THE MARINE ALGAE OF KANGAROO ISLAND

by

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A THESIS

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PREFACE

The seven parts of this thesis are written as separate papers, of which the first three have been published in the Transactions of the Royal Society of South Australia. References are therefore given at the end of each part. It is hoped that Parts 1V - V11 will be published in the near future.

Unless acknowledged otherwise in the text, the material in this thesis is entirely the work of the author.

THE MARINE ALGAE OF KANGAROO ISLAND.

CONTENTS

Womersley, H. B. S. (1947). The marine algae of Kangaroo Island: I. A general account of the algal ecology. *Transactions of the Royal Society of South Australia*, *71*(2), 228-251[plates].

NOTE:

This publication is included in the print copy
of the thesis held in the University of Adelaide Library.

Womersley, H. B. S. (1948). The marine algae of Kangaroo Island: II. The Pennington Bay region. *Transactions of the Royal Society of South Australia, 72*(1), 143-166[plates].

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Womersley, H. B. S. (1950). The marine algae of Kangaroo Island: III. List of species. *Transactions of the Royal Society of South Australia, 73*(2), 137-197.

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THE MARINE ALGAE OF KANGAROO ISLAND

IV. List of Species, 2.

This list is a provisional account of most of the remaining species now known from Kangaroo Island. Species which appear to be undescribed are included, but no formal descriptions are given, while many other species have been determined only to the genus. In both cases it is necessary to check the specimens with authentic material (mainly in European herbaria) before accurate determination of the species is possible. The list includes 162 species - Chlorophyta 11, Phaeophyta 19, Rhodophyta 122, Cyanophyta 10.

CHLOROPHYTA

SCHIZOGONIALES - Schizogoniaceae

GAYELLA Rosenvinge

Gayella polyrhiza Rosenvinge. Setchell and Gardner 1920,280 - AP.

Supralittoral on Shag Rock, July 1947, Jan. 1948. PB. Supralittoral on certain cliffs, Aug. 1948. R. supralittoral, Aug. 1950. This alga occurs only where shag or penguin colonies are present. Some authors consider Gayella only a form of Prasiola crispa, but only the Gayella form occurs on Kangaroo Island.

CHAETOPHORALES - Chaetophoraceae

ENTOCLADIA Reinke

Entocladia viridis Reinke. Setchell and Gardner 1920, 289.

Newton 1931, 62. Taylor 1937, 53, pl.2, f.1,2, - RP. Drift, in Gloioderma, Aug. 1950.

CLADOPHORALES - Cladophoraceae

CLADOPHORA

Cladophora bulbosa Sonder herb. - PB. On Sargassum in reef pools, Jan. 1944, and drift, Jan.1946. Rare. Sonder's specimens from Queenscliff, Vic., are in Melbourne National Herbarium. They were apparently never described, but are listed by Lucas (1909).

Cladophora (A12,608) - BS. Drift, Jan. 1950. Forming spherical balls, 1 - 2½ cm. in diameter, cast up in huge numbers on the beach.

RHIZOCLONIUM Kützing

Rhizoclonium implexum (Dillw.) Kütz. Setchell and Gardner 1920, 183. Newton 1931, 93. Smith 1944, 62, pl. 8, f.3. - AR. On the cockle bank near Strawbridge Point, upper sublittoral, Jan. 1948.

CHAETOMORPHA Kützing

Chaetomorpha capillaris (Kützing) Borgesen 1925, 45. Feldmann 1937, 208, f.17. - AR. Upper littoral under samphires in Pelican Lagoon, Jan., Aug. 1950.

Chaetomorpha AR. Upper sublittoral and lower littoral on the tidal flats throughout the lagoons, all seasons. K. Drift, Jan. 1944, 1945. This species forms extensive yellow-green masses on the tidal flats. It is allied to C. linum but the cells are 1½-6 times (mostly 2-3) as long as wide.

SIPHONALES - Bryopsidaceae

BRYOPSIS Lamx.

Bryopsis pennata Lamx. Taylor 1928, 93, pl.11, f.13. Feldmann 1937, 221, f.24. Bryopsis plumosa var. pennata, Borgesen 1913, 117. - K. Low littoral on stones, Jan. 1950.

Bryopsis delicatula n.sp.

AR. On black buoy, Sept. 1946.

Derbesiaceae

DERBESIA Solier

Derbesia marina (Lyngbye) Solier. Setchell and Gardner 1920,165. Smith 1944, 71, pl. 3, f.4. - VB. Shaded end of pool 1, South side of Ellen Pt., Jan. 1948, 1950.

Codiaceae

CHLORODESMIS Bailey and Harvey

Chlorodesmis australis n.sp.

P.B. In a small shaded pool at the rear of the main reef, Sept. 1946, Jan. 1948. VB. In a shaded pool, south side of Ellen Pt., Aug. 1950.

PHAEOPHYTA

ISOGENERATAE - ECTOCARPALES

Ectocarpaceae

ECTOCARPUS Lyngbye

Ectocarpus fasciculatus (Griff.) Harvey 1871, pl. 273. Newton

1931, 121. Taylor 1937, 110. - AR. On the buoys, Sept. 1946, July 1947. MR. In low pools, Jan. 1946 and lower littoral, Jan. 1947. VB. Low littoral on reef in bay, Jan. 1950. PB. On Brongniartella feredayae in the sub-littoral fringe, Dec. 1949. CW. Upper sublittoral, east side (on Sargassum bracteolosum and Cystophora intermedia) Jan. 1948.

Ectocarpus sordidus Harvey 1860b, 294. De Toni 1895, 560. - AR. Upper sublittoral in the lagoons, May 1947, Aug. 1948. VB. Shaded end of pool 1, south side of Ellen Pt., Jan. 1947, 1948. The AR. specimens agree well with Tasmanian ones in Sydney National Herbarium. The VB. specimens are very similar but sterile.

Ralfsiaceae

RALFSIA Berkeley

Ralfsia borneti Kuckuck. Taylor 1937, 124. Kylin 1947, 44, f.33 E-F. - PB. Lower littoral on rocks, not common, Aug. 1950.

Ralfsia australis n.sp.

Widely distributed in the lower and mid littoral zone within the Sheltered Rocky Coast Subformation (MR to AB), all seasons.

DICTYOTALES - Dictyotaceae

DICTYOTA Lamx.

Dictyota

MR and WR. Drift, Jan. 1946.

DILOPHUS J.Ag.

Dilophus fasciculatus ? J.Agardh 1894a, 87. De Toni 1895, 285 - PB. In pools on reef, Jan. 1944.

Dilophus opacus ? J. Agardh 1882, 107; 1894a, 88. De Toni 1895, 286 - PB. In outer reef pools, Jan. 1948, 1950.

Dilophus tener ? J. Agardh 1894a, 95. De Toni 1895, 290 - PB. In a pool on the main reef, Nov. 1947. MR. Drift, ~~Jan~~ Jan. 1950.

Dilophus

PB. Sublittoral fringe pools, Nov. 1947, Dec. 1948 and drift, Jan. 1948.

The above species of Dilophus need checking with Agardh's types in Lund. Some may be forms of one species.

DISTROMIUM Levring

Distromium diesingianum (Kützing) comb. nov. Zonaria diesingiana Kützing 1859, pl. 75,II.- RP. Drift, Aug. 1948. The sporangia occur in concentric zones on the thallus.

Distromium australasicum n.sp.

AB. Drift, Aug. 1948.

HETEROGENERATAE - DICTYOSIPHONALES

Giraudyaceae

GIRAUDYA

Giraudya posidoniae n.sp.

PB. Drift, Jan. 1944, 1946, 1947, 1948. AB. Drift, Jan. 1948. Epiphytic on Posidonia australis.

CYCLOSPOREAE - FUCALES

Cystoseiraceae

CYSTOPHORA J. Agardh

Cystophora crassicaulis n. sp.

DB. Outer reef pools, Jan. 1950. MR. Drift, Jan. 1948, and upper sublittoral, Jan. 1947.

Cystophora gracilis n.sp.

VB. In a large littoral pool, south side of Ellen Pt., Jan. 1946, 1947, 1949, 1950.

Sargassaceae

SARGASSUM

Sargassum grande J. Agardh 1889, 72, pl.22,I. De Toni 1895, 32-

BH. Upper sublittoral, Dec. 1948. MR. Drift, Jan. 1950. HB. Drift, Jan. 1944.

Sargassum halitrichum (Areschoug) J. Agardh 1889, 43, pl. 13. De Toni 1895, 9. - RP. Drift, Aug. 1950.

Sargassum linearifolium (Turner) J. Agardh 1889, 45, pl.14, III. De Toni 1895, II. - MR. Upper sublittoral, Jan. 1948. VB. Drift, Jan. 1949. DB. Outer reef pools, Jan. 1950. PB. Drift, Jan. 1944; outer reef pools, Jan. 1947, 1948. CW. Drift, Jan. 1947.

Sargassum paradoxum (R.Br.) Harvey. J. Agardh 1889, 68, pl.20, II. De Toni 1895, 29. - RP. Upper sublittoral, Jan. 1945, 1947, 1948.

Sargassum verruculosum (Mertens) C. Agardh.? J.Agardh 1889, 53, pl. 18. De Toni 1895, 16. S. raoulii, Harvey 1859, pl. 110. - BH. Upper sublittoral, Oct. 1947. EB. Upper sublittoral, Jan. 1945. VB. Large littoral pool, south side of Ellen Pt., Jan. 1946, 1949. These specimens show prominent cryptostomata on the upper filiform ramuli, but the receptacles are small and grouped into small panicles. Specimens of S. trichophyllum (first list) have no cryptostomata, but the receptacles resemble those figured for S. verruculosum by J. Agardh.

RHODOPHYTA

BANGIOIDEAE - BANGIALES

Bangiaceae

ERYTHROCLADIA Rosenvinge

Erythrocladia rubra n.sp.

AB. On wood lying in the upper sublittoral, Jan. 1948.

FLORIDEAE - NEMALIONALES

Acrochaetiaceae

ACROCHAETIUM Naegeli

Acrochaetium sargassi n.sp.

PB. On Sargassum bracteolosum in the sublittoral fringe, all seasons.

Acrochaetium

AR. On Scytosiphon on black buoy, Sept. 1946.

Helminthocladiaceae

ENDOSIRA J. Agardh

Endosira australis J. Agardh 1899, 106, t.1, f.3. De Toni 1924, 86. - AR. On sinker of a buoy outside mouth of inlet and 1½-2 fathoms below low water at Muston, Jan. 1948.

HELMINTHOCLADIA J. Agardh

Helminthocladia australis Harvey 1863, pl. 272. J. Agardh 1879, 96. De Toni 1897, 83 - PB. Rear littoral, main reef, Aug. 1948.

HELMINTHORA J. Agardh

Helminthora australis J.Agardh herb. (This name, and the form below are being published by Dr. T. Levring) - AR. Sublittoral on tidal flats, Oct., Nov. 1947, Aug. 1948. PB. Rear littoral, all seasons, but variable in occurrence

f. pyramidalis Levring. VB. Mid littoral, south side of Ellen Pt., Dec. 1945, Jan. 1950.

Chaetangiaceae

CHAETANGIUM Kützing

Chaetangium ?

PB. Drift, Jan. 1946.

CRYPTONEMIALES

Cruoriaceae

CRUORIA Fries

Cruoria ?

AR. On wood cast up in Pelican Lagoon, Aug. 1950. The specimens are sterile but agree on vegetative characters with <u>Cruoria</u>.

Squamariaceae

<u>HILDENBRANDIA</u> Nardo

<u>Hildenbrandia crouani</u> J. Agradh. Rosenvinge 1917, 207, f.126. Newton 1931, 297. - BH and MR. Upper sublittoral and lower littoral, Jan. 1948. CW. Mid littoral, east side, Jan. 1950. VB. Mid littoral pools, south side of Ellen Pt., Aug. 1950.

<u>Hildenbrandia prototypus</u> Nardo. Rosenvinge 1917, 202, f.121-125 Newton 1931, 297. Taylor 1937, 257.- VB. In a shaded mid littoral pool, south side of Ellen Pt., Aug. 1950

Corallinaceae - Corallineae

<u>CORALLINA</u> L.

<u>Corallina</u>

AR. Upper sublittoral in lagoons, Jan.,Nov. 1947. This species forms dense hemispherical masses up to 20 cm. across and 8 cm. high.

<u>JANIA</u> Lamx.

<u>Jania plumosa</u> n. sp.?

DB. In outer reef pools, Jan., Aug. 1950. The thallus is dichotomously branched, but the articulations bear fine, almost plumose, ramelli.

<u>Jania</u> (A12, 678)

AR. Mid littoral, north side of Pelican Lagoon, Jan. 1950.

Lithothamnieae

Several other species besides those listed below are still undetermined, and all need checking against authentic specimens.

ARCHAEOLITHOTHAMNION Rothpl.

Archaeolithothamnion durum Foslie 1907, 11; 1929, 28, pl.43, f.1-3. -CW. In a shaded pool, south side, Aug. 1948. RP. Upper sublittoral, Jan. 1948.

LITHOTHAMNION Philippi

Lithothamnion engelhardtii Foslie 1900, 18; 1929, 40, pl.7,

f. 12-18. - MR, AR and RP. Upper sublittoral, Jan. 1948.

Lithothamnion erubescens ? Foslie 1904, 32; 1929, 40, pl. 15 -

AR. Sublittoral fringe in lagoons, all seasons.

Lithothamnion muelleri Lenormand. Foslie 1900, [illegible] 43,

pl. 7, f.1-10. Levring 1946, 220, f.4. - PB. On stipes and holdfasts of Ecklonia and Cystophora paniculata, Jan., 1948.

NEOGONIOLITHON Setchell and Mason.

Neogoniolithon finitimum (Foslie) Setchell and Mason 1943, 91. Goniolithon finitimum Foslie 1908, 8; 1929, 29, pl.47, f.18-21. - VB. In littoral pools, south side of Ellen Pt., all seasons. CW. In rock pools, south side, Jan. 1948, 1950.

MELOBESIA

Melobesia cymodoceae Foslie 1901, 23. - VB, and RP. Drift, Aug. 1950. Epiphytic on Cymodocea, and probably general wherever the plant occurs (around most of Kangaroo Island.)

Melobesia lejolisii Rosanoff. Newton 1931, 302. Fosliella lejolisii (Ros.) Howe. Taylor 1937, 270, pl. 36, f.6-8.- CW. On Laurencia heteroclada, lower littoral, Jan. 1946.

Melobesia

BH. Upper sublittoral on Cystophora cephalornithos, Jan. 1948. K. Upper sublittoral on C. cephalornithos and C. polycystidea, Jan. 1950.

Melobesia

CW. On Xiphophora in the upper sublittoral, Jan. 1948.

Grateloupiaceae

CARPOPELTIS Schmitz

Carpopeltis phyllophora (H. and H.) Schmitz. De Toni 1905, 1604. Acropeltis phyllophora, Harvey 1863, pl. 283. - VB. Drift, Jan. 1949.

CRYPTONEMIA J. Agardh

Cryptonemia undulata Sonder. Harvey 1862, pl. 205. Kützing 1869, pl. 31. De Toni 1905, 1610. Lucas and Perrin 1947, 380, f.191. - DB. Side of an outer reef pool, Jan. 1950.

POLYOPES J. Agardh

Polyopes constrictus (Turner) J. Agardh 1851, 239; 1876, 148. De Toni 1905, 1595. Lucas and Perrin 1947, 379. Fucus constrictus Turner 1811, 40, pl. 152. - CC. Lower littoral, Jan. 1948. CW. Lower littoral, south side, Jan. 1946.

Callymeniaceae

CALLOPHYLLIS Kützing

Callophyllis ceratoclada (J. Agardh) comb. nov.

Hymenocladia ceratoclada J. Agardh 1894, 57. De Toni 1900, 501. Kylin 1931, 33, pl.19, f.46. - AR. Sublittoral at Muston and near the mouth, Nov. 1947, Aug. 1948. RP. Drift, Aug. 1948. The cruciate tetraspores and cystocarpic structure show that this is a species of Callophyllis.

POLYCOELIA J. Agardh

Polycoelia australis, J.Agardh 1879, pl. 13, f.1-4. De Toni 1897, 294. - VB. Drift, Jan. 1949.

GIGARTINALES

Nemastomaceaea

NEMASTOMA J. Agardh

Nemastoma irregularis n. sp.

PB. Sublittoral fringe on an eastern reef, Jan. 1948.

Gracilariaceae

GRACILARIA Greville

Gracilaria secundata Harvey 1863, syn. n. 432. Alg. Aus. exs. n. 325. J.Agardh 1876, 418. May 1948, 46, pl. 11-13.- PB. Low reef pool, Aug. 1950.

Plocamiaceae

PLOCAMIUM Lamx.

Plocamium telfairiae Harvey 1834, 149, pl. 125. De Toni 1900, 595. Yendo 1915, 111. Levring 1946, 222.

This name must replace P. gracile in the first list. Tetrasporic material from PB? (Aug. 1950) shows that it belongs to P. angustum (J. Ag.) H, and H , which is specifically identical with P. telfairiae

Sarcodiaceae

SARCODIA J. Agardh

Sarcodia ?

VB. Drift, Jan, 1949. (sterile).

Rhabdoniaceae

RHABDONIA Harvey

Rhabdonia nigrescens Harvey 1860b, 321. J.Agardh 1851, 354; 1876, 590. De Toni 1897, 357. Kylin 1932, 36. - VB. Drift, Jan. 1948. PB. Drift, Jan. 1946, Dec. 1949. RP. Drift, Aug. 1948.

Rhodophyllidaceae

RHODOPHYLLIS Kützing

Rhodophyllis gunnii Harvey. J. Agardh 1876, 366. De Toni 1897, 345. Kylin 1932, 42. Cladhymenia gunnii Harvey 1847, 87, pl.32. - AB. Drift, Aug. 1948.

Hypneaceae

HYPNEA Lamx.

Hypnea

PB. Sublittoral fringe on main reef, Jan. 1946, April 1947.

Hypnea

PB. Rear littoral on a western reef, Jan. 1948.

Mychodeaceae

MYCHODEA Harvey

Mychodea pusilla (Harv.) J. Agardh 1876, 571. De Toni 1897, 264. Kylin 1932, 64. Lucas and Perrin 1947, 156. Acanthococcus pusillus Harvey 1863, pl. 266. - PB. Drift, Jan. 1946.

Mychodea

PB. Drift, Jan. 1947.

APOPHLOEOPSIS n. gen. (position uncertain)

Very similar to Apophloea Harvey in habit and tetrasporic receptacles, but differing in the medulla being cellular instead of filamentous.

Apophloeopsis crustaceam n. sp.

CW. In high rock pools on the south side, Jan. 1948, 1950. The alga forms red-brown crusts with upright projections, rarely more than 3-4 mm. high. The texture is hard and horney.

Gigartinaceae

GIGARTINA Stackhouse

Gigartina gigantea ? J. Agardh 1885, 31; 1899, 37, 42. De Toni 1897, 222. Lucas and Perrin 1947, 152, f.24. - VB. Drift, Jan. 1948. (sterile)

Gigartina rubra Sonder herb.

PB. Sublittoral fringe on reefs, Nov. 1947, Dec. 1948, Jan., Dec. 1949. DB. Sublittoral fringe, Jan. 1947, 1950.

Gigartina

PB. Sublittoral fringe on main reef, Jan. 1946, 1947, Dec. 1948.

Gigartina ?

VB. Drift, Jan. 1949.

IRIDAEA Bory

Iridaea australasica ? J. Agardh 1892, 60. De Toni 1897, 188.- PB. Drift, Jan. 1946. VB. Drift, Jan. 1948, 1949. (Sterile).

Iridaea harveyi ? De Toni 1897, 189. Gigartina lanceolata Harvey 1860b, 326; 1863, pl. 288. - VB. Drift, Jan. 1948. (Sterile).

Iridaea pusilla n.sp.

MR. Lower littoral, Jan. 1947.

RHODYMENIALES - Rhodymeniaceae

BINDERA Harvey

Bindera splachnoides Harvey 1859, pl. III (part). J.Agardh 1876, 536. De Toni 1900, 548. Kylin 1931, 5. Lucas and Perrin 1947, 204. - PB. Drift, Dec. 1948, 1949. VB. Drift, Dec. 1946, Jan. 1949. WR. Drift, Jan. 1946. These specimens are slenderer than Harvey's, but are probably forms of the same species. The difference between this species and B. kaliformis is that the lesser branches are only constricted at the base in B. splachnoides, but also at intervals in B. kaliformis.

HYMENOCLADIA J.Agardh

Hymenocladia divaricata (R.Br.) Harvey 1858, pl. 20. J.Agardh 1876, 314. De Toni 1900, 502. - DB. Drift, Jan. 1950.

Champiaceae

CHAMPIA Desveau

Champia compressa Harvey 1847, 78, pl. 30. J. Agardh 1851, 370; 1876, 305. De Toni 1900, 561. Lucas and Perrin 1947, 206. - PB. Low littoral on edge of pools, just west of main reef, Aug. 1950.

Champia oppositifolia ? J.Agardh. De Toni 1924, 309. Kylin 1931, 29, pl. 16, f.37. - AR. Sublittoral near Muston, Nov. 1947, Jan. 1948. AB. Drift, Aug. 1948.

Champia

AR. Upper sublittoral on flats near mouth, May 1945, and at Pig Island, Jan. 1947.

CERAMIALES - Ceramiaceae

Spermothamnieae

LEJOLISIA J. Agardh

Lejolisia aegagropila J.Agardh 1892, 126, pl. 2, f.1-8. De Toni 1903, 1255. Lucas and Perrin 1947, 324 - PB. On Lenormandia in sub-littoral fringe pools, western terraced reef, Jan. 1946.

SPERMOTHAMNION Areschoug

Spermothamnion codicola n.sp. ?

PB. Drift, on Codium galeatum, June 1945, Jan. 1947.

Spermothamnion ?

DB. In outer reef pools, on Cymodocea, Jan. 1950 and on Spyridia opposita, Jan. 1947.

Griffithsieae

GRIFFITHSIA C. Agardh

Griffithsia gunniana J.Agardh 1876, 68. De Toni 1903, 1273. Lucas and Perrin 1947, 326, f.157. - WB. Drift, Jan. 1946. A single tetrasporic specimen which agrees well with specimens from the Tamar.

Griffithsia tenuis Agardh. J.Agardh 1851, 84; 1876, 70. De Toni 1903, 1284. Borgeson 1920, 462, f.423. - AR. On Posidonia, upper sublittoral, head of the inlet, Jan. 1950.

Monosporeae

NEOMONOSPORA Setchell and Gardner

Neomonospora australis (Harvey) comb. nov. Monospora australis, J.Agardh 1876, 610. De Toni 1903, 1299. Lucas and Perrin 1947, 328, f.159. Corynospora australis Harvey 1863, pl. 253. - AR. On Hormosira , very low littoral, near Muston, Jan. 1950.

PLEONOSPORIUM Naegeli

Pleonosporium comatum (J.Ag.) De Toni 1903, 1309. Lucas and Perrin 1947, 331. Lophothamnion comatum J.Agardh 1892, 43. - CC. Lower littoral, Jan. 1948, 1950.

Callithamnieae

CALLITHAMNION Lyngbye

Callithamnion

AR. On Black buoy, Sept. 1946, Jan. 1948. Very close to C. debile H.

Callithamnion ?

PB. On Chaetomorpha darwinii and Caulerpa longifolia, sublittoral fringe, Dec. 1948.

Spongoclonieae

SPONGOCLONIUM Sonder

Spongoclonium conspicuum Sonder 1853, 515. Lucas 1927a, 463. - PB. Drift, Jan. 1944, 1946, 1947, 1948. VB. Drift, Jan. 1948, 1949.

Spongoclonium

PB. Low littoral pools on a western reef, Jan. 1948

Ptiloteae

THAMNOCARPUS Harvey

Thamnocarpus

PB. Drift, Jan. 1948. WB. Drift, Jan. 1946.

Dasyphileae

PSILOTHALLIA Schmitz

Psilothallia ? siliculosa (Harvey) Schmitz. De Toni 1903, 1390. Ptilota siliculosa Harvey 1854, 559. J.Agardh 1876, 79.- VB. Drift, Jan. 1948, 1949.

Crouanieae

ANTITHAMNION Naegeli

Several species of *Antithamnion* occur around Kangaroo Island, but without type material it is almost impossible to determine them. Some may belong to *Antithamnionella* Lyle, which has tetrahedral sporangia. A.

A. Ramuli in pairs, distichous.

Antithamnion horizontale ? (Harvey) J.Agardh 1892, 20. De Toni 1903. 1398. *Callithamnion horizontale* Harvey 1854, 560 J. Agardh 1876, 26. - VB. Drift, Jan. 1946. PB. Drift, on *Sargassum*, Dec. 1948.

Antithamnion

WB. Drift, Jan. 1946. CC. Drift, Jan. 1947.

Antithamnion (A8732, A4342)

PB. On *Cystophora siliquosa* and *C. intermedia* in the sublittoral fringe, Jan. 1947, Aug. 1948, Jan. 1950.

B. Ramuli in pairs, decussate.

Antithamnion (A2560, A8659)

PB. Drift, May 1945. AB. Drift, Aug. 1948.

Antithamnion (A13, 031)

MR. Lower littoral, on *Corallina*, Jan. 1947.

Antithamnion (A10, 763)

PB. Drift, on *Sargassum*, Dec. 1948.

C. Ramuli in whorls of three.

Antithamnion (A6500)

PB. In a littoral pool, western reef, Jan. 1948.

Antithamnion (A3426)

MR. Drift, Jan. 1946.

D. Ramuli in whorls of four.

Antithamnion (A13, 032)

PB. Drift, on Sargassum, Dec. 1948.

Antithamnion (A2558)

PB. Drift, May 1945

BALLIA Harvey

Ballia mariana Harvey 1862, pl. 212. J.Agardh 1876, 58. De Toni 1903, 1394. Lucas and Perrin 1947, 350. - South Coast. Winter 1937, coll. J. Cork.

CROUANIA J.Agardh

Crouania mucosa n.sp.

PB. Rear, calmer parts of the main reef, Sept. 1946, Nov. 1947, Jan. 1950.

