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2. GELIDIUM PUSILLUM ASSOCIATION

This association at Pennington Bay is but a poor example of the *Gelidium pusillum* (Stackh.) Le Jol. association on calmer coasts, such as at Rocky Point or in the American River inlet. Conditions at Pennington Bay are mostly too rough, and it is restricted to thin patches on vertical and sloping rock in locally sheltered places. On the main reef the cliff above the ledge forming the sandy pool has thin scattered patches in shaded hollows; it also occurs in the fallen rock region, mainly on the sides of the rocks.

On exposed rock, *Gelidium pusillum* forms yellowish-brown much branched thalli, but when growing in pools the fronds are upright, less branched, and 1 to 3 cm. high.

Like *Symploca*, this is not a conspicuous association, but it is of general occurrence in similar habitats on the sandrock reefs. In some areas it is co-dominant with the serpulid worm *Galeolaria caespitosa* in a biocenose.

3. RIVULARIA FIRMA ASSOCIATION

Rivularia firma Womersley forms dark blue-green gelatinous blobs up to 2 cm. across (masses to 4 or 5 cm. across) in parts of the rear littoral where there is constant wave splash, or on ledges over which waves stream. Such habitats were exposed between waves at low tide, but only for very short periods. A high degree of aeration seems to be of most importance. The firm gelatinous thalli can resist considerable exposure during the occasional very low tide and hot summer weather.

Rivularia firma occurs along the south and west coasts of Kangaroo Island, in the upper littoral, whatever the type of rock. The association varies greatly in its development from place to place, for no obvious reason. At Pennington Bay rocks in the rear littoral may be densely covered with the hemispherical blobs (pl. X, fig. 2, pt. 1), with no other algae present; in other places, and at different times, the rock may be bare. Development is usually better during winter months, and may be very poor in summer.

On the main reef, the ledge running in a curve through the centre of the reef to the south-east corner is usually dominated by *Rivularia firma*. This is a region of constantly streaming, broken water, and is colonised by a distinctive group of algae. Apart from *R. firma*, the commonest are *Hydrocoleum glutinosum* (Ag.) Gomont, *Rivularia atra* Roth., *Polysiphonia frutex* (epiphytised by *Calothrix confervicola* (Roth.) (Ag.), *Hormosira banksii* Dene., *Laurencia heteroclada*, with scattered plants of *Wrangelia plumosa* Harv., and *Champia obsoleta* Harv. The dominance of blue-green algae on this ledge is striking, but similar ledges have not been found elsewhere in Pennington Bay, though they may occur.

On the small "islands" on the ledge (see map) and in more exposed parts of this association, *Galeolaria caespitosa* often becomes co-dominant with the *Rivularia*.

4. ECTOCARPUS CONFERVOIDES AND PYLAIELLA FULVESCENS SEASONAL ASSOCIATIONS

Ectocarpus confervoides and *Pylaiella* (*Bachelotia*) *fulvescens* Bornet occur in the same habitat on sloping rock in the lower rear littoral, or sometimes in pools in a similar position, at different times of the year. *Ectocarpus* occurs during winter months (April to November), *Pylaiella* during the summer (September to May). Both species grow on sloping, well washed rock which is exposed between waves at low tide (fig. 1; pl. XII, fig. 3 and 4, and map). They reach their greatest size (to 7 or 8 cm. high) however where always covered, with

slight wave action. During summer the sloping rock at the rear of the sandy pool (main reef) is usually buried under sand, preventing *Pylaiella* from developing there.

In appearance both algae are very similar, forming brown tufts, but whereas *Ectocarpus* is abundantly branched, *Pylaiella fulvescens* is branched only at the base and the tufts are less distinct.

Scytosiphon lomentarius (Lyngb.) J. Ag. is frequently found in both associations, especially in winter when it is heavily epiphytised by *Ectocarpus confervoides*.

5. Enteromorpha acanthophora association

Enteromorpha acanthophora Kütz. forms a striking and pure association in the rear littoral of the Pennington Bay reefs, in very much the same habitat as *Ectocarpus* and *Pylaiella*. Both associations however are remarkably distinct, with rarely any intermixing. Why this is so is not clear, for rock on the same slope and subject to apparently identical conditions may be covered by two quite distinct areas of *Ectocarpus* and *Enteromorpha*. The association varies considerably in its development from time to time, being best developed in late winter. Small scattered plants occur in the inner channel area from time to time.

Both the *Enteromorpha* and *Ectocarpus – Pylaiella* associations occur where loose sand is carried about by the waves. The algae appear to be very tolerant to this sand movement, and may even survive short periods of burial in sand.

6. Ulva lactuca association

Ulva lactuca L. (f. *rigida* (Ag.) Le Jol.) often colonises areas slightly lower than *Enteromorpha*, and scattered plants occur at the rear of many reefs. The habitat is less exposed than that of *Enteromorpha*. The plants are variable in form, from broad expanded sheets to elongate undulate ribbons, and rarely more than 12 cm. high.

Littoral associations

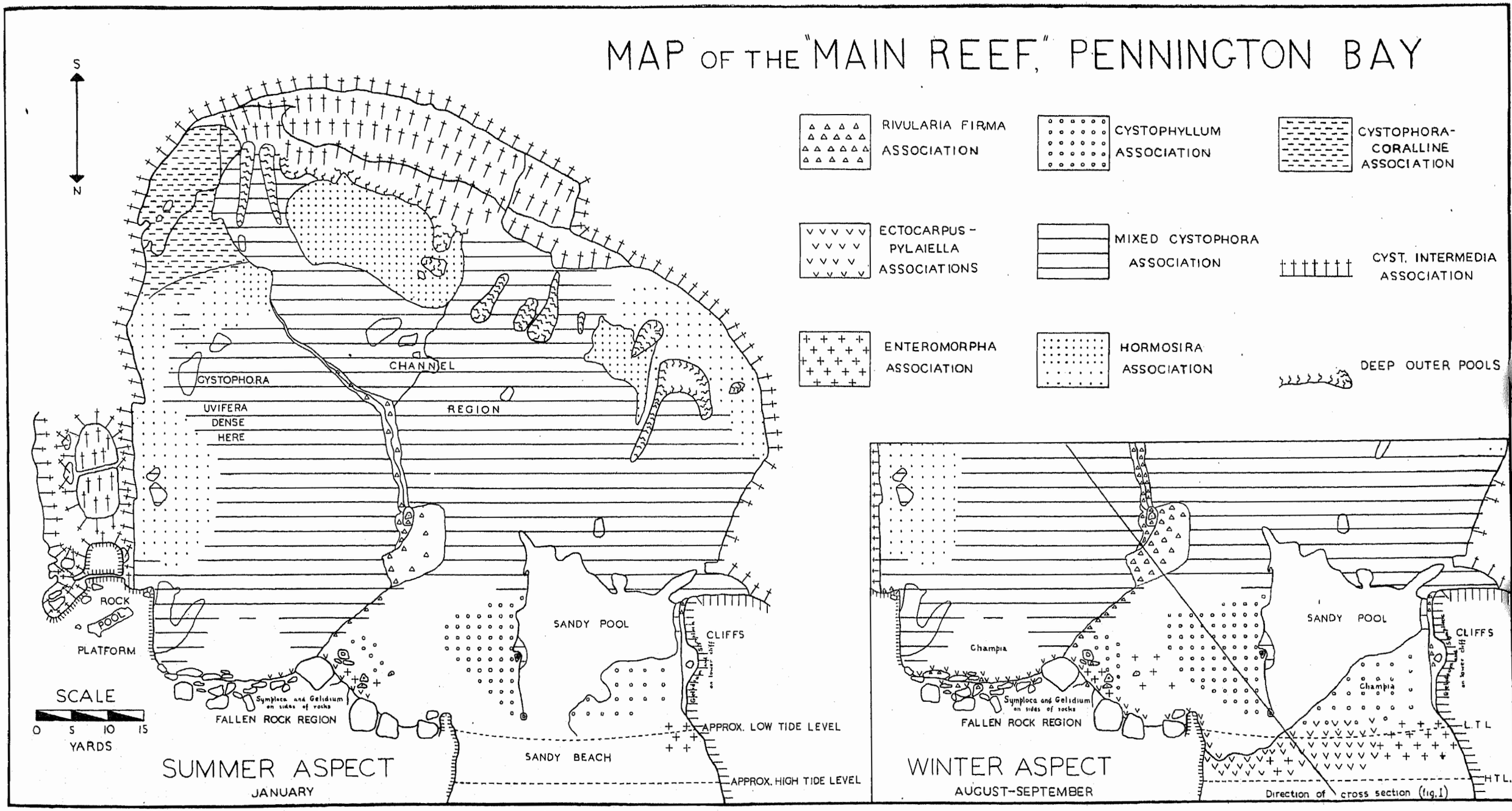
The associations described below as being in the littoral zone are not strictly so, as most of the algae are rarely exposed for any length of time. At low tide many of the larger species reach the water surface, and others are covered by only a few inches of water. A few, such as *Hormosira*, are exposed at every low tide. On calmer coasts *Cystophora subfarcinata*, *C. siliquosa* and often *C. brownii* are characteristic of the upper sublittoral, but with the exception of *C. siliquosa* few of the reef algae extend into the sublittoral. From most viewpoints it is convenient to regard the following associations as characteristic of the littoral zone.

