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The Seasonality of the algal epiphytes of *Posidonia sinuosa* in upper Spencer Gulf

by

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DECLARATION

This is to certify that the material contained in this thesis is the work of the author except where otherwise acknowledged and has not been accepted for the award of any other degree or diploma.

John E. Johnson

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SUMMARY

This study examined the seasonality of the "erect" algal epiphytes of *Posidonia sinuosa* near Redcliff Point, upper Spencer Gulf, between February 1975 and March 1977. During this period 17 collections of *P. sinuosa* were taken from eight permanently marked collection sites, with additional collections being made in September 1977 and June 1978.

The presence or absence of the "erect" algal epiphyte species on the distal one-third of the 30 longest whole leaves of *P. sinuosa* from each collection site was recorded and percentage frequency of occurrence of each of the species at each collection was estimated.

The density index, an estimate of the number of individuals in each species population within a standard leaf surface area, was estimated from the species' occurrence on the distal one-third of the nine longest whole leaves in each collection.

The size index, an estimate of the average size of the most common plants in each species' population, and also the reproductive state of the plants occurring on the seagrass leaf-blades was recorded.

53 "erect" algal species were recorded as epiphytic on *Posidonia sinuosa*. Species of Chlorophyta were inconspicuous compared to species of Phaeophyta and Rhodophyta.

Seven groups of "erect" epiphytes within three major categories were recognized in this study:

A. the Irregular Transient or chance species,

B. the Non-Seasonal species,

(i) those species that are present all year round,

(ii) those species which are irregular in their occurrence and are not present all year round,

C. the Seasonal species,

(i) the summer species,

(ii) the summer-autumn species,

(iii) the autumn-winter species and

(iv) the summer-winter species.

Five common non-seasonal species, *Sphacelaria* spp., *Jania micrarthrodia*, *Herposiphonia* sp. 1, *Polysiphonia decipiens*, and *Ceramium puberulum*, were nominated as potential indicator species and it was recommended that laboratory studies to determine the effects of pollution loads and/or environmental factors on the species' populations be undertaken.

The seasonal repetition of the "erect" algal epiphytic community was examined by cluster analysis of association values as determined by the Spearman Rank correlation coefficients of all the samples collected within a particular sampling site. Although many of the individual algal epiphyte species were sensitive to environmental changes and could prove to be valuable monitoring tools in a marine environmental monitoring programme, the strength of the seasonal repetition of the algal epiphytic community was not such that one would be able to determine if the differences observed in the algal epiphytic communities, collected at the same site and in the same season but in different years, were the result of a pollution source or a natural fluctuation. Therefore a minimum bi-monthly sampling programme would need to be included in any marine monitoring study utilizing the algal epiphytic community as an indicator parameter.

ACKNOWLEDGEMENTS

This study was conducted as part of a programme established by a former Director of South Australian Fisheries, Mr. A.M. Olsen, to examine some of the biological and physical parameters of upper Spencer Gulf. Mr. Olsen saw the need to establish a monitoring study in upper Spencer Gulf and was instrumental in obtaining financial support for the programme. I thank him for his continued support and direction throughout the study.

My Supervisor, Professor H.B.S. Womersley, not only provided direction and encouragement during the study but made freely available to me, laboratory space as well as his extensive literature and algal collections.

The permanent marking of the underwater sampling sites was exhaustive but effective and I thank Messrs. K. Branden, M. Nelson and L. Gray for assisting me. I would also like to thank them and the other divers, D. Roberts, H. Kirkman, G. Wright and R. Kennedy for assisting in the collection of the subtidal seagrass samples under all seasonal conditions, which was not always a pleasant task.

I acknowledge the field assistance, accommodation and workshop facilities that Mr. J.D. Reilly provided on-site at Chinaman Creek-Redcliff Point throughout the field programmes.

Ms. Kathy Haskard designed and ran the computer programme to determine the Spearman Rank Correlation coefficients between the collections (Tables 51-74).

I would also like to thank Messrs. I. Kirkegaard (Assistant Director - Fisheries) and R. Stevens (Director of Fisheries) for allowing the study to continue through to completion.

Finally I am indebted to Miss Julie Bailetti for typing the final manuscript.

Key to abbreviations used with the reproductive plants

(Tables 9-42).

-	reproductive plants absent
X	samples not collected
f	female plants present
m	male plants present
⊕	tetrasporangiate plants present
O	monosporangiate plants present
Z	plants with zoospores present
S	sori present on the plants
sp	plants with sporangia present
p	plants with propagula
+	fertile plants present but not identified

CHAPTER ONE: INTRODUCTION

Three industrial towns are situated on the coast of northern Spencer Gulf, South Australia. These are Whyalla on the western coast, with iron and steel works and ship-building yards; Port Augusta at the head of the gulf, with a large coal-burning power station and railway workshops; and Port Pirie on the eastern coast, with silver, lead and zinc smelters. A petrochemical complex has also been planned for Redcliff Point, on the eastern coast between Port Pirie and Port Augusta, though this plant is not as yet proceeding.

Although some degree of pollution is evident from the above established industries, especially of heavy metals and thermal effluent, no in depth studies have been reported from within northern Spencer Gulf on the effect of the effluents, either chemically or biologically.

The most common, often dominant, subtidal plants in the region are seagrasses (particularly *Posidonia* spp)., which occur generally from low tide level down to 10 m depth, on sandy-mud bottom. Above low tide level, the seagrass *Zostera* occurs sporadically, and the mangrove *Avicennia marina* var. *australasica* fringes many parts of the coast in the upper intertidal region.

Upper Spencer Gulf is also a commercial fishing area and is particularly important as a nursery for several species, such as western king prawns, *Penaeus latisulcatus*, King George whiting, *Sillaginodes punctatus*, western sand whiting, *Sillago schomburgkii*, and garfish *Hyporhamphus melanochir*. With the proposed major development of a petrochemical complex near

Redcliff Point, it became particularly important to gain baseline data of the marine biology of the area. With good baseline data, further monitoring during and following the establishment of the complex would permit a far better assessment of the effect of the plant and its effluent. In particular, with knowledge of natural seasonal effects and quantitative data, the effect of effluents could be separated from the natural variation.

The purpose of this study was therefore to:-

(1) Gain an understanding, over2-3 years, of the occurrence and the seasonal variation of the algal epiphytes on the *Posidonia sinuosa* leaves, and

(2) attempt to select epiphytes which might be suitable as "indicator species" for an affected environment, and which could be monitored in detail following the establishment of the complex.

Review of the relevant Literature.