LASIOTHALIA Harvey

Lasiothalia (A2741)

PB. Drift, May 1945.

Ceramieae

CERAMIUM Wiggers

Ceramium rubrum (Huds.) C. Agardh. De Toni 1903, 1476. Newton

1931, 400, f.239. Taylor 1937, 340, pl. 47, f.1; pl. 52, f.5-7. - AR. Sublittoral near Muston, Nov. 1947.

Ceramium (A8186)

AR. Sublittoral near Picnic Pt., Jan. 1948.

Ceramium (A12,942)

CW. Rock pool, south side, Jan. 1950.

Ceramium (A9496)

AR. On black buoy, Jan. 1948.

Ceramium (A2573)

VB. In shaded pools, south side of Ellen Pt., May 1945, Jan. 1947, 1949, Aug. 1950.

Ceramium (A8209, A10,813)

VB. In shaded pools, south side of Ellen Pt., Jan. 1948, 1949.

Dasyaceae

DASYA C.Agardh

Dasya frutescens? Harvey 1854, 542. Kützing 1864, 24, pl. 67 d-g. De Toni 1903, 1194. - AR. Upper sublittoral, western flats, July 1947.

Dasya tomentosa n.sp.

PB. On Cystophora siliquosa in the sublittoral fringe, all seasons. CC. Drift, Jan. 1947.

Dasya (A2614)

PB. Drift, May 1945.

Dasya (A10,621)

VB. Drift, Jan. 1949.

HETEROSIPHONIA Montagne

Heterosiphonia wrangelioides (Harvey) Falkenberg 1901, 647. De Toni 1903, 1223. Lucas and Perrin 1947, 317. Dasya Wrangelioides Harvey 1860a, pl. 174 - VB. Drift, Aug. 1950.

Delesseriaceae

BRANCHIOGLOSSUM Kylin

Branchioglossum crispatulum (Harvey) Kylin 1924, 8. Delesseria crispatula Harvey 1863, pl. 268. J.Agardh 1876, 268. Hypoglossum crispatulum, De Toni 1900, 688. - VB. Drift, Jan. 1949.

HYPOGLOSSUM Kützing

Hypoglossum microdonthum J. Agardh. De Toni 1900, 691. - PB. Drift, Jan. 1948.

SARCOMENIA Sonder

Sarcomenia corymbosa J.Agardh 1896, 134. De Toni 1900, 737. Lucas and Perrin 1947, 234.

PLATYSIPHONIA Børgesen

Platysiphonia miniata (Ag.) Borgesen 1931, 1-9. Sarcomenia miniata (Ag.) J. Agardh 1896, 133. De Toni 1900, 735. -

VB. In rear littoral pools on reefs in the bay, Jan. 1950. PB. In a shallow pool on the west side of the main reef, Jan. 1948.

HEMINEURA Harvey

Hemineura wilsonis J. Agardh. De Toni 1900, 720. Kylin 1924, 6. - WB. Drift, Jan. 1946.

Nitophylleae

ACROSORIUM Zanardini

Acrosorium ciliolatum (Harvey) Kylin 1928, 78. Nitophyllum ciliolatum Harvey 1854, 549. Aglaophyllum ciliolatum Kützing 1869, pl. 7. - VB. Shaded end of pool 1, south side of Ellen Pt., Jan. 1948.

HETERODOXIA J. Agardh

Heterodoxia denticulata (Harvey) J. Agardh. De Toni 1900,697. Kylin 1924, 45. Delesseria denticulata Harvey 1854, 548; 1863, pl. 244. - VB. and PB. Drift, Jan. 1948.

HYMENENA Greville

Hymenena multipartita (H. and H.) Kylin 1929, 11, pl. 8, f. 20. Nitophyllum multipartitum Harvey 1847, 121. J.Agardh 1876, 457. De Toni 1900, 653. Aglaophyllum multipartitum Kützing 1869, pl.7. - PB. Sublittoral fringe, Jan. 1948.

MYRIOGRAMME Kylin

Myriogramme cartilaginea (Harvey) comb. nov. Nitophyllum cartilaginea Harvey 1854, 549. J.Agardh 1876, 459.

De Toni 1900, 634. Kylin 1924, 96. - VB. Drift, Jan. 1948. PB. Sublittoral fringe on a western reef, Jan., Dec. 1948. The carpospores occur in distinct chains, which is characteristic of Myriogramme.

NITOPHYLLUM Greville

Nitophyllum pulchellum ? Harvey 1854, 549. J.Agardh 1876, 447. De Toni 1900, 627. Kylin 1924, 96. Kützing 1869, pl. 5a-b. - AR. Upper sublittoral near Muston, Nov. 1947, Dec. 1949.

Nitophyllum

AR. Sublittoral amongst Posidonia near the mouth, May 1945, Jan. 1946.

PLATYCLINIA J.Agardh

Platyclinia crispata (J.Ag.) De Toni 1900, 670. Kylin 1924, 66. Neuroglossum crispatum J.Agardh 1899, pl.2, f.8. - WB. and PB. Drift, Jan. 1946.

Rhodomelaceae - Polysiphonieae

POLYSIPHONIA Greville

Polysiphonia blandi Harvey 1862, pl. 184. De Toni 1903, 899. Lucas and Perrin 1947, 269, f.123. - AR. On red buoy, Jan. 1948. PB. On main reef (rare), May 1945.

Polysiphonia compacta Lucas 1913, 56. De Toni 1924, 399. Lucas and Perrin 1947, 276. - MR. Lower littoral, Jan. 1947. VB. Lower littoral in bay, Jan. 1950. PB. Lower littoral

Dec. 1948 and on a chiton in the sublittoral fringe, May 1945. CW. Lower littoral, Jan. 1946.

Polysiphonia constricta n.sp.

AR. On buoys near mouth, Jan. 1946, 1948.

Polysiphonia densa n.sp.

PB. Sublittoral fringe, main reef, Aug. Dec. 1948.

Polysiphonia mollis Hooker and Harvey 1847, 43. Kützing 1863, pl. 88 a-c. De Toni 1903, 877. Lucas and Perrin 1947, 267. - AR. On Zostera on the tidal flats and on the buoys, all seasons. P. zostericola Lucas is not significantly different from P. mollis.

Polysiphonia (4 siphons)

MR. Lower littoral, Jan. 1947.

Polysiphonia (4 siphons)

PB. Shallow pools on main reef , Jan. 1948.

Polysiphonia (7 siphons)

CC. Lower littoral in inlet, Jan. 1950. PB. Lower littoral on main reef, Jan. 1949. MR. Mid littoral, Jan. 1946.

Lophothalieae

LOPHOTHALIA J.Ag.

Lophothalia hormoclados J.Agardh 1890, 59. Falkenberg 1901, 534. De Toni 1903, 1019. Dasya hormoclados, Harvey 1847, p.65, t.26A. - PB. Drift, Jan. 1946.

Chondrieae

CHONDRIA C.Agardh

Chondria

AR. Upper sublittoral near mouth, Aug. 1948. RP. Drift, Aug. 1948

Chondria

PB. Sublittoral fringe, mostly epiphytic on other algae, all seasons. DB. Sublittoral fringe, Jan. 1947.

Laurencieae

CORYNECLADIA J.Agardh

Corynecladia umbellata J.Agardh 1876, 643. De Toni 1903, 810. Lucas and Perrin 1947, 250. - DB. On sides of outer reef pools, Jan. 1950.

LAURENCIA Lamx.

Laurencia filiformis (Ag.) Montagne. Harvey 1847, 84. J.Agardh 1876, 644. De Toni 1903, 779. Yamada 1931a, 226. Lucas and Perrin 1947, 247. - AR. On buoys and in the upper sublittoral, all seasons. RP. Drift, Aug. 1948.

Laurencia forsteri (Mert.) Greville. Harvey 1847, 85. Kützing 1865, pl. 46c-d. De Toni 1903, 779. Yamada 1931a, 213, pl. 13a. Lucas and Perrin 1947, 247. - PB. Drift, May 1945. VB. Drift, Jan. 1949.

Laurencia regia Harvey 1863, syn. n. 309a. Yamada 1931a, 234, pl. 22a. - AR. (no details).

Laurencia

AR. Upper sublittoral, Aug. 1948. AB. Drift, Aug. 1948.

Pterosiphonieae

APHANOCLADIA Falkenberg

Aphanocladia bicornis n.sp.

WB. Drift, Jan. 1946. VB. Drift, Jan. 1948, 1949, 1950. PB. Drift, Jan. 1944, 1946, 1947. Sonder gave a herbarium name of Rytiphloea bicornis to this species.

Herposiphonieae

DIPTEROSIPHONIA Schmitz and Falkenberg

Dipterosiphonia dendritica (Ag.) Falkenberg 1901, 324. De Toni 1903, 1047. Borgesen 1918, 292, f.290-291. Lucas and Perrin 1947, 291. - PB. On Gigartina in the sublittoral fringe, Dec. 1948.

Dipterosiphonia heteroclada (J.Ag.) Falkenberg 1901, 320, t.3, f.1-3. De Toni 1903, 1046. Polysiphonia heteroclada J.Agardh 1885, 98. - VB. On Myriodesma latifolia in large pools, south side of Ellen Pt., Jan. 1946.

Dipterosiphonia ? prorepens (J.Ag.) Falkenberg 1901, 328. De Toni 1903, 1050. Lucas and Perrin 1947, 292. - DB. In outer reef pools, on Cymodocea, Jan. 1950.

HERPOSIPHONIA Naegeli

Herposiphonia versicolor (H. and H.) Falkenberg 1901, 315. De Toni 1903, 1056. Lucas and Perrin 1947, 293, f.138. Polysiphonia versicolor, Harvey 1847, 48, pl. 16.

Kützing 1863, pl. 31 a-c. - PB. Drift, May 1945, July 1947. WB. Drift, Jan. 1946.

Lophosiphonieae

LOPHOSIPHONIA Falkenberg

Lophosiphonia

RP. Lower littoral pools, Jan. 1947.

Amansieae

LENORMANDIA Sonder

Lenormandia pardalis J. Agardh 1894b, 80. De Toni 1903, 1119. Lucas and Perrin 1947, 302. - PB. Drift, Jan. 1944,1946.

Lenormandia

PB. Sublittoral fringe on western terraced reef, Jan. 1946, and in a shaded pool at the rear of the main reef, Jan. 1948. DB. Sublittoral fringe pools, Jan. 1950.

VIDALIA Lamouroux

Vidalia ? (A6960)

K. Drift, Jan. 1948.

CYANOPHYTA

CHROOCOCCALES - Chroococcaceae

GLOEOCAPSA Kützing

Gloeocapsa membranina (Menegh,) Drouet and Daily.

Chroococcus membraninus, Rabenhorst 1932, 238, f. 116a - MR. On sides and bottom of high littoral pools, amongst Lyngbya semiplena, Jan. 1950.

PALMOPHYLLUM

Palmophyllum crassum (Nacc.) Rabenhorst

AR. Mid littoral and floating in Pelican Lagoon, Jan. 1950.

NOSTOCALES - Oscillatoriaceae

LYNGBYA Agardh

Lyngbya aestuarii Liebm. Gomont 1892, 127, pl. 3, f.1,2. Setchell and Gardner 1919, 75. Rabenhorst 1932, 1052. - AR. As a film on mid littoral rock in Pelican Lagoon, Jan. 1950.

Lyngbya lagerheimii (Moeb,) Gomont 1892, 147, pl.4, f.6,7. - VB. Shaded end of pool 1, south side of Ellen Point, Jan. 1950.

Lyngbya meneghiniana (Kütz.) Gomont 1892, 125. - VB. shaded end of pool 1, south side of Ellen Point, Jan. 1950.

MICROCOLEUS Desmaz.

Microcoleus chthonoplastes Thuret. Gomont 1892, 353, pl. 14, f. 5-8. Setchell and Gardner 1919, 86. Rabenhorst 1932, 1133, f.739. - AR. As a film on mid littoral rock, and on

mud below samphires, in Pelican Lagoon, Jan. 1950.
SB. Just below water level in a shaded pool, Jan. 1950.

Microcoleus tenerrimus Gomont 1892, 355, pl. 14, f. 9-11. Setchell and Gardner 1919, 87. Rabenhorst 1932, 1135, f.740. - SB. Just below water level in a shaded pool, Jan. 1950.

OSCILLATORIA Gomont.

Oscillatoria laetevirens Crouan. Gomont 1892, 226, pl. 7, f.11. Setchell and Gardner 1919, 64. Rabenhorst 1932, 949. - SB. Just below water level in a shaded pool, Jan. 1950.

SPIRULINA Turpin

Spirulina major Kütz. Gomont 1892, 251, pl. 7, f.29. Setchell and Gardner 1919, 56, pl. 1, f.5. Rabenhorst 1932, 930, f. 595 - VB. Shaded end of pool 1, south side of Ellen Point, Jan. 1950.

Microchaetaceae

FREMYELLA J. de Toni

Fremyella grisea (Thuret) J. de Toni. Microchaete grisea, Rabenhorst 1932, 666, f. 427. - AB. On wood in low littoral, Jan. 1948.

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THE MARINE ALGAE OF KANGAROO ISLAND.

V. The American River Inlet

CONTENTS

INTRODUCTION

American River is a tidal inlet from the north coast of Kangaroo Island, extending to within half a mile of the south coast. The term "River" is a misnomer as the amount of fresh water entering the lagoons is negligible.

From a narrow neck about a quarter of a mile wide the inlet widens into several extensive lagoons, measuring some 5 miles in a north-south direction and 4 miles from west to east. From the opening a narrow channel (2-3 fathoms deep) extends up past Muston jetty and into Pelican lagoon, where several small islands occur. (see map.) The channel is bordered by sandy or muddy tidal flats which are covered by less than 2 feet of water at low tide, with the shoreward parts usually exposed. The drop-off over the flats is very gentle, sometimes less than one foot on a flat 600 feet wide. Parts of Pelican Lagoon are from two to five fathoms deep (shown by lighter green in the map.)

In the first paper of this series (Womersley 1947), the basic terminology used in describing the zonation of organisms on Kangaroo Island coasts was outlined, and this has been further discussed and slightly modified in a separate paper. (Womersley and Edmonds 1951, in press; see also Pt. VII of this thesis). In Part I reasons were also given for regarding American River Inlet as a distinct formation, and this will be further discussed later in this paper.

In December 1949 the South Australian Harbours' Board established an automatic tide gauge at American River jetty. The continuous tidal records from this have made possible an attempt to correlate the zones of algae and animals with the tidal fluctuations, and to define critical tidal levels.

The entire coast of the inlet has been covered during this survey, mainly during January 1950. From these detailed observations broader generalisations have been drawn, and it is clear that while the basic zones of organisms are quite stable, minor species of the sublittoral fringe and lowest littoral may vary in their presence and distribution in different seasons. Sufficient boat traverses have been made across the deeper parts of the lagoons to show the dominant organisms, and information from Mr. H. Ratcliff, a local fisherman, supports the conclusions drawn.

The names of the islands in Pelican Lagoon are those used locally, but the more prominent points around the lagoons have been given names for convenience, as there seem to be no locally used names.

This paper also deals briefly with those animals which form a conspicuous and important part of the zonation. The area impresses one as being a "zoologists paradise", and a detailed zoological survey of the inlet would be of great interest.

THE ENVIRONMENT.

The Substratum

The tidal flats are composed mainly of black mud, 4 to 10 inches deep, often with a layer of sand on top. Near the shore the mud or sand layer is shallower, sometimes with exposed rock. The mid and upper parts of the littoral zones consist of either sandy beach, samphires, or the base of low rocky cliffs of calcareous sand rock (see pl. 1, f.1, 2.).

Where rock is exposed, marine algae occur directly attached to it, but wherever there is a layer of mud the algae grow either on molluscs in the mud (e.g. Hormosira on Brachyodontes) or on the marine angiosperms which cover most of the tidal flats.

The channel supports plant growth mainly on the upper sides, as the bottom consists of loose shells and the current (up to 2½ knots) prevents a stable substratum. Occasional patches of rock near Muston and American River jetty allow the development of some brown algae, mainly Sargassum.

The Tides

The continuous tidal curves obtained at American River jetty were graphed in weekly periods from January 1st. 1950 onwards, and from them mean sea level and means of the higher and lower daily tides were calculated. Several 24 hour surveys done previously at American River jetty, Muston and in Pelican Lagoon simultaneously show that the tides are of the same form throughout the inlet and of very nearly the same amplitude. (see Pt. I, fig.2.) Differences in amplitude from American River jetty to Pelican Lagoon are usually less than 2 inches in a rise of 3½ to 4 feet and this difference may sometimes be due to wind effect.

The tidal range at American River jetty is usually 3.9 to 4.3 feet (extremes of 3.4 and 4.8) for spring tides and 3.0 to 3.6 feet (extremes of 3.75 and 2.0 or less) for neap (dodge) tides, but the range is extremely variable.

The tides at Muston are ½ to 1 hour behind, and in

TIDE CURVES FROM AMERICAN RIVER INLET, 1950

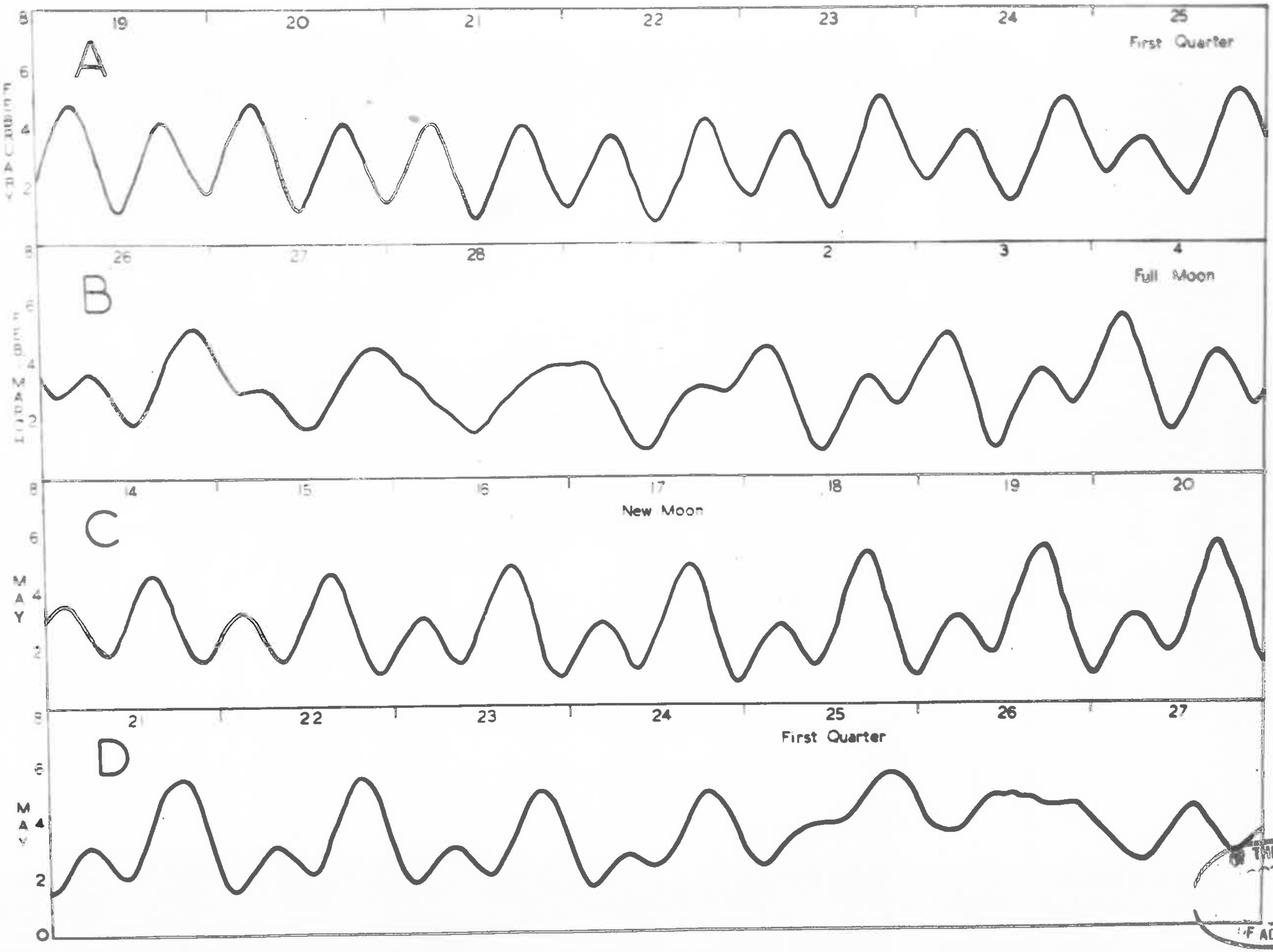

Figure 1.

Pelican Lagoon up to 2 hours behind the tides at American River jetty.

An examination of the tidal curves for the first eight months of 1950 shows their great irregularity compared with many other regions. (e.g. compare the curves given by Doty 1946, fig. 1 for the Pacific Coast of the United States of America). Tides in many localities in South Australia are noted for their irregularity, both at one locality and between different localities. Some examples of the American River Inlet tides are given in Fig. 1. Curves A and C are of spring tides, curves B and D of neap (dodge) tides.

At spring periods the tides are semidiurnal, but the two daily tides may be almost equal in amplitude (fig. 1A) or markedly unequal (fig. 1C), or between the two types. The highest tides usually occur between 0 and 3 days after new or full moon, but may occur at other times. The three highest tides recorded occurred at full moon, 1 day after and 2 days before full moon. Rarely do the lowest tides of the spring period occur at the same time as the highest tides, but are most irregular. In fact, the lowest tides more often occur at the"dodge" periods.

At the neap period the "dodge" effect occurs, but is shown in different ways. In most cases only one tide per 24 hours occurs over 2 to 4 days at the neap period (fig. 1B), but occasionally 2 tides of lesser amplitude occur; on other occasions a more typical "dodging" tide occurs, with the water level remaining almost stationary for 6 to 10 hours (fig. 1D). When the single tide occurs, the low level is usually lower than tides before and after, while the high may be nearly as high as some spring tides. The neap period occurs at very varying times, from a day before the first and third quarters of the moon to 4 or 5 days after.

Even when the tide is ebbing or flowing relatively strongly, it may be very irregular over short periods, sometimes dropping or rising as much as 4 to 6 inches from the general trend of the tide.

In calculating means of tidal levels it was found impossible to average such levels as high and low water of spring and neap tides, due to this irregularity. Means of the following levels could however be calculated and are given below (Table 1.)

Mean of the higher of the two daily high waters	M.H.H.W.
Mean of the lower of the two daily high waters	M.L.H.W.
Mean of the higher of the two daily low waters	M.H.L.W.
Mean of the lower of the two daily low waters	M.L.L.W.
Mean sea level	M.S.L.

These levels are similar to those used by Doty (1946). though not so comprehensive. At the neap periods, when only one high and one low tide occurred, L.H.W. and H.L.W. were omitted. Records for January, February and April and incomplete, as about 1 week's readings were not taken in each month.

TABLE I

Tidal Data, American River jetty, 1950. (figures in feet)*

	M.H.H.W.	M.L.H.W.	M.S.L.	M.H.L.W.	M.L.L.W.
January	4.88	3.51	3.01	2.28	1.37
February	4.47	3.47	2.73	1.94	1.01
March	4.35	3.32	2.64	1.77	0.99
April	4.50	3.23	2.68	1.61	1.81
May	5.13	3.13	3.13	2.00	1.66
June	5.33	3.21	3.29	2.47	1.73
July	5.19	3.41	3.16	2.36	1.61
August	4.94	3.83	3.11	2.16	1.49
Average to end of August	4.88	3.37	2.98	2.08	1.39

Highest high water in 8 months - 7.1 feet.

Lowest low water in 8 months - 0.0 feet.

The variation in the means from month to month is considerable. Figures for June and July tend to be higher, and for February, March and April lower than the average.

A partial cause of the tidal irregularities is the wind. Strong westerly winds across Investigator Strait (26 miles wide) raise the sea level generally in the gulf region, as the water cannot be forced out through Backstairs Passage (10 miles wide) to the same extent. This results in higher

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* All tidal figures are based on, or corrected to, the Harbours Board tide gauge at American River jetty.

tides at American River Inlet. A south wind tends to have the opposite effect.

Little is known of the cause of the dodge effect, which is largely confined to the Gulf Region in South Australia. The hypothesis given by R.W. Chapman (1924) is that during the neap period the sun and the moon, together with the other tide producing forces, exert almost equal but opposite effects, one nullifying the other. It has been suggested that the abnormally large effect of the sun is due to the synchronising of the natural period of swing of the basin of water between Australia and Antarctica with the period of the tide producing forces.

Exposure to air.

The time (as %) covered by water at different heights, for each month of 1950, is given in Table II. The figures vary very considerable from month to month, and also for weekly periods within each momth. This is a direct result of the tidal irregularities. The heights for which percentages have been calculated cprrespond to the main changes between zones and to tidal levels given in Table I which lie within a zone. Table II will be referred to later when dealing with critical levels.

TABLE II

Time (as %) during which certain levels are covered.

Height (feet)	5.3	4.9 M.H.H.W.	3.4	3.0 M.S.L.	2.6	2.1 M.H.L.W.	1.4 M.L.L.W.
January	3.0	6.5	33.8	46.3	60.6	78.7	93.8
February	0	2.2	27.3	40.3	52.4	69.2	87.8
March	0.3	1.5	23.5	34.6	48.5	66.2	86.5
April	1.3	4.3	22.1	31.9	33.7	65.7	88.7
May	4.1	7.8	37.8	47.6	60.8	81.5	95.6
June	7.0	12.2	38.7	51.8	66.6	86.0	98.6
July	5.9	10.2	39.5	49.7	64.4	80.4	92.5
August	3.1	8.0	37.8	49.5	63.9	79.6	93.2
Mean (8 months)	3.3	6.8	33.1	44.5	57.3	76.5	92.3

Wind.