7. Polysiphonia frutex association

Polysiphonia frutex is common throughout the year on the ledge and calmer areas of the main reef. On other reefs at Pennington Bay, including one immediately west of the main reef, it forms a pure association on flat or sloping rock in areas of medium to slight wave action. The alga reaches a height of only 5 to 7 cm., but is dense enough to give the area a dark brown appearance. Common epiphytes are *Polysiphonia abscissa* and *Calothrix confervicola*.

8. Cystophyllum muricatum association

The area between the sandy pool and the ledge on the main reef (see map) is covered by a pure association of *Cystophyllum muricatum* (Turn.) J. Ag. Other algae are virtually absent from this area. *Cystophyllum* also occurs as scattered plants on rock in the sandy pool and near the fallen rock region. On other reefs it is not common, but usually pure when it does occur.


MAP OF THE "MAIN REEF," PENNINGTON BAY
S
N
RIVULARIA FIRMA ASSOCIATION
CYSTOPHYLLUM ASSOCIATION
CYSTOPHORA-CORALLINE ASSOCIATION
ECTOCARPUS-PYLAIELLA ASSOCIATIONS
MIXED CYSTOPHORA ASSOCIATION
CYST. INTERMEDIA ASSOCIATION
ENTEROMORPHA ASSOCIATION
HORMOSIRA ASSOCIATION
DEEP OUTER POOLS
CYSTOPHORA
UVIFERA DENSE HERE
CHANNEL
REGION
ROCK POOL
PLATFORM
SCALE
0 5 10 15
YARDS
Symploca and Gelidium on sides of rocks
FALLEN ROCK REGION
SANDY POOL
CLIFFS
on lower cliff
APPROX. LOW TIDE LEVEL
SANDY BEACH
APPROX. HIGH TIDE LEVEL
SUMMER ASPECT
JANUARY
Champia
Symploca and Gelidium on sides of rocks
FALLEN ROCK REGION
SANDY POOL
CLIFFS
on lower cliff
Champia
L.T.L.
H.T.L.
Direction of cross section (fig. 1)
WINTER ASPECT
AUGUST-SEPTEMBER

The alga reaches a height of 20 cm., developing best at the edges of slightly deeper pools. *Sphacelaria biradiata* Asken. and *Sphacelaria furcigera* Kütz. are common epiphytes on the lower stems during summer. Occasionally the plants are almost buried in sand, but appear to suffer little damage. The association is always, but only just, submerged.

The rocky bottom in the north-eastern half of the sandy pool is rarely covered by sand, and bears a very mixed assemblage of species. At low tide it is covered by 1-3 feet of water, with fairly calm conditions. *Cystophyllum muricatum* is present here, though not well developed and in varying amounts throughout the year. Other species may be prominent at different times, developing rapidly and disappearing after two or three months. Such species are *Liagora harveyana* Zeh., *Helminthora tumens* J. Ag.? *Champia obsoleta* (winter), *Dictyopteris acrostichoides* (J. Ag.) Schmitz? *Ectocarpus confervoides* and *Scytosiphon lomentarius* (both winter), *Pylaiella fulvescens* (summer), *Muellerena* sp. (winter), with *Ulva lactuca* and *Enteromorpha acanthophora* in the shallower parts. This mixed group of species is also found on the eastern part of the main reef, in shallower water near the fallen rock region, but is less well developed here. Most of the species are found in other associations on the reef.

9. Jania fastigiata association

On several reefs in the Pennington Bay region (one immediately east of the main reef) and also on reefs in Vivonne Bay, *Jania fastigiata* Harv. colonises otherwise bare rock in the littoral zone. The association is not a dense one, but distinctive in appearance. The fronds (to 4 or 5 cm. high) are bleached white in summer, but in many cases are heavily epiphytised by *Calothrix confervicola*, giving the association a blackish-green appearance. The habitat is usually of fairly even rock, just exposed at very low tides.

10. Laurencia heteroclada association

Laurencia heteroclada occurs as a minor component of several reef associations, and is widely distributed along the south coast of Kangaroo Island. On the lower level of the western terraced reef (pl. XI, fig. 2), and similar sloping rock in the low littoral, it forms a community which is doubtfully of association rank. The alga grows as a dense turf, up to 7 cm. high, yellowish-brown in colour, of stunted plants where it is subject to fairly heavy wave action. This habitat is rarely exposed, being only slightly higher than the sublittoral fringe. A stunted *Sargassum, Cladostephus verticillatus* (Lightf.) Ag., *Caulerpa brownii* Endl., *C. simpliciuscula* Ag., and *Chaetomorpha darwinii* Kütz. often occur with it.

11. The Cystophora complex

The greater part of most of the Pennington Bay reefs is colonised by species of *Cystophora*. Their extent on the main reef is shown by the map. The mixed *Cystophora* association covers the area east of the ledge, consisting of numerous shallow pools retaining 4 to 10 inches of water at low tide, and also the channel area and most of the western part of the reef.

Four species of *Cystophora, C. uvifera* (Ag.) J. Ag., *C. subfarcinata* (Mert.) J. Ag., *C. siliquosa* J. Ag. and to a lesser extent *C. brownii* (Turn.) J. Ag., together with *Sargassum muriculatum* J. Ag., form a complex of associations. Depending on small variations in depth of water and calmness, each may form an almost pure association, or, as is more common, a mixed association of almost any combination of two or more species (pl. X, fig. 1, pt. I). The shallow pool area east of the ledge on the main reef is dominated by *Cystophora subfarcinata, C. siliquosa* and *C. uvifera*, with some *Sargassum muriculatum*. This is referred to as a "mixed *Cystophora* association". As pure associations,

C. subfarcinata and *C. siliquosa* are most frequent.

The importance of *Cystophora* in the algal ecology of Kangaroo Island is in many ways analagous to the importance of Eucalypts in South Australian land ecology. In the previous paper it was shown that the algal formations and subformations around Kangaroo Island can be characterised by the presence or absence of species of *Cystophora*. Of some 25 species in the genus, 17 occur around Kangaroo Island.