(a) The taxonomy and biology of Australian seagrasses

Seagrasses are aquatic angiosperms that are completely adapted to life in the intertidal and shallow coastal marine areas (Den Hartog 1970). The coastal waters around Australia are well-endowed with seagrasses, and as early as 1792 Labillardiere found a sterile seagrass on the West Australian coast near Cape Leeuwin and described it in 1806 under the name *Ruppia antarctica*. Gaudichaud (1826) collected the same species in 1818 at Shark Bay, Western Australia. Harvey (1855) mentions seagrasses only incidently, however Bentham (1877) listed from Australia seven genera of marine angiosperms. Ostenfeld, who was an early student of seagrass taxonomy and ecology, published several papers relating to

Australian seagrasses. In 1914 he discussed the distribution of 30 known seagrass species and arranged them into 8 groups. The "Australian Group", which was placed in the broad category of a warm-temperate zone, contained 5 species. In 1916 he described and discussed 7 seagrass species from West Australia. Ostenfeld (1929) listed 15 seagrass species that he had recorded around the Australian coast and in 1930 made further additions to the localities at which these 15 species had been recorded.

One of the earliest reports on the zonation and occurrence of marine angiosperms in South Australia was Womersley (1947), when he described the "sand and sandy-mud" formation of Kangaroo Island. He mentioned that in relatively calm areas, especially American River Inlet, the intertidal flats are colonized by the brown alga *Hormosira banksii,* and the seagrass *Zostera muelleri* (now known to be *Heterozostera tasmanica).* In the deeper water, from Low Water Spring to 3 m depth, *Posidonia australis* colonizes the sand and mud flats. However in Eastern Cove, Kangaroo Island, *Posidonia* extends its range to 13 m depth. A third marine angiosperm, *Halophila ovalis,* was observed to form dense patches between 0.6 m and 4 m depth.

Wood (1959a, b) described some of the seagrass communities of eastern Australia, and according to Wood, *Posidonia* normally occurs in waters with slight turbidity from 0.6 m to 10 m below low tide mark, while *Zostera* is commonly found on sandy-mud flats from low tide mark to about 6 m depth. Larkum (1976) and Hutchings & Recher (1974) reported similar seagrass zonation boundaries in Jervis and Careel Bays, eastern Australia, respectively. However Larkum (1976) noted that *Posidonia australis* only grew down to 3 m depth in Botany Bay, New South Wales.

Womersley & Edmonds (1958) gave a general account of the intertidal ecology of the South Australian coast and reported that the marine angiosperms, *Heterozostera* and *Posidonia* were common along coasts of slight wave action with sandy or muddy flats or beaches. This type of habitat included a number of semi-enclosed bays on Eyre Peninsula and the north east coast of Kangaroo Island and much of the northern parts of Spencer and St. Vincent Gulfs. In more recent years Shepherd & Womersley (1970, 1971, 1976) have examined the sub-tidal ecology of several islands along the South Australian coast and have reported several seagrasses, including *Posidonia australis* (broad and narrow leaf forms) and *Amphibolis antarctica*, as occurring in sheltered areas around these islands. Morphological and taxonomic studies on *Posidonia* species by Kuo 1978, Kuo & Cambridge 1978 and Cambridge & Kuo 1979 have clarified the broad-leaf and narrow-leaf taxa. The broad-leaf taxon is *P. australis* and two narrow-leaf taxa have been recognized, *P. angustifolia* and *P. sinuosa*.

Subtidal marine surveys by the S.A. Department of Fisheries (unpublished reports, 1973, 1974) in upper Spencer Gulf drew attention to the extensive seagrass beds in this part of the gulf. The most common seagrass to be observed from Low Water Mark to 10 m depth was the narrow leaf form of *Posidonia australis* (=*P. sinuosa*). *Zostera mucronata* was confined to the intertidal sandy-mud flats, *Amphibolis antarctica* was common between 0.8 m and 7.2 m depth, while the broad leaf form (true) *P. australis* was recorded from Low Water Mark to 6 m depth.

Much of the emphasis of studies on Australian seagrasses has been on their zonation and distribution although it was early this century their importance to coastal productivity was first indicated in the classic studies of eelgrass *(Zostera marina* L.) in Danish waters (Petersen 1891, 1913; Ostenfeld 1908; Petersen & Boysen-Jensen 1911; Boysen-Jensen 1914). Since the late 1950's studies in Australia have mentioned the importance of these coastal seagrass habitats as nursery and feeding areas for many animal species and more recently estimates of the leaf productivity of *P. australis* have been reported. Kirkman & Reid (1979) estimated the average relative leaf growth of this species in Port Hacking, New South Wales, was 2.3 mg C g dry wt^{-1} day^{-1}, and the leaf growth rates showed a seasonal trend and high correlation with surface water temperature. West & Larkum (1979) recorded that leaf blade production rate for the same species at Chinaman Creek near Redcliff Point, upper Spencer Gulf in summer was 5.5 g dry wt m^{-2} day^{-1}, and in winter was 2.7 g dry wt m^{-2} day^{-1}, with a leaf turnover of 7.7 mg dry wt m^{-2} day^{-1}. They concluded that leaf blade production rates of *P. australis* in comparison to other temperate plant communities were quite high and surpassed in general only by production in agricultural crops and in turn suggested that this primary production was likely to be significant in supporting the food-web in waters in which *P. australis* occurred. Furthermore their estimates for Botany Bay, New South Wales, indicated that the seagrass communities contributed a major proportion of the total primary production within the bay.

(b) Seagrass Communities as fish habitats

Wood (1959a, b) reported that the *Zostera* community was rich with plant and animal life, including bacteria, diatoms, flagellates, ciliates, blue-green, green, brown and red algae. He also commented that the flora of the mud substrate around the seagrasses was distinct from the epiphytic flora. The organisms, including the epiphytes, serve as food for phytophagous fish (e.g. the mullets) and gastropods, while the nudibranch, *Aplysia*, and the garfish, *Hemirhamphus ardelio* (now *Hyporhamphus regularis ardelio* (Collette 1974)) have also been observed to consume *Zostera* itself (Thomson 1959; Wood 1959b). Swans were noted to feed on the stolons of *Zostera* plants and have been observed to leave bare areas susceptible to wave and current erosion, Hutchings & Recher (1974) also reported that the *Zostera* zone was a most important feeding area for diving and wading birds in Careel Bay. These authors pointed out that the invertebrate fauna of the *Zostera* and *Posidonia* habitats were dominated by detritus feeding animals, which must rely on bacteria, fungi and small invertebrates to break down the leaves, algae and other organic material of the seagrass habitat to a size which can be ingested by the detritus feeders. The detritus feeders are in turn fed upon by predators. Dredge et al. (1977) believed that the leaf litter from the seagrass beds and mangroves acts as the base of the food chain for juvenile fish and penaeid prawns in Tin Can Bay Queensland.

Hutchings & Recher also reported that the seagrass flats supported large numbers of young fish of commercially important species and that these fish depend on the shallow waters for their early growth and survival.