The prevailing winds are from south to west, with some northerly winds in summer. The effect of westerly winds in causing generally higher tides has been referred to above. Within the inlet mild breezes have little effect except to cause waves in the channel. However, on one area of the north coast of Pelican Lagoon the water is 4 or more feet deep at the base of vertical cliffs, and even a light southerly wind (having passed over 2 or 3 miles of water) causes continuous lapping of waves on the base of the cliffs. This results in some 200 yards of coast which is more allied to other areas of the north coast of Kangaroo Island than to the rest of American River Inlet. At Salt Lake Point also wave action is more pronounced and some organisms characteristic of the Sheltered Rocky Coast Subformation occur here.

Strong winds (especially in late winter) will cause wave action along the edge of the channel sufficient to remove many epiphytic algae from their angiosperm hosts.

Wave action.

Wave action is completely dependent on wind, and under calm conditions the water surface is quite smooth. Wave action on the whole is very slight, and is one of the main causes of the distinctness of the American River inlet. Several minor exceptions have been mentioned above under "wind".

Water Turbitity

The water carries a certain amount of fine suspended mud, especially in and near the channel when strong tides are running. The bottom of the channel (2-3 fathoms deep) can only be seen when there is no tidal current. The turbidity doubtless has some effect on the organisms, and is possibly a partial cause of the yellow, or grey or brownish colour of most of the Rhodophyceae, in contrast to the brighter red colour of deeper and cleaner water forms.

Temperature

Air temperatures given for Kingscote in Pt. I probably apply fairly well at American River inlet, though cool southerly breezes would have greater effect in the inlet. The Kingscote figures show a range (monthly averages) from 8.7 - 14.2 C in July to 15.6 - 22.7 C in February. Probably more important that mean temperatures however are occasional very high temperatures (100° F.) in summer, which cause extreme conditions during low tides on the flats.

Sea temperatures range from about 10°C on the tidal flats and channel on cold winter days to 23°C in the channel and over 30°C on shallow flats on hot summer days. The annual, and also the daily range in summer, is great, and doubtless prevent some algal species from occurring in the inlet. The annual range is 3 to 5 times as great as on the south coast of Kangaroo Island.

Shade

Most of the intertidal zones are exposed to full sunlight except the upper littoral (occasionally also the mid littoral) which occurs at the base of low cliffs. The upper littoral is often completely shaded, or has many shaded holes and crevices which allow the development of the algae Bostrychia and Gelidium.

Salinity

The following ranges in chlorinity were obtained during a 24 hour survey on January 20th.-21st., 1946.

American River jetty	19.9 - 20.0
Muston jetty	19.9 - 20.1
Pelican Lagoon	20.5 - 20.6

The increase in Pelican Lagoon is due to greater isolation of the water with summer evaporation.

The amount of fresh water entering the inlet is negligible except after heavy rain, when a few creeks may flow, and even then they exert only a minor local effect. On rare occasions very heavy rain during low tides may lower the chlorinity on the tidal flats. During January 1946, over 5" of rain fell in four days, and at one stage the chlorinity on the tidal flats was 16.7 - 17.6 . For several days afterwards there was a noticeable stench of decay, apparently from algae killed by this low salinity.

Oxygen.

Oxygen saturation of the water varies considerable during the day and night. Figures of 130% saturation during the day in summer are common, dropping to 50-60% at night. Broken water tends to keep this latter figure higher. In shallow water over dense algal growth, saturation figures as high as 200% occur.

The oxygen in the water is controlled firstly by the plants present, and secondly by wave action and broken water, which tend to keep the saturation nearer 100%. Oxygen saturation is rarely if ever likely to be a controlling factor in algal growth or distribution.

Phosphate.

Samples taken in January 1946 showed varying phosphate figures, mostly between 2 and 16 p.p. 10^9 PO_4/P. One sample from Pelican Lagoon contained 63 p.p. 10^9, but this was probably a local effect due to bird colonies.

Nitrate

In six samples taken at the same time as the phosphate samples no nitrate could be detected. Now nitrate is usual in South Australian waters. Both low phosphate and low nitrate are due largely to the absence of any large rivers in the region, but at American River inlet may also be due to a high phytoplankton population.

On Shag Rock, in Pelican Lagoon, Gayella occurs plentifully on rocks where shags roost. As in many localities in other countries, Gayella (and Prasiola) occurs where there is nitrogenous excrement from birds.

ZONATION IN RELATION TO TIDAL LEVELS.

Zonation of algae and animals is relatively constant throughout the inlet, especially at or below the mid littoral level. However, two types of coast are found within the inlet, resulting in differences at the upper littoral and supralittoral levels.

1. Rocky cliffs (6 to 30 feet high) descending to the mid littoral, with shaded hollows at their base. (fig. 2, Section B; pl. 1, fig. 2.) Cliffs occur around most of the islands in Pelican Lagoon, on much of the north side of Pelican Lagoon, and as outcrops elsewhere in the inlet.

2. Areas where the tidal flats shelve gently through the littoral, with samphires or shelly beaches in the upper littoral and supralittoral. (fig.2, Section A; pl.1, fig.1). Most of the coast from American River jetty to Muston and on to the head of the lagoons is of this type, while smaller areas occur in Pelican Laggon. The larger areas of samphires are shown in the map,

but a fringe of samphires occurs around most of the coast where there are no rocky cliffs.

The Typical Zonation.

The typical zonation where cliffs occur is shown in fig. 3. (see also fig. 2, Section B).

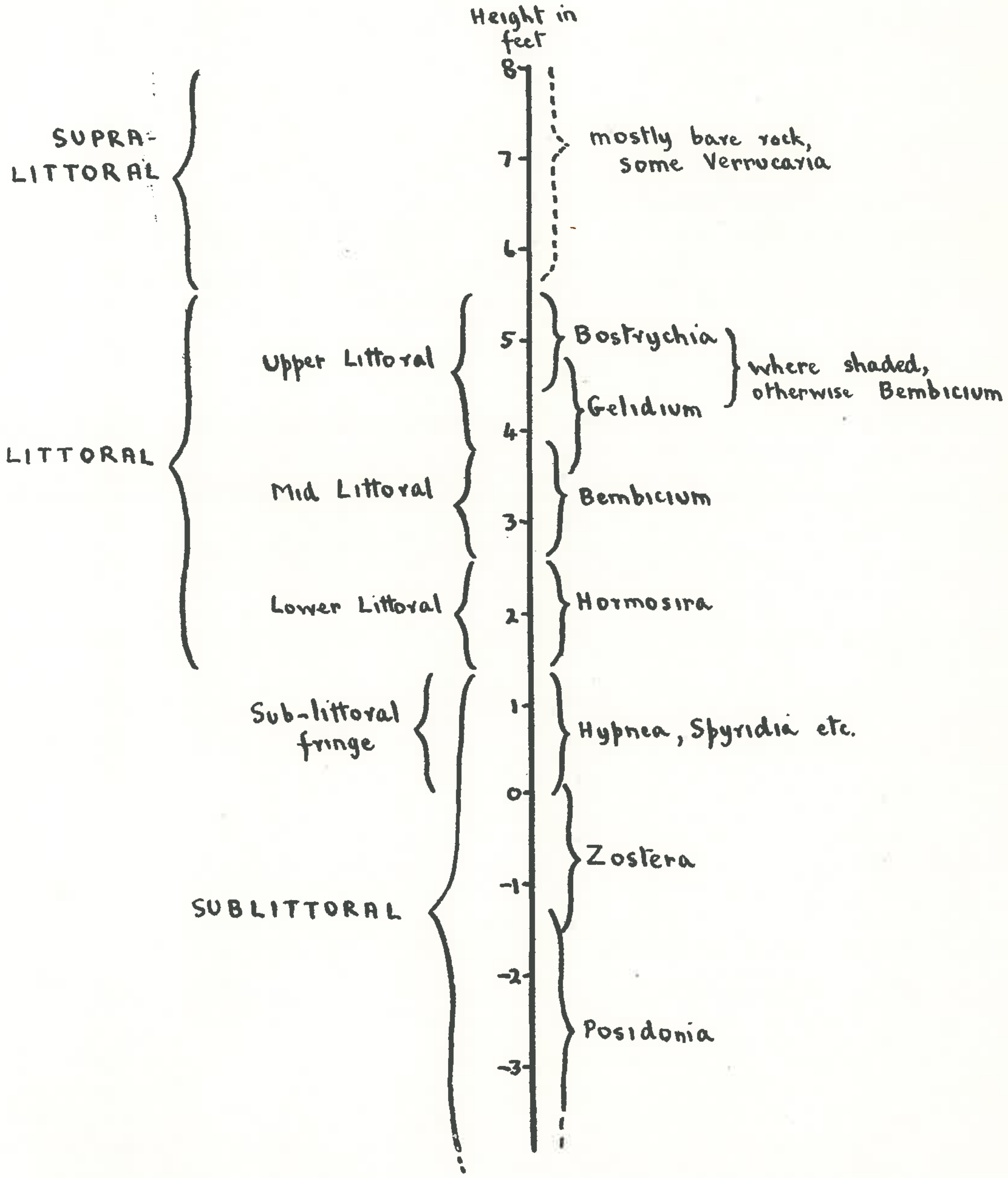
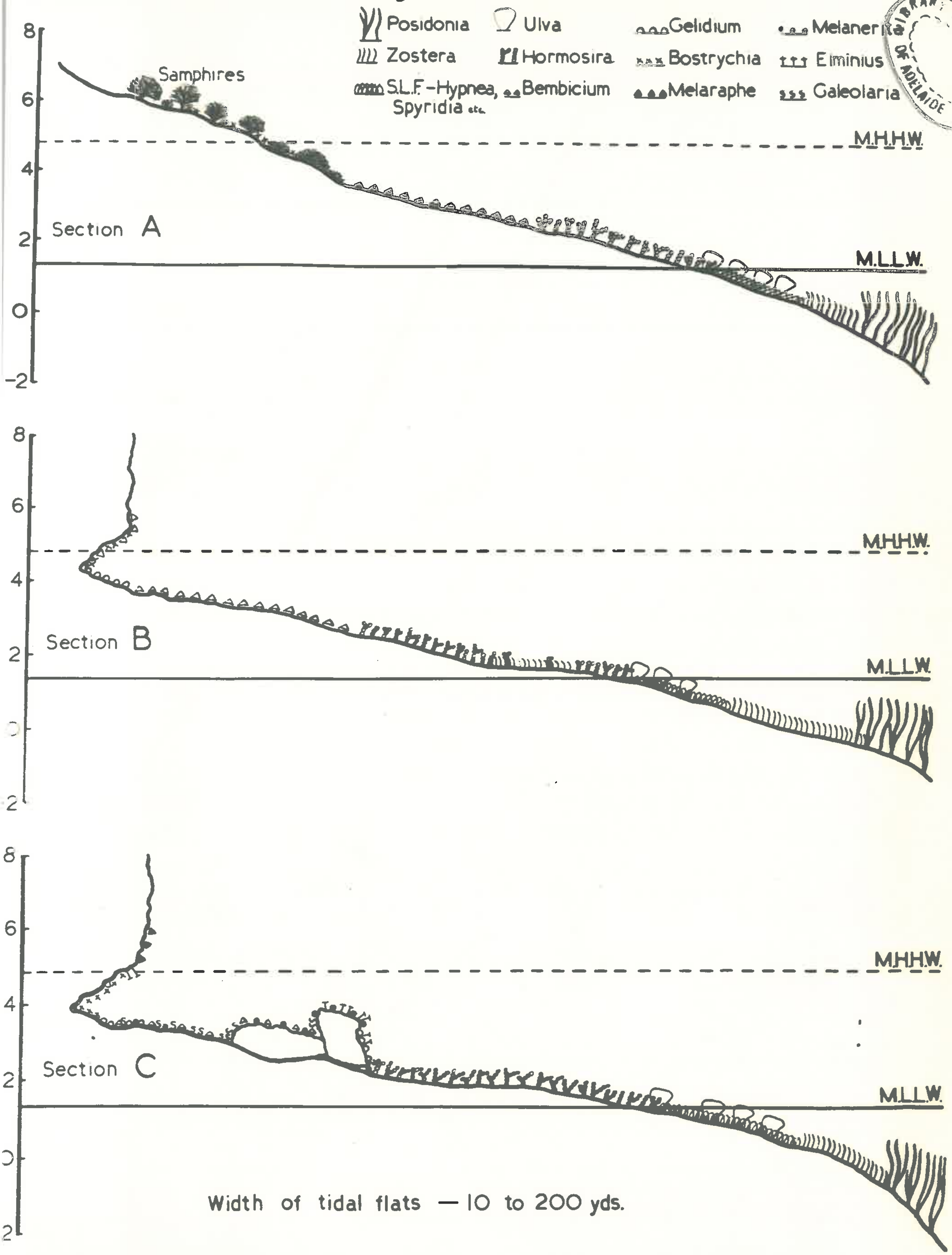


Fig. 3. Zonation in American River Inlet.

Figure 2.



Width of tidal flats — 10 to 200 yds.

The Supralittoral.

The supralittoral is generally almost bare of macroscopic organisms. Occasional Bembicium melanostoma may extend into it, and the lichen Verrucaria microsporoides Nyl. occurs in the lower part as tiny black spots, which in some places give a dark appearance to the rock.

The littoral

For convenience the littoral mat be divided into three zones.

Upper littoral. On rock not in shade, the upper limit of the littoral can probably best be placed at about M.H.H.W. or just above (about the 5.0 ft. level). The chief organism here is the mollusc Bembicium, which extends upwards from the mid-littoral. In some places Verrucaria darkens the rock.

In shaded places, Bostrychia simpliciuscula occurs from 5.4 feet to 4.5 feet, and Gelidium pusillum from 5.0 feet to 3.4 feet. The levels of these algae are as much dependent on shade as on tidal exposure, and are therefore rather variable. Gelidium tends to occur in less shaded places than Bostrychia, sometimes where direct sunlight falls on it for short periods.

Mid littoral. This zone is dominated by Bembicium (pl. 3, fig. 2), which is one of the few organisms able to withstand the exposure to air and to direct sunlight of the zone. The lower limit lies at the 2.5 - 2.6 ft. level; above about 3.5 feet on unshaded rock Bembicium becomes less common, but individuals can be found well above this level. The lobivalve Modiolus areolatus may form patches in the mid littoral and become co-dominant with Bembicium (pl. 4 fig.1). Small communities of Enteromorpha clathrata may also occur here.

Lower littoral. This zone is dominated by Hormosira banksii throughout most of the inlet. Its limits are from 2.5 - 2.6 feet to 1.3 - 1.4 feet., and the lower limit corresponds closely to M.L.L.W.

The Sublittoral.

The littoral - sublittoral boundary lies at the junction of the Hormosira zone and a zone of red algae dominated by Hypnea and Spyridia. The upper limit is at 1.2 - 1.4 feet (M.L.L.W.). This zone extends down for only a short distance, rarely more than the 0.0 ft. level, though isolated plants may occur lower. This Hypnea - Spyridia zone is referred to as the sublittoral fringe (see Pt. VII).

Zostera muelleri occurs from about 0.5 feet to -3 feet or lower, though in some areas it occurs as high as 2.0 feet. Growth is best where it is never properly exposed.

Posidonia australis forms dense "meadows" from -0.5feet downwards, especially in deeper water in Pelican Lagoon.

Zonation where cliffs do not occur.

This is essentially similar to the zonation described above, except that samphires (Salicornia, Arthrocnemum) occur in the upper littoral (3.5 feet upwards) and supralittoral. (fig. 2, Section A; pl.1, fig.1; pl.2, fig.1). The roots and lower stems of these plants are flooded at high tides, and low plants may even be completely covered. In the shade of the samphires, Bostrychia and Chaetomorpha capillaris occur, with Gelidium on the lower stems.

Variations on the typical zonation.

On Shag Rock in Pelican Lagoon, Gayella polyrhiza grows as mats on the rock in the supralittoral where shag excrement is plentifull. Only occasional spray reaches this zone.

At Salt lake Point, wave action becomes moderate as the prevailing south west wind blows across 2 miles of water. Due to the wave action the zones are slightly elevated and several species occur here which are more characteristic of the Sheltered Rocky Coast Subformation (see fig. 2, Section C). Zones below the mid- littoral are typical, but in the mid littoral serpulid worm tubes (Galeolaria caespitosa) occur at the base of the cliffs and rocks, while in the upper littoral the barnacle Elminius modestus is common on rock faces exposed to the waves. (i.e. facing the south-west). Scattered Melanerita melanotragus also occur. Nevertheless, Bembecium is dominant in the mid littoral generally. In the supralittoral a few Melaraphe unifasciata occur. The lichen Verrucaria is also more prominent in the upper littoral and lower supralittoral.

An area of the central north coast of Pelican Lagoon, some 300 - 400 yards long, consists of cliffs dropping vertically to below low tide level, with no intertidal flat. Here, also, wave action is greater than elsewhere in the inlet, due to deeper water at the base of the cliffs and also to stronger wind action across Pelican Lagoon. As a result of the stronger wave action, the zonation here is more like that outside American River inlet. The organisms mentioned in the previous paragraph occur here, and in addition the sublittoral fringe is dominated by the brown alga Cystophora polycystidea. This alga is not found elsewhere in the inlet, but is characteristic of the north coast of Kangaroo Island. Hormosira occurs as a very compressed zone (with dense tufts of Jania sp, amongst it) on a small rocky ledge in the lower littoral. Peyssonnelia gunniana and a lithothamnion growing on Brachyodontes erosus are other unusual components of the sublittoral fringe.

This area of coast is really a fragment of the Sheltered Rocky Coast Subformation within American River inlet, and demonstrates the fundamental importance of wave action in determining the algal formations.

Critical levels.

Doty (1946), Beveridge & Chapman (1950) and others have found that certain tidal levels ("critical levels") correspond to the breaks between zones on the shore. An attempt has been made to relate the zones at American River inlet to tidal levels, but owing to the relatively small tidal rise and great irregularity in the tides, the attempt has met with only limited success.

Table I gives the means of tidal levels which were calculated. If these are compared with the breaks between zones (fig. 3), it is evident that two levels can probably be termed critical. These are M.L.L.W. which is very close to the Hormosira - sublittoral fringe break, and M.L.H.W. which corresponds to the lower limit of Gelidium. The other tidal levels in Table I come within zones and do not appear to be critical.

In the upper littoral, the determining factor is shade rather than tidal fluctuations, so that close correlation of Bostrychia and Gelidium limits with tides would not be expected.

There remains however, one clear cut level that cannot at present be related to tidal levels, i.e. the upper limit of Hormosira, which falls about half way between M.H.L.W. and M.S.L.

The degree of exposure to air is probably an important determining feature of the zonation, and is directly dependent on tidal fluctuations. Table II gave monthly percentage times during which certain levels are covered, and the following are the limits for the main intertidal zones.

The Upper littoral (Bostrychia and Gelidium) is covered between 3% and 33% of the time (monthly extremes, 0% to 7% and 22% to 40%).

The mid littoral (Bembicium) is covered between 33% and 57% of the time (monthly extremes 22% to 40% and 34% to 67%).

The lower littoral (Hormosira) is covered between 57% and 92% of the time (monthly extremes, 34% to 67% and 87% to 99%).

The sublittoral fringe (Hypnea - Spyridia) is covered for more than 92% of the time.

The monthly variation (and to an even larger extent the daily variation) in exposure to air of the different zones is very considerable. It seems impossible to consider any particular organism as sharply limited by a certain degree of exposure, partly no doubt because of the importance of the other factors, such as shade and in the case of Hormosira the presence of reservoirs of water in each vesicle.

THE PLANT AND ANIMAL ASSOCIATIONS

The more extensive plant associations of the tidal flats are shown in the map, which was drawn from aerial photographs. Owing to the scale, it is not possible to show associations higher (i.e. nearer the shore) than the Hormosira association as they form comparatively narrow bands. For the same reason the sublittoral fringe association of Hypnea - Spyridia is not shown, but it occurs between Hormosira and Zostera, often mixing with the latter.

The tidal flats are very largely covered with plant growth, but there are a few sandy areas which apparently do not provide a suitable substratum for algae or any of the angiosperms. These sandy areas are left uncoloured in the map, but they often bear communities of Ectocarpus confervoides and Polysiphonia patersonis, both growing on cockle shells buried in the sand.

Most of the tidal flats are covered by marine angiosperms. These are the only plants which can colonise sandy or muddy areas, but they provide a place on which many algae can grow.

The main plant and animal associations will be described as they occur from the supralittoral downwards. Species for which the seasonal distribution is not given almost certainly occur throughout the year. Variations from the typical zonation have been described previously, so only the main associations will be described here.

THE SUPRALITTORAL

1. Gayella polyrhiza association

Gayella polyrhiza occurs only on Shag Rock, where there is excrement from a shag (cormorant) colony. It forms thin green mats over the rock and is best developed during winter. In Pt. I it was reported as Prasiola, and like this closely related genus it is dependent on an increased supply of nitrogen. Gayella on Shag Rock is rarely wet by spray and is as much a terrestrial as a marine alga.

THE LITTORAL

2. Bostrychia simpliciuscula association

Bostrychia occurs only in well shaded places of the upper littoral, usually as scattered patches but frequently lining the floor and sides of small caverns (6-8 feet long) in the base of the cliffs. It forms soft, dark-brown mats, ½-1 cm. thick (pl. 2, fig. 2). Bostrychia mixta sometimes occurs mixed up with B. simpliciuscula. The latter also occurs in the shade of the samphires, growing on mud or the base of the plants.

3. Gelidium pusillum association.

Gelidium occurs mainly below Bostrychia, but they often grow in the same area, though never intimately mixed. In growth habit they are very similar, the Gelidium being firmer and coarser than Bostrychia (pl.2, fig. 1.) Gelidium grows in less shaded places than Bostrychia, and may even receive direct sunlight for a short time each day.

Both the Gelidium and Bostrychia associations are relatively pure. Few other algae occur in the upper littoral zone, though Cladophora repens and Chaetomorpha capillaris are occasionally found. The mollusc Bembicium occurs on otherwise bare rock between patches of Gelidium and Bostrychia, but mainly where exposed to sunlight.

During winter months (July - November) Porphyra umbilicalis occurs in the lower Gelidium zone in Pelican Lagoon, on the more exposed rock. It is very variable in occurrence and seems to be absent in some years. The plants are not well developed, being only 6 to 12 cm. high.

4. The Samphire association

Three species of Chenopodiaceae occur in the upper littoral and extend into the supralittoral, viz. Salicornia australis, Arthrocnemum arbuscula and Kochia oppositifolia. These are commonly called "samphires", and may occupy relatively large areas (see map; also pl.1, fig. 1 and pl. 2, fig. 1). Salicornia australis is the smallest (6 - 8 inches high) and occurs lowest. Some plants are completely submerged at high tide. Arthrocnemum arbuscula grows to a low bush 3 feet high, while Kochia oppositifolia grows to 5 feet in height and occurs highest on the shore. The roots and stems only of the latter two species are covered by high tides.

In the shade of the samphires, Bostrychia simpliciuscula Gelidium pusillum and Chaetomorpha capillaris occur. Bostrychia and Chaetomorpha form loose, soft mats on the mud, while Gelidium grows mainly on the stems of the samphires. Microcoleus chthonoplastes (together with Calothrix scopulorum (?) also form mats on the mud.

5. Bembicium melanostoma * association

This mollusc dominates the midlittoral and extends up through the upper littoral, occurring on rock or mud (pl. 3, fig. 2).throughout the inlet. On upper littoral rock not in shade, tiny black spots of the lichen Verrucaria microsporoides occur with Bembicium.

On flat areas of the mid littoral, exposed to full sunlight, Bembicium is often the only macroscopic organism present, but on some flat rocky areas the bivalve Modiolus areolatus may be codominant. The Modiolus grow in small clumps on the rock, with scattered Bembicium between them. (pl. 4, fig. 1). Beds of Brachyodontes erosus are also found in the mid littoral in a few places, though this bivalve is commoner in the lower littoral.

Algae are not common in the mid littoral, but the following occur:

Enteromorpha clathrata forms isolated patches, especially in slight hollws which remain moister at low tide, or near the base of the cliffs where there is some shade. Occasionally it occurs under the samphires. This alga is very variable in form and frequently stunted, but agrees with type II of Bliding.

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* This name includes a complex of forms. The one at American River inlet is sometimes known as B. nanum.

Rivularia nitida occurs as tiny scattered plants on rock on the south side of Pelican Lagoon, but is not common. Several other blue-green algae inhabit the mid littoral in the lagoons; Isactis plana grows on small rocks and old shells; Palmophyllum crassum (in the gloeocystoid state) forms irregular brownish blobs to 1 cm. across, lying very loosely on the mud or rock; and Lyngbya confervoides forms flat mats which become very thin when dry and peel off readily. In a few small areas Lyngbya dominates the mid littoral.

6. Hormosira banksii association.

Throughout most of the inlet Hormosira banksii forms a conspicuous zone, varying in width from a few feet to 100 yards (see map.) On the western coast of the inlet, and between Strawbridge Point and Picnic Point, Hormosira is almost absent from long areas, occurring only on small rocky outcrops. The plants grow on rock or on the mollusc Brachyodontes erosus embedded in the mud, and do not occur where the substratum is mud without Brachyodontes.

Hormosira forms a pure and dense association (pl. 4, fig.2; pl.5, fig.1). On the lower side it merges with the sublittoral fringe association of Hypnea - Spyridia, but only scattered Hormosira plants occur in the latter association proper. Ulva lactuca (pl.6, fig.1) and Chaetomorpha sp. (pl. 5, fig.2) occur in the lowest part of the Hormosira association, while in some places stunted tufts or fragments of Corallina are found.

The plants of Hormosira at American River inlet are much branched, to 25 cm. long, and with individual vesicles up to 3½ cm. in diameter. This is the forma labillardieri, and is very different from forma sieberi of rougher localities. Another difference is that Hormosira in the inlet is never epiphytised by Notheia anomala.

Hormosira can withstand the exposure to air, and to high temperatures in summer, because of its large water-containing vesicles. No other alga in the inlet is adapted to withstand lower littoral conditions so well.

Epiphytes on Hormosira are few. During winter months Ectocarpus confervoides is oftem dense on it, while at most seasons a small Lophosiphonia (?) creeps over the vesicles.

The mollusc Austrocochlea zebra occurs on Hormosira, and a small anemonie is found in sand near the base of rocks in th the lower and even the mid littoral.

