallow channel, 6 to 10 inches below the eastern part of the reef, which widens out towards the sandy pool. Except at an extremely low tide there is some water movement along this channel. A less well defined channel passes in from the outside edge of the reef between the two main areas of *Hormosira.* The western side of the reef is fairly even and 6 to 12 inches lower than the eastern half.

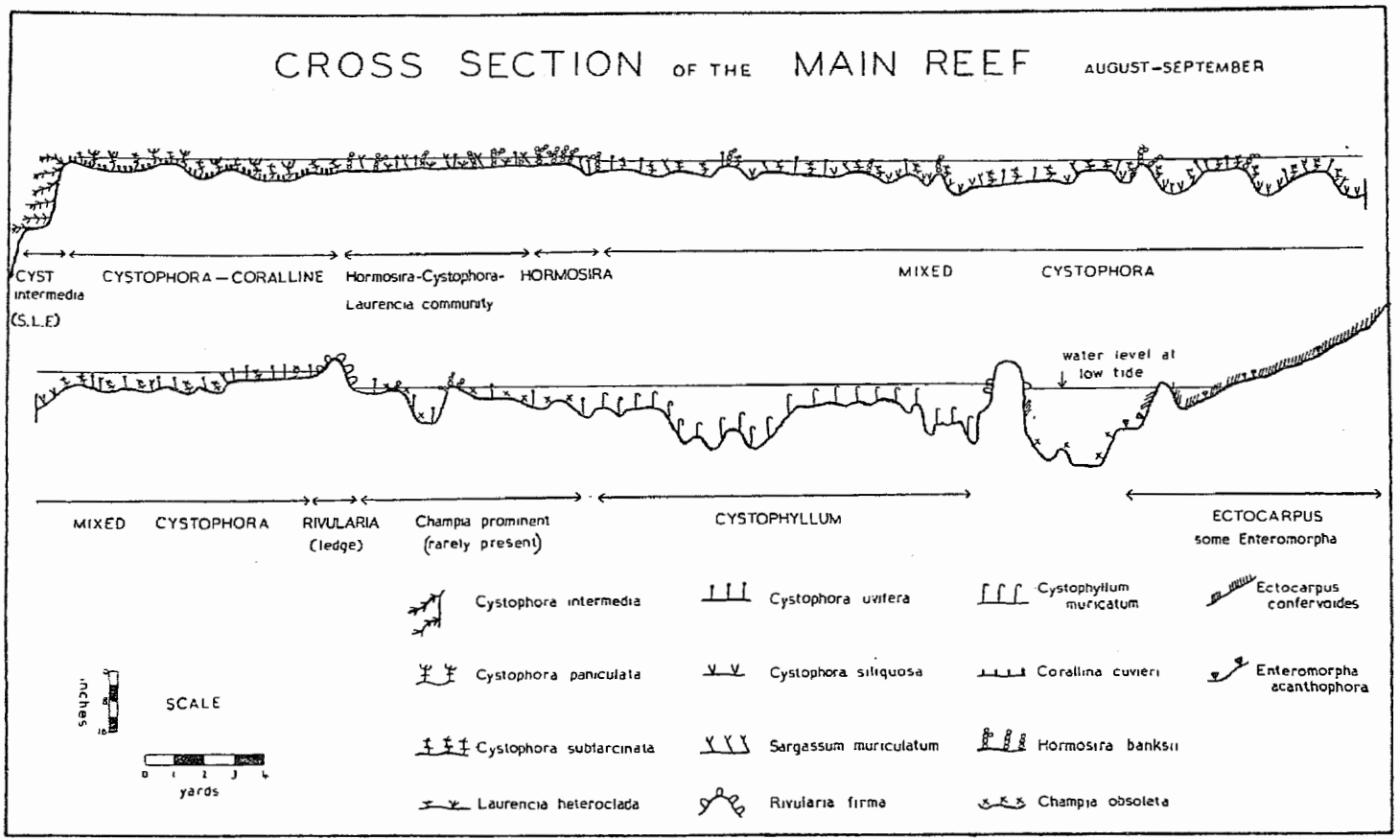

Fig. 1 Cross section of the main reef, Pennington Bay. For direction and position, see map.

The outer edge of the main reef is greatly dissected, with numerous pools and pot-holes (pl. XV, fig. 3). This is the roughest area of the reef and bears the dense and distinctive sublittoral fringe association. The south-eastern corner is more even, but slightly higher, with a greater degree of exposure between waves. An association characterised by the articulated corallines, *Corallina* and *Jania*, together with species of *Cystophora*, is developed here.

Owing to the position of the shallow channel, and slightly higher eastern side of the reef, general water movement is across the reef to the western side where it streams off the reef. Very little debris is ever cast up at the rear of the main reef, but is deposited on beaches on either side.