Bell et al. (1978a) state that the sub-adult fortescue, *Centropogan australis,* appeared to be highly dependent on the *Posidonia australis* habitat and its invertebrate community as a food source in Port Hacking, New South Wales. Further studies (Bell et al. 1978b) showed that three leatherjacket species associated with the seagrasses of Port Hacking were highly dependent on the encrusting fauna, epiphytic algae and other epifauna and infauna of this habitat and suggested that little of the seagrass consumed was digested by the fish. Conacher et al. (1979) examined the feeding ecology of one of these leatherjacket species, *Monacanthus chinensis*, in Botany Bay, and found that significant amounts of labile carbon compounds from the seagrass and algae were removed and assimilated during digestion.

Robertson (1977) in his study on King George whiting, *Sillaginodes punctatus*, in Western Port, Victoria, determined that the whiting depend on the seagrass flats and their associated macrofauna through the first three years of its life, and studies by the S.A. Department of Fisheries (unpublished data) confirm that the shallow subtidal seagrass areas of South Australia are nursery areas for several commercial fish species.

(c) Pollution effects on algae and seagrasses

Since early this century it has been recognised that pollution of coastal waters may affect the growth of benthic algae. Cotton (1910, 1911) examined the link between the luxuriant growth of *Ulva* and sewage pollution and other workers (Sawyer 1965; Subbaramaiah & Parekh 1966; Golubic 1970) have confirmed his findings. The value of benthic marine algae as indicators of pollution has been demonstrated in Norway (Sundene 1953; Grenager 1957; Munda 1974), in the Netherlands (Den Hartog 1959), in the U.S.A. (Clendenning & North 1960; North 1969), in the British Isles (Burrows 1971; Burrows & Pybus 1971; Edwards 1972; Pybus 1973) and in Australia

(Borowitzka 1972). Also Edwards (1975) demonstrated that a reduction in algal species abundance may be associated with various industrial pollutants. Furthermore algae have been demonstrated to accumulate heavy metals (Bryan 1969, 1971; Bryan & Hummerstone 1973; Preston et al. 1972; Young 1975; Seeligeer & Edwards 1977; Romeril 1977) including radioactive isotopes (Czapke 1966; Tanaka et al. 1973).

The algae that live on seagrasses are also potentially good indicators of pollution because they are distributed through the water column, exposed to light, nutrients,wave action, tidal flow, are of relatively small size, have simple morphology and structure and according to Harlin (1975) are sensitive to environmental changes.

The epiphytic algae of *Posidonia sinuosa* are likely to be better indicators of pollution than the host plant because northern hemisphere studies (Wood & Zieman 1969; Roessler & Zieman 1969; Zieman 1970) have indicated that *Thalassia* with its extensive rhizome mat, similar to that of *Posidonia*, is not severely affected by short term variations in its environment, as are the inshore algae.

CHAPTER TWO: UPPER SPENCER GULF AND THE STUDY AREAS

A. The Region

Spencer Gulf is located in southern Australia (Fig. 1) and penetrates deeply into the Australian continent. Upper Spencer Gulf referred to in this study is that part of Spencer Gulf north of 33°S latitude. The width of the gulf at this latitude is 15.2 km, but near the entrance to the upper basin Ward Spit projects 10.2 km south-westwards from the eastern shore into the gulf creating a relatively narrow opening (about 6.7 km) into upper Spencer Gulf (Fig. 2). The gulf gradually narrows northwards of Lowly Point until abreast of Snapper Point (32°34'S, 137°47'E) it is approximately 1 300 m between the mangroves on either side and the gulf assumes the appearance of a river. North of Snapper Point a thermal power station has been located. The city of Port Augusta (population C. 14 000) is at the head of Spencer Gulf.

The major geological features of upper Spencer Gulf are the Torrens Sunkland, a major downfaulted block lying between two horsts, the Flinders Rangers to the east and the Stuart shelf to the west (Chittleborough _et al._ 1974). The horst blocks are composed of igneous rocks and indurated sediments of Precambrian age which are in parts folded and faulted. Sediments in the Torrens Sunkland are generally flat lying and unconsolidated (Dow E.E.S. 1980).

B. The Environment

Upper Spencer Gulf has a narrow channel basin up to 24 m deep flanked on either side by shallow sublittoral platforms. The intertidal region is of varying width, but is generally wider along the eastern shore than the western shore of the Gulf.