7. Minor communities of sandy areas

Two communities, both rather variable in their occurrence are found on dandy areas of the lower littoral or just below. These are dominated by Ectocarpus confervoides (which occurs only in winter) and Polysiphonia patersonis. Both species may occur together, or quite separately, in areas around Samphire Island, between Strawbridge Point and Picnic Point, and elsewhere in the inlet. They are usually attached to cockle (Katelysia scalarina) or other shells in the sand.

THE SUBLITTORAL FRINGE

8. Hypnea musciformis - Syridia biannulata association.

This association of the sublittoral fringe occurs for about 1 - 1½ feet below the Hormosira association. It is characterised by a variety of species, with Hypnea musciformis and Spyridia biannulata usually dominant, and Centroceras clavulatum a common constituent.

In a few places this association does not occur. North of the American River jetty Zostera extends shorewards to a fairly steeply shelving sand-pebble beach, and only scattered plants of Hypnea and Spyridia are found amongst the Zostera. Similar areas occur between American River jetty and Muston, and between Strawbridge Point and Picnic Point. Throughout the lagoons* however the Hypnea - Spyridia association is fairly distinct, although in many places this and the Zostera association grade over several yards.

The majority of algae in the sublittoral fringe are Rhodophyceae, with a few Chlorophyceae and Phaeophyceae. All the Rhodophyceae are yellow-brown in colour and are covered with a fine film of mud. They grow on cockle and other shells, or on small pebbles, buried in the mud.

The distinctive feature of the sublittoral fringe in the inlet is the dominance of Rhodophyceae and virtual absence of larger brown algae. This was stressed in Pt.I, and will be referred to later in this paper.

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* "the lagoons" includes those parts of the inlet south of Muston.

Hypnea musciformis and Spyridia biannulata may each be dominant in some areas, but more often occur together. Centroceras clavulatum is rather variable, and less conspicuous, and has therefore been dropped from the name of the association as given in Pt. I. Numerous other species occur in the association, but are variable in occurrence and density. Some of them form almost pure localised communities in a few places. Notes on these species are given below. Unless otherwise stated they are restricted to the zone from about the 1.3 ft. to the - 0.5 ft. levels, but some extend deeper while others (e.g. Ulva, Chaetomorpha sp.) extend up into the lowest littoral zone.

Ulva lactuca is often a very common constituent of the sub-littoral fringe and extends into the Hormosira association. (pl. 6, fig.1.) In winter it may form (with Enteromorpha) a prominent green strip along the shore, often lying partly on the Zostera association. The plants reach a length and expanse of 50 cm. or more (forma latissima). A common epiphyte is Myrionema strangulans.

Enteromorpha clathrata is common and widespread throughout the inlet. Bliding's type II often forms a dense belt along the flats (with Ulva) where it is just exposed at low tide, while Blidings type III (E. plumosa) is frequently found as dense masses in the sublittoral fringe.

Cladophora fascicularis is occasional in the sublittoral fringe, though small dense patches occur in the lagoons.

Chaetomorpha sp. (close to, but distinct from, C. linum). Extensive masses of this filamentous alga are left lying on the sand or mud at very low tides. It extends from the low littoral through the sublittoral fringe, and is found mainly in the lagoons. Often it forms quite a distinct community (pl. 5, fig. 2).

Chaetomorpha valida occurs throughout the lagoons at or just below lowest low waters, but only occasionally below -1.0 feet. Usually it is not common, but patches several feet across do occur.

Acetabularia peniculus grows on old cockle shells from just south of Channel Point around the coast of the lagoon to about Shark Point. In some areas it is quite dense and almost pure, but is more often overgrown and hidden by larger species. It ranges from very low littoral to -1.0 feet and rarely deeper, and is frequently mixed up with Zostera.

Codium galeatum is not common, only isolated plants being found on the edge of islands near the channel.

Caulerpa remotifolia forms masses to 3 feet across in the sublittoral fringe, on the channel side of some of the islands and occasionally elsewhere, but is mainly found in deeper holes in the Posidonia association.

Caulerpa simpliciuscula var. vesiculifera occurs only occasionally in small clumps, near Strawbridge Point and on the channel side of Shag Rock and Pig Island.

Ectocarpus confervoides is common in the sublittoral fringe in winter (may to November) but also occurs in the lower littoral. It grows on shells or stones or epiphytically on larger algae, and may form a pure community on sandy areas.

Dictyota dichotoma var. *intricata* occurs throughout the inlet but is only plentiful in patches in the lagoons, extending from about the 0.5 to -1 ft. levels.

Stilopsis harveyana is largely confined to the Head of the Lagoons and the south and east sides of Pelican Lagoon, where it may be quite common between about 0.6 and -0.9 ft. levels. Odd plants may be found elsewhere.

Cystophora cephalornithos grows mostly in the Head of the Lagoons where conditions are very calm, but odd plants occur throughout the inlet. It is restricted to the 0.5 to -1.5 ft. levels, often reaching the surface at low tide.

Cystophyllum muricatum. Scattered plants occur on the flats throughout the inlet, in the *Zostera* and upper *Posidonia* associations as well as the sublittoral fringe. One of the very few places where it is common is in part of the shallow channel between Wallaby Island and Wallaby Point, where there is a tidal current.

Sargassum biforme grows along the edge of the channel where rock occurs (e.g. the channel edge on Pig Island and Shag Rock and in the channel near Muston), extending from the sublittoral fringe to about 2 fathoms.

Gelidium pusillum. Coarse tufts (to 5 cm. high) of a form of this variable species grow in the sublittoral fringe for some distance on both sides of Wallaby Point.

Corallina sp. forms dense hemisperical masses (to 15 cm. across) in parts of Pelican Lagoon, especially just south of Pig Island. It is best developed 2-4 feet below low tide, but fragments occur up to the lowest *Hormosira* level.

Jania natalensis is quite dense in a few small bays in Pelican Lagoon where it may form an almost pure community. Elsewhere it is only occasionally found.

Lithothamnion erubescens (?) This calcareous alga is confined to the sublittoral fringe, from near Channel Point throughout the lagoons (and around the islands) to just west of Shark Point. Usually it forms unattached nodules (2-8 cm. across) but may encrust rock.

Gracilaria confervoides occurs as scattered plants over much of the tidal flats from American River jetty to Muston, and occasionally elsewhere. It may reach the lowest littoral level (e.g. on Pig Island), but is mostly attached to small stones or shells amongst Zostera.

Centroceras clavulatum is common throughout the inlet in the sublittoral fringe. It also occurs as a dense fringe on Zostera leaves (mainly in summer) and during winter (May to November) it grows as dense dark brown tufts (4 to 12 cm. high) on stones in the lower littoral on the beach north and south of American River jetty.

Polysiphonia fuscescens is general throughout the inlet, extending from the sublittoral fringe down for some distance, (especially just outside the mouth of the inlet).

Polysiphonia patersonis grows in the lowest littoral and sub-littoral fringe, usually on cockle or other small shells. On sandy areas, such as between Strawbridge and Picnic Points and around Samphire Island it may form a fairly distinct community.

Chondria dasyphylla occurs in the sublittoral fringe throughout the inlet, varying in abundance and in form under slightly different habitats.

Laurencia gracilis and L. majuscula are general throughout the inlet and often common in the lagoons, from lowest littoral to 5 or 6 feet below.

Laurencia tasmanica is mainly restricted to the channel between Wallaby Island and Wallaby Point, but occasional plants occur elsewhere.

Several animal groups are represented in the sublittoral fringe. Crustaceans occur in enormous numbers amongst the Chaetomorpha mats and other algae. Brachyodontes erosus is common, and a purple sponge (2 to 6 cm. high) occurs just below the Hormosira zone in the lagoons. Other shells, polychaetes etc. are common in the mud and under any small stones.

9. Lepilaena preissii association.

The brackish-water angiosperm Lepilaena preissii forms a pure and dense association in several isolated parts of the inlet (see map). The reasons for its distribution are not clear, but it seems to prefer a muddy substratum between the 1.5 ft. and 0.6 ft. levels. Few algae occur with it.

THE SUBLITTORAL

Associations which extend well below lowest tide level, as distinct from those limited just below this level, will be dealt with under the sublittoral zone.

10. Zostera muelleri association

Zostera muelleri covers large areas of the tidal flats and forms a dense association (see map). It occurs as an almost continuous band around the coast except for a few places on either side of Wallaby Point which are either rocky or sandy. Most luxuriant growth occurs between the 1.0 and - 4 ft. levels, but it may reach -8 feet and often extends into the lower littoral (though it is poorly developed here). Frequently it is mixed with the Hypnea - Spyridia association, and sub-littoral fringe species such as Gracilaria confervoides, Cystophora cephalornithos and Cystophyllum muricatum are found in the Zostera association in some places. In a few areas (see map) Zostera occurs nearer the shore than Hormosira, due to lower lying areas between Hormosira and the shore.

Zostera is often free from epiphytes, but more usually has masses of Cladophora ceratina or Centroceras clavulatum growing on the leaves. These masses of epiphytes float on the water surface at low tide if not growing in the deeper parts of the association. Other epiphytes on Zostera are Rivularia polyotis, diatoms and minute blue-green algae.

11. Posidonia australis association.

Posidonia australis forms a dense association in all the deeper parts of the inlet, from the -0.5 ft. level downwards. The long strap-like leaves just project above the surface at low tide in higher parts of the association, giving a very characteristic appearance (pl. 6, fig. 2; pl. 7, fig.1).

On the south side of the channel between Muston and

Wallaby Island are extensive beds of *Zostera*, growing in a depth of water in which *Posidonia* is normally dominant. Why *Zostera* is dominant here is not clear. Along most of the channel edge *Posidonia* forms a distinct band, from 1 to 50 yards wide.

In the map, two shades of green have been used in delimiting the *Posidonia* association. Lighter green is used for deeper areas (as shown in an aerial photograph) and darker green for shallow areas where the leaves are at or near the surface at low tide.

Posidonia is remarkable for the wealth of epiphytes growing on the leaves. The commonest ones are: *Polysiphonia succulenta*, *P. mollis*, *Jania micrarthrodia* (north side of Pelican Lagoon and just outside the inlet especially) *Crouania vestita*, *Asperococcus bullosus* (best developed in winter) *Colpomenia sinuosa*, *Laurencia gracilis*, *Rivularia polyotis*, *Centroceras clavulatum* and *Ceramium miniatum*. Other less common species are: *Polysiphonia davyae*, *Ceramium* spp., *Griffithsia tenuis*, *Ulva lactuca*, *Enteromorpha clathrata*, *Cladophora fascicularis*, *Ectocarpus fasciculatus*, *Sphacelaria furcigera*, *Rivularia atra*, *Calothrix confervicola* and *Microdictyon umbilicatum*.

The reason for this wealth of epiphytes lies in the rough fibrous leaves of *Posidonia*. The other marine angiosperms (*Zostera*, *Halophila*, *Lepilaena*) have much smoother leaves and bear far fewer epiphytes.

In shallower water near the shore *Posidonia* becomes less dense, and here other species may grow amongst it. Often the Zostera and Posidonia associations merge over several yards, while Dictyota dichotoma var. intricata, Cystophyllum muricatum and Cystophora cephalornithos occur as scattered plants in some areas. Pl. 7, fig. 2 shows an area between Wallaby Island and Wallaby Point where Asperococcus bullosus is plentiful in winter, together with Cystophyllum and Laurencia tasmanica.

In Pelican Lagoon there are a number of deep holes (2½ - 3 fathoms) in shallower areas. These holes bear a dense growth of masses of Caulerpa remotifolia on the sides and bottom, while the edges are often muddy with little growth.

12. Halophila ovalis association

Halophila ovalis grows as a fringe in deeper water along the channel, and as small patches in deeper water in the lagoons. On a bank 4 to 8 ft. below mean low tide level, between the flats north of American River jetty and the channel proper, it is pure and dense. More frequently however it is mixed up with Zostera and Posidonia, and may extend as high as the zero tide level.

Epiphytes on Halophila are few. Occasionally Ectocarpus confervoides and Ceramium sp. grow on the leaves

13. The flora of the channel.

The channel proper supports little algal growth owing to the loose, shelly bottom, which must constantly shift with the strong tidal current. Near Muston however there are rocky parts in the channel on which grow Sargassum biforme (to 1½ meters tall) and <u>Scaberia agardhii</u>. On some larger shells small plants of <u>Laurencia forsteri</u> (?) occur, while just outside the mouth of the inlet <u>Chiracanthia arborea</u> and <u>Polysiphonia fuscescens</u> are plentiful in 2-3 fathoms.

Along the edge of the channel near Muston, and probably on rock in the channel, numerous species occur which are rarely found elsewhere in the inlet. Most of them are Rhodophyceae. Their presence is due to a relatively firm substratum in deeper water, together with the water movement of the tidal current. Many of the species are removed and cast up by boisterous conditions in late winter. They also grow on the deeper flats north of American River jetty, and occasionally along the channel elsewhere (rarely extending to the 0.0 ft. level) but most of the drift material near American River jetty after storms seems to come from outside the inlet.

The species concerned are: <u>Caulerpa hypnoides</u>, <u>Cutleria multifida</u>, <u>Helminthora australis</u>, <u>Callophyllis ceratoclada</u>, <u>Botryocladia obovata</u>, <u>Champia obsoleta</u>, <u>C. affinis</u>, <u>C. tasmanica</u>, <u>Lomentaria australis</u>, <u>Griffithsia antarctica</u>, <u>G. flabelliformis</u>, <u>G. ovalis</u> (rare), <u>Wrangelia protensa</u>, <u>Ceramium rubrum</u>, <u>Heterosiphonia gunniana</u>, <u>Halodictyon arachnoideum</u>, <u>Hypoglossum spathulatum</u>, <u>H. revolutum</u>, <u>Nitophyllum sp.</u>, <u>Sarcomenia tenera</u>, <u>S. mutabilis</u>, <u>Polysiphonia cancellata</u>, <u>P. fuscescens</u>, <u>P. hookeri</u>, <u>Chiracanthia arborea</u>, <u>Brongniartella australis</u>, <u>Lophocladia harveyi</u>, <u>Coeloclonium opuntioides</u>, <u>Chondria dasyphylla</u> <u>Dictymenia harveyana</u>, <u>Jeannerettia pedicellata</u>.

Among the animal groups, sting rays, eagle rays and other smaller rays are common in the channel. Various kinds of sharks also occur, and starfish are often very plentiful on sandy patches on the edge of the channel. Large yellow sponges occur in the deeper parts of the channel.

14. The flora of the buoys.

Two buoys near American River jetty and several outside the mouth of the inlet provide a habitat for some species which are not found elsewhere in the inlet. The rushing water movement around the buoys as the tide ebbs and flows, and the less murky water in the channel, provide conditions rather different from those on the tidal flats.

Common species on the buoys are : Ulva lactuca, Enteromorpha clathrata, E. compressa, Cladophora fascicularis, Bryopsis delicatula, Ectocarpus confervoides (winter), E. fasciculatus, Colpomenia sinuosa, Scytosiphon lomentarius, Bangia fuscopurpurea (winter), Acrochaetium sp., Gloiosaccion brownii, Champia obsoleta, Monospora australis, Wrangelia plumosa, Dasya naccarioides, Polysiphonia abscissa, P. succulenta, P. mollis, Chondria dasyphylla and Laurencia forsteri. Less common species are Callymenia cribrosa, Gloioderma halymenioides and G. fruticulosum (?).

The buoys are cleaned each year, so fast growing species are more prominent. In winter Bangia fuscopurpurea forms a band 1 -2 inches high just above the water level, Enteromorpha just at or below water level, while Scytosiphon and Ectocarpus *confervoides* are prominent below this. Most of the other species occur on the lower sides or underneath the buoys. During winter a fringe of *Ulothrix implexa* grows at the waterline on boats which have not been cleaned, with *Enteromorpha* below it.

AMERICAN RIVER INLET AS A DISTINCT MARINE FORMATION.

In the introductory account of the algal ecology of Kangaroo Island (Pt. I), reasons were advanced for regarding American River inlet as an algal formation distinct from the rest of the coast of the island. It is perhaps better referred to as a "marine" formation, as angiosperms and animals as well as algae are involved. Following the terminology of Cotton, it was called the "Sand and sandy-mud flat formation". The following are regarded as the distinctive features:

1. The very calm environmental conditions, with wave action at a minimum. This has allowed the devopment of wide tidal flats of mud or sand, with occasional exposed rock in the littoral zone.
2. The characteristic flora, of which the main features are the virtual absence of large brown algae in the sublittoral fringe, and the presence of very extensive beds of the marine angiosperms *Zostera* and *Posidonia*.

The detailed survey of the inlet that has now been made has substantiated the opinions expressed in Pt. I, but has shown that there are a few exceptions withih the inlet.

The absence of large brown algae (*Cystophora*, *Sargassum* etc.) in the sublittoral fringe within the inlet is not complete.

For instance, Cystophora polycystidea dominates the sublittoral fringe over some 300 yards of the north coast of Pelican Lagoon. This alga is a characteristic component of the upper sublittoral on parts of the north coast of Kangaroo Island. The reasons for its occurrence in the inlet are the sharp drop of the cliffs to 3 or 4 feet below low tide level, and a greater degree of wave action due to the prevailing south-west winds passing over some 2 miles of open water, coupled with deeper water close inshore.

This small area of coast is a fragment of the Sheltered Rocky Coast Subformation within the inlet, due to the unusual conditions.

Three other species of larger brown algae occur within the inlet, viz. Cystophora cephalornithos, Cystophyllum muricatum and Sargassum biforme. These species however are never found dominant in the sublittoral fringe, and in general are not common. Sargassum biforme is restricted to the channel where water movement is greater, while the Cystophora and Cystophyllum occur as scattered plants in the sublittoral fringe and just below. The latter are two of the few species of fucoids which grow well under very calm conditions and where the temperature range is considerable. Cystophyllum muricatum also occurs on the much rougher south coast reefs (though as a stunted form), but Cystophora cephalornithos is rare outside the inlet.

The development of beds of Zostera is restricted to American River inlet, and this seems to be a useful distinguishing characteristic. Posidonia beds however occur elsewhere around Kangaroo Island, but always in deeper water. The Posidonia at the inlet is a broad leaved form, whereas elsewhere it is mostly a narrow leaved form.

Many other differences between American River inlet and the rest of the Kangaroo Island coast are found. Species characteristic of the south coast are rarely found in the inlet, and vice versa, although some species with wide environmental tolerance occur in both calm and rough localities. It cases such as Hormosira banksii, distinct ecological forms are largely restricted to the different formations.

Animals also provide points of difference. Barnacles (Elminius) are virtually absent from the inlet (except where wave splash is greater, or on jetty piles), whereas they form a conspicuous feature of the upper littoral on the rest of the north coast. Characteristic molluscs of the north coast such as Melaraphe unifasciata, Melanerita melanotragus, Cellana tramoserica and Siphonaria diemensis are also absent from the inlet but for a few very restricted places.

American River inlet, if considered as a whole, presents many features of its marine ecology which justify it being considered as a distinct marine formation.

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Doty, M.S. 1946. Critical tide factors that are correlated with the vertival distribution of marine algae and other organisms along the Pacific Coast. Ecology 27 (4), 315 - 328.

PLATE 1.

Fig. 1. The coast on Wallaby Island. The zones from left to right are (1) samphires, (2) *Bembicium*, (3) *Hormosira*, (4) *Hypnea* - *Spyridia* and (5) *Posidonia* just breaking the water surface.

Fig. 2. The coast near Salt Lake Point, with low cliffs and shaded hollows as the base.

PLATE 2.

Fig. 1. A general view of the samphire association on Wallaby Island.

Fig. 2. Bostrychia covering rocks in irregular patches. (These rocks were removed from a shaded cavern.)

PLATE 3.

Fig. 1. Gelidium on a rock at Salt Lake Point. A few molluscs are present and Galeolaria at the base of the rock.

Fig. 2. Bembicium on firm mud near Wallaby Point.

PLATE 4.

Fig. 1. Patches of Modiolus on rock in the mid littoral, with Bembicium between them.

Fig. 2. The Hormosira association on Wallaby Island.

PLATE 5.

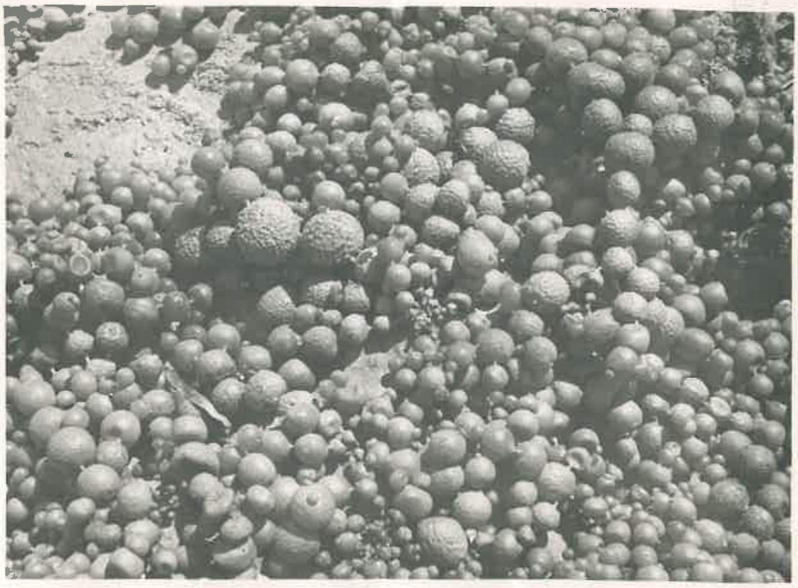


Fig. 1. Close up view of Hormosira.

Fig. 2. Chaetomorpha sp. lying below and partly on Hormosira at Wallaby Point.

PLATE 6.

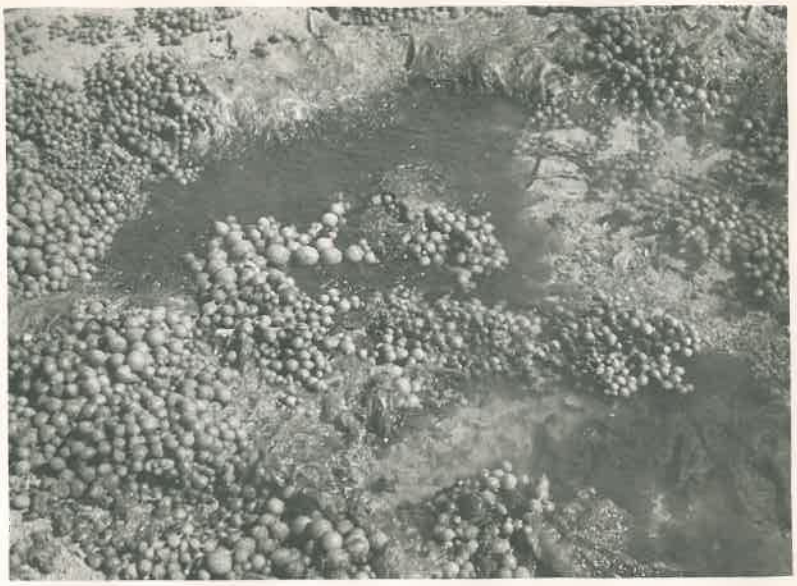


Fig. 1. Ulva lactuca in small pools in the lower part of the Hormosira association.

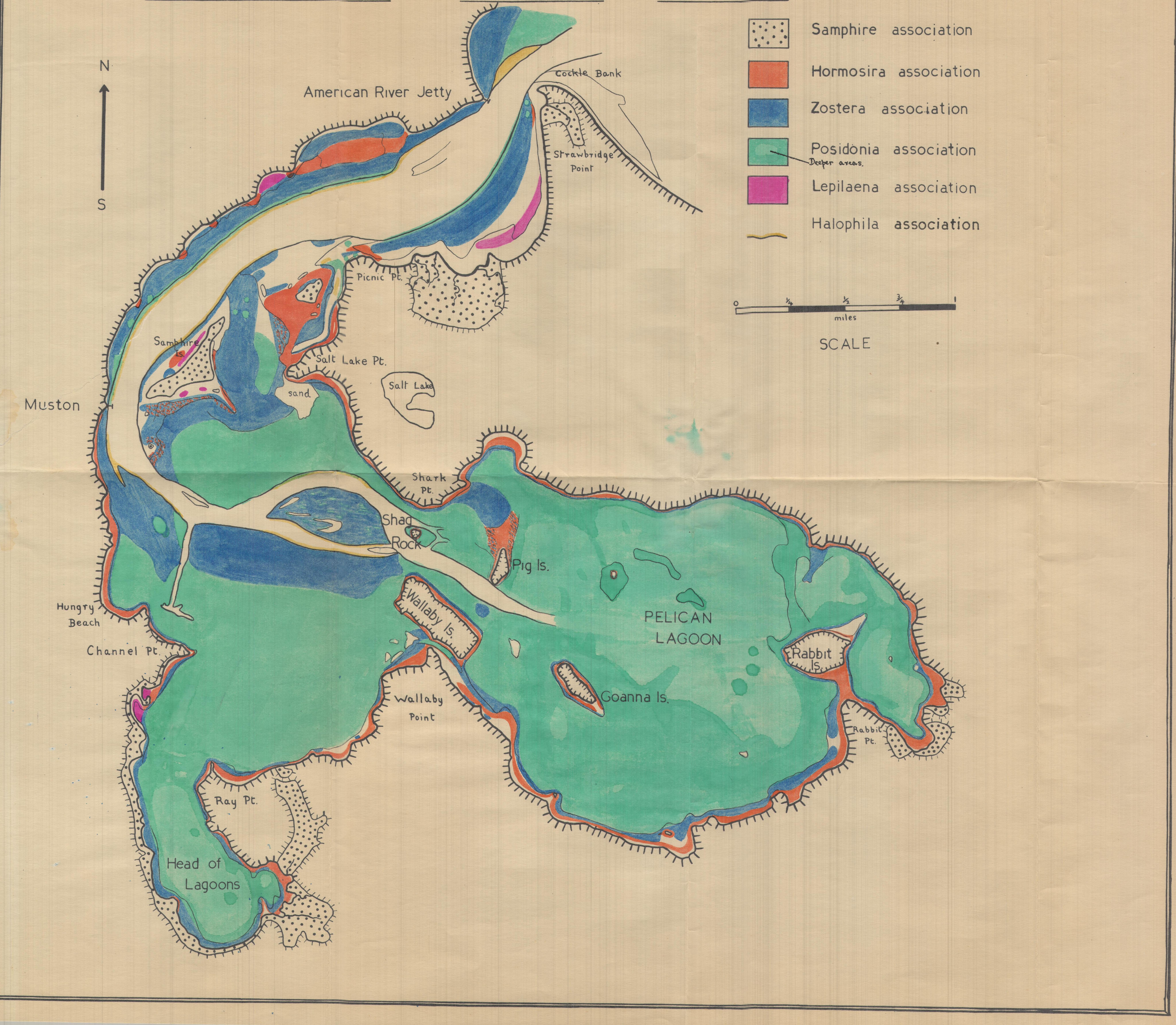
Fig. 2. A general view of the Posidonia association, with the leaves just projecting above the surface at low tide.