(a) *Cystophora uvifera* forms a pure association on flatter and calmer parts of the reefs. On the main reef it dominates an area of more even rock running outwards towards the south-east corner, and also parts near the western edge (pl. XIV, fig. 3). It is densest where just covered at low tide, partly due to insufficient depth of water at low tide to allow other (and larger) species of *Cystophora* to develop.

C. uvifera forms short, rather stunted plants, to 25 cm. high, with one to several stems arising from the base. It shows remarkable seasonal variation in vesicle production, which seems to be attributable only to seasonal variation in sea temperature (a range of about 5·5° C. on the reef). *C. uvifera* has always been described as bearing spherical mutic vesicles on the main stem (Harvey Phyc. Aus., pl. 175). This is the form found in calmer waters or rarely cast up from the sublittoral. On the Pennington Bay reefs, vesicles have never been found on the plants during January. By May, small elongate vesicles with a strongly developed mucro occur in small numbers on most plants. These approach closely the vesicles of *C. cephalornithos*, which is only found in much calmer habitats. In September vesicles are numerous, the older ones being almost spherical and with only a small mucro. The "typical" mutic vesicles are rarely seen, and by mid-summer the vesicles are lost. It seems evident that besides the controlling effect of temperature in vesicle formation, the relatively rough conditions on the Pennington Bay reefs cause the juvenile forms of vesicle (elongated and mucronate) to be largely retained.

Sargassum muriculatum is commonly present in the same area as *C. uvifera*. *Sphacelaria furcigera*, and occasionally *Sph. biradiata*, grow epiphytically on the stems.

(b) *Cystophora subfarcinata*—This alga grows in slightly deeper water than *C. uvifera*, where wave action is greater but not extreme. Apart from *Hormosira banksii*, it is the most widespread species on the reefs. On the main reef it is one of the dominants of the mixed *Cystophora* association, and is particularly prominent in pools more than 6 inches deep and in the channel area, where it is always in 6 to 12 inches of water (pl. XIV, fig. 3).

Cystophora subfarcinata never produces vesicles on the Pennington Bay reefs, or elsewhere on the south coast. In sheltered parts of the north coast, however, vesicle formation is common. This is a clear case of ecological forms under different degrees of wave action.

(c) *Cystophora siliquosa* inhabits deeper pools than *C. subfarcinata*. It forms a characteristic fringe around most of the deeper rock pools towards the outside of the reef, and also on the western side of the reef where water streams off. It cannot survive strong direct wave action. Small plants occur over most of the mixed *Cystophora* association on the main reef, but only in deeper rock pools does it attain its maximum length of 5 or 6 feet. Near the western edge of the reef, *Antithamnion hanowioides* (Sond.) De Toni, *Antithamnion* sp. and *Dasya* spp. are common epiphytes on *C. siliquosa*.

On other reefs, and rock off the edges of reefs, *C. siliquosa* forms a pure association in 2 to 5 or more feet of water.

(d) *Cystophora brownii*—This species is less common than the previous three, and does not occur on the main reef. On reefs east of Pennington Bay it is sometimes codominant with *C. subfarcinata* in 1-2 feet of water (at low tide) towards the rear. Only rarely has it been seen pure.

(e) *Sargassum muriculatum*—This, the only important littoral species of *Sargassum,* is common on most of the rock platforms, and shows remarkable seasonal development. On the main reef it occurs near the fallen rock region, on flatter areas with *C. uvifera,* and in the channel, but is densest on the western side of the reef where it thrives in the constantly streaming water. In the latter area it is often dominant, but elsewhere is usually subdominant to the *Cystophora.*

During summer *Sargassum muriculatum* is a short stunted plant rarely more than 10 or 12 cm. high, and it can be easily distinguished from *Cystophora uvifera* only by its flattened stem. Growth commences during March or early April, and during winter the fertile fronds are developed, reaching a height of 40 or 45 cm. By September small vesicles, almost identical with those of *S. sonderi* J. Ag., are produced, but by early November the fruiting frond disintegrates, losing both receptacles and vesicles. The stalk of the old frond persists for some weeks, but by January the plants are reduced to a short stem bearing a few branches with crowded, almost terete leaves (such as figured by Agardh [1889]). This striking seasonal development must be due to lower water temperatures, though the annual range, as given previously, is small.

Throughout the *Cystophora* associations scattered plants of *Hormosira banksii* may occur chiefly on higher ridges (pl. X, fig. 1, pt. I). Tiny dark blue-green thalli of *Rivularia atra* are also common on bare rock in the association. An intermediate community between the mixed *Cystophora* and *Hormosira* associations on the main reef will be discussed later.

Several other algae occur irregularly in the *Cystophora* complex, varying greatly in their distribution and occurrence in different seasons. These will be dealt with later under "Chance distribution of minor species" (see p. 157).

Although the species of *Cystophora* are the largest algae growing on the reefs, much of the rock between the plants is left bare. This is probably due in some measure to removal of young plants of other species by the fronds of the *Cystophora* as the latter are moved over the rock by waves. On one occasion (April, 1947) the channel area had been almost denuded of algae, only the holdfasts remaining. Growth of new plants in this area was poor, and it would seem that few species apart from those of *Cystophora* grow readily in areas of shallow streaming water. Yet such a habitat appears to be just as suitable as many where algal growth is heavy, such as the sublittoral fringe association. When compared with the latter association the *Cystophora* complex is poor in number of species, though composed of larger plants.

12. Hormosira banksii association.

Hormosira banksii (f. *sieberi* [Bory] Dene.) is more widespread than any other alga on the Pennington Bay reefs. It occurs from the outer edge to the inner calmer areas, but only on higher parts of the reefs in fairly rough conditions does it form a dense and distinct association. On two areas on the outside of the channel on the main reef, and a smaller area just east of the ledge near the *Cystophora*-coralline association (see map), it becomes very dense, to the exclusion of all other algae except a few epiphytes (pl. XIII, fig. 2 and 3). The areas of pure *Hormosira* are only a few inches above the rest of the reef, but are exposed between waves at low tide, sometimes for several minutes. On many reefs the *Hormosira* association is near the outer edge or sides. Many reefs have the surfaces markedly ridged, and bear *Hormosira* only on the ridges where it is exposed at low tide (pl. XIII, fig. 1).

The chains of bead-like vesicles (about 1 cm. across) of *Hormosira* provide an abundant reservoir of water for the alga to tolerate exposure and desiccation. No other alga has a similar structure, so it is not surprising that *Hormosira* alone can colonise these higher areas. The abundance of the plants in the pure areas, and their large size compared with the same species elsewhere on the reef, would indicate however that some degree of exposure is beneficial to the growth of *Hormosira*.

On the rare occasions of a hot north wind and very low tide, leaving the reef exposed for some hours, *Hormosira* on higher areas may suffer considerable damage, becoming black and withered.

Nothcia anomala is a very common parasite, growing from the conceptacles. Other epiphytes are the black tufts of *Polysiphonia nigrita* Sonder, and *Hydrocoleum lyngbyaceum* Kütz. which forms small dark blue-green furry growths in the constrictions between the vesicles.

The second level of the western terraced reef (pl. XI, fig. 2) comprises numerous pools, 3 to 6 feet across and up to 1 foot deep. Waves enter the pools at medium and high tides. *Hormosira banksii* forms a dense fringe around the edges, and well-developed plants occur on the bottom, usually reaching to the surface (pl. XIII, fig. 4). Also on the bottom of the pools occur brown tufts of the filamentous species *Polysiphonia abscissa, Ectocarpus confervoides* (winter) and *Pylaiella fulvescens* (summer). The red anemone *Actinia tenebrosa* is prominent in shaded hollows around the edges of the pools, just below and for a few inches above the water line.