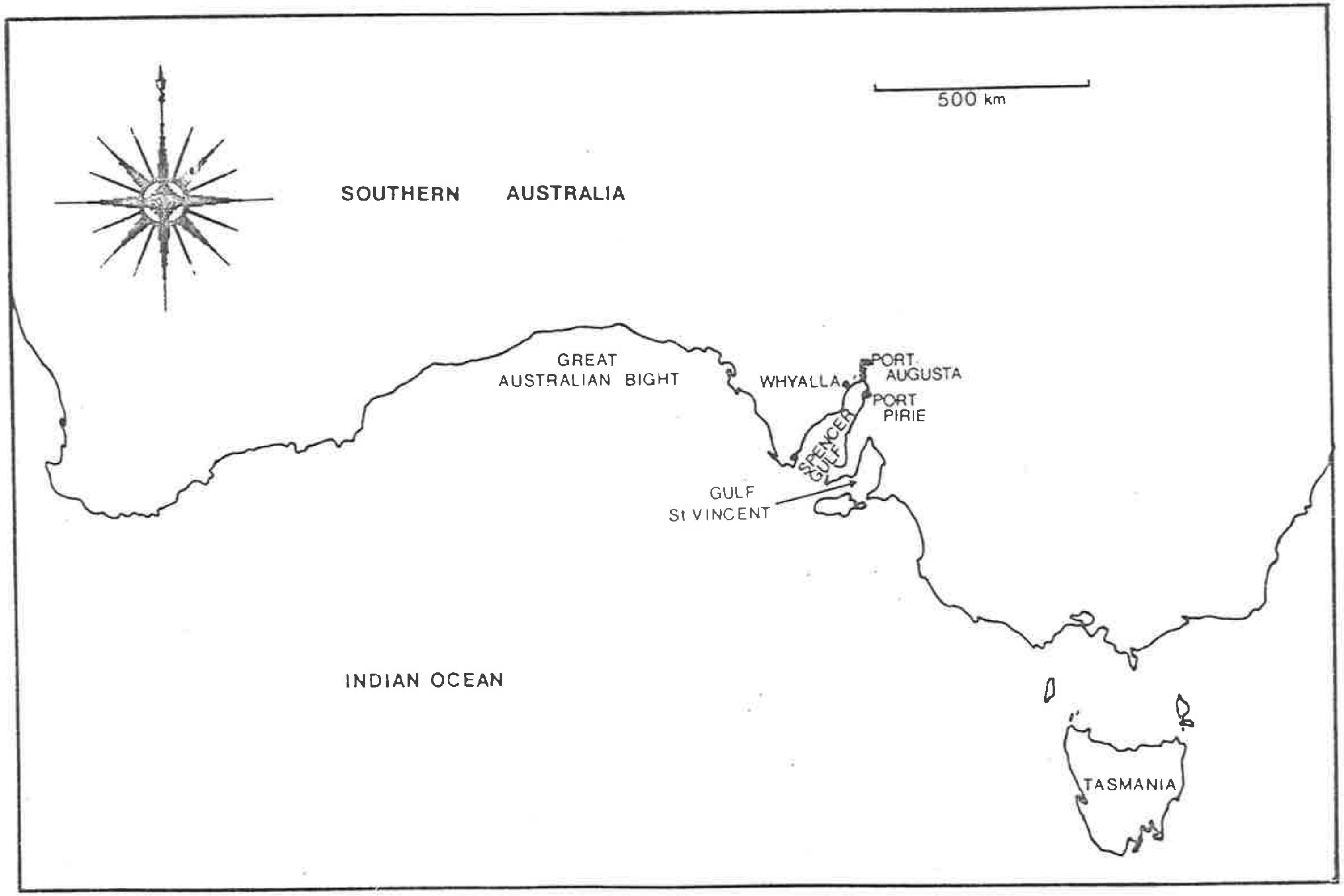

Fig. 1: Map of southern Australia showing Spencer Gulf, where this study was conducted.

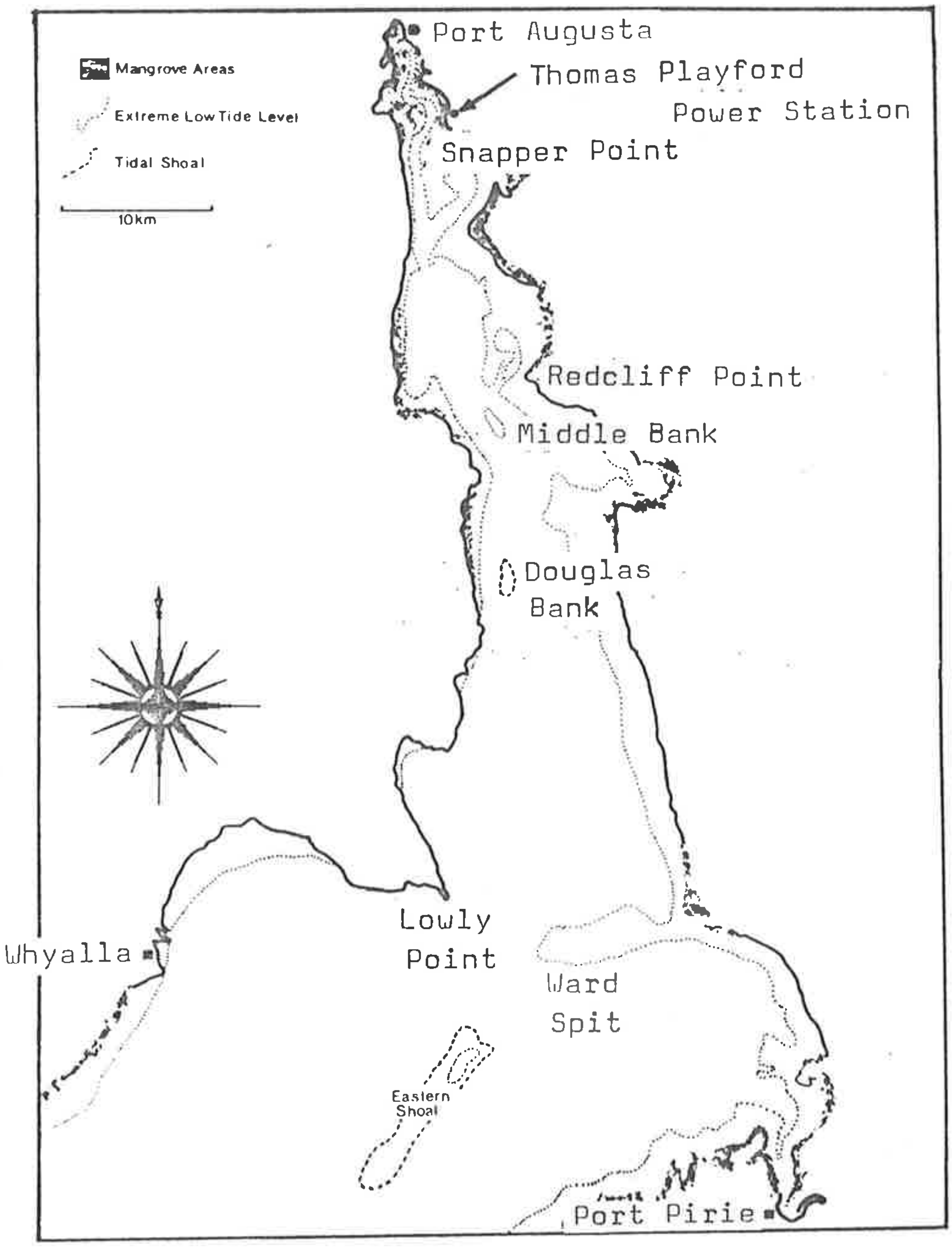

Fig. 2: Map of upper Spencer Gulf showing Redcliff Point in relation to the industrial centres of Whyalla, Port Augusta and Port Pirie.

1. Physical and Chemical Parameters

(a) Climate

The macroclimate of the region is formed by weather systems travelling in seasonally shifting belts from west to east and a monsoonal wind system generated by temperature differences between the Australian continent and the southern Indian Ocean.

According to meteorological records, from the South Australian Bureau of Meteorology most rain in upper Spencer Gulf falls during mid-autumn to mid-spring and Port Pirie receives more winter rain than Port Augusta. Mean maxima and minima air temperatures at Port Augusta and Port Pirie are within 1°C throughout the year. Air temperatures at Port Augusta range from hot during summer (average daily maximum temperature in January, 32°C) to cool in winter (average daily maximum temperature in July, 17°C).

The local climatic conditions near Redcliff Point are modified by the geological features of upper Spencer Gulf. The north-south configuration of the gulf and the mountain ranges on each side of it in the upper part cause the winds to be funnelled in a northerly or southerly direction. Prevailing winds are southerly and are reinforced in summer by a strong seabreeze system. Breezes are more common and stronger in the afternoon.

(b) Tides

Spencer Gulf experiences a semi-diurnal astronomical tide the range of which varies from 3.1 m at Whyalla, 3.5 m at Port Pirie to 3.9 m at Port Augusta (Radok, 1978). In addition the gulf waters are subject to mean sea level changes and these have raised on occasions the astronomical tide by up to 2 m (Provis & Radok, 1979).