PLATE 7.

Fig. 1. The upper part of the Posidonia association. Cystophora cephalornithos is present at the bottom of the photograph, while most of the dark masses are Laurencia.

Fig. 2. Asperococcus bullosus (center) just above Posidonia in Wallaby Point channel. Other algae shown are Laurencia and some Cystophyllum

AMERICAN RIVER INLET



THE MARINE ALGAE OF KANGAROO ISLAND.

VI. Geographical Relationships of the Algal Flora.

CONTENTS

INTRODUCTION.

A list of all fully determined species of marine algae from Kangaroo Island, and their distribution as far as can be ascertained, is given in Table I. Unfilled spaces in this table (except at the bottom of each page) represent undetermined species of the genus above. The list comprises 478 named species (plus 4 varieties which are rather distinct), and the following discussion and tables are based on these. Over 60 species remain to be identified.

In this discussion the Cyanophyta are omitted, as all species from Kangaroo Island (except Rivularia firma) are cosmopolitan.

It is clear that thorough surveys of many more localities are necessary before comprehensive comparisons of the Australian coasts can be made. No area has been intensively studied of recent years except Kangaroo Island. In Western Australia, for instance, the most recent published lists are those of Sonder (1846) and Harvey (1854) and (1854 - 1863). There are also no lists comprehensive enough to use for the tropical coasts of Australia.

Other localities in Table I have been chosen for their relationship to Australia. To the east, New Zealand and South America; to the south, the subantarctic islands have been considered as a group, since many species are circum sub-antarctic. In the Indian Ocean, South Africa, the Indian region (including Ceylon and the Arabian sea) and the Malay Archapelago have been chosen, and also Japan as several south-

Table I.

CHLOROPHYTA	Australia				New Zealand	South America	Sub-antarctic	South Africa	India	Malay Archip.	Japan	California	England
	W Aus	Vic	Tas	N S W									
ULOTHRIX implexa	−	−	−	−	+	−	+	−	−	+	−	+	+
ENTOCLADIA viridis	−	+	−	+	−	+	+	−	−	+	−	+	−
ULVA lactuca	+	+	+	+	+	+	+	+	+	+	+	+	+
ENTEROMORPHA acanthophora	−	−	+	−	+	−	−	?	−	−	−	+	−
clathrata	−	+	+	+	+	−	+	+	−	+	+	+	+
compressa	+	+	+	+	+	+	+	+	+	+	+	+	+
intestinalis	+	+	+	+	+	+	+	+	+	+	+	+	+
BLIDINGIA minima	+	−	−	−	+	−	−	−	−	−	+	+	+
GAYELLA polyrhiza	−	−	−	−	−	−	−	−	−	−	−	+	+
CLADOPHORA bulbosa	−	+	−	−	−	−	−	−	−	−	−	−	−
ceratina	−	−	−	−	+	−	−	−	−	−	−	+	Europe
delicatula	−	−	−	−	−	+	−	−	−	−	−	+	−
fascicularis	−	+	−	−	+	+	−	−	+	−	+	−	−
feredayae	+	+	+	−	+	−	−	−	−	−	−	−	−
repens	−	−	−	−	+	−	+	−	+	−	+	−	+
valonioides	+	+	+	−	+	−	−	−	−	−	−	−	−
RHIZOCLONIUM implexum	−	−	−	−	+	−	−	−	−	−	−	+	+
CHAETOMORPHA aerea	+	+	+	+	+	+	−	+	+	+	+	+	+
darwinii	−	+	+	−	+	−	+	−	−	−	−	−	−
capillaris	−	−	−	−	+	−	−	−	+	−	−	−	−
linum	−	+	+	−	+	+	+	+	+	+	+	+	+
valida	−	+	+	−	−	−	−	−	−	−	−	−	−
DICTYOSPHAERIA sericea	+	+	+	−	−	−	−	−	−	−	−	−	−
APJOHNIA laetevirens	−	+	+	+	−	−	−	−	−	−	−	−	−
STRUVEA plumosa	+	−	−	−	−	−	−	−	−	−	−	−	−
MICRODICTYON umbilicatum	−	−	−	+	−	−	−	−	−	−	−	−	−
ACETABULARIA peniculus	+	+	−	+	−	−	−	−	−	−	−	−	−
BRYOPSIS baculifera	−	+	−	+	−	−	−	−	−	−	−	−	−
cupressoides	−	−	−	−	−	−	−	−	−	−	−	−	Europe
delicatula n. sp.	−	−	−	−	−	−	−	−	−	−	−	−	−
pennata	−	−	−	−	+	−	−	−	+	+	+	−	−
plumosa	+	+	+	+	+	+	+	+	+	+	+	+	+
DERBESIA clavaeformis	−	+	−	−	−	−	−	−	−	−	−	−	−
marina	−	−	−	−	+	−	−	−	−	−	+	+	−
CHLORODESMIS australis n. sp.	−	−	−	−	−	−	−	−	−	−	−	−	−
CODIUM galeatum	+	+	+	+	−	−	−	−	−	−	−	−	−
lucasii	−	+	−	+	−	−	−	+	−	−	−	−	−
mamillosum	+	+	−	−	−	−	−	+	−	−	+	−	−
muelleri	+	+	+	−	−	−	−	−	−	−	−	−	−
perrinae	−	−	+	−	−	−	−	−	−	−	−	−	−
pomoides	−	+	+	−	−	−	−	−	−	−	−	−	−
spongiosum	+	+	−	+	−	−	+	+	−	−	−	−	−
RHIPILIOPSIS peltata	−	+	−	−	−	−	−	−	−	−	−	−	−
CAULERPA brownii	−	+	+	−	+	−	−	−	−	−	−	−	−
cactoides	+	+	+	+	−	−	−	−	−	−	−	−	−
ethelae	+	+	+	−	−	−	−	−	−	−	−	−	−
hedleyi	−	−	−	−	−	−	−	−	−	−	−	−	−
hypnoides	+	+	+	+	+	−	−	−	−	−	−	−	−
var. muelleri	+	+	+	+	−	−	−	−	−	−	−	−	−
longifolia	−	+	+	−	−	−	−	−	−	−	−	−	−
var. crispata	−	+	−	−	−	−	−	−	−	−	−	−	−
obscura	+	+	+	−	−	−	−	−	−	−	−	−	−
remotifolia	+	−	−	−	−	−	−	−	−	−	−	−	−
scalpelliformis	+	+	+	+	−	−	−	+	+	+	+	−	−
sedoides	+	+	+	+	+	−	−	−	−	+	−	−	−
simpliciuscula	+	+	+	−	−	−	−	−	−	+	−	−	−
var. vesiculifera	−	+	+	−	−	−	−	−	−	−	−	−	−
trifaria	+	+	+	−	−	−	−	−	−	−	−	−	−

PHAEOPHYTA	Australia				New Zealand	South America	Sub-Antarctic	South Africa	India	Malay Archip	Japan	California	England
	W Aus	Vic	Tas	N S W									
ECTOCARPUS confervoides	+	+	+	+	+	+	+	+	−	−	+	+	+
fasciculatus	+	+	+	+	−	+	+	−	−	−	−	−	+
sordidus	−	+	+	−	−	−	−	−	−	−	−	−	−
PYLAIELLA fulvescens	−	+	−	−	−	−	−	+	−	−	−	−	−
RALFSIA australis n.sp.	−	−	−	−	−	−	−	−	−	−	−	−	−
borneti	−	−	−	−	−	−	−	−	−	−	−	−	Europe excl USA
SPHACELARIA biradiata	−	+	+	−	−	−	−	−	−	−	−	−	−
furcigera	+	−	−	−	+	−	+	+	+	+	+	+	+
pygmaea	−	+	−	−	−	−	−	−	−	−	−	−	−
tribuloides	−	−	−	+	+	−	−	+	+	+	+	−	+
HALOPTERIS funicularis	−	+	+	−	+	+	+	−	−	+	−	−	−
hordacea	−	+	+	+	+	+	−	+	−	−	−	−	−
pseudospicata	+	+	+	−	−	−	−	−	−	−	−	−	−
spicigera	−	−	−	−	+		−	−	−	−	−	−	−
PHLOEOCAULON spectabile	−	+	+	−	−	−	−	−	−	−	−	−	−
CLADOSTEPHUS verticillatus	−	+	+	+	+	−	−	−	−	−	−	−	+
CUTLERIA multifida	−	+	+	−	+	−	−	−	−	−	−	−	+
DICTYOTA apiculata	−	+	−	−	−	−	−	−	−	+	−	−	−
bifurca	−	+	−	−	−	−	−	−	−	−	−	−	−
dichotoma	+	+	+	+	+	+	−	+	+	+	+	−	+
var. intricata	−	−	−	−	+	−	−	+	+	−	−	−	+
diemensis	−	+	+	−	−	−	−	−	−	−	−	−	−
furcellata	+	+	+	−	−	−	−	−	−	−	−	−	−
latifolia	+	+	−	−	−	−	−	−	−	−	−	−	−
radicans	+	+	−	+	+	−	−	−	−	−	−	−	−
PACHYDICTYON furcellatum	+	+	−	−	−	−	−	−	−	−	−	−	−
paniculatum	+	+	+	+	−	−	−	−	−	−	−	−	−
DILOPHUS fasciculatus	−	+	+	−	−	−	−	−	−	−	−	−	−
fastigiatus	+	+	−	−	−	−	−	−	−	−	−	−	−
foliosus	−	+	−	−	−	−	−	−	−	−	−	−	−
opacus	+	+	−	−	−	−	−	−	−	−	−	−	−
tener	−	+	−	−	−	−	−	−	−	−	−	−	−
DICTYOPTERIS muelleri	+	+	+	+	−	−	−	−	−	+	−	−	−
nigricans	−	+	−	−	−	−	−	−	−	−	−	−	−
LOBOSPIRA bicuspidata	+	+	−	+	−	−	−	−	−	−	−	−	−
CHLANIDOPHORA microphylla	−	+	−	−	−	−	−	−	−	−	−	−	−
DISTROMIUM diesingianum	−	−	−	−	−	−	−	−	−	−	−	−	−
australasicum n.sp.	−	−	−	−	−	−	−	−	−	−	−	−	−
POCOCKIELLA variegata	+	+	−	+	−	−	−	+	+	+	−	−	−
TRONIA australasica	−	+	−	−	−	−	−	−	−	−	−	−	−
ZONARIA crenata	+	+	+	+	−	−	−	−	−	+	−	−	−
diesingiana	+	−	+	+	−	−	−	−	−	−	+	−	−
spiralis	+	+	−	−	−	−	−	−	−	−	−	−	−
stuposa	−	+	+	−	−	−	−	−	−	−	−	−	−
subarticulata	+	+	+	+	+	−	−	−	−	−	−	−	−
MYRIONEMA strangulans	−	+	+	−	+	−	−	−	−	−	−	+	+
CORYNOPHLOEA cystophorae	−	+	−	−	+	−	−	−	−	−	−	−	−
CLADOSIPHON filum	+	+	−	+	−	−	−	−	−	−	−	−	−
vermicularis	−	+	+	−	−	−	−	−	+	−	−	−	−
MYRIOGLOIA sciurus	−	+	+	+	−	−	−	−	+	−	−	−	−
POLYCERIA nigrescens	−	+	+	+	−	−	−	−	−	−	−	−	−
zostericola	+	+	+	−	−	−	−	−	−	−	−	−	−
TINOCLADIA australis	−	+	+	−	−	−	−	−	−	−	−	−	−
STILOPSIS harveyana	+	+	+	−	−	−	−	−	−	−	−	−	−
SPLACHNIDIUM rugosum	−	+	+	+	+	+	−	+	−	−	−	−	−
SPOROCHNUS harveyanus	+	+	+	+	−	−	−	−	−	−	−	−	−
radiciformis	+	+	+	+	−	−	−	−	−	−	+	−	−
scoparius	+	+	−	−	−	−	−	−	−	−	+	−	−
ENCYOTHALIA cliftoni	+	−	−	−	−	−	−	−	−	−	−	−	−
BELLOTIA eriophorum	−	+	+	−	−	−	−	−	−	−	−	−	−
PERITHALIA inermis	−	+	+	−	−	−	−	−	−	−	−	−	−
NEREIA australis	−	+	+	−	−	−	−	−	−	−	−	−	−
CARPOMITRA costata	−	+	+	+	+	−	−	−	−	−	+	−	+
GIRAUDYA posidoniae n.sp.	−	−	−	−	−	−	−	−	−	−	−	−	−
ASPEROCOCCUS bullosus	+	+	+	+	−	−	+	+	−	−	−	−	+
COLPOMENIA sinuosa	+	+	+	+	+	+	+	+	+	+	+	+	+
HYDROCLATHRUS clathratus	+	+	−	+	−	−	−	−	+	+	+	+	−
SCYTOSIPHON lomentaria	+	+	+	+	+	+	+	+	−	−	+	+	+
MACROCYSTIS pyrifera	−	+	+	+	+	+	+	+	−	−	−	+	−
ECKLONIA radiata	+	+	+	+	+	+	+	+	−	−	−	−	−

PHAEOPHYTA	Australia W Aus	Vic	Tas	N S W	New Zealand	South America	Sub-Ant arctic	South Africa	India	Malay Archip	Japan	California	England
HORMOSIRA banksii	+	+	+	+	+	−	−	−	−	−	−	−	−
NOTHEIA anomala	+	+	+	+	+	−	−	−	−	−	−	−	−
MYRIODESMA integrifolia	−	+	+	−	−	−	−	−	−	−	−	−	−
latifolia var duriuscula	+	−	−	−	−	−	−	−	−	−	−	−	−
quercifolium	+	+	+	−	−	−	−	−	−	−	−	−	−
SCYTOTHALIA dorycarpa	+	+	−	−	−	−	−	−	−	−	−	−	−
SEIROCOCCUS axillaris	−	+	+	−	−	−	−	−	−	−	−	−	−
XIPHOPHORA chondrophylla var minus	−	+	+	−	+	−	+	−	−	−	−	−	−
CARPOGLOSSUM confluens	−	+	+	−	−	−	−	−	−	−	−	−	−
CYSTOPHORA botryocystis	+	+	−	−	−	−	−	−	−	−	−	−	−
brownii	+	−	−	−	−	?	−	−	−	−	−	−	−
cephalornithos	−	+	+	+	−	−	−	−	−	−	−	−	−
crassicaulis n sp	+	−	−	−	−	−	−	−	−	−	−	−	−
dumosa	+	+	+	+	+	−	−	−	−	−	−	−	−
gracilis n sp	−	−	−	−	−	−	−	−	−	−	−	−	−
grevillei	+	+	+	−	−	−	−	−	−	−	−	−	−
intermedia	−	+	−	−	−	−	−	−	−	−	−	−	−
monilifera	+	+	+	+	−	−	−	−	−	−	−	−	−
paniculata	+	+	+	+	−	−	−	−	−	−	−	−	−
pectinata	+	−	−	−	−	−	−	−	−	−	−	−	−
platylobium	+	+	+	+	+	−	−	−	−	−	−	−	−
polycystidea	−	+	+	+	−	−	−	−	−	−	−	−	−
racemosa	+	+	−	−	−	−	−	−	−	−	−	−	−
retorta	+	+	+	−	−	−	−	−	−	−	−	−	−
siliquosa	−	+	+	+	−	−	−	−	−	−	−	−	−
spartioides	−	+	+	+	−	−	−	−	−	−	−	−	−
subfarcinata	+	+	+	−	−	−	−	−	−	−	−	−	−
uvifera	+	+	+	+	−	−	−	−	−	−	−	−	−
CYSTOPHYLLUM muricatum	+	+	+	+	−	−	−	−	+	+	−	−	−
SARGASSUM biforme	+	+	−	−	−	−	−	−	−	−	−	−	−
bracteolosum	−	+	+	−	−	−	−	−	−	−	−	−	−
cristatum	−	+	−	−	−	−	−	−	−	−	−	−	−
grande	−	−	+	−	−	−	−	−	−	−	−	−	−
halitrichum	+	+	−	−	−	−	−	−	−	−	−	−	−
lacerifolium	+	−	+	+	+	−	−	−	−	−	−	−	−
linearifolium	+	+	−	+	−	−	−	−	−	−	−	−	−
merrifieldii	+	+	−	−	−	−	−	−	−	−	−	−	−
muriculatum	−	+	+	−	−	−	−	−	−	−	−	−	−
paradoxum	+	+	+	+	−	−	−	−	−	−	−	−	−
sonderi	+	+	+	−	−	−	−	−	−	−	−	−	−
trichophyllum	+	+	−	−	−	−	−	−	−	−	−	−	−
varians	+	+	+	−	−	−	−	−	−	−	−	−	−
verruculosum	+	+	+	+	+	−	−	−	−	−	−	−	−
SCABERIA agardhii	+	+	+	+	−	−	−	−	−	−	−	−	−
RHODOPHYTA													
BANGIA fuscopurpurea	−	+	+	+	+	+	−	+	−	−	+	−	+
PORPHYRA umbilicalis	+	+	+	−	+	+	+	−	−	−	−	−	+
ERYTHROCLADIA rubra n sp	−	−	−	−	−	−	−	−	−	−	−	−	−
ACROCHAETIUM botryocarpum	+	−	−	−	−	−	−	−	−	−	−	−	−
sargassi n sp	−	−	−	−	−	−	−	−	−	−	−	−	−
ASPARAGOPSIS armata	+	+	+	+	+	−	−	−	−	−	−	−	+
taxiformis	+	−	−	−	+	−	−	−	+	−	−	−	−
BONNEMAISONIA asparagoides	−	+	−	−	−	−	−	−	−	−	−	−	+
DELISEA hypneoides	−	+	+	−	−	−	−	−	−	−	−	−	−
pulchra	+	+	+	+	+	−	+	−	−	−	+	−	−
ENDOSIRA australis	−	−	−	−	−	−	−	−	−	−	−	−	−
HELMINTHOCLADIA australis	+	+	−	−	+	−	−	−	+	−	+	−	−
HELMINTHORA australis	−	+	+	−	−	−	−	−	−	−	−	−	−
LIAGORA harveyana	+	+	+	−	+	−	−	−	−	−	−	−	−
wilsoniana	−	+	−	−	−	−	−	−	−	−	−	−	−
NEMALION helminthoides	−	+	+	+	+	+	−	−	−	−	+	−	+
CHAETANGIUM													
GLOIOPHLOEA scinaioides	+	+	+	−	+	−	−	−	−	−	−	−	−
GALAXAURA spathulata	+	+	−	−	−	−	−	−	−	−	−	−	−
GELIDIUM australe	−	+	+	+	−	−	−	−	−	−	−	−	−
pusillum	+	+	+	+	+	+	−	−	+	+	+	+	+
PTEROCLADIA capillacea	+	+	−	+	+	−	−	−	−	−	−	−	+
lucida	+	+	−	+	+	−	−	+	+	+	−	−	−

RHODOPHYTA

	Australia: W Aus	Vic	Tas	N S W	New Zealand	South America	Sub-Ant-arctic	South Africa	India	Malay Archip	Japan	Calif-ornia	Engl-and
DASYPHLOEA tasmanica	−	+	+	−	−	−	−	−	−	−	−	−	−
RHODOPELTIS australis	+	+	−	−	−	−	−	−	−	−	−	−	−
CRUORIA													
HILDENBRANDTIA crouani	−	−	−	−	−	−	−	−	−	−	−	−	+
prototypus	−	−	−	+	−	−	+	−	+	+	+	−	+
ETHELIA australis	+	+	+	−	−	−	−	−	−	+	−	−	−
PEYSSONNELIA gunniana	+	+	+	+	+	−	−	−	−	+	−	−	−
AMPHIROA anceps	+	+	−	+	−	−	−	+	+	+	−	−	−
CORALLINA cuvieri	+	+	+	+	+	−	+	−	−	−	−	−	−
lenormandiana	−	+	−	−	−	−	−	−	−	−	−	−	−
officinalis	−	+	+	+	+	+	+	+	+	+	+	−	+
pilifera	−	+	+	−	−	−	−	−	−	+	+	−	−
JANIA fastigiata	+	+	−	−	−	−	−	+	−	−	−	−	−
micrarthrodia	+	+	+	+	+	−	−	−	−	−	−	−	−
natalensis	−	−	−	+	−	−	−	+	+	−	−	−	−
plumosa n. sp.	−	−	−	−	−	−	−	−	−	−	−	−	−
METAGONIOLITHON charoides	+	+	+	−	−	−	−	−	−	−	−	−	−
gracile	+	−	−	−	−	−	−	−	−	−	−	−	−
stelligera	+	+	+	−	−	−	−	−	−	−	−	−	−
METAMASTOPHORA flabellata	+	+	+	−	−	−	−	−	−	−	−	−	−
ARCHEOLITHOTHAMNION durum	−	−	−	−	−	−	−	−	−	−	−	−	−
LITHOTHAMNION engelhardtii	−	−	−	−	−	−	−	−	−	−	−	−	−
erubescens	−	−	−	−	−	−	−	−	+	+	+	−	−
muelleri	−	−	−	−	−	+	−	−	−	−	−	−	−
patena	−	+	+	+	+	−	+	+	−	−	−	−	−
MELOBESIA cymodoceae	−	+	−	−	−	−	−	−	−	−	−	−	−
lejolisii	−	−	−	−	−	−	−	−	−	−	−	−	+
NEOGONIOLITHON finitimum	−	+	−	−	−	−	−	−	−	−	−	−	−
CARPOPELTIS phyllophora	+	−	+	−	−	−	−	−	−	+	−	−	−
CRYPTONEMIA undulata	+	+	−	−	−	−	−	−	+	−	−	−	−
POLYOPES constrictus	+	+	−	−	−	−	−	+	−	+	−	−	−
HALYMENIA harveyana	+	+	−	−	−	−	−	−	−	−	+	−	−
THAMNOCLONIUM claviferum	+	+	+	−	+	−	−	−	−	−	−	−	−
CALLOPHYLLIS ceratoclada	−	+	−	−	−	−	−	−	−	−	−	−	−
cervicornis	−	−	−	−	−	−	−	−	−	−	−	−	−
coccinea	+	+	+	−	+	−	−	−	−	−	−	−	−
harveyana	−	+	+	−	−	−	−	−	−	−	−	−	−
lambertii	+	+	+	−	+	−	−	−	−	−	−	−	−
CALLYMENIA cribrosa	+	+	+	−	−	−	−	−	−	−	−	−	−
GELINARIA ulvoidea	+	−	−	−	−	−	−	−	−	−	−	−	−
POLYCOELIA australis	−	+?	−	−	−	−	−	−	−	−	−	−	−
laciniata	+	+	+	−	−	−	−	−	−	−	−	−	−
NEMASTOMA feredayae	−	+	+	−	−	−	−	−	−	−	−	−	−
irregularis n. sp.	−	−	−	−	−	−	−	−	−	−	−	−	−
CURDIEA laciniata	−	+	+	+	+	−	+	−	−	−	−	−	−
obesa	+	−	−	−	−	−	−	−	−	−	−	−	−
GRACILARIA confervoides	+	+	+	+	+	+	+	+	+	+	+	+	+
furcellata	+	+	+	−	−	−	−	−	−	−	−	−	−
secundata	+	+	+	+	+	−	−	−	−	−	−	−	−
MELANTHALIA concinna	−	+	+	−	−	−	−	−	−	−	−	−	−
obtusata	−	+	+	+	−	−	−	−	−	−	−	−	−
TYLOTUS obtusatus	+	+	−	−	−	−	−	−	−	−	−	−	−
PLOCAMIUM costatum	+	+	+	−	+	−	−	−	−	−	−	−	−
leptophyllum	+	+	+	+	+	−	−	−	−	−	+	−	−
mertensii	+	+	+	−	−	−	−	−	−	−	−	−	−
nidificum	+	+	−	−	−	−	−	−	−	−	−	−	−
preissianum	+	+	−	−	−	−	−	−	−	−	−	−	−
telfairiae	+	+	+	−	+	−	+	−	+	−	+	−	−
PHACELOCARPUS labillardieri	+	+	+	+	+	−	−	+	−	−	−	−	−
sessilis	+	+	−	−	−	−	−	−	−	−	−	−	−
STENOCLADIA conferta	+	+	−	−	−	−	−	−	−	−	−	−	−
SARCODIA													
NIZYMENIA australis	+	+	+	−	−	−	−	−	−	−	−	−	−
SOLIERIA robusta	+	+	+	−	−	−	−	−	+	+	+	−	−
THYSANOCLADIA laxa	+	+	−	−	+	−	−	−	−	+	−	−	−
oppositifolia	+	−	−	−	−	−	−	−	−	−	−	−	−
ARESCHOUGIA australis	+	+	−	−	−	−	−	−	−	−	−	−	−
laurencia	+	+	+	−	+	−	−	−	−	−	−	−	−