The development of this *Hormosira-Actinia* biocenose is due essentially to the specialised habitat—shallow pools exposed at low tides and subject to wave influx at higher tides. From the algal viewpoint it is best considered as a variant of the typical *Hormosira* association and has been seen only on the western terraced reef.

13. Cystophora – coralline association

The south-east corner of the main reef receives the full force of breakers, though on the eastern side waves tend to surge over and along the edge. This corner is slightly higher than most of the reef, and bears a closed and dense association (pl. XV, fig. 1). On higher, but rough and constantly wave-swept parts of other reefs the same association is prominent.

Dominant are the dark brown, densely branched fronds of *Cystophora paniculata* (Turn.) J. Ag., often stunted lighter-brown fronds of *C. subfarcinata*, and two species of the articulated coralline algae. Small tufts and mats of *Corallina cuvieri* Lamx. cover most of the rock between the larger algae, while *Jania fastigiata* Harv. is heavily epiphytic on *C. subfarcinata* (pl. XV, fig. 1 and 2). During winter *Corallina cuveri* (f. *crispata* Lamx.) is a pale pink, while *Jania* is a brighter red. In summer both are bleached to a faint pink or white, but on all occasions the contrast of the brown fronds of *Cystophora* and the pink or white of the corallines gives the association a distinctive appearance (pl. XV, fig. 1 and 2).

Cystophora paniculata is well developed in the rough areas but absent from the rest of the reef. Though usually abundant, on occasion it has been almost absent (September 1946). On some reefs it is rare and the association is dominated by the corallines.

The degree of epiphytism in this association is very high. Most species can grow on either rock or the *Cystophora*. The rough warted stem of *C. paniculata* provides an excellent substrate for many species. Some epiphytes are seasonal in their occurrence.

Species present throughout the year include: *Dasyopsis clavigera* Womersley, *Polysiphonia nigrita, P. dasyoides, Heterosiphonia gunniana* (Harv.) Falk., *Chaetomorpha darwinii, Caulerpa brownii, C. simpliciuscula, Laurencia heteroclada* and *Antithamnion hanovioides.* Less common ones are *Zonaria subarticulata* (Lamx.) Papenfuss, *Pachydictyon paniculatum* J. Ag., *Sargassum bracteolosum* J. Ag., *S. muriculatum, Xiphophora chondrophylla* (R. Br.) Harv. (in pure but small patches), odd plants of *Hormosira banksii, Ceramium nobile* J. Ag., *C. miniatum, Wrangelia plumosa, Metagoniolithon charoides* (Lamx.) W. v. B. *Melobesia* sp. and *Calothrix confervicola.*

Monospora elongata (Harv.) De Toni and *Griffithsia monilis* Harv. are common epiphytes, forming bright red tufts, but they only occur during the winter (April to November). *Thuretia teres* Harv. and *Mychodea foliosa* (Harv.) J. Ag. are found mainly on the stems of *C. paniculata.*

Intermediate Communities

Intermediate and grading communities between the associations discussed above are not frequent, but as is expected on such reefs variations in height and exposure between different associations will result in a mixing of species. In addition, other species may be suited by the intermediate habitats yet not occur in either of the main associations.

On the main reef, rock to the east and south-east of the mixed *Cystophora* association bears a community dominated by *Hormosira banksii, Cystophora uvifera* and *Laurencia heteroclada* (which varies greatly in abundance during the year). *Sargassum muriculatum* also occurs. The change between this community and the *Cystophora* – coralline association takes place over 2 or 3 feet. It is essentially an intermediate community between the mixed *Cystophora* and *Hormosira* associations, under conditions which are suitable for *Laurencia heteroclada.* Near the eastern edge of the reef *Hormosira* becomes dominant.

The mixed and variable assemblage of species found in shallow areas near the fallen rock region and on rock in the sandy pool is described on page 153.

The *Hormosira* – anemone pool variant of the *Hormosira* association has been dealt with on p. 156. *Ectocarpus confervoides* and *Pylaiella fulvescens,* which are subdominant in this community, dominate seasonal associations in the rear littoral, while *Polysiphonia abscissa* is also characteristic of more isolated rock pools (see p. 150).

Chance Distribution of Minor Species on the Main Reef

A number of algae occur on the main reef, but do not form a stable component of any particular association. At different times during the year they may occur on widely separated areas of the reef, usually in relatively small patches within larger fairly uniform habitats. Chance establishment of the species under temporarily suitable conditions, rapid development of individual plants and relatively small spread from the original area, followed within a few months by death under changed conditions, seems to account for the observed distribution. The following species have attracted attention.

Liagora harveyana grew near the fallen rock region and the eastern edge of the reef in January 1946. In January 1948 it was prominent on rock in the sandy pool, while in November 1947 it was found only on the outer western part of the channel area. On other occasions it has been found confined to the ledge.

Helminthora tumens (?) is best developed in the late winter, occurring on inner parts of the reef. In September 1946 it was partly buried by sand in the rear littoral, where it was exposed between waves. At other times it has been confined

to the sandy pool (January 1948) and a small area on the western side of the channel (November 1947). Plants exposed and buffeted by waves are considerably stouter than those always covered.

Champia obsoleta, during September 1946, was so prominent in shallow inner areas of the reef that it could well be considered to dominate a community. At other times it has been confined to the ledge or eastern edge of the reef, but often is virtually absent from the reef surface.

Cladosiphon filum (Harv.) Kylin is often absent from the reef, but a few scattered plants may occur near the fallen rock region, and in November 1947 it was quite dense over a few square yards of the mixed *Cystophora* association in the channel.

Cladosiphon vermicularis (J. Ag.) Kylin has been found in outer pools on the main reef (November 1947), but is quite common in a cove west of the main reef.

Halopteris pseudospicata Sauv. and *Phlococaulon spectabile* Reinke occur in pools in 2 or 3 feet of water, and occasionally on rock in the sandy pool.

Cladostephus verticillatus is only rarely found in pools on the main reef, but on the sides of rock in the lower littoral and upper sublittoral in other parts of Pennington Bay it may be quite dense.

Cladophora valonioides Sonder may occur as scattered plants almost anywhere on the reef, but usually only in a restricted area at any one time.

Flora of Shaded, Rear Littoral Pools

A number of reefs in the eastern part of the Pennington Bay region have small caves, up to 8 or 10 yards in length, at the base of the cliffs. At high tide waves usually enter them, and pools often occur at the entrance or just inside. Such pools are shaded, relatively calm, and contain an assemblage of algae of sublittoral affinities. The habitat is similar to sublittoral conditions in light and degree of roughness.

Algae most frequently found in these pools are *Apjohnia laetevirens* Harv. (stunted), *Rhipiliopsis peltata* (J. Ag.) A. & E. S. Gepp, *Ecklonia radiata* (Turn.) J. Ag. (in larger pools), *Plocamium angustum* (J. Ag.) H. & H., *Phacelocarpus labillardieri* J. Ag., *Corallina cuvieri, Laurencia elata* (Ag.) Harv., *Haloplegma preissii* Sonder, *Spyridia opposita* Harv., *Ballia scoparia* Harv. In one small pool less than 2 feet long and 1 foot wide, under an overhanging rock in the fallen region of the main reef, the following small Chlorophyceae were found: *Rhipiliopsis peltata* (abundant), *Bryopsis baculifera* J. Ag., *Derbesia clavaeformis* (J. Ag.) De Toni, *Caulerpa* sp. and *Vaucheria* sp. These are all rare species at Pennington Bay.