In upper Spencer Gulf spring tides occur near the time of the new or full moon phases of the lunar cycle, with the highest tides occurring between 0 and 3 days after these lunar phases. During spring periods the tides are semidiurnal with a tidal period of 12½ hours duration, but the two daily tides may be almost equal in amplitude or markedly different or intermediate.

The 'dodge' effect in upper Spencer Gulf occurs during the neap period. At times only one tide per 24 hrs occurs for 2-4 days, whereas on other occasions a more typical 'dodging' tide occurs with the water level remaining almost stationary for up to 2 days.

(c) Wave Action

Wave action is wind dependent and generally waves are less than 1.25 m high near Redcliff Point.

(d) Water Temperatures

In the channel areas, the summer average (23°C) and winter average (13°C) seawater temperatures are quite uniform throughout upper Spencer Gulf and there is little difference between the average daily surface and bottom temperatures (Table 1). However the surface water near the Thomas Playford Power Station, Port Augusta, is generally 1.0 - 1.5°C warmer than the bottom water, as a result of warm water effluent flowing from the station.

Table 1: Summer average (from readings taken by S.A. Department of of Fisheries) (months Dec. - Mar.) and Winter average (months June - Aug.) temperatures for surface and bottom water at ten sites in upper Spencer Gulf for January 1974 to April 1978.

Site	Sea Water Temperature			
	Summer Average ^{o}C		Winter Average ^{o}C	
	Surface	Bottom	Surface	Bottom
Whyalla	22.7	22.8	13.1	13.3
Port Pirie	23.9	23.6	12.0	11.9
Point Lowly	22.8	22.9	12.8	13.0
Backy Point	22.9	22.9	13.7	13.5
Douglas Bank	23.4	-	13.6	-
Two Hummock Point	23.0	23.0	12.9	12.9
Middle Bank(West)	23.1	23.1	12.8	12.8
Middle Bank(East)	23.0	23.1	11.4	12.9
Power Station	25.3	23.5	14.1	13.6
Port Augusta - Road Bridge	23.2	23.2	13.1	13.1

The annual winter temperature ranges recorded in the channel at the Port Augusta road bridge, Middle Bank (eastern channel) and Douglas Bank is 14^{o}C (Figs 3,4,5) although the difference between summer average and winter average temperatures was 10^{o}C. Seawater temperatures on the tidal flats were not recorded.

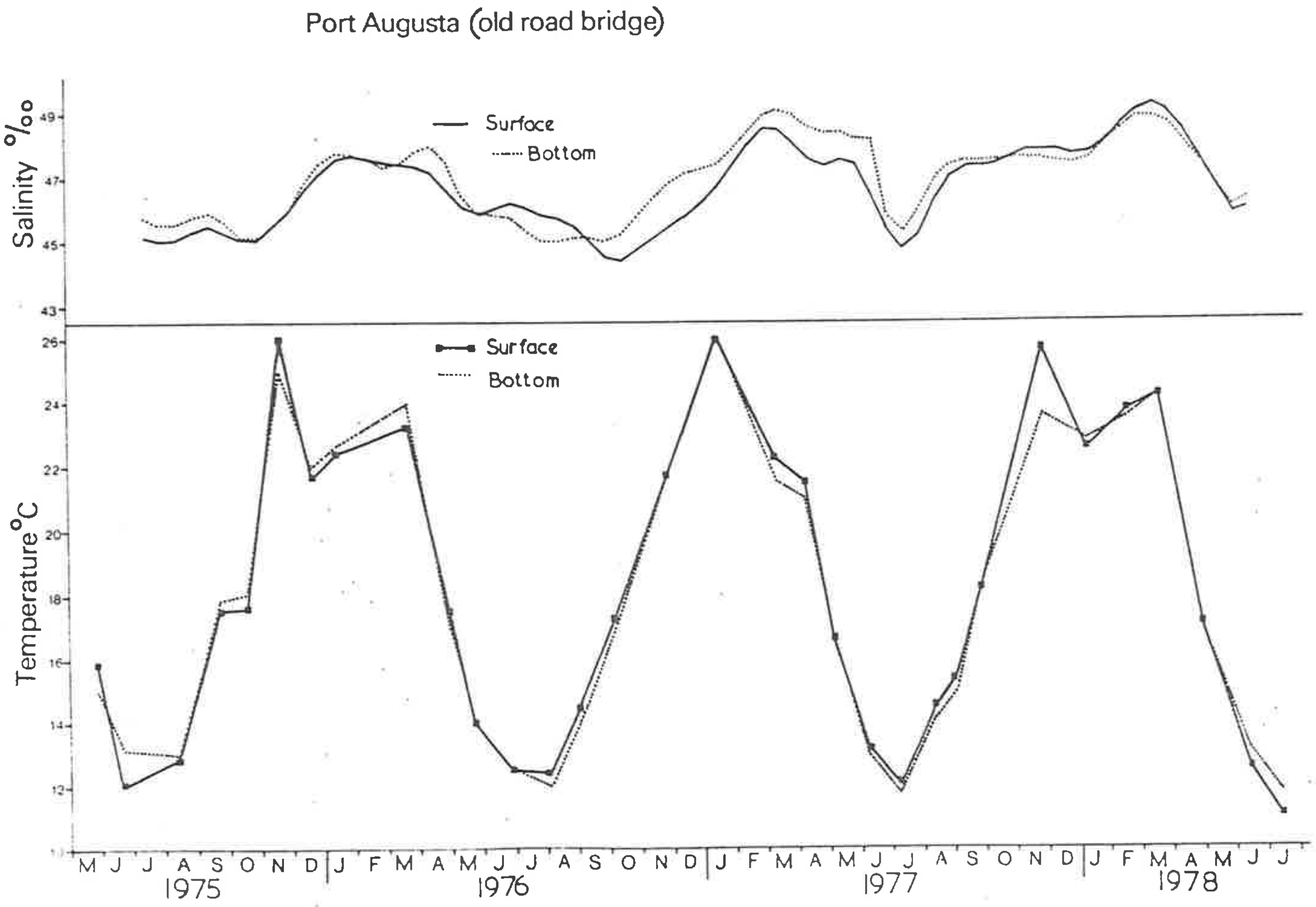

Fig. 3: Surface and Bottom Salinity (‰) and Water Temperature (^{o}C) recorded between May 1975 and July 1978 at the old road bridge, Port Augusta, upper Spencer Gulf.