RHODOPHYTA

Genus	Species	W Aus	Vic	Tas	N S W	New Zealand	South America	Sub-Antarctic	South Africa	India	Malay Archip	Japan	California	England
ERYTHROCLONIUM	angustatum	−	+	−	−	−	−	−	−	−	−	−	−	−
	muelleri	+	+	+	−	−	−	−	−	−	−	−	−	−
	sonderi	+	+	−	−	−	−	−	−	−	−	−	−	−
RHABDONIA	clavigera	−	+	−	−	−	−	−	−	−	−	−	−	−
	coccinea	+	+	+	−	−	−	−	−	−	−	−	−	−
	nigrescens	−	+	+	+	−	−	−	−	−	−	−	−	−
	verticillata	−	+	+	−	−	−	−	−	−	−	−	−	−
GRUNOWIELLA	barkeriae	−	+	−	−	−	−	−	−	−	−	−	−	−
RHODOPHYLLIS	gunnii	−	+	+	−	+	−	−	−	−	−	−	−	−
	multipartita	−	+	+	−	−	−	−	−	−	−	−	−	−
	tenuifolia	+	+	−	−	−	−	−	−	−	−	−	−	−
HYPNEA	episcopalis	+	+	+	−	−	−	−	+	−	−	−	−	−
	musciformis	+	+	−	+	+	+	−	+	+	+	−	+	−
RHODODACTYLIS	rubra	+	−	−	−	−	−	−	−	−	−	−	−	−
APOPHLOEOPSIS	crustacea n. sp.	−	−	−	−	−	−	−	−	−	−	−	−	−
MYCHODEA	carnosa	+	+	+	−	−	−	−	+	−	−	−	−	−
	compressa	−	+	−	−	−	−	+	−	−	−	−	−	−
	fastigiata	−	+	−	−	−	−	−	−	−	−	−	−	−
	foliosa	−	+	−	−	+	−	−	−	−	−	−	−	−
	hamata	−	+	+	−	−	−	−	−	−	−	−	−	−
	pusilla	+	+	−	−	−	−	−	−	−	−	−	−	−
	terminalis	−	+	+	−	−	−	−	−	−	−	−	−	−
DICRANEMA	grevillei	+	+	−	−	+	−	−	−	−	−	−	−	−
	revolutum	+	+	+	−	−	−	−	−	−	−	−	−	−
ACROTYLUS	australis	+	+	+	+	−	−	−	−	−	−	−	−	−
GIGARTINA	brachiata	−	+	+	+	−	−	−	−	−	−	−	−	−
	disticha	+	−	−	−	−	−	−	−	−	−	−	−	−
	gigantea	−	+	+	−	−	−	−	−	−	−	−	−	−
	rubra	−	+	−	−	−	−	−	−	−	−	−	−	−
IRIDAEA	australasica	−	+	+	−	−	−	−	−	−	−	−	−	−
	harveyi	−	−	+	−	−	−	−	−	−	−	−	−	−
	pusilla n. sp.	−	−	−	−	−	−	−	−	−	−	−	−	−
RHODOGLOSSUM	proliferum	−	+	+	−	−	−	−	−	−	−	−	−	−
BINDERA	kaliformis	−	+	−	−	−	−	−	−	−	−	−	−	−
	splachnoides	+	+	+	−	−	−	−	−	−	−	−	−	−
GLOIODERMA	australis	+	+	+	−	−	−	−	−	−	−	−	−	−
	halymenioides	+	+	−	−	−	−	−	−	−	−	−	−	−
	speciosa	−	+	+	−	−	−	−	−	−	−	−	−	−
	wilsonis	−	+	−	−	−	−	−	−	−	−	−	−	−
BOTRYOCLADIA	obovata	+	+	+	+	−	−	−	−	−	−	−	−	−
COELARTHRUM	muelleri	+	+	−	−	−	−	−	−	+	−	+	−	−
ERYTHRYMENIA	minuta	−	+	−	−	−	−	−	−	−	−	−	−	−
GLOIOSACCION	brownii	+	+	+	−	−	−	−	−	−	−	−	−	−
RHODYMENIA	folifera	+	+	+	−	+	−	−	−	−	−	−	−	−
HYMENOCLADIA	divaricata	+	−	−	−	−	−	−	−	−	−	−	−	−
	polymorpha	+	+	+	−	+	−	−	−	−	−	−	−	−
	usnea	+	+	−	+	−	−	−	−	−	−	−	−	−
LOMENTARIA	australis	−	+	+	+	−	−	−	−	−	−	−	−	−
CHAMPIA	affinis	+	+	+	−	−	−	−	−	−	−	−	−	−
	compressa	−	+	−	+	−	−	−	+	−	+	−	−	−
	obsoleta	−	+	+	−	−	−	−	−	−	−	−	−	−
	oppositifolia	−	−	−	−	−	−	−	−	−	−	−	−	−
	tasmanica	+	+	+	−	−	−	−	−	−	−	−	−	−
SPERMOTHAMNION	codicola	−	−	−	−	−	−	−	−	−	−	−	−	−
LEJOLISIA	aegagropila	−	+	−	−	−	−	−	−	−	−	−	−	−
GRIFFITHSIA	antarctica	+	+	+	−	+	+	+	−	−	−	−	−	−
	flabelliformis	−	+	+	−	−	−	−	−	+	−	−	−	−
	gunniana	−	+	+	−	−	−	−	−	−	−	−	−	−
	monilis	+	+	+	−	−	−	−	−	−	−	−	−	−
	ovalis	+	−	−	−	−	−	−	−	−	−	−	−	−
	tenuis	+	−	−	+	−	−	−	−	+	+	−	−	−
NEOMONOSPORA	australis	+	+	−	−	−	−	−	−	−	−	−	−	−
	elongata	−	+	+	−	−	−	−	−	−	−	−	−	−
	griffithsioides	−	+	+	−	+	−	−	−	−	−	−	−	−
	licmophora	+	+	−	−	−	−	−	−	−	−	−	−	−

RHODOPHYTA

	Australia				New	South	Sub-Ant-	South		Malay		Calif-	Engl-
	W Aus	Vic	Tas	N S W	Zealand	America	arctic	Africa	India	Archip	Japan	ornia	and
PLEONOSPORIUM comatum	−	+	+	−	−	−	−	−	−	−	−	−	−
CALLITHAMNION laricinum	+	+	+	−	−	−	−	−	−	−	−	−	−
HALOPLEGMA preissii	+	+	+	−	−	−	−	−	+	−	+	−	−
SPONGOCLONIUM brounianum	+	+	−	−	+	−	−	−	−	−	−	−	−
conspicuum	−	+	+	−	−	−	−	−	−	−	−	−	−
fasciculatum	−	+	−	−	−	−	−	−	−	−	−	−	−
EUPTILOTA articulata	+	+	+	−	−	−	−	−	−	−	+	−	−
corallodea	+	+	+	−	−	−	−	−	−	−	−	−	−
PERISCHELIA glomerulifera	+	+	−	−	−	−	−	+	−	−	−	−	−
THAMNOCARPUS													
DASYPHILA preissii	+	+	−	−	−	−	−	−	−	−	−	−	−
MUELLERENA insignis	−	+	+	−	−	−	−	−	−	−	−	−	−
PSILOTHALIA siliculosa	+	+	−	−	−	−	−	−	−	−	−	−	−
GULSONIA annulata	−	+	+	−	−	−	−	−	−	−	−	−	−
ANTITHAMNION dispar	+	+	+	−	−	−	−	−	−	−	−	−	−
hanowioides	+	+	−	−	−	−	−	−	−	−	−	−	−
horizontale	+	+	−	−	−	−	−	−	−	−	−	−	−
mucronatum	+	+	+	−	+	−	−	−	−	−	−	−	−
nodiferum	+	+	+	−	−	−	−	−	−	−	−	−	−
BALLIA callitricha	+	+	+	−	+	+	+	−	−	−	−	−	−
mariana	−	+	−	−	−	−	−	−	−	−	−	−	−
robertiana	−	+	+	−	−	−	−	−	−	−	−	−	−
scoparia	−	+	+	−	+	+	+	−	−	−	−	−	−
CROUANIA australis	+	+	+	−	−	−	−	−	−	+	−	−	−
mucosa	−	−	−	−	−	−	−	−	−	−	−	−	−
muelleri	−	+	−	−	−	−	−	−	−	−	−	−	−
vestita	+	−	−	−	−	−	−	−	−	−	−	−	−
LASIOTHALIA formosa	−	+	−	−	−	−	−	−	−	−	−	−	−
PTILOCLADIA pulchra	+	+	−	−	−	−	−	−	−	−	−	−	−
SPYRIDIA biannulata	+	+	+	−	+	−	−	−	−	−	−	−	−
opposita	+	+	+	−	+	−	−	−	−	−	−	−	−
CENTROCERAS clavulatum	+	+	+	+	+	+	−	+	+	+	+	+	−
CERAMIUM isogonum	+	+	+	−	−	−	−	−	−	+	−	−	−
miniatum	+	+	−	+	+?	+	−	−	+	−	−	−	−
nobile	+	−	+	−	+	−	−	−	−	−	−	−	−
puberulum	+	+	+	−	−	−	−	−	−	−	−	−	−
rubrum	+	+	−	−	+	+	+	−	+	−	+	−	+
WRANGELIA clavigera	−	+	−	−	−	−	−	−	−	−	−	−	−
crassa	+	+	+	−	−	−	−	−	−	−	−	−	−
halurus	+	+	−	−	−	−	−	−	−	−	−	−	−
myriophylloides	+	+	−	−	−	−	−	−	−	−	−	−	−
plumosa	−	+	+	+	−	−	−	−	−	−	−	−	−
princeps	+	+	−	−	−	−	−	−	−	−	−	−	−
protensa	−	+	+	−	−	−	−	−	−	−	−	−	−
velutina	+	+	−	−	−	−	−	−	−	+	+	−	−
verticillata	−	+	−	−	−	−	−	−	−	−	−	−	−
wattsii	+	+	−	−	−	−	−	−	−	−	−	−	−

RHODOPHYTA

		Australia				New Zealand	South America	Sub-Ant-arctic	South Africa	India	Malay Archip	Japan	California	England
		W Aus	Vic	Tas	N S W									
DASYA	capillaris	−	−	+	+	−	−	−	−	−	−	−	−	−
	feredayae	−	+	+	−	−	−	−	−	−	−	−	−	−
	frutescens	+	−	−	−	−	−	−	−	−	−	−	−	−
	haffiae	−	+	+	−	−	−	−	−	−	−	−	−	−
	naccarioides	+	+	+	+	−	−	−	−	−	−	−	−	−
	scopulifera	+	−	−	−	−	−	−	−	−	−	−	−	−
	tomentosa n. sp.	−	−	−	−	−	−	−	−	−	−	−	−	−
	urceolata	−	+	+	−	−	−	−	−	−	−	−	−	−
	villosa	+	+	+	−	−	−	−	−	−	−	+	−	−
DASYOPSIS	clavigera	+	−	−	−	−	−	−	−	−	−	−	−	−
HALODICTYON	arachnoideum	+	+	−	−	−	−	−	−	−	−	−	−	−
	robustum	+	+	−	−	−	−	−	−	−	−	−	−	−
HETEROSIPHONIA	curdieana	−	−	−	−	−	−	−	−	−	−	−	−	−
	gunniana	+	+	+	−	−	−	−	−	−	−	−	−	−
	microcladioides	+	+	−	−	−	−	−	−	−	−	−	−	−
	muelleri	+	+	+	−	−	−	−	−	+	+	−	−	−
	wrangelioides	+	+	−	−	−	−	−	−	−	−	−	−	−
THURETIA	quercifolia	+	+	−	−	−	−	−	−	−	−	−	−	−
	teres	+	+	−	−	−	−	−	−	−	−	−	−	−
APOGLOSSUM	tasmanicum	−	−	+	−	−	−	−	−	−	−	−	−	−
BRANCHIOGLOSSUM	crispatulum	+	−	−	−	−	−	−	−	−	−	−	−	−
CHAUVINEA	coriifolia	+	+	−	−	−	−	−	−	−	−	−	−	−
CLAUDEA	elegans	+	+	+	−	−	−	−	−	+	+	−	−	−
HEMINEURA	frondosa	+	+	+	−	−	−	−	−	−	−	−	−	−
	wilsonis	−	+	+	−	−	−	−	−	−	−	−	−	−
HYPOGLOSSUM	microdonthum	−	−	−	−	−	−	−	−	−	−	−	−	−
	revolutum	+	+	−	−	−	−	−	−	−	−	−	−	−
	spathulatum	+	−	+	+	−	−	−	−	+	+	−	−	−
PHITYMOPHORA	imbricata	−	+	+	−	−	−	−	−	−	−	−	−	−
SARCOMENIA	corymbosa	−	+	+	−	−	−	−	−	−	−	−	−	−
	dasyoides	−	+	+	−	−	−	−	−	−	−	−	−	−
	delesserioides	+	+	−	−	−	−	−	−	−	−	−	−	−
	mutabilis	+	+	−	−	−	−	−	−	−	−	−	−	−
	tenera	+	+	+	−	−	−	−	−	−	−	−	−	−
PLATYSIPHONIA	miniata	−	+	−	+	−	−	−	+	+	−	−	−	−
CRYPTOPLEURA	endiviaefolia	−	+	+	−	−	−	−	−	−	−	−	−	−
HETERODOXIA	denticulata	+	−	−	−	−	−	−	−	−	−	−	−	−
HYMENEMA	curdieana	−	+	+	−	−	−	−	−	−	−	−	−	−
	multipartita	+	+	+	−	−	−	−	−	−	−	−	−	−
MYRIOGRAMME	cartilaginea	+	−	−	−	−	−	−	−	−	−	−	−	−
	erosa	+	+	−	−	−	−	−	−	−	?	−	−	−
	pristoidea	−	+	−	−	−	−	−	−	−	−	−	−	−
NITOPHYLLUM	pulchellum	+	+	+	−	−	−	−	−	−	−	−	−	−
ACROSORIUM	ciliolatum	+	+	−	+	+	−	−	−	−	−	−	−	−
PLATYCLINIA	crispata	−	−	−	−	?	−	−	−	−	−	−	−	−
CHIRACANTHIA	arborea	−	+	+	−	−	−	−	−	−	−	−	−	−
LOPHURELLA	periclados	−	+	+	−	−	−	−	−	−	−	−	−	−
POLYSIPHONIA	abscissa	+	+	+	−	+	+	+	−	−	−	−	−	−
	blandi	+	+	−	−	+	−	−	−	−	−	−	−	−
	cancellata	+	+	+	−	+	−	−	−	−	−	+	−	−
	compacta	−	−	−	+	−	−	−	−	−	−	−	−	−
	constricta n. sp.	−	−	−	−	−	−	−	−	−	−	−	−	−
	dasyoides	−	−	+	−	−	−	−	−	−	−	−	−	−
	densa n. sp.	−	−	−	−	−	−	−	−	−	−	−	−	−
	davyae	−	−	−	−	−	−	−	−	−	−	−	−	−
	frutex	+	+	+	−	+	−	−	−	−	−	−	−	−
	fuscescens	−	+	+	−	−	−	−	−	−	−	−	−	−
	hookeri	−	+	+	−	+	−	−	−	−	−	−	−	−
	hystrix	+	+	+	−	+	−	−	−	−	−	−	−	−
	mallardiae	+	+	+	−	+	−	+	−	−	−	−	−	−
	mollis	+	+	+	+	+	−	−	−	−	+	+	−	−
	nigrita	+	+	−	−	−	−	−	−	−	−	−	−	−
	patersonis	−	+	+	−	−	−	−	−	−	−	−	−	−
	succulenta	−	+	+	−	−	−	−	−	−	−	−	−	−
BRONGNIARTELLA	australis	+	+	+	−	+	−	+	−	−	−	−	−	−
	feredayae	−	+	+	−	−	−	−	−	−	−	−	−	−
	sarcocaulon	+	−	+	−	−	−	−	−	−	−	−	−	−
DOXODASYA	bulbochaete	+	+	+	−	−	−	−	−	−	−	−	−	−

RHODOPHYTA

	Australia				New Zealand	South America	Sub-Ant. arctic	South Africa	India	Malay Archip	Japan	California	England
	W Aus	Vic	Tas	N S W									
LOPHOCLADIA harveyi	+	−	−	−	−	−	−	−	−	−	−	−	−
LOPHOTHALIA hormoclados	−	+	+	−	−	−	−	−	−	−	−	−	−
BOSTRYCHIA mixta	−	−	+	+	+	−	−	+	−	−	−	−	−
simpliciuscula	−	+	+	−	−	−	−	−	−	−	−	−	−
CHONDRIA dasyphylla	+	+	+	−	−	+	−	−	+	+	+	−	+
CLADURUS elatus	+	+	+	−	−	−	−	−	−	−	−	−	−
COELOCLONIUM opuntioides	+	+	+	−	−	−	−	−	−	−	−	−	−
JANCZEWSKIA tasmanica	−	+	+	−	−	−	−	−	−	−	−	−	−
LAURENCIA botryoides	+	+	+	−	+	−	−	−	−	−	−	−	−
clavata	+	+	+	−	−	+	−	−	−	+	−	−	−
elata	+	+	+	−	+	−	−	−	−	−	−	−	−
filiformis	+	+	+	−	−	−	−	−	+	−	−	−	−
forsteri	+	+	+	+	+	−	−	+	−	+	+	−	−
gracilis	−	−	−	−	+	−	−	−	−	−	−	−	−
heteroclada	+	+	+	−	+	−	−	−	−	−	−	−	−
majuscula	+	+	−	−	−	−	−	−	+	−	+	−	−
regia	+	−	−	−	−	−	−	−	−	−	−	−	−
tasmanica	+	+	+	−	−	−	−	−	−	−	−	−	−
CORYNECLADIA umbellata	−	+	−	−	−	−	−	−	−	−	−	−	−
DICTYMENIA harveyana	+	+	+	−	−	−	−	−	−	−	−	−	−
tridens	+	+	−	−	−	−	−	−	−	−	−	−	−
JEANNERETTIA lobata	+	+	+	−	−	−	−	−	−	−	−	−	−
pedicellata	+	+	+	−	−	−	−	−	−	−	−	−	−
DIPTEROSIPHONIA dendritica	−	+	−	−	+	+	−	−	−	−	−	−	−
heteroclada	−	−	−	−	+	−	+	−	−	−	−	−	−
prorepens	+	−	−	−	−	−	−	−	−	−	−	−	−
HERPOSIPHONIA versicolor	+	+	+	−	−	−	−	−	−	−	−	−	−
LOPHOSIPHONIA scopulorum	+	−	−	−	−	−	−	−	−	−	−	−	−
CLIFTONAEA pectinata	+	+	−	−	−	−	−	−	−	−	−	−	−
EUZONIELLA flaccida	+	+	−	−	−	−	−	−	−	−	+	−	−
incisa	+	+	+	+	+	−	−	−	−	−	−	−	−
AMANSIA kuetzingioides	+	−	−	−	−	−	−	−	−	−	−	−	−
pinnatifida	+	−	−	−	−	−	−	−	−	−	−	−	−
ANEURIA latifolia	+	−	−	−	−	−	−	−	−	−	−	−	−
LENORMANDIA muelleri	+	+	−	−	−	−	−	−	−	−	−	−	−
parcalis	−	−	−	−	−	−	−	−	−	−	−	−	−
smithiae	−	+	+	−	−	−	−	−	−	−	−	−	−
spectabilis	+	−	−	−	−	−	−	−	−	−	−	−	−
OSMUNDARIA prolifera	+	−	−	−	−	−	−	−	−	−	−	−	−
PROTOKUETZINGIA australasica	+	+	+	−	−	−	−	−	−	−	−	−	−
VIDALIA spiralis	+	+	−	−	−	−	−	−	−	−	−	−	−
APHANOCLADIA bicornis n.sp.	+	−	−	−	−	−	−	−	−	−	−	−	−
TRICENIA umbellata	−	+	−	−	−	−	−	−	−	−	−	−	−

ern Australian Species have been recorded from there. California and England have been chosen to bring out the cosmopolitan element.

The main publications used in compiling Table I are as follows :

Western Australia : Sonder (1846), Harvey (1845). and the list has been checked by Mr. G.G. Smith.

Victoria : Wilson (1892), Tisdall (1898).

Tasmania : Lucas (1928).

New South Wales : May (1938, 1939, 1946, 1947, 1948 a and b, 1949), A. and E.S. Gepp (1906).

For Australia in general, Harvey (1858 - 1863), Lucas (1909, 1912), De Toni and Forti (1923) and Levring (1946) have been used, though unfortunately records in the census of Lucas are far too generalised. Records from the Algal Herbarium of the University of Adelaide, including the author's collections in the above states, and records from other herbaria have been incorporated.

New Zealand: Laing (1927, Lindauer (1947) and the Chlorophyta have been checked from an unpublished list of Dr. V.J. Chapman.

South America: Howe (1914) Taylor (1938, 1945), Levring (1941) and miscellaneous records elsewhere.

Subantarctic islands : Laing (1909), Gain (1912), Levring (1944, 1945).

South Africa: Barton (1893), Stephenson (1947), and the list has been checked by Dr. G.F. Papenfuss.

Indian region : Borgesen (1931 to 1937)

Malay Archipelago : W. v. Bosse (1928), where records applying to other localities are also given.

Japan : Yendo (1909 - 1918), Okamura (1932) and the list has been checked by Dr. Y. Yamada.

California : Setchell and Gardener (1919 - 1925). Smith (1944).

England: Newton (1931);

De Toni (1889-1924) has been used where possible, and W. v. Bosse (1898) for the genus Caulerpa, and any other records in miscellaneous papers have been incorporated. (see references to Pt. III).

It is inevitable, in the present state of our knowledge, that distribution tables for southern Australia should be incomplete, mainly because of the serious lack of records, but also through possible incorrect determinations. Many records in certain old lists are open to question. Nevertheless, the general features and relationships shown in the accompanying tables seem to be clear. This paper is based only on a comparison of the Kangaroo Island algal flora with other regions, but because of its richness and central position in southern Australia the comparisons with places outside Australia are probably well founded and apply to southern Australia generally.

Okamura (1932) has compared the Australian region (in which he included north, east and southern Australia, New Zealand and the subantarctic islands) with other parts of the Pacific region. The only other attempt to analyse the relationships of the Australian algal flora is that of May (1940), which was confined to the Chlorophyta and Phaeophyta.

THE RICHNESS OF THE ALGAL FLORA

The total number of marine algae from Kangaroo Island (see Table 2) is probably over 600 (over 576 are known to occur), excluding microscopical forms such as diatoms. For an island 90 miles long and 30 miles wide this total is large, and the island is probably as rich or richer in number of species than any other area of the Australasian region, or even of the world.

Table 2.

Number of species of marine algae from Kangaroo Island.

	Identified	Unidentified
Cyanophyta	36	?
Chlorophyta	55 (+ 3 var.)	-
Phaeophyta	113 (+ 1 var.)	2
Rhodophyta	310	60 +
Total	514	62 +

Some parts of the coast of Kangaroo Island are much richer than others. At Pennington Bay just over 300 species occur over about 2 miles, and this is typical of much of the south coast. On the other hand, less than one third of this number might be found over a similar length of the central north coast.

The island flora is also rich in genera. (Table 6). Of 229 genera at present known, some 95 are endemic or

Table 3.

Number of species common to Kangaroo Island and other regions.

		Australia					
	K.Is.	W. Aus.	Vic.	Tas.	N.S.W.	New Zealand	South America
Chlorophyta	58	25	39	30	19	23	9
Phaeophyta	114	61	96	68	44	27	10
Rhodophyta	310	186	243	161	44	66	18
Total	482	272	378	259	107	116	37
As a %		56	78	54	22	24	8

(cont.)	Sub-Antarctic	South Africa	Indian region	Malay Arch.	Japan	California	England
Chlorophyta	11	11	11	13	14	16	12
Phaeophyta	10	14	10	11	11	7	13
Rhodophyta	18	19	28	26	27	4	14
Total	39	44	49	50	52	27	39
As a %	8	9	10	10	11	6	8

concentrated in the southern Australian region. Several authors have remarked on the richness of southern Australia generally. Okamura (1932), for instance, regarded the Australian region as "a very distinct region surpassing all others in the astonishing number of endemic genera and endemic species and in the great number of species".

RELATIONSHIPS WITH OTHER PARTS OF AUSTRALIA.

Table 3 gives the number of Kangaroo Island species of Chlorophyta, Phaeophyta and Rhodophyta which occur in other states of Australia and in regions elsewhere in the world.

a. The Southern Australian region.

When the affinites of the Kangaroo Island algae with other parts of southern Australia are analysed, six groups may be distinguished. (Table 4).

Table 4.

Affinites of Kangaroo Island species within southern Australia.

Cosmopolitan species	46
General southern Australian species	212
Species of eastern affinities	153
Species of western affinities	33
Species from South Australia only	28
Species from Kangaroo Is. only in Aust. but also from elsewhere.	10

1. The cosmopolitan element.

Some 46 species which are either cosmopolitan or very widely distributed occur in the Kangaroo Island algal flora and are found generally along southern Australia. Some of the widely distributed species may be missing from the tropics, but are found in the temperate regions of both hemispheres. Where any of the species have not been recorded from a state of Australia it is probably due to insufficient collecting.

The cosmopolitan species are almost equally distributed in the three main groups, as follows:

Chlorophyta : *Ulothrix implexa*, *Entocladia viridis*, *Ulva lactuca*, *Enteromorpha clathrata*, *E. compressa*, *E. intestinalis*, *Blidingia minima*, *Cladophora fascicularis*, *C. repens*, *Rhizoclonium implexum*, *Chaetomorpha aerea*, *C. linum*, *Bryopsis plumosa*, *B. pennata* and *Derbesia marina*.

Phaeophyta : *Ectocarpus confervoides*, *E. fasciculatus*, *Sphacelaria furcigera*, *S. tribuloides*, *Cladostephus verticillatus*, *Cutleria multifida*, *Dictyota dichotoma*, and var. *intricata*, *Pocockiella variegata*, *Myrionema strangulans*, *Carpomitra costata*, *Asperococcus bullosus*, *Colpomenia sinuosa*, *Hydroclathrus clathratus*, *Scytosiphon lomentarius*, *Macrocystis pyrifera*.

Rhodophyta : *Bangia fuscopurpurea*, *Porphyra umbilicalis*, *Nemalion helminthoides*, *Asparagopsis taxiformis*, *Gelidium pusillum*, *Pterocladia capillacea*, *Hildenbrandtia prototypus*, *Amphiroa anceps*, *Corallina officinalis*, *Melobesia lejolisii*, *Gracilaria confervoides*, *Hypnea musciformis*, *Centroceras clavulatum*, *Ceramium rubrum*, *Chondria dasyphylla*.

The proportion of cosmopolitan species amongst the Chlorophyta (26%) is strikingly higher than in the Phaeophyta (14%) and Rhodophyta (5%).