Other sublittoral species probably occur in such pools on other parts of the south coast of Kangaroo Island.

The Sub-littoral Fringe Zone

Cystophora intermedia association

The sub-littoral fringe on the Pennington Bay reefs corresponds to the outer and side edges and a foot or so below (pl. XIV, fig. 4, and pl. XV, fig. 3). The outer edge of some reefs is probably a little above mean low water mark, and on other reefs slightly below, but the conditions at the reef edge are uniform as even at low tide waves are constantly breaking on it, leaving it almost or just exposed for a few seconds between waves. The outer edge is the roughest habitat on the reefs; the sides are less rough, but both are habitats of high aeration of the water, short but frequent exposure between breakers, and heavy forces from wave action.

The sublittoral fringe bears the densest algal association found anywhere on the reefs. The rock is usually completely covered, and epiphytic growth is profuse. In number of species the association is very rich. On an area of 4 or 5 square yards at the outside of the main reef over 50 species have been collected; most are small in size and often stunted, only the Fucales being of any bulk. The chief requisite of an alga in this association is a strongly developed holdfast. The masses of fronds, however, afford considerable protection for each plant, as wave forces can be exerted only from above and not from underneath the plants.

The association is dominated by *Cystophora intermedia* J. Ag. The dark brown pinnately branched fronds of this alga reach a length of 50 cm., and give a characteristic appearance to the reef edge (pl. XIV, fig. 4, and pl. XV, fig. 4). *C. intermedia* is remarkable for its inability to grow anywhere except in the roughest, well aerated places. No satisfactory explanation of this is available at present. Although its stems are only 3 or 4 mm. in diameter, they are extremely strong. A very heavy pull is needed to remove a well-developed plant, and only on extremely rare occasions has this alga been found cast up on the beach.

The algae of the sub-littoral fringe belong mainly to two types. The majority have elongate, often much divided fronds which offer minimum resistance to waves; others form mat-like masses on the rock which are also protected by larger bushier forms.

Where waves pass along the reef edge (eastern side of main reef), *C. intermedia* grows densely from the edge to 2 feet below. In situations where there is heavy wave splash, caused by projecting parts of the reef, it will grow on the surface; this is particularly so on the outer highly dissected part of the main reef and on the large rocks off the eastern edge. However, where water streams off the western side of the reef, and breakers are of reduced force, *C. siliquosa* replaces *C. intermedia* in the sublittoral fringe to a large extent.

Cystophora intermedia is often heavily epiphytised by other algae, which grow only from the conceptacles. The stem is too smooth and mucoid to provide a hold for algal spores. During summer the small brown blobs of *Corynophloea cystophorae* J. Ag. are common on the upper fronds, while a species of *Dasya* and *Crouania muelleri* Harv. occur in winter.

Other larger algae of the sublittoral fringe are *Sargassum bracteolosum* (with *Acrochaetium* sp. epiphytic on the leaves) (pl. XV, fig. 4) and occasional plants of *Ecklonia radiata, Scytothalia dorycarpa* (Turn.) Grev., *Cystophora spartioides* (Turn.) J. Ag., and *C. paniculata; C. subfarcinata* and *C. siliquosa* do not occur below the reef edge except in calmer places.

The following are the most important of the smaller species. Nearly all are stunted in size owing to the rough habitat, much larger forms being cast up from deeper water.

Caulerpa brownii, C. sedoides (R. Br.) Ag., *C. simpliciuscula; Codium pomoides* J. Ag., *Pachydictyon paniculatum, Lobospira bicuspidata Aresch., Dictyopteris acrostichoides* (?), *Gymnosorus variegatus* (Lamx.) J. Ag.; *Liagora harveyana, Gelidium australe* J. Ag., *Metagoniolithon charoides, Corallina cuvieri, Mychodea foliosa, Gigartina* sp., *Iridaea prolifera* (J. Ag.) De Toni (rare), *Champia obsoleta, Hymenocladia polymorpha* (Harv.) J. Ag. *H. conspersa* (Harv.) J. Ag. (juvenile state only), *Nemastoma feredayae* Harv., *Phytimophora imbricata,* J. Ag., *Sarcomenia dasyoides* Harv., *Ballia scoparia, Callithamnion laricinum* Harv., *Griffithsia antarctica* H. & H. *Haloplegma preissii, Wrangelia plumosa, Chondria* sp., *Laurencia heteroclada, L. robusta,*[2] *L. elata*

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[2] M.S. name for an apparently undescribed species.

(with epiphytic *Janczewskia tasmanica* Falk.), *Jeannerettia lobata* H. & H. *Dasyopsis clavigera, Heterosiphonia gunniana, Thuretia teres.* In addition the following species are usually epiphytic on larger fucoids: *Ceramium nobile, Antithamnion hanowioides, Crouania Muelleri, Monospora elongata* and *Griffithsia monilis* (both only in winter months), *Muellerena insignis* (Harv.), De Toni, *Polysiphonia nigrita* and *P. dasyoides.*

The large rocks off the eastern edge of the main reef (see map, and pl. IX, fig. 2, pt. I) provide a habitat particularly favourable to *Laurencia, L. heteroclada, L. elata* and *L. robusta* occurring in abundance. *Antithamnion hanowioides* is often densely epiphytic on all three species. The bright green of *Caulerpa brownii* and *C. simpliciuscula* provides a striking contract amongst the deep red of the other species.

The Sublittoral Zone

Zonation below the sublittoral fringe

Study of zonation in the sublittoral is limited to 3 or 4 feet down the vertical sides of some reefs; even this can be observed only on very calm days with low tides. The following is, very broadly, the zonation down the eastern edge of the main reef.

To 2 feet below edge - -	*Cystophora intermedia*
From 1½-2½ feet below edge -	*Wrangelia clavigera* Harv., *Gelidium australe* and *Scytothalia dorycarpa*
From 2-3 feet below edge - -	*Perithalia inermis* (R. Br.) J. Ag., and usually below this *Plocamium costatum* (J. Ag.) H. & H. and *Phacelocarpus labillardieri*
	Laurencia elata may be prominent at about this level

Flora of deep outer pools on the reefs

Scattered over most of the Pennington Bay reefs, particularly on the outer parts (often within the sublittoral fringe—pl. XV, fig. 3), are rock pools up to 6 feet or more deep, with vertical or steeply sloping sides. The flora of these pools is always submerged and must therefore be considered sublittoral. Light intensity is lower in the pools than on the reef surface, especially for smaller species which are usually shaded by large fronds of *Cystophora* growing around the edge. Conditions within the pools are calmer than on the reef surface.

Around the edge *Cystophora siliquosa* is usually dominant. Here the fronds remain well submerged, and with ample room for their development often reach a length of 2 metres. *Sargassum bracteolosum,* and to a lesser extent *Scytothalia dorycarpa* and *Ecklonia radiata,* are common near the edge.

Apart from the fringing edge of *Cystophora,* the conspicuous feature of these pools is the bright green masses of *Caulerpa* which cover the sides in patches up to a foot or more across. *Caulerpa brownii, C. obcura* Sond., *C. hypnoides* (R. Br.) Ag. var. *muelleri* (Sond.) W. v. Bosse, *C. longifolia* Ag., *C. simpliciuscula, C. sedoides* and sometimes *C. scalpelliformis* (R. Br.) Ag. are found, best developed where shaded by other algae or the pool edge. The characteristic vegetative growth by means of surculi results in fairly pure patches of one species, but much of the rock is left bare.