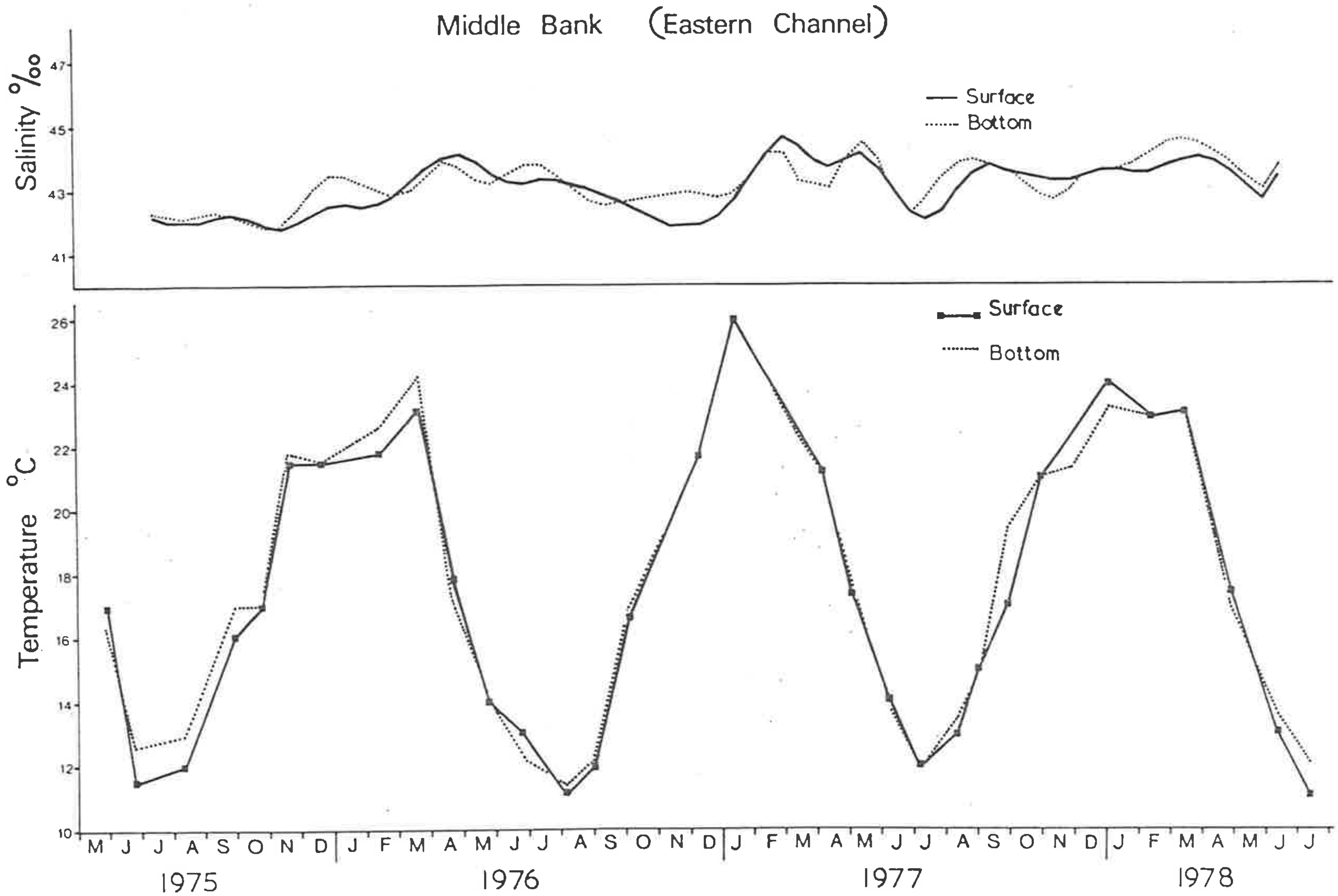

Fig. 4: Surface and Bottom Salinity (‰) and Water Temperature (°C) recorded between May 1975 and July 1978 at Middle Bank (eastern channel), upper Spencer Gulf.

Surface Salinity (‰) and Temperature (°C) recorded at Douglas Bank.

N.B. Salinities at all sites showed an increase between June 1976 and Dec. 1976.

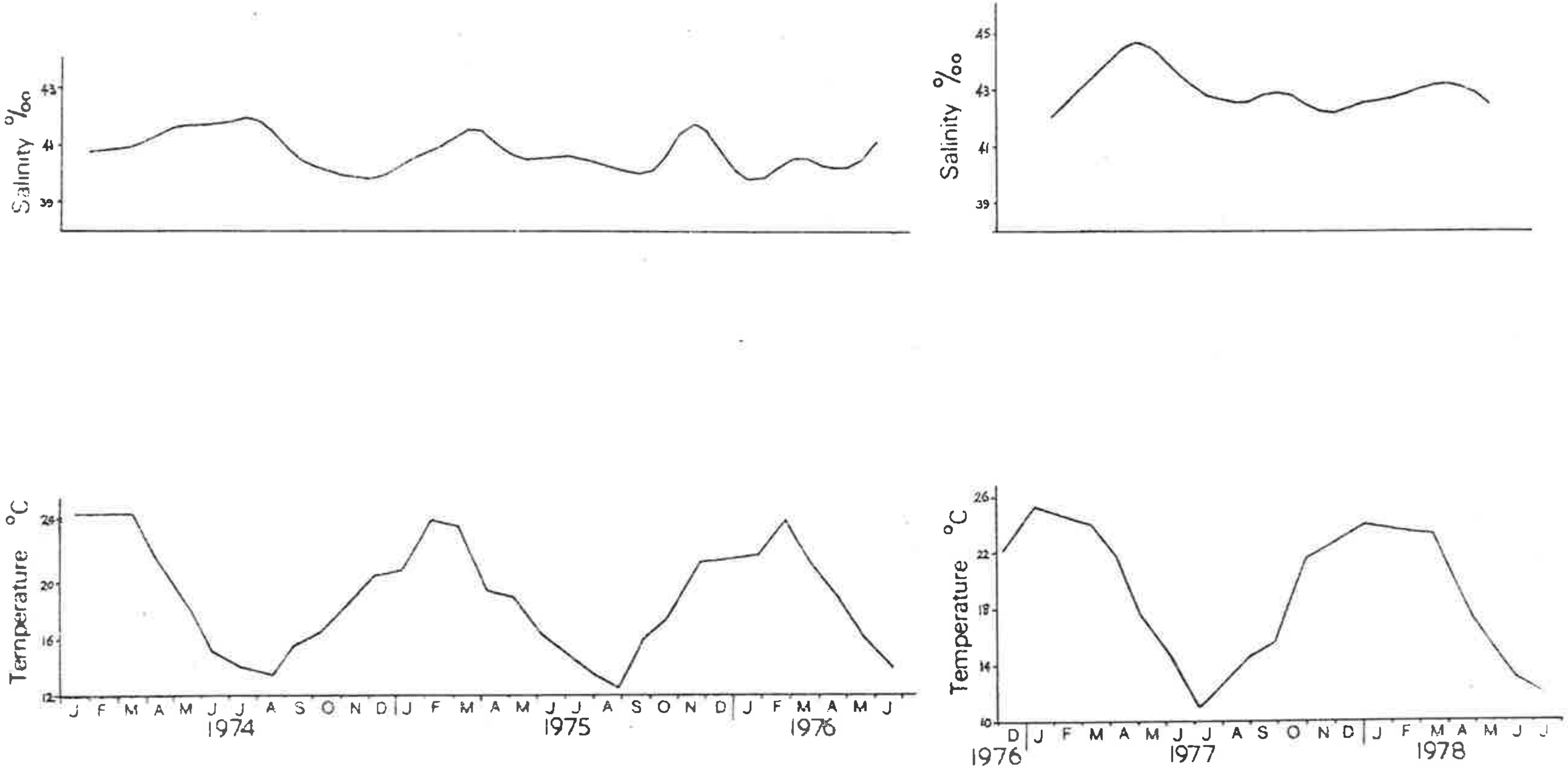

Fig. 5: Surface Salinity (‰) and Water Temperature (°C) recorded between January 1974 and July 1978 at Douglas Bank, upper Spencer Gulf.