2. Species with general southern Australian distribution.

This group is found both in Western Australia and in one or more of the eastern states (Victoria, Tasmania or New South Wales), and comprises 212 species. To this must be added the cosmopolitan element, giving a total of 258 (54%). This high figure is strong evidence of the uniformity of the southern Australian region, and with more intensive collecting will probably be raised even higher.

3. Eastern affinities.

. Species found to the east of Kangaroo Island, but not in Western Australia number 153 (32%). This is a high proportion (68%) of those which are not generally distributed along southern Australia.

The close affinity of the algal flora with the east is also shown in Table 3. 78% of the Kangaroo Island species occur in Victoria and 56% in Tasmania. For New South Wales however the figure is much lower (22%), which is evidence of the rapid change up the east coast of Australia.

4. Western affinities.

Some 33 species occur in Western Australia but not to the east of Kangaroo Island. At first sight this figure appears small, but taken with the generally distributed and cosmopolitan groups, 272 species (56%) are common to Western

Australia and Kangaroo Island (Table 3). There is strong relationship with the west, and the Kangaroo Island flora contains a distinct group of species of western affinities.

5. Species known only from South Australia.*

This group of 28 species (6%) comprises 11 described species from South Australia and 17 species known only from Kangaroo Island which appear to be undescribed and have been given manuscript names. This latter group will very likely be increased considerable when the island flora is fully known. At present it shows a low degree of endemism for Kangaroo Island algae.

6. Species known only from Kangaroo Island in Australia but but also from other regions.

This is a small group of 10 species which will almost certainly be reduced by intensive examination of other parts of the southern Australian coasts. The species concerned are : Gayella polyrhiza, Cladophora ceratina, C. delicatula, Chaetomorpha capillaris, Bryopsis cupressoides, Ralfsia borneti, Hildenbrandtia crouani, Lithothamnion erubescens (?), Laurencia gracilis and Dipterosiphonia heteroclada.

Most of these species are probably widely though irregularly distributed. The cause of their distribution is uncertain, but some may have been spread by shipping. Their presence on Kangaroo Island can scarcely be considered as evidence of affinity with other regions from which they are known.

*The state of South Australia, as distinct from southern Australia.

7. Conclusions as to the southern Australian distribution.

The Kangaroo Island algal flora is a typical example of a flora which is relatively uniform throughout the whole southern Australian region (i.e. from south west corner of Australia to about the Victoria - New South Wales border, and including Tasmania). A high proportion of the species is found throughout this region.

Kangaroo Island shows very close relationship with Victoria, and also (though slightly less) with Tasmania and Western Australia. A fairly high proportion of eastern species reach Kangaroo Island but apparently not much further to the west, while a smaller group of western species do not extend much further east than Kangaroo Island. Hence it would seem that the island is a meeting place, and the limit of the distribution, of many western and eastern species.

The low degree of endemism of Kangaroo Island algae is further evidence of the floristic unity of the southern Australian region.

It is interesting to note that this is also a uniform region in the distribution of animal groups such as the molluscs. Stephenson (1947), referring to Ekman's "Tiergeographie des Meeres", notes also that the endemic element in the fauna of southern Australia is very high.

b. Changes from southern to tropical Australian coasts.

Passing to warmer waters up both the western and eastern coasts of Australia there is a marked change in the algal flora. Lack of detailed reports from tropical or sub-tropical Australian coasts prevents an analysis of this change, but the figures for New South Wales indicate it strongly. Here (Table 3) only 107 (22%) of the Kangaroo Island species occur, and these are probably largely confined to the more southern parts of the state. Of these 107, about 30 are cosmopolitan species. It is striking also that there is slightly greater relationship between Kangaroo Island and New Zealand than with New South Wales, though this may alter as New South Wales becomes better known.

While the New South Wales algal flora is much poorer in numbers than the southern states (only about 200 species have been recorded from New South Wales), it includes many species of tropical or subtropical affinities. These rarely reach as far south as the New South Wales-Victorian border. On the other hand, most of the characteristic endemic genera of southern Australia are not found north of the Victorian border, or else drop out somewhere up the New South Wales coast.

The distribution of the typically southern kelps and fucoids illustrates well the disappearance of the southern element and its replacement by a subtropical one. Dakin, Bennett and Pope (1948) report that *Sarcophycus potatorum* reaches only to Bermagui, about 80 miles north of the Victorian border, *Phyllospora comosa* to Grants Head and *Ecklonia radiata* to the extreme north of New South Wales, while *Corallina* and *Sargassum* become more important as these drop out.

The algae of the Western Australian coast from

Fremantle upwards are poorly known, though they would provide a fascinating field for study. From personal observations and the little information available it would appear that the change from the southern Australian flora to a subtropical one commences at about Fremantle. *Halimeda* and *Penicillis* occur on Rottnest Island near Fremantle, and at Geraldton numerous subtropical species occur and *Sargassum* and *lithothamnia* are dominant in the sublittoral fringe. At the Abrolhos Islands, off the coast near Geraldton, there are typical coral reefs.

Most of the southern fucoids do not reach Fremantle, though a few extend further north. *Cystophora uvifera* is an unusual species, for although typically southern Australian it occurs at the Abrolhos Islands. *Hormosira* reaches only as far as Albany, while *Ecklonia radiata* disappears shortly above Fremantle. Even at Point Peron, just south of Fremantle, *Sargassum* spp. are the most plentiful algae on the reefs, in contrast to the dominance of *Cystophora* spp. and *Hormosira* on Kangaroo Island reefs.

There are quite a large number of species which appear to form a distinct West Australian element. They are confined to the south-west corner and lower part of the west coast of Australia.

The gradual change from a southern Australian to a subtropical algal flora on the east and west coasts of Australia occurs in similar latitudes. From the maps of surface temperatures of the oceans given by Sverdrup et al (1942), the southern Australian region as understood here lies within the temperature ranges of 14 - 20°C in February and 11 - 16°C in August. While inshore temperatures vary more than these figures for ocean conditions, the region lies in a fairly distinct temperature belt, and it is only when the Australian coasts pass directly northwards that marked temperature changes occur.

The characteristic southern Australian algal flora is probably directly dependent on the relatively uniform water temperatures, and likewise the changes on the western and eastern coasts are caused by the increase in temperature. Setchell (1920 and previous papers) put forward a theory that the isotheres and isocrymes of 10°, 15°, 20° and 25°C are important limits in the distribution of many species. Whether these temperatures do limit the distribution of many species on Australian coasts cannot be verified at present due both to lack of temperature data and also lack of information on the exact limits of any species. But it is striking that there is an annual range of about 5°C at almost any place in the southern Australian region, and also that the region as a whole lies within a 5°C range at any time of the year.

RELATIONSHIPS WITH REGIONS OUTSIDE AUSTRALIA

Table 3 gives the number of species from Kangaroo Island which are found in various other regions. In Table 5 these figures are divided into cosmopolitan species and those which can be regarded as characteristic southern Australian species. For certain regions circum sub-antarctic species have also been separated.

TABLE 8

Showing the degree of relationship between Kangaroo Island and regions outside Australia

	New Zealand	South America	Sub-antarctic	South Africa	India	Malay Archip.	Japan	California	England
Species common to Kangaroo Is. and the region	116	37	39	44	49	50	52	27	39
Cosmopolitan species	38	25	21	25	30	25	31	27	39
Species showing southern Australian relationship	69	5	8	17	19	25	21	-	-
Circum. sub-antarctic species	9	7	10	2	-	-	-	-	-

1. The cosmopolitan element

In all cases except New Zealand the cosmopolitan element comprises the majority of species common to the two regions, varying from 21 to 39 species. It is remarkable that England has the highest number of cosmopolitan species, though most isolated geographically from Kangaroo Island. No explanation of this is apparent.

2. Relationships with New Zealand.

New Zealand shows distinct relationship with Kangaroo Island, having 38 cosmopolitan, 9 subantarctic and 69 southern Australian species in common. This total of 116 is slightly greater than the number for New South Wales (107) and shows the change which occurs passing into warmer waters up the eastern Australian coast. While New Zealand has many endemic species and some endemic genera, it can well be considered as an outlier of the southern Australian region.

3. Relationships with South America.

Only 5 species (of the Kangaroo Island flora) which can be regarded as southern Australian are found in South America, indicating a low degree of relationship. This might be expected in view of the wide ocean separating Australia and South America, though records from the latter continent are only fragmentary.

4. Relationships with the subantarctic island.

The algal flora of the subantarctic islands can be divided into:

a. cosmopolitan species.

b. Species common to most islands, the southern part of South America, and just touching New Zealand, southern Australia and South Africa, i.e. circum-subantarctic species.

c. Species restricted to one or a group of the subantarctic islands.

Amongst the Kangaroo Island algae are 10 species which belong to the second group of circum sub-antarctic species. These are Chaetomorpha darwinii, Halopteris funicularis, Macrocystis pyrifera, Delisea pulchra, Lithothamnion patena, Griffithsia antarctica, Ballia callitricha, B. scoparia, Polysiphonia abscissa and Dipterosiphonia heteroclada. In addition there are 8 species found on the subantarctic islands hearer to Australia and New Zealand, namely : Codium spongiosum, Ecklonia radiata, Xiphophora chondrophylla, Corallina cuvieri, Curdiea laciniata, Mychodea compressa, Polysiphonia mallardiae and Brongniartella australis. Also 21 cosmopolitan species are common to Kangaroo Island and the subantarctic islands.

These figures show that Kangaroo Island possesses a small, but definite, subantarctic element, but can be regarded as only on the fringe of the subantactic region.

5. Relationships with South Africa.

Of 44 species common to Kangaroo Island and South Africa, 25 are cosmopolitan, 2 subantarctic and 17 are southern Australian species. Most of these 17 were known from Australia first (though a few were described from South Africa) and the problem of their distribution will be discussed later as it is similar for other Indian Ocean localities.

6. Relationships with the Indian Region.

The Indian region has 49 species in common with Kangaroo Island, comprising 30 cosmopolitan and 19 southern Australian ones. This distribution will be discussed later, but has previously been pointed out by Borgesen (1934b).

7. Relationships with the Malay Archipelago.

Species common to the various islands of the Malay Archipelago and Kangaroo Island number 50, of which 25 are cosmopolitan and 25 of southern Australian affinities. The large number of species common to a tropical region and a cool temperate one is most surprising, and detailed comparisons of their habitats in the Malay Archipelago would be of interest.

8. Relationships with Japan.

From the various islands of Japan 52 of the Kangaroo Island species have been recorded. Of these, 31 are cosmopolitan and 21 of southern Australian affinities, showing a similar degree of relationships to that which the Indian Ocean localities show. This will be discussed later.

9. Relationships with California.

California possesses only 27 cosmopolitan species common to Kangaroo Island. Apparently the double barrier of the tropics and wide Pacific Ocean has up to the present proved too great for migration or transference of any southern

Australian species to western North America, although the climate of California is probably closest to that of southern Australia of any region chosen in this analysis.

10. Relationships with England.

39 cosmopolitan or widely distributed species are common to England and Kangaroo Island. This is higher than for any of the other regions, though several (such as *Gayella polyrhiza*, *Asparagopsis armata*, *Bonnemaisonia asparagoides* and *Hildenbrandtia crouani*) are apparently not really cosmopolitan as yet.

Possible causes of the distribution of southern Australian species in the Indian Ocean and Japan.

The three Indian Ocean localities, South Africa, India and the Malay Archipelago, together with Japan, each have between 17 and 25 Kangaroo Island species which belong to the southern Australian group, in their algal flora. These comprise about 80% of all the southern Australian species found in the above regions. Most of the species were known from Australia first, and it would seem that there has been a spread of southern Australian species through the Indian Ocean and to Japan to much the same extent in all places. Whether this spread has occurred in recent years is doubtful (though possible), for the time when they were first recorded in any place is probably insignificant. There is also no evidence as yet of characteristic South African (with a few exceptions), Indian, Malayan or Japanese algae having been found on southern Australian coasts, so the spread seems to have been only from Australia.

The species concerned are not the same ones in each locality. Of a total of 60 species involved, none are found in all four regions, only 4 in 3 regions (Caulerpa scalpelliformis, Pterocladia lucida, Solieria robusta and Laurencia forsteri), 13 in 2 regions and 43 in one region.

Means by which this spread has occurred are very doubtful, and any suggestions are little more than guesswork. Possible explanations are :

1. There may be some cases of incorrect determinations, but the numbers are too high for this to lower them significantly. Even in doubtful cases, we are dealing with very closely related species or varieties.

2. Transport by ocean currents. According to the map given by Sverdrup et al (1942), a surface current passes northwards along the Western Australian coast and swings westward to form the equatorial current, thence southward to join the Agulhas current on the east coast of South Africa. A possible means of transport of spores to South African coasts thus exists. Another current passes up the Western Australian coast to at least the lower part pf the Malay Archipelago. Between Western Australian and India and Japan however there are numerous counter currents.

Transport of viable algal fragments or spores by currents is dependent on two factors.

a. The life of the spore. . Very little is known of this aspect but it seems probable that few spores or fragments of algae could remain viable over the period of at least several months necessary to transport them in currents over the Indian Ocean. Gradual spread by currents along land is possible, but could not have taken place in these cases.

b. The temperature of the ocean. The tropical waters are usually considered a barrier to the spread of species from colder waters. This is certainly generally true, and the spread of southern Australian species across the tropics to India and Japan, and their existence in the Malay Archipelago is very remarkable.

3. Carriage by shipping. This is the most likely of all the possibilities, as it is known that many species (mostly cosmopolitan) are carried on ships' hulls, and many Florideae can regenerate from quite small fragments of their thalli. (Fritsch 1945, 13). A noteworthy case is that of the Australian Asparagopsis armata, which in recent years has established itself in the Mediterranean and spread around the coast to Ireland. There are direct shipping routes between southern Australia and India, Malaya and Japan by which spores or fragments attached to ships' hulls could be transported through the tropical barrier in a relatively short time. The route to South Africa does not involve passing through warmer waters.

If spread from southern Australia by shipping has occurred, introduction of species from South Africa, India etc. to Australia might also be expected. At present there is no evidence for this, but this may be for want of intensive collecting in Western Australia.

Shipping may be the cause of the occurrence of a small group of species dealt with previously, those known only from Kangaroo Island in Australia but also from elsewhere (mainly from Europe).

4. Spread by sea birds (Fritsch 1945, 13) is a possibility of which little is known.
5. In some cases, in other parts of the world, former land connections and continental drift in past geological ages have been suggested as the only way of explaining present discontinuous distribution (Svedelius 1924, Borgesen 1934, Fritsch 1945). There seems to be no evidence for land bridges in the case of southern Australia and south Africa though migration northwards through the Malay Archipelago and around the coast of the Indian Ocean may have been possible in past ages. To build hypotheses on the theory of continental drift would be very rash when other possiblities exist, especially when the spread of these species may have occurred in the past 100 or so years.

GENERIC RELATIONSHIPS

The total number of genera in the different classes of Kangaroo Island marine algae, and the number which are either endemic or with most of their species in the southern Australian-New Zealand region, are given in Table 6.

Table 6.

	Number of Genera	Endemic Genera
Cyanophyta	14	0
Chlorophyta	20	3
Phaeophyta	50	20
Rhodophyta	145	70
Total	229	93

The genera of Cyanophyta are all cosmopolitan, while only three genera of Chlorophyta are largely southern Australian. These are *Apjohnia* (also in South Africa), *Struvea* (some tropical species) and *Rhipiliopsis*.

Of 50 genera of Phaeophyta, 20 (40%) are endemic or have many Australian species, namely: *Phloeocaulon*, *Pachydictyon*, *Dilophus*, *Lobospira*, *Chlanidophora*, *Myriogloia*, *Polycerea*, *Tinocladia*, *Stilopsis*, *Encyothalia*, *Bellotia*, *Perithalia*, *Hormosira*, *Notheia*, *Myriodesma*, *Scytothalia*, *Seirococcus*, *Carpoglossum*, *Cystophora* and *Scaberia*.

The Rhodophyta show by far the highest degree of endemism, with 70 of 145 genera (48%) largely confined to the southern

Australian region. These are: Delisea, Endosira, Helminthocladia Dasyphloea, Rhodopeltis, Metagoniolithon, Thamnoclonium, Gelinaria, Polycoelia, Curdiea, Melanthalia, Tylotus, Phacelocarpus, Stenocladia, Nizymenia, Thysanocladia, Areschougia, Erythroclonium, Rhabdonia, Grunowiella, Rhododactylis, Mychodea, Dicranema, Acrotylus, Bindera, Gloioderma, Erythrymenia, Gloiosaccion, Hymenocladia, Haloplegma, Spongoclonium, Euptilota Perischelia, Thamnocarpus, Dasyphila, Muellerena, Psilothalia, Gulsonia, Ballia, Lasiothalia, Ptilocladia, Wrangelia, Dasya, Halodictyon, Thuretia, Apoglossum, Branchioglossum, Chauvinea, Claudea, Hypoglossum, Phitymorphora, Sarcomenia, Heterodoxia, Platyclinea, Chiracanthia, Doxodasya, Lothothalia, Cladurus, Coeloclonium, Corynecladia, Dictymenia, Jeannerettia, Cliftonia, Euzoniella, Amansia, Lenormandia, Osmundaria, Protokuetzingia, Vidalia, Trigenia.

In addition there are distinctive suites of southern Australian species in many large genera, such as Sargassum and Polysiphonia.

The large proportion of endemic genera emphasizes the distinctiveness of the southern Australian region, both in the unity of the algal flora within the region and in its separation from other parts of the world.

Certain genera or groups (such as the Dictyotaceae) are often regarded as being largely tropical, yet are very well represented along southern Australia. In such cases, however, the species which occur in southern Australia are usually restricted to this region, and can hardly be said to show any tropical affinities of the algal flora. There are, on the other hand, a few species which are widely distributed in the tropics, and which do form a slight tropical element in the Kangaroo Island algae. Such species are Pocockiella variegata (which is very widely distributed and almost cosmopolitan), Griffithsia tenuis Asparagopsis taxiformis, Amphiroa anceps and Lithothamnion erubescens (this determinations however needs confirmation)

GENERAL CONCLUSIONS AND SUMMARY.

Kangaroo Island is a rich and typical part of the southern Australian region. This region, extending from the south-west corner of Australia to about the Victorian - New South Wales border, and including Tasmania, forms a distinctive geographical unit in which many genera and species of marine algae are widely distributed. The degree of endemism is probably higher than in most parts of the world. Kangaroo Island is centrally situated in southern Australia and has both western and eastern elements in its algal flora, the strongest affinities being with the east. New Zealand may be regarded as an outlier of the southern Australian region, though it has many endemic species. A small subantarctic element is also present at Kangaroo Island.

Besides having many cosmopolitan species in common, parts of the Indian Ocean (South africa, India and the Malay Archipelago) and Japan have similar numbers of characteristic southern Australian species. The causes of this discontinuous distribution are uncertain.

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THE MARINE ALGAE OF KANGAROO ISLAND.

VII. Ecological relationships with other regions.

CONTENTS.

INTRODUCTION.

This section is in part complimentary to the discussion of terminology and general ecological features given in Pt. I. The terminology used in naming the zones and formations has been supported by investigations elsewhere in South Australia, and is also applicable to coasts of Western Australia, Tasmania, New South Wales and New Zealand which the author has seen. Slight modifications of the zonation scheme will be considered later.

It is not intended here to review or discuss in detail ecological studies made elsewhere in the world, for this has been done by Chapman (1946a), and ecological factors were reviewed at a symposium held by the Linnaean Society of London (Chapman 1942, Stephenaon 1942). Mention may be made, however, of several recent papers which are of general importance or deal specifically with parts of the Australian-New Zealand region. In particular, southern Austrahia will be considered in relation to the general zonation scheme, "standard" zonation and broad southern hemisphere regions which have been discussed by Stephenson in recent papers, since these papers take into account previous ecological studies as well as his wide personal experience.

In Australia, Dakin, Bennett and Pope (1948) have described the zonation and changes which occur over the whole coastline of New South Wales, and have more recently extended their observations to the Victoria coast. In Western Australia, Choules and Rutt have described the ecology of a number of limestone reefs, which are similar in structure to those at Pennington Bay. Guiler (Roy. Soc. Tas. 1950) has commenced a series of papers on Tasmanian marine coastal ecology.

Apart from Stephenson's papers on the South African coast, notable publications are those of Ricketts and Calvin (1948) who have described the characteristic animals of the intertidal region of the west coast of North America. Although this work is not primarily ecological, the animals are related to zones on the shore and habitat conditions are discussed. A detailed analysis of the relation of zones to tidal factors on the Californian coast is given by Doty (1946).

In England, Evans (1947) has described the intertidal ecology of the Plymouth district, with emphasis on critical levels. Yonge (1949) has given an excellent semi-popular account of the sea shore of the British Isles.

In New Zealand, Chapman has commenced a series of papers on marine zonation (Chapman 1950, Beveridge and Chapman 1950).

COMPARISONS OF THE ZONES AND COMMUNITIES ON KANGAROO ISLAND WITH OTHER REGIONS.

The coast of Kangaroo Island displays almost every type of coastal environment in South Australia, and probably in most of southern Australia as well. The type of horizontal rock platform at Pennington Bay occurs generally around the coast to Western Australia (Choules and Rutt), and also into Victoria. The steeply sloping coasts of the Rocky Coast Formation are very common and widely distributed, while sheltered bays with tidal sand-flats similar to American River inlet occur on Eyre Peninsular and elsewhere.

It has been stressed before that the tidal range on Kangaroo Island is relatively small. This results in fewer zones and less well marked zonation than in many parts of the world, such as England (Chapman 1941) and California (Doty 1946). Zonation is nevertheless a feature of any coastal area, and even in the tropics where the tidal rise is very small a striking case has been reported (Chapman 1946b).

The presence of fewer zones in the littoral is possibly also due to the higher air temperatures and lower humidity in South Australia than in many other places.

Kangaroo Island coasts agree fairly well with the "standard" zonation of T.A. and A. Stephenson (1949), though variations from this standard are frequent. The Stephensons scheme will be discussed later, but some comparisons of the algae in the different zones can be made here.

In the supralittoral, which is dominated by the littorinid mollusc Melaraphe unifasciata in all but the calmest places, macroscopic algae are generally absent. The lichens Lichina and Verrucaria are common in moderately rough and calm localities, and high in the supralittoral zone other red and yellow lichens may form prominent bands. This banding of lichens well above high tide level is typical of many coasts of the world.

The uppermost algal zone on the shore (at mid or upper littoral level) is usually one of blue-green algae, represented on Kangaroo Island by Rivularia and Isactis, with Brachytrichia and Calothrix in some localities. The Stephensons (1949) have recognised a blue-green zone in the littorinid zone ("supralittoral fringe") of their general scheme. This seems to be distinctly above the level of the blue-green zone on Kangaroo Island.

The lower littoral is usually dominated by coralline algae (Corallina and Jania), though other algae are usually mixed with them. Hormosira occurs on horizontal areas (e.g. at Pennington Bay and American River inlet). A "turf" or mat of short algae is found in the lower littoral in many regions, but Hormosira is restricted to southern Australia and New Zealand. On Kangaroo Island the corallines and Hormosira usually form distinct associations, but in other parts of southern Australia and New Zealand (Oliver 1923) they may occur mixed.

As in most temperate parts of the world, the upper sublittoral (or sublittoral fringe) is dominated by the larger brown algae. The most important genus is Cystophora, which occurs in all but the very calmest parts. Ecklonia radiata, Sargassum and Xiphophora occur where wave action is medium to strong. The very characteristic "laminarian" zone of the northern cold temperate waters is thus replaced by a fucoid zone on Kangaroo Island. The species of this zone are also relatively small (less than 1 meter long). The only member of the Laminariales, Ecklonia, is dominant only in small areas.

The algal formations on Kangaroo Island, which were described in Part I, are very similar to those of Cotton on Clare Island and Rees at Lough Ine. Ricketts and Calvin (1948) have divided the western coast of North America into several types depending on conditions of wave action, and although they do not name formations as such, their types of coast are very similar to the formations recognised on Kangaroo Island.

Such marine coastal formations are distinguishable in many parts of the world, and can be applied to all parts of the Australian and New Zealand coast that the writer has seen. The "sand or sandy-mud flat formation" is a type of habitat that has been recognised in many places. Johnson and York (1915) described the Zostera association of Cold Spring Harbour, New York, which is very similat to American River inlet. In New Zealand, Oliver (1923) described similar sheltered areas colonised by Zostera, as does Hedley (1915) for New South Wales.

Such formations are major units of the coastal ecology, depending on the conditions of roughness and the substratum. They may be grouped within the different geographical regions (e.g. the southern Australian region), which may be in turn classed within the major regions of Stephenson (1947), namely the Subantarctic, Cold and warm temperate and subtropical regions.

This use of the term "formation" fits in well with the broader and narrower categories, and is similar to the use of formation in land ecology. (see Part I)

Within the formations, zones (depending on tidal variations) occur, and within the zones associations or communities of organisms can be recognised. Chapman (1946a) advocates the adoption of ecological terms in the sense used by land ecologists. It was pointed out in Part I, however, that land ecologists are far from being in agreement on their terminology, and Chapman does not state which school (British, Scandinavian, Australian etc) marine ecologists should follow. Beveridge and Chapman (1950) also use numerous terms of lesser ranking than association. At the present time however, the prime need of marine ecology is simple description of the zones and communities of marine organisms and their relation to the environment. Criticism of the "horde of technical terms" used by some ecologists is well expressed by T.A. and A. Stephenson (1949), and in this account of the ecology of Kangaroo Island only a few basic terms have been used.

The fundamental environmental factors, in order of their importance as they apply to Kangaroo Island, are summarised briefly below.

1. The degree of roughness. This is the basic factor which determines the broad formations and the distribution of many species.

2. The substratum, which is correlated and interdependent with the degree of roughness in determining the formations.
3. The tidal fluctuations, which control the zonation in the intertidal zone. As shown in Part V, the tides at Kangaroo Island are very variable.
4. The light factor, which is important below E.L.W.S. and in shaded parts of the intertidal zone.
5. Temperature variations, both of the water and the air in the case of littoral and supralittoral species.

A ZONATION SCHEME OF WORLD WIDE APPLICATION.