Other species irregularly distributed in these pools are *Rhipiliopsis peltata, Dictyosphaeria sericea* Harv., *Apjohnia laetevirens* (often the basal part only), *Halopteris pseudospicata, Phloeocaulon spectabile, Cladosiphon vermicularis, Dictyopteris acrostichoides, Dilophus* sp. and *Gymnosorus variegatus.*

THE DEEPER SUBLITTORAL FLORA

The following list of species includes those found cast up but known not to grow on the reef surface. Other species in the list do grow in the littoral or sublittoral fringe zones. but are usually much larger when growing in the deeper sublittoral. All sublittoral species found in the Pennington Bay region are not listed here, but a complete census and notes on the species known from Kangaroo Island will be published as a later paper. The cast up species found at any one time depends greatly on the weather over the previous few days, and no reliable data as to the absence of a sublittoral species at any time can be obtained.

CHLOROPHYCEAE: *Codium galeatum* J. Ag. (common), *C. mamillosum* Harv., *C. spongiosum* Harv., *C. pomoides, Caulerpa harveyi* W. v. B., *Cau. obscura, Cau. hypnoides, Cau. ethelae* W. v. B., *Apjohnia lactevirens, Cladophora valonioides.*

PHAEOPHYCEAE: *Giraudya* sp. (on *Posidonia australis*); *Phloeocaulon spectabile, Halopteris pseudospicata* Sauv.; *Dictyota latifolia* J. Ag., *D. radicans* Harv., *Dictyopteris muelleri* (Sond.) Schmitz, *Dilophus fastigiatus* (Sond.) J. Ag., *Zonaria subarticulata* (syn. *Z. turneriana* J. Ag.), *Z. crenata* J. Ag., *Chlanidophora microphylla* (Harv.) J. Ag., *Homoeostrichus stuposus* (R. Br.) J. Ag., *H. spiralis* J. Ag., *Lobospira bicuspidata, Sporochnus scoparius* Harv., *S. comosus* Ag., *Encyothalia cliftoni* Harv., *Bellolia eriophorum* Harv., *Polycerea zostericola* (Harv.) Kylin (?), *Nercia australis* Harv., *Myriodesma calophyllum* J. Ag., *M. integrifolia* Harv., *Sierococcus axillaris* Grev., *Carpoglossum confluens* (R. Br.) Kütz., *Scaberia agardhii* Grev. (very common), *Cystophora racemosa* Harv., *C. pectinata* (Grev. and Ag.) J. Ag., *C. platylobium* (Mert.) J. Ag., *C. retorta* (Mert.) J. Ag., *C. grevillei* (Ag.) J. Ag., *C. dumosa* J. Ag., *C. monilifera* J. Ag., *Sargassum bracteolosum, S. cristatum* J. Ag., *S. trichophyllum* J. Ag., *S. decipiens* (R. Br.) J. Ag., *S. sonderi* J. Ag., *S. varians* Sond.

RHODOPHYCEAE. Common: *Asparagopsis armata* Harv., *Delisea hypneoides* Harv., *Callophyllis lambertii* H. & H., *Areschougia laurencia* Harv., *Erthroclonium muelleri* Sond., *Hypnea episcopalis* H. and H., *Plocamium costatum, P. nidificum* (Harv.) J. Ag., *P. mertensii* (Grev.) Harv., *P. preissianum* Sond., *Phacelocarpus labillardieri, Mychodea compressa* Harv., *M. carnosa* H. and H., *Gloiosaccion brownii* Harv., *Hymenocladia polymorpha, Antithamnion mucronatum* (J. Ag.) De Toni, *Ballia scoparia, B. callitricha* J. Ag., *Ceramium puberulum* Sond., *Dasyphila preissii* Sond., *Euptilota articulata* (J. Ag.) Schmitz, *Lasiothalia formosa* (Harv.) De Toni, *Monospora elongata, Muellerena insignis, Spongoclonium* sp., *Spyridia opposita, Sarcomenia dasyoides, Polysiphonia mallardiae* Harv., *Brongniartella australis* (Ag.) Schmitz., *Doxodasya bulbochaete* (Harv.) Falk., *Amansia pinnatifida* Harv., *Aneuria latifolia* (Harv.) J. Ag., *Osmundaria prolifera* Lamx., *Dasya naccarioides* Harv., *Thuretia quercifolia* Dene.

OCCASIONAL: *Gulsonia annulata* Harv. (rare), *Delisea pulchra* Mont., *Brachycladia marginata* (Sol.) Schmitz, *Callophyllis coccinea* Harv., *Gelinaria ulvoidea* Sond., *Thamnoclonium claviferum* J. Ag., *Peyssonnelia australis* Sond., *Metagoniolithon stelligerum* (Lamx.) W. v. B., *Corallina pilifera* Lamx., *Areschougia gracilarioides* (?), *Thysanocladia laxa* Sond., *Erythroclonium angustatum* Sond., *Gloiophyllis barkeriae* (Harv.) J. Ag., *Rhodophyllis tenuifolia* (Harv.) J. Ag., *Plocamium angustum, P. leptophyllum* Kütz., *Phacelocarpus sessilis* Harv., *Stenocladia harveyana* J. Ag., *Acrotylus australis* J. Ag., *Gigartina disticha* Sond., *Iridaea australasica* J. Ag., *Champia affinis* (H. and H.) J. Ag.,

C. tasmanica Harv., *Gloioderma tasmanica* Zan., *Rhodymenia australis* (Sond.) Harv., *Hymenocladia usnea* J. Ag., *Antithamnion dispar* (*Harv.*) J. Ag., *Griffithsia antarctica, Ceramium isogonum* Harv., *Crouania vestita* Harv., *Ptilocladia pulchra* Sond., *Spongoclonium brounianum* (Harv.) J. Ag., *Wrangelia crassa* H. and H., *W. myriophylloides* Harv., *W. princeps* Harv., *Sarcomenia delesserioides* Sond., *Hypoglossum microdontum* J. Ag. (?), *Claudia elegans* Lamx., *Polysiphonia davyae* Reinb., *Cladurus elatus* (Sond.) Falk., *Coeloclonium opuntioides* (Harv.) J. Ag., *Laurencia filiformis* Mont., *Jeannerettia lobata, Protokützingia australasica* (Mont.) Falk., *Amansia kützingioides* Harv., *Lenormandia marginata* H. and H., *L. muelleri* Sond., *L. smithiae* (H. and H.) Falk., *Trigenia umbellata* J. Ag., *Halodictyon robustum* Harv., *Dasya villosa* Harv., *D. haffiae* Harv., *Heterosiphonia muelleri* (Sond.) De Toni.

SEASONAL VARIATION IN THE ALGAL FLORA

(a) *Seasonal occurrence*

The great majority of the algae growing on the Pennington Bay rock platforms are present throughout the year. The larger brown algae, nearly all members of the Fucales, are the most stable species, and probably live for several years.

The *Ectocarpus confervoides* and *Pylaiella fulvescens* seasonal associations are the only ones limited in their occurrence to definite periods of the year. Certain characteristic species within other associations, particularly the *Cystophora*–coralline and sublittoral fringe associations, are also seasonal. In both these asociations *Monopora elongata* and *Griffithsia monilis* are found only during winter months, although the former is occasionally cast up from the sublittoral in summer. *Nemastoma feredayae* is strictly a summer species. A number of epiphytes are also of seasonal occurrence. *Corynophloca cystophorae* is epiphytic on the receptacles of *Cystophora intermedia* and *C. siliquosa* during the summer, while a species of *Dasya* and *Crouania muelleri* epiphytise the same species of *Cystophora* mainly during winter months.