The main reef has been described in some detail because it illustrates well the manner in which slight differences in height of the reef (sometimes only 2 or 3 inches), and the degree of roughness in different parts, control the occurrence and distribution of the algal associations (pl. XIII, fig. 2). This will be evident in discussing the associations, and also from the cross section of the reef shown in fig. 1. The map shows the distribution of algal associations on the main reef during January (full map), and during August-September 1946 (inset). These illustrate the summer and winter appearances of the main reef, but owing to the varying amounts of sand covering parts of the rear littoral in winter months, the distribution of rear littoral associations often differs from that shown for August-September 1946.

At the western end of Pennington Bay, near the headland of Precambrian rock, is a reef formed of three or four horizontal terraces, each 1 to 2 feet vertically above the next and sloping steeply between each (pl. XI, fig. 2). The sand rock of this reef is the same as elsewhere in the bay, and there seems no obvious reason for the development of such a distinctive and different type of reef.

This "western terraced reef" bears several algal-animal communities which are absent or poorly developed on the typical rock platforms. The *Hormosira*–*Ectocarpus / Pylaiella*–anemone community will be referred to later, and a very prominent *Modiolus* (mollusc) association is described by Edmonds. An association of stunted *Laurencia heteroclada* occurs at a low littoral level.

The following account of the algal associations of the Pennington Bay region is based largely on their distribution on the main reef. Reference is made where necessary to their distribution on other reefs elsewhere in the Pennington Bay region and also in Vivonne Bay, but the main reef has proved to be very typical of this type of reef generally.

The Supralittoral Zone

Over most of the coast no algae are found in the supralittoral zone, but in restricted areas two poorly developed algal communities occur, and also a sparse lichen community.

Prasiola community

Prasiola sp. occurs on rock or stones on sloping parts of the cliffs up to 25 feet above high water, but only where well developed penguin tracks pass up these cliffs. One such locality is about ½ mile east of the main reef. The community is not prominent, and of infrequent occurrence. The alga, which is undetermined specifically, forms small green patches, rarely more than 2 or 3 cm. across, of tangled cylindrical filaments. Its habitat is subject to fine blown spray in considerable amount, but it is best regarded as a semi-terrestrial alga rather than a marine one. *Prasiola* is best developed during the winter months.

The other two communities described below are not strictly supralittoral but occur at a level above the main littoral communities, and are described here as a matter of convenience.

LICHINA COMMUNITY

Small black patches of the lichen *Lichina confinis* (Muell.) Ag. occasionally occur in sheltered areas in the fallen rock region of the main reef, and in similar habitats along most of the coast. On the south coast of Kangaroo Island it rarely forms a distinct association, but is much more prominent and covers considerable areas of rock in calmer areas on the north coast. It occurs at least partly above high tide level, its distribution being controlled by wave splash and shade.

ISOLATED ROCK-POOL COMMUNITY

On the small elevated platform at the north-east corner of the main reef (see map) occur several isolated pools. These pools are about 4½ feet above the reef surface, and are subject to wave splash only under rough conditions. Similar pools situated above high tide level occur infrequently in the Pennington Bay region. Owing to their small size, habitat conditions in the pools are extreme; on hot summer days water temperatures may reach 35° C., falling to 20° C. or less at night; while winter temperatures are often lower than the sea temperature. Salinity conditions are also variable.

The flora of these pools is sparse and variable in its occurrence, but characteristic of the habitat. It is usually better developed during the winter. The following species are most frequent: *Polysiphonia abscissa* H. & H., *P. frutex* Harv., *P. dasyoides* Zan., *Laurencia heteroclada* Harv., *Ectocarpus confervoides* (Roth.) Le Jol. (winter), *Ceramium miniatum* Suhr. and *Centroceras clavulatum* Ag. All are species of wide habitat range, and in many cases they are common in littoral associations.

THE LITTORAL ZONE

The associations of this zone are conveniently divided into those occurring on sloping rock at the rear of the reefs, and those on the flat reef surface. Those in the rear littoral are more tolerant of exposure than the reef surface forms, and except at high tide are exposed between each wave. The distribution of the associations on the main reef during summer (January) and winter (August-September) is shown in the map. The cross section of the reef during September (fig. 1) shows the vertical relationships of the associations between the shore and the outside edge of the reef.

Rear littoral associations

1. SYMPLOCA HYDNOIDES ASSOCIATION

Symploca hydnoides Kütz., a filamentous blue-green alga, forms dark, felt-like irregular patches, to 3 or 4 cm. across, on sloping and vertical rock at the rear of the reefs. At high tide it is washed or splashed by each wave, but may be left exposed for several hours at low tide. The soft spongy mats of the alga retain water strongly. The height to which *Symploca* reaches is controlled by the amount of wave splash, varying from 1 to 4 or 5 feet above the reef surface. It is best developed in shaded areas.

Although at times this association is very inconspicuous, *Symploca hydnoides* occurs on rock bare of other algae. It is found in similar habitats on rock-platforms elsewhere along the south coast of Kangaroo Island.

On one shaded rock in the fallen-rock region of the main reef a biocenose of *Symploca hydnoides* and the barnacle *Tetraclita purpurascens* occurs.