(e) Salinity

The summer salinity levels range from 48‰ near Port Augusta at the head of the gulf, to 42‰ near Lowly Point and to oceanic (35.8‰) near the southern entrance to the Gulf. The winter salinity levels for the same three sites ranges from 46‰ to 41‰ down to oceanic, respectively.

The salinity of the water at the Port Augusta road bridge is seasonally higher during January-April (48‰) (Fig. 3). The minimum salinity at this site of 44‰ was recorded in July 1977, while the maximum salinity of 49.4‰ was recorded in March 1977. At the other water sampling sites in upper Spencer Gulf these seasonal salinity differences are not so apparent.

As would be expected in an almost totally enclosed body of water with limited water exchange, the range of salinities (Table 2) increases towards the north of upper Spencer Gulf.

Table 2: The salinity range (‰) recorded by the S.A. Department of Fisheries for surface and bottom water samples at ten sites in upper Spencer Gulf from January 1974 to April 1978.

	Salinity Range ‰	
	Surface	Bottom
Whyalla	38.7 - 41.6	38.8 - 41.5
Port Pirie	41.2 - 47.2	41.4 - 47.2
Lowly Point	40.2 - 42.8	40.3 - 43
Backy Point	39.9 - 44.8	40.0 - 43.8
Douglas Bank	39.5 - 45.0	-
Two Hummock Point	40.8 - 44.3	40.6 - 45.2
Middle Bank (West)	41.5 - 45.2	41.6 - 45.4
Middle Bank (East)	41.5 - 45.4	41.5 - 45.6
Power Station	42.2 - 47.2	43.5 - 46.8
Pt. Augusta - Road Bridge	44.0 - 49.1	44.3 - 49.4

Figures 6 and 7 show that salinity levels increase from Two Hummock Point to Port Augusta bridge. Upper Spencer Gulf may be described as a "hyper-saline" or "negative" estuary, occurring in an arid region of very slight runoff, where water exchange is poor because of the restriction between Lowly Point and Ward Spit, and salinities are higher than in the ocean.

(f) Oxygen

Oxygen samples were collected during the day usually between 10 a.m. and 4 p.m. at monthly intervals at eleven sites in upper Spencer Gulf between May 1975 and October 1978 by the South Australian Department of Fisheries. These

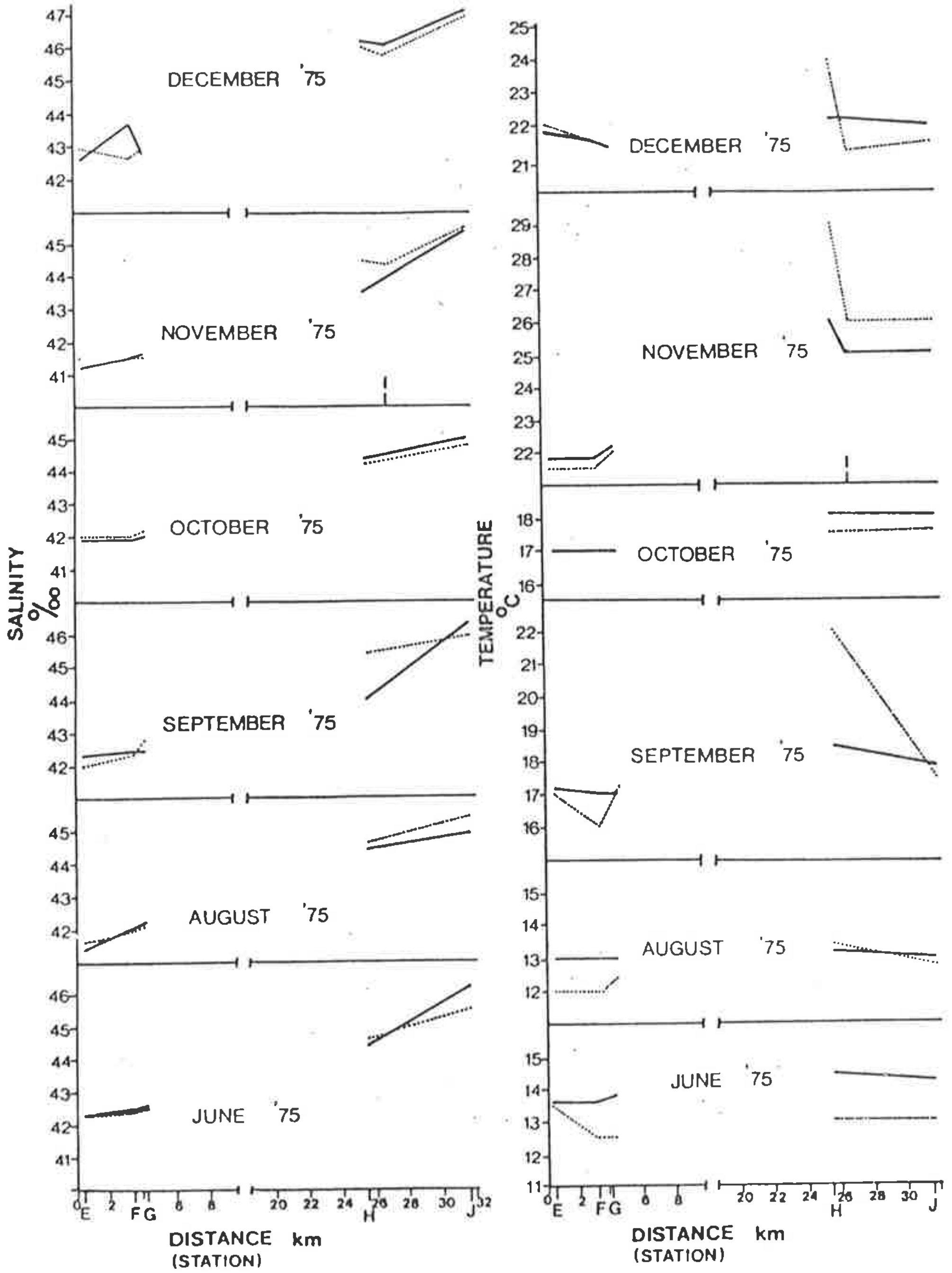

Fig. 6: Surface and bottom salinities (‰) and Water temperatures (^{o}C) at 5 water sampling stations in upper Spencer Gulf. Sampling stations are plotted in relation to their distances apart.