Species dealt with under "Chance distribution of minor species" are very irregular in their occurrence and apparently not restricted to any one period.

Information on seasonal occurrence of sublittoral species, derived from cast up plants, is not reliable, but definite collection records will be given in the census in a later paper.

(b) *Seasonal development of stable species*

Many species on the reefs attain their maximum development in the late winter. This is probably associated with lower sea temperatures. The seasonal development of vesicles in *Cystophora uvifera* and of the fertile fronds of *Sargassum muriculatum* has been described on pages 154 and 155. Other species of *Sargassum* cast up from the sublittoral are best developed in late winter when the fertile fronds are borne. In this state the plants are most easily torn off and cast up.

The *Cystophora*–coralline association is better developed in winter when the corallines are actively growing. *Rivularia firma* and *Enteromorpha acanthophora* attain their maximum size in late winter.

(c) *Seasonal variation in reproduction*

Many species have been found bearing reproductive organs on every visit to Pennington Bay (at approximately 2-monthly intervals during 1947), and it is probable that most species are not strictly limited to any one period of the year.

Whether any monthly cycle in reproduction correlated with the tidal cycle occurs is not known, but is unlikely, as monthly tidal variation on the south coast of Kangaroo Island is small and its effect minimised by constant breakers.

During late winter (September) nearly every species on the reef bears reproductive organs, usually abundantly, and this time seems to be the most favourable period for reproduction. In September 1946 it was difficult to find a specimen of most of the small Rhodophyceae—such as *Champia obsoleta, Muellerena* sp., *Monospora elongata* and *Liagora harveyana*—not bearing reproductive cells, but at other times (*e.g.*, mid-summer) most specimens are sterile. Often 80% or 90% of the plants of diplobiontic Rhodophyceae are tetrasporic, while very few plants are spermatangial.

Liberation of zoospores and gametes in *Enteromorpha* and *Ulva* is probably dependant on sufficiently long exposure during very low tides. Most of the fucoids are fertile throughout the year, but the species of *Sargassum* produce fertile fronds in winter and lose them in early summer.

VARIATION UNDER WAVE ACTION

Stunting of algae under severe wave action is a general feature of species which grow both in the sublittoral proper and the sublittoral fringe or *Cystophora*–coralline associations. The roughest situations always show the densest algal growth, but reduction in the degree of branching in some (*e.g.*, *Hymenocladia polymorpha, Dasyopsis clavigera*), and increase in branching from the base giving compact tufted forms in others (*e.g.*, *Cladophora valonioides*) are the most general adaptions to withstand the mechanical force of the breakers. *Cystophora intermedia,* which grows best in the roughest localities and not on calmer coasts, is one notable exception to stunting under rough conditions.

In many cases it is evident that size and gross external form are of little use as specific characters. Normally pinnate or well-branched forms may become simple or nearly so on the edges of reefs, and all variations of form between the extremes occur in intermediate habitats. Other species may retain distinctive branching in all habitats, but until the range in form of a species under varying environmental conditions is known, differences in size and degree of branching can be used in separating entities only with great caution. Internal tissues and cell structure, on the other hand, are usually reliable. All stunted species on the reef edges become fertile and must therefore be considered as mature plants.

The variation in *Dasyopsis clavigera* has been described previously (Womersley 1946). The following examples also illustrate the type of variation found.

Hymenocladia polymorpha on the reef edge consists of a few (2 to 5) unbranched elongate fronds from a common base, up to 12 cm. high, but sublittoral forms are pinnately and often bipinnately branched and reach a height of 70 cm.

Cladophora valonioides—Sublittoral forms are loosely branched, often with one or a few main filaments, and to 20 cm. or more tall. In calmer parts of the reefs it is 5 to 10 cm. tall, but on the edge of the reef the thallus is a hemispherical mass of filaments only 2 or 3 cm. high.

Laurencia heteroclada—The variation in form of this alga was commented on by Harvey (1860, pl. cxlviii), and similar variation occurs in the Pennington Bay forms. Small, poorly branched specimens are always found in rough places or in shallow water.

Caulerpa spp.—The species of *Caulerpa* found growing in outer deep rock pools on the reef (p. 160) are stunted when compared with cast-up specimens, but the degree of branching and external form is fairly constant. When growing on the reef surface stunting is even more pronounced, while shade from other algae or pool edges allows development of larger fronds.

PARASITISM AND EPIPHYTISM

When describing the various associations, the common epiphytes on other algae have been listed. In nearly every case it appears that the epiphytic alga uses the "host" only as a suitable form of attachment, there being no intimate physiological relation between the two. This is indicated by the wide range of "hosts" of many epiphytes, and also by the ability of most to grow on bare rock as well. As yet no critical examination of the method of union of epiphyte to host has been made.

One exception is that of *Notheia anomala* on *Hormosira banksii* (see Williams 1923), in which there appears to be some definite relationship as *Hormosira* is the only alga at Pennington Bay on which *Notheia* will grow. Although this case is usually referred to as "parasitism," it is only partial, for it is very doubtful how much, if any, nutrient *Notheia* derives from its host.

Several other species appear to favour certain hosts because of the rough nature of the stems or presence of conceptacles which provide suitable germination places. *Cystophora paniculata* has unusually rough stems and usually shows profuse epiphytic growth. On a single plant of this species the following species will often be found: *Polysiphonia nigrita, Mychodia foliosa, Thuretia teres, Antithamnion hanowioides, Melobesia* sp. and fragments of *Corallina*. Most other species of *Cystophora* have smoother stems, and epiphytes grow mainly from the conceptacles. Species of *Dasya* and *Crouania muelleri* are frequently found on *C. intermedia* and *C. siliquosa*. *Jania fastigiata* grows on the stems of *C. subfarcinata* very heavily in the *Cystophora*–coralline association, while *Polysiphonia nigrita* is very prevalent on *Scytothalia dorycarpa* in outer rough pools.

Epiphytes on algae growing in calmer parts of the reef are much sparser. *Sphacelaria biradiata* and *Sph. furcigera* are commonly found on *Cystophora uvifera* and *Cystophyllum muricatum*, but any others are usually microscopic.

Detailed information on recorded hosts for all species will be given in the census.

VERTICAL DISTRIBUTION IN RELATION TO LIGHT

The horizontal surface of the Pennington Bay reefs provides a large area for algal growth subject to fairly uniform light conditions. Only below the reef edge, or in deeper pools, where algae are constantly submerged and the water in a turbulent state does light intensity fall off greatly. These reefs are therefore suitable for estimating the numbers and percentages of the algae which are restricted to the reef surface (*i.e.*, with high light intensity) and those restricted to the sublittoral (lower light intensity). This data for the Pennington Bay region is presented in Table II.

TABLE II

Distribution of the Algal Classes in the Littoral and Sublittoral

	Myxophyceae	Chlorophyceae	Phaeophyceae	Rhodophyceae	Total
Restricted to reef surface (littoral)	6	5	21	30	62
Restricted to sublittoral - -	0	14	38	90	142
Common to littoral and sublittoral	1	7	11	23	42
Total for each class - - -	7	26	70	143	246
Each class as % total - - -	3	11	28	58	100
% of each class in littoral - -	100	46	46	37	42

Numbers of species in the various divisions of the table are not necessarily exact, as some 30 unnamed species have not been included, and a few others have been omitted as insufficient specimens and information about them are available. The edge of the reefs has been used as a dividing line between littoral and sub-

littoral, but algae growing on the reef surface or edge in the sublittoral fringe are included in the littoral as the light relations are closest to true littoral conditions. It is inevitable that there is a personal factor in drawing up such a table, but with the large numbers available this is probably small.