As a result of their South African survey, and knowledge of coasts in England, parts of the Indian Ocean, the Atlantic and Pacific coasts of the United States, and the Great Barrier Reef, T.A. and A. Stephenson (1949) have proposed a scheme of coastal zonation which they believe may be of general application. Stephenson has seen more coasts of the world than any other marine ecologist, and is in an excellent position to put forward such a scheme. However, it does not seem to apply quite satisfactorily to southern Australian coasts, and certain objections may be raised to their terminology.

The Stephensons' discussion of "standard" zonation and variations from this holds fairly well for Southern Australian rocky coasts. Their "Balanoid" and Littorinid" zones are features of most of our coastline, but not all, and as they realise such terms can hardly be used in a general scheme.

From the title of their paper, the Stephensons' scheme is intended to apply to Rocky Coasts. A general scheme of coastal zonation should be applicable to any type of coast (whether it be a gently shelving mud flat with a sandy beach or mangroves at the rear, the many variations of rocky coasts, or any other kind). While schemes developed for rocky coasts will probably be applicable to other types of coast, this may not always be so. In particular, different organisms may have to be used as indicator species.

THE SUBLITTORAL ZONE.

The littoral-Sublittoral Boundary.

The evidence of many observers suggests that on most coasts there exists an important critical level in the vertical distribution of organisms at some distance above extreme low water mark of spring tides. (E.L.W.S.).

On the Pacific Coast of the United States of America Doty (1946) found that this level corresponded with the mean of lowest low water, which was about 18 inches above the lowest low of of low water (E.L.W.S.). His figures show strikingly that this level is by far the most important tidal level for limitation of algal species.

Colman (1933) in his detailed survey of zonation in Wembury Bay, England, found critical levels between M.L.W.S. and E.L.W.S. and also between M.L.W. of neap and spring tides.

Evans (1947) working near Plymouth found that the position of critical levels changes in relation to local variations in surf action, rock configuration, and illumination, but was convinced of the real existence of critical levels. He found the region between M.L.W.S. and M.L.W.N. critical as the majority of intertidal organisms reached their lower limits here, and certain sublittoral species (including Laminaria) extended up to a level just below M.L.W.N.

Feldmann (1937) in his monograph on the algal vegetation of the Mediterranean, limits the littoral at zero low water, but in this sea tides are almost absent and barometric pressure and winds play an important part. Feldmann shows clearly in his Table I that the zero water mark is a limiting level for most species, and the number of species limited to his 0 - 5 m. upper infra-littoral zone is most striking.

Dakin, Bennett and Pope (1948), in their study of the New South Wales coast in Australia use the term "littoral - sublittoral fringe". This zone comprises the kelp zone (extending just above E.L.W.S.) and above it a zone of the ascidian Pyura which extends to 2 feet above E.L.W.S. The Pyura zone here may perhaps be better placed in the littoral zone, and the top of the kelp considered as marking the sub-littoral - littoral boundary.

Stephenson (1944, p.335), regards the Pyura of South African coasts as forming part of his sublittoral fringe, as it occurs at the same level as the uppermost kelp. This may be different from the position in New South Wales. Stephenson (1949) is his generalised scheme draws his midlittoral - infra-littoral fringe boundary at the top of the zone of laminarians (or other dominant algae).

Experience on southern Australian coasts shows that there is a most important critical level a short distance above E.L.W.S. The small tidal rise along most of the coast (2 to 4 feet) makes accurate fixing of this level difficult, but below it there exists a zone of brown algae (Cystophora spp., Sarcophycus and sometimes Sargassum) or occasionally of red algae in some calm localities (e.g. Hypnea, Spyridia in American River Inlet)

All the above repotts, as well as many others, on widely scattered areas of coasts, have recognised the existence of a critical level some distance above E.L.W.S. Where accurate studies have been made its position has been fixed at somewhere between or about M.L.W.S. and M.L.W.N., but the precise level probably varies slightly under different conditions of wave action, rock configuration etc. In any case, it seems logical that this natural line of demarkation should be fixed as the littoral - sublittoral boundary.

Further, the work of Evans and Doty shows that below M.L.W.S. the amount of exposure to air is very small (less than 3 or 4%), while it increases rapidly above M.L.W.S. This small degree of exposure is unlikely to affect the distribution of many organisms, especially where there is some wave action to wet this zone at extreme low tides.

On most coasts of cold-temperate regions the top of the zone of large brown algae (laminarians or fucoids) can safely be considered to mark the littoral - sublittoral boundary. On tropical coasts the upper boundary of corals and Sargassum could be used, though critical correlation of the organisms with tidal phenomena in the tropics is needed. Chapman (1946, 654) criticises the use of organisms to delimit such critical levels, but sufficient detailed studies have been carried out to make this possible on extended coastal surveys such as those of Stephenson in South Africa, of Dakin, Bennett and Pope in New South Wales and of these studies on Kangaroo Island in South Australia.

<u>The Sublittoral Fringe and Upper Sublittoral.</u>

Stephenson (1939) introduced the term "Sublittoral fringe" for the uppermost part of the sublittoral which is exposed only at extreme low tides. On most temperate and cold water coasts throughout the world this is essentially a zone of large brown algae, usually laminarians or fucoids. In their 1949 paper, the Stephensons regard the lower limit of the sublittoral fringe as being at E.L.W.S. In actual fact this restricted zone usually includes only the upper part of a uniform zone which extends down much below E.L.W.S. On English coasts the kelp zone extends down to 10 fathoms, and in Stephensons' scheme the uppermost plants of this zone, and often the upper parts of the plants only, would come within the sublittoral fringe. Many other algae and animals which occur just above E.L.W.S. also occur below this level.

Feldmann (1937) used the term "upper infralittoral" for the zone to 5 meters deep below the littoral. This zone is very similar to "upper sublittoral" as used on Kangaroo Island, and is a much more natural zone than Stephensons' sublittoral fringe. The lower limit of the upper sublittoral will vary from place to place, and it is best regarded as a useful distinction for the upper part of the sublittoral which is dominated by large brown algae in colder waters, or by other forms in the tropics.

In some restricted areas however, sublittoral fringe is a distinctly useful term. On rough coasts of Kangaroo Island the uppermost zone of the sublittoral is dominated by the brown alga Cystophora intermedia, which extends down for only 2 or 3 feet. This zone is often completely exposed - though momentarily - between heavy waves at low tides, and it does constitute a distinct fringing zone to the sublittoral.

On calmer coasts of Kangaroo Island, other species of Cystophora extend from just above E.L.W.S. to 10 or 15 feet or more below. Here the term "upper sublittoral" is more appropriate than "sublittoral fringe".

The affinities of organisms occurring in the sublittoral fringe are largely with those of the sublittoral, and the uppermost zone is logically regarded as being a fringe of the sublittoral and not the littoral.

It is proposed therefore that the upper zone of the sublittoral should be known as the "upper sublittoral" in a general scheme; and that "sublittoral fringe" be used only for localities where there is a true fringing zone of algae or animals, not extending much below E.L.W.S.

"Sub" or "Infra" - littoral.

Stephenson, after using the term sublittoral in all his previous papers, in the 1949 paper changes this to infralittoral, on the grounds that "the only objection to supralittoral which we have encountered lies in the fact that on a printed page it looks very like sublittoral, and in reading over our own notes we find that the eye often confuses the two, with unfortunate results". They therefore propose to substitute the word infralittoral for sublittoral.

We have never found this difficulty in distinguishing sub and supra, either in printed papers or in field notes (where sublittoral is abbreviated to S.L. and supralittoral to supra-L). If terms are to be changed for such slight reasons as "looking alike", only confusion can result.

Probably the majority of marine biological workers have used the term sublittoral, while Feldmann introduced the term infralittoral in 1937. The words are almost identical in their meaning of "under the littoral", and we prefer to use the older and better established term sublittoral, especially as there seems no real reason to change it.

THE LITTORAL ZONE.

The littoral zone comprises the intertidal region proper, above the sublittoral. The upper limit of the littoral is difficult to fix with any certainty, being complicated by factors other than the tidal range - e.g. the amount of splash and spray, and the presence of shade.

The Stephensons limitation of the upper limit of the littoral to where littorinids become dominant is probably as satisfactory as is possible at present. This does constitute a line of demarkation on most rocky shores, and corresponds to a level at or above M.H.W.S., depending on the degree of wave splash. Where wave splash is heavy the littoral may be elevated several feet above actual high water mark. While littorinids are useful indicator species for the littoral-supralittoral boundary, on some sheltered coasts other species will probably have to be used as indicators.

In their earlier papers, Stephenson and his co-workers considered that so many different interpretations had been placed on the term littoral that they discarded it, using instead "intertidal" for that zone of the shore. However, they did use sublittoral and supralittoral, and as long as these terms are used the region between them must logically be the littoral. In their most recent paper, the Stephensons rename this zone the midlittoral, classing the sub-littoral fringe and the lower half of their supra-littoral fringe as parts of the littoral. As already pointed out, the sublittoral fringe is related to the sublittoral rather than the littoral in its affinities, and should therefore not be placed within the littoral. The supra-littoral fringe will be referred to later.

Further difficulties arise when the littoral zone shows several subzones, as it does in many localities. On southern Australian coasts two or three zones often occur within the littoral, and these can conveniently be called the upper and lower, or the upper, mid and lower littoral zones. An example of three littoral zones is found on moderately sheltered South Australia coasts where the zonation is:

upper littoral - barnacles

mid littoral - limpets, Galeolaria and blue-green algae

lower littoral - Jania - Corallina mats.

On coasts with greater tidal ranges the littoral could be further subdivided as found necessary. In some cases it has been possible to give the exact tidal range of the different zones, (Doty, 1946, Evans 1947) but where the tidal range is small and tidal data are inadequate this is not possible.

However, if mid littoral is used as suggested by the Stephensons for the main intertidal region, these subzones would then become the upper mid-littoral

mid mid-littoral

and lower mid-littoral.

Such terms are far too cumbersome for standard usage.

THE SUPRALITTORAL.

The supralittoral has usually been regarded as the region above the littoral (above direct tide or wave action) comprising organisms of marine affinities, and extending up to the limit of influential spray or to the land vegetation. The lower limit can often be drawn at the bottom of the littorinid zone, which seems to be a feature of most, though not all, coasts (for some very calm coasts have few littorinids).

Few algae occur in this zone, and these are usually small and inconspicuous. On South Australian coasts Melaraphe unifasciata is the dominant littorinid of the supralittoral.

The Stephensons place the littorinid zone in their supralittoral fringe. This zone in their scheme comprises part of the littoral and part of the supralittoral. They do not indicate how far the remaining supralittoral zone extends upwards, nor in any detail the organisms which occur in it, though the lichens common on most rocky coasts occur here.

It may be questioned however, whether their separation of the supralittoral fringe and supralittoral zone is distinct enough for general recognition of these two zones. The littorinids extend for varying distances upwards, depending on spray, and on southern Australian coasts often occur among the lichens and almost up to the land plants. Dakin, Bennett and Pope, referring to the New South Wales coasts, state "of our three common littorinids, Bembicium, Melaraphe and Nodilittorina, the first is restricted to the upper parts of the barnacle zone (upper intertidal); Melaraphe occurs at the same levels, but also higher; and Nodilittorina is best adapted to the conditions of dry land". Other migratory animals such as Ligia and crabs may extend above the littorinids but also occur within the littorinid zone where there is shelter in cracks and hollows.

As far as South Australian coasts are concerned, we feel that the littorinids (excluding Bembicium which is a mid and upper littoral inhabitant) should not be separated as a distinct zone, but regarded as simply the lower part of the supralittoral.

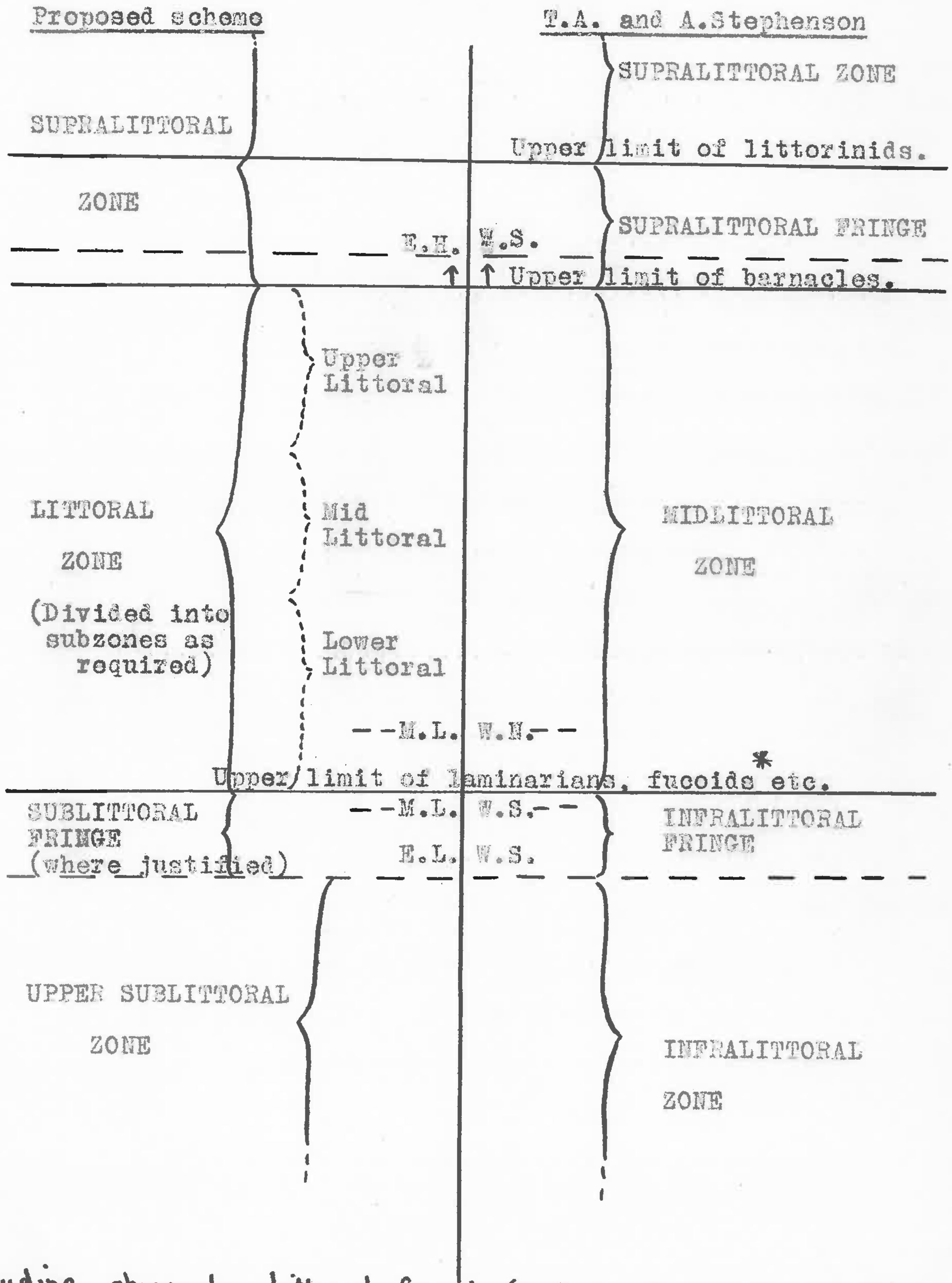
A further difficulty about the supralittoral fringe is that the organisms present in the littorinid zone are more closely related to the upper part of the littoral, and this region should therefore be called the "littoral fringe" if it is to be regarded as a fringe zone.

It appears difficult, and probably unnecessary, to recognise a supralittoral fringe zone in a general scheme. A supralittoral zone has been found adequate by most workers in the past. If zones within the supralittoral occur in particular localities, these can perhaps be referred to as upper and lower supralittoral zones etc.

The scheme which applies generally to the coastal zonation in South Australia, and which seems to be of more general application than that of the Stephensons, is summarised below: the Stephensons scheme is given alongside for comparison. Whether this scheme will prove to be of general application must rest on its critical examination and application to coasts elsewhere, especially coasts varying in topography and habitat conditions from typical rocky coasts.

Figure 1.

Comparison of Zonation Schemes.



* Excluding obviously littoral fucoids. (Such as Fucus spp. and Pelvetia in England, and Hormosira in Australia)

SOUTHERN AUSTRALIA IN STEPHENSON'S CLASSIFICATION OF SOUTHERN HEMISPHERE FAUNAS AND FLORAS.

Stephenson (1947) recognises three distinct littoral faunas on the South African coast, namely, a cold temperate one on the west coast (due to upwelling of cold water), a warm temperate one on the south coast, and a sub-tropical fauna on the east coast. His Plate XV shows the general distribution of southern hemisphere littoral faunas, primarily as described by Ekman, but modified for South Africa. Ekman's "Tiergeographie des Meeres" is not available to the writer, so this discussion must necessarily be based on Stephenson's map and comments.

Although Ekman's work was apparently based only on the fauna, Stephenson's took adequate account of the flora of the South African coast. It seems very probable however that Stephenson's map of southern hemisphere faunas applies equally well to the littoral floras, with certain modifications dealt with below.

Stephenson gives the following temperature limits of the different regions, basing them mainly on Ekman's data, and he comments that they agree very well with the temperature limits of the belts distinguished in the "Discovery" reports.

<u>Tropical-subtropical faunas</u> occur where the winter sea temperature does not fall below 20°C.

<u>Antarctic and sub-antarctic faunas</u> occur where the winter sea temperature falls to 0°C and the summer temperature does not rise above 10°C.

<u>Temperate faunas</u> inhabit the region between the above, where the winter sea temperature does not fall to zero but falls below 20°C. Within this region, warm temperate and cold temperate faunas may be distinguished.

> <u>Warm temperate faunas</u> occur where the winter temperatures are between 10°C and 20°C. Stephenson regards a summer range of 16-25°C as typical.
>
> <u>Cold temperate faunas</u> occur where the water temperature falls below 10°C in winter but not usually to zero. Summer temperatures may approach 20°C.

The water covering the organisms of the intertidal zone is likely to vary considerably more in temperature than the water even a few yards off shore when air temperatures are high.

While using sea temperature as a basis, Stephenson places considerable emphasis on the fauna and flora as an aid to defining the regions. In South Africa he regards the presence of a well defined "laminarian zone" in the upper sub-littoral as indicative of cold temperate conditions. The ascidian <u>Pyura</u> is absent (or not common) in this region, but becomes dominant in the sublittoral fringe under warm temperate conditions, where a laminarian zone is absent or very poorly developed. The laminarian zone is regarded as a characteristic feature of cold temperate coasts of the northern hemisphere.

When the concepts are applied to southern Australia, it is evident that certain modifications are necessary to Stephenson's map. Stephenson himself regarded the position of southern Australia and New Zealand as only tentative.

According to the sea temperature charts given by Sverdrup et al (1942), the southern Australian region lies between mean summer temperatures of 14°C and 20°C, and mean winter temperatures of 10°C to 15°C. These figures seem reasonable accurate, though inshore temperatures show a greater range, especially in calm shallow areas such as the Gulf region of South Australia. At the head of the Great Australian Bight summer temperatures may be higher than 20°C, but they are as yet very little known.

The southern Australian region is therefore just within the warm temperate range of temperatures, though the more southern parts such as Tasmania may well be regarded as on the verge of cold temperate conditions.

When the organisms of the upper sublittoral are considered, this region becomes clearer. The giant brown algae *Sarcophycus potatorum* and *Macrocystis pyrifera* occur around Tasmania and from just above the Victoria - New South Wales border around the Victoria coast to about Robe in South Australia. Of the medium sized brown algae, *Ecklonia radiata* occurs throughout the southern Australian region and *Phyllospora comosa* from Victor Harbour in South Australia to well up the New South Wales coast. These kelps and fucoids represent the lamarian zone of northern hemisphere and South African coasts, but only where the giant species (*Macrocystis* and *Sarcophycus*) occur can this kelp-fucoid zone be considered fully developed.

Along most of southern Australia *Pyura* seems to be absent (except for a few small localities in Victoria), but on the

New South Wales coast Pyura becomes a conspicuous feature at about low tide level. (Dakin, Bennett and Pope 1948).

When both sea temperature and the distinctive organisms of the upper sublittoral are considered, it appears that the coasts of Tasmania and Victoria (extending just into New South Wales and to Robe in South Australia) belong to the cold temperate region. Passing up the New South Wales coast the conditions become warm temperate and change to subtropical about or above the Queensland border.

The rest of the southern Australian coast from Robe westwards, and including Kangaroo Island, is best regarded as intermediate between typical cold temperate and typical warm temperate. Small kelps (Ecklonia radiata)and fucoids (Cystophora, Sargassum) only dominate the upper sublittoral, and Pyura does not occur till the warmer waters of the Western Australian coasts are encountered.

These modifications are shown in Figure 2, which is based on Stephenson's map; Parts of New Zealand and more of South America are also removed from warm temperate to cold temperate regions. The reasons for this will be discussed below.

While Tasmania and Victoria may be separated from the rest of southern Australia on ecological grounds, it has been shown in Part VI that these states are similar to the rest of southern Australia floristically. These two opposing view points depend on whether emphasis is to be placed on a few characteristic organisms, such as the large kelps and fucoids and Pyura, or whether the whole flora (and fauna) is to be considered. The southern part of Tasmania may show some floristic differences, for most collecting has been on the north coast of the island, but data is as yet insufficient.

Stephenson also suggested that at least the South Island of New Zealand might better be placed in the cold temperate region, and this would seem desirable, Around the South Island and lowest part of the North Island Macrocystis and Durvillea are features of the upper sublittoral, and Pyura is absent.

Reference may also be made to South America. Stephenson's map shows the warm temperate region commencing at about Puerto Montt on the west coast. However Howe (1914) describes how the Peruvian current flowing northwards along the coast brings cold antarctic waters up to the tropics. At Callao (latitude 12°S) the water temperature in early summer is 15-19°C and in early winter 16.5-19°C. The temperatures are apparently very similar for a thousand miles or more to the south. Also, giant kelps such as Macrocystis, Lessonia and Eisenia extend up the west coast of South America to the northern part of Peru.

While the sea temperatures of Peru are within the warm temperate range, the giant kelps point to cold temperate affinities. At least it seems likely that the cold temperate region extends considerably further up the west coast of South America than indicated in Stephenson's map.

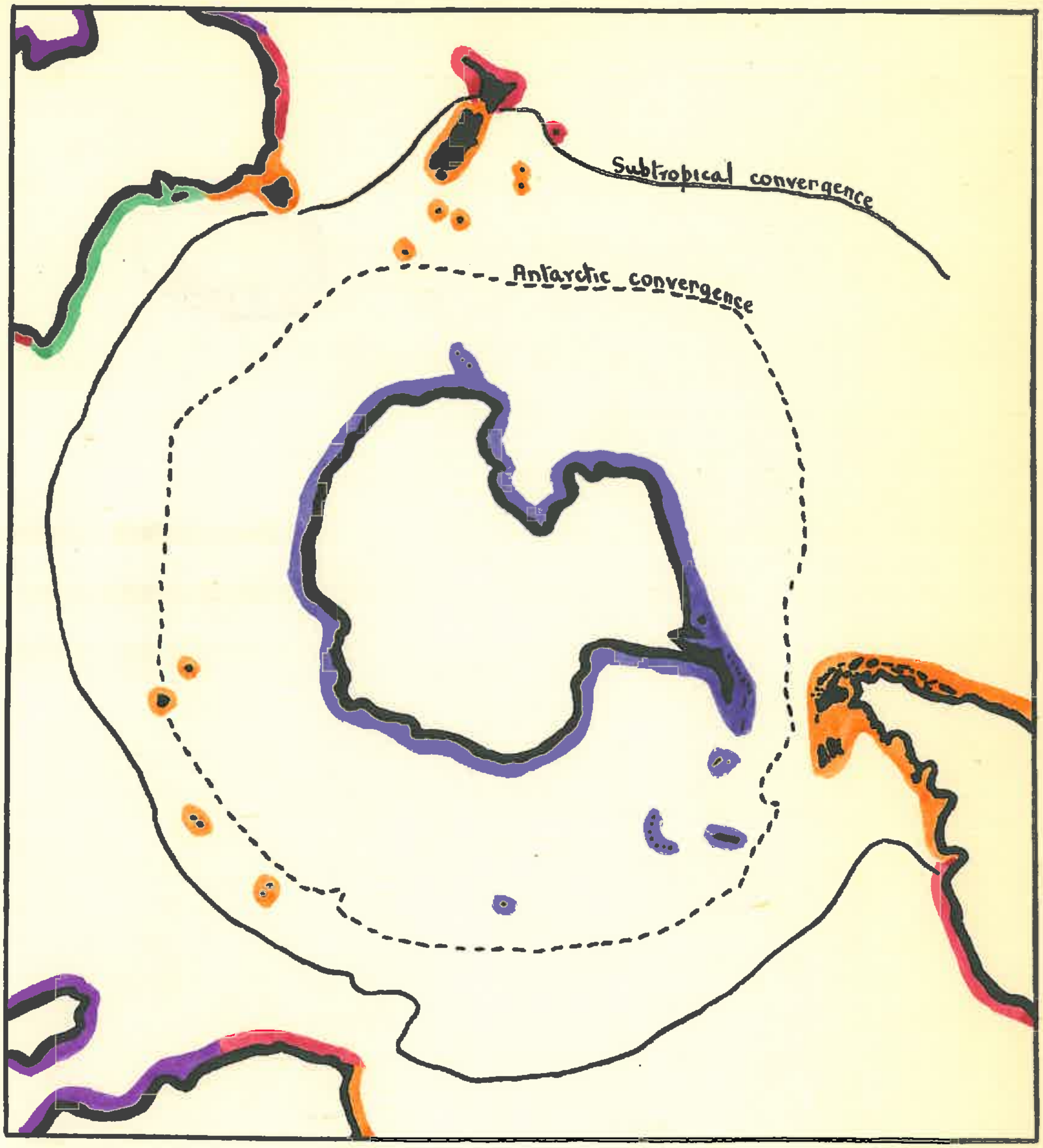


Fig. 2. Southern hemisphere littoral faunas and floras.

Antarctic and subantarctic

Cold temperate

Warm temperate

Intermediate cold-warm temperate

Tropical and subtropical

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