It is not suggested that light intensity is the only controlling factor in whether an alga grows on the reef or in deeper water. On the reef edge, degree of roughness is of considerable importance, but light intensity is the major factor for most species, and the edge of the reef is a natural line of division in this respect.

The total number of species collected from about one mile of fairly uniform coastline is over 270 (including unnamed species). On the main reef, an area of about 75 yards by 70 yards, some 60 or more species have been found. The Pennington Bay area is clearly a rich one, and numerous other species are probably still to be found.

The Rhodophyceae comprise over half the total number of species, and twice as many as the Phaeophyceae. Numbers for the Myxophyceae would be increased if microscopic species were thoroughly collected. On the reef surface there are more Rhodophyceae than any of the other groups, and more Phaeophyceae than Chlorophyceae. Most of the Rhodophyceae, however, occur on the outer rougher parts of the reefs.

When the percentage of each class in the littoral zone is estimated, the Chlorophyceae and Phaeophyceae give the highest figure, 46% for both. The proportion of Rhodophyceae in the littoral is lower, 37%, owing to the much larger numbers of red algae which are restricted to the sublittoral. All the species of Myxophyceae known from the region occur in the littoral.

The numbers of each class common to both littoral and sublittoral is relatively small, and most of these occur near the edge of the reef in rough conditions, where the light intensity at high tide is slightly lower than on the reef surface proper.

The Chlorophyceae and Phaeophyceae show no difference in the proportions of each class in higher or lower light intensities, but owing to the larger numbers of the browns, more species than the greens are found on the reefs and also in the sublittoral. The proportion of Rhodophyceae in the littoral is small, showing that red algae do tend to grow in deeper water, but owing to their much greater numbers, more occur in the littoral than the other classes.

The long standing concept of a broad vertical distribution of green, brown and red algae, in that order, holds only for the Rhodophyceae at Pennington Bay. Red algae cast up from deep water are always a brighter red in colour than reef forms, which are often yellowish-brown. Myxophyceae, however, show a strong tendency to grow in bright light intensities, though the thick gelatinous sheaths of most species must greatly reduce the amount of light reaching the actual cell.

SUMMARY

The algal associations of the wave-cut rock platforms of the Pennington Bay region are described. These are classed into supralittoral (*Prasiola* community only), littoral, and sublittoral fringe associations, while the deeper sublittoral flora is also listed.

Most of the flat surface of the reefs is covered by the *Cystophora* complex (including several associations) and the *Hormosira banksii* association, while the rich and dense *Cystophora intermedia* association is characteristic of the sublittoral fringe on the edge of the reefs. Other important associations are those of *Rivularia firma, Ectocarpus – Pylaiella* (seasonal), *Enteromorpha, Cystophyllum* and *Cystophora* – coralline.

Although the reef surface is remarkably horizontal, differences in height of only a few inches cause clear-cut changes in the algal associations. The densest associations are those in the roughest places, where stunting of most species is pronounced. Associations in calmer regions are sparse in number of species, with considerable bare rock between plants, but often consist of larger individual plants.

The algal flora of the region is very rich, over 270 species having been found along 1½ miles of coast. Seasonal variation in the algal flora is discussed, and examples given of the great variation in external form of many species caused by different degrees of wave action. Data on the vertical distribution of the algal classes in relation to light intensity is also given.

Correction to Part I (Womersley 1947)

For *Acrotylus australis* read *Xiphophora chondrophylla* (R. Br.) Harv. [pp. 241, 242, 247, and legend to fig. 3 (p. 239)]. The provisional determination of this alga was based on sterile material, and fertile specimens collected in January 1948 show that it is the brown alga *Xiphophora chondrophylla*. In external form and T.S. of the thallus the resemblance to *Acrotylus* is remarkable. Our specimens are probably a small form of the var. *minus* J. Ag. The species has not been previously recorded from South Australia.

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EXPLANATION OF PLATES X TO XV

PLATE X

Fig. 1 View of Pennington Bay from the east, with a low, calm sea. The main reef is in the left centre, and other reefs can be seen at the base of small rocky outcrops further around the bay.

Photo T. Levring

PLATE XI

Fig. 1 The main reef, Pennington Bay, from the cliffs above. The dark areas on the outer parts are covered with *Hormosira*, while the sandy pool is on the lower right. Photo taken at a very low tide.

Photo H. B. S. W.

Fig. 2 The western terraced reef, Pennington Bay, during a very low tide. The second level bears the *Hormosira*-anemone rock pools, with dense masses of the black bivalve *Modiolus* on and just below this level.

Photo H. B. S. W.

PLATE XII

Fig. 1 The eastern part of the fallen rock region. The mixed *Cystophora* association covers the foreground.

Photo H. B. S. W.

Fig. 2 The fallen rock region on the main reef, during a calm high tide. *Symploca hydnoides* occurs on the wave washed rock, with *Rivularia firma* just above and below water level in the photo.

Photo H. B. S. W.

Fig. 3 Rock, normally covered by the sandy beach, exposed in September, 1946. On the wave washed rock *Ectocarpus* and *Enteromorpha* associations were well developed.

Photo S. J. E.

Fig. 4 *Ectocarpus confervoides* densely covering rock shown in Figure 3.

Photo H. B. S. W.

PLATE XIII

Fig. 1 *Hormosira banksii* association on ridged rock. *Hormosira* only occurs on the ridges, where it is exposed at low tide, with bare or sand covered rock between each ridge.

Photo T. L.

Fig. 2 Junction between the *Hormosira* and mixed *Cystophora* association on the channel edge. The sudden change due to a drop of 3 or 4 inches in the height of the reef is clearly shown.

Photo T. L.

Fig. 3 *Hormosira banksii* association, showing slight intermixture with *Cystophora*.

Fig. 4 The *Hormosira*-anemone pool on the western terraced reef. The anemones appear as dark areas in hollows on the rock at the far side of the pool.

Photo H. B. S. W.

PLATE XIV

Fig. 1 The ledge on the main reef, looking shorewards. The beach was heavily sanded up at this time (January 1948). The mixed *Cystophora* association of the channel is shown on the left of the ledge.

Photo T. L.

Fig. 2 The ledge on the main reef, from the fallen rock region. The alga in the left foreground is *Cystophyllum*, with some *Cystophora uvifera*.

Photo T. L.

Fig. 3 The mixed *Cystophora* association, showing almost pure *C. uvifera*. *C. subfarcinata* occurs on the lower left.

Photo T. L.

Fig. 4 The eastern edge of the main reef, showing the sudden drop off into deep water. *Cystophora intermedia* forms a dense fringe hanging down the side.

Photo I. Thomes

PLATE XV

Fig. 1 The *Cystophora*-coralline association on the main reef. The black tufts are *Cystophora paniculata*, the lighter coloured fronds *C. subfarcinata*. *Corallina* and *Jania* appear as light coloured patches.

Photo T. L.

Fig. 2 Close up view of the *Cystophora*-coralline association. The white pinnate fronds of *Corallina* and dense tufts of *Jania* contrast with the dark fronds of *Cystophora subfarcinata*, with some *Hormosira* also present.

Photo H. B. S. W.

Fig. 3 The outer, highly dissected part of the main reef, where the sublittoral fringe association is developed. Photo taken at a very low tide.

Photo I. T.

Fig. 4 The *Cystophora intermedia* association of the sublittoral fringe. This alga is prominent on the left of the photo, with *Sargassum bracteolosum* in the centre and a plant of *Codium pomoides* above the latter.

Photo H. B. S. W.