Station	E	Two Hummock Point
	F	Middle Bank - eastern channel
	G	Middle Bank - western channel
	H	Channel opposite Thomas Playford Power Station
	J	Old road bridge, Port Augusta

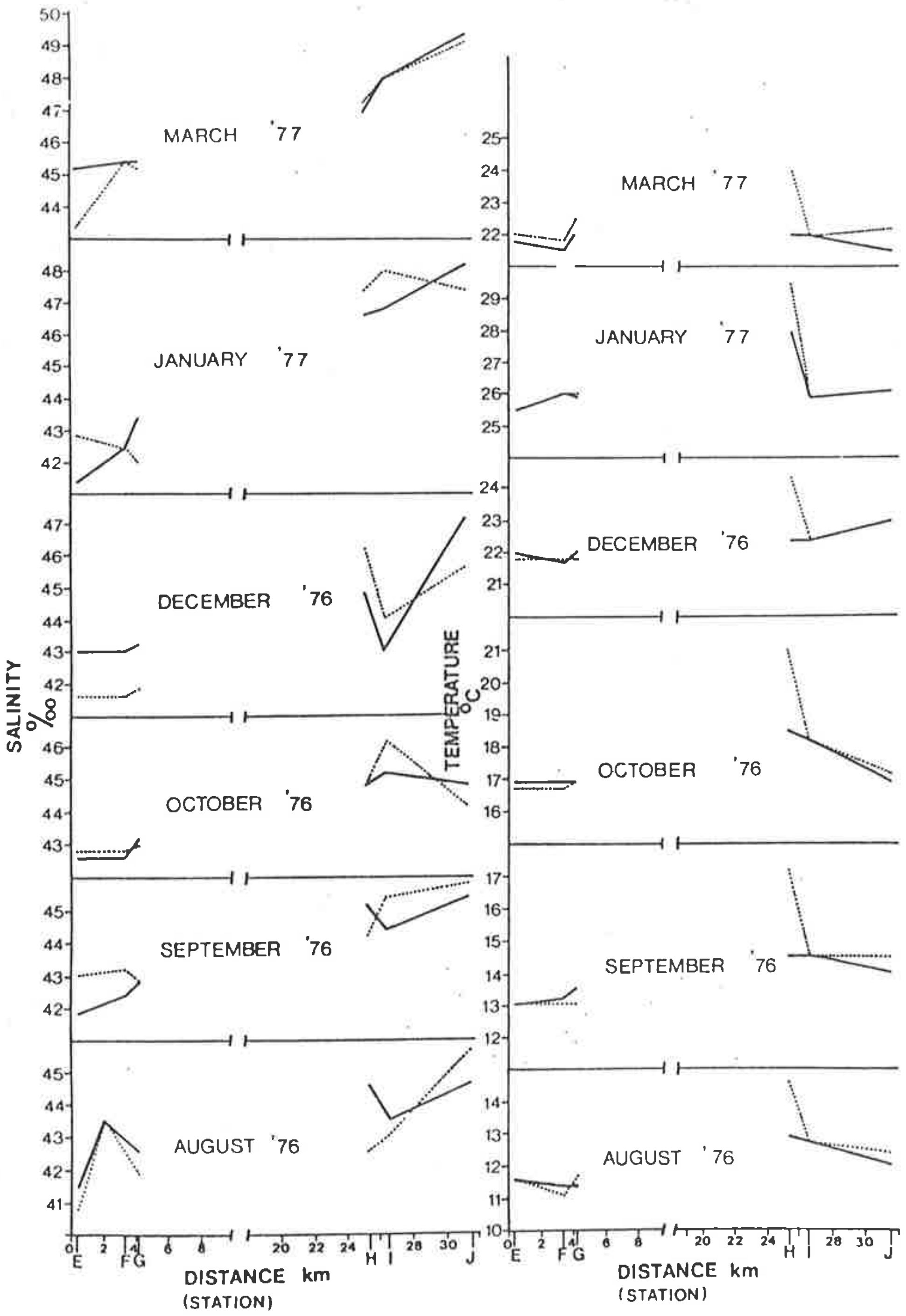

Fig. 7: Surface and bottom salinities (‰) and water temperatures (°C) at 6 Water sampling stations in upper Spencer Gulf.

Station E Two Hummock Point
F Middle Bank - eastern channel
G Middle Bank - western channel
H Channel opposite Thomas Playford Power Station
I Channel north of Curlew Point
J Old road bridge, Port Augusta

samples were analysed by the South Australian Department of Services and supply, Chemistry Division using the Winkler's method as described by Major *et al.* (1972).

Oxygen percent saturation values were calculated from the S.A. Department of Fisheries unpublished data according to the equation:

$$O_2 \text{ (\% Saturation)} = \frac{O_2(\text{ml/l}) \times (33.5 + T^{o}C) \times 100}{332.4 - (1.854 \times s‰)}$$

where T = water temperature (^{o}C)

and S = water salinity (‰),

from Richards & Corwin (1956).

The oxygen percent saturation values near Redcliff Point were always high with little difference between surface and bottom samples (Table 3).

Table 3: Oxygen percent saturation values at Middle Bank (Eastern Channel) upper Spencer Gulf.

	Oxygen Percent Saturation Values			
Sample	Range	Mean	Standard Deviation	Sample Size
Surface	94 - 126	106	±7.4	27
Bottom	95 - 123	105	±7.3	28

These values indicate that there is considerable mixing of surface and bottom waters, and oxygen content of the water would not be a limiting factor in the growth of marine organisms in the area.

(g) Nitrate and Nitrite

The nitrate levels recorded in upper Spencer Gulf are variable and the mean values of nitrate and nitrite were low (Table 4). This is not unusual in South Australian waters, especially in the gulf systems where there is an absence of any large rivers supplying a nutrient input.

Table 4: Mean Nitrate and Nitrite Values (µg at. N/l) at Middle Bank (Eastern Channel), upper Spencer Gulf (S.A. Department of Fisheries, unpublished data).

*Nitrate and Nitrite Values (µg at. N/l)			
	Mean	Standard Deviation	Sample Size
Nitrate:	0.29	±0.30	108
Nitrite:	0.11	±0.10	108

*Sea water samples were analysed for Nitrate and Nitrite by the South Australian Department of Services and Supply, Chemistry Division using the Cadmium Reduction method as described by Major et al. (1972).

There was no seasonal variation in the nitrate values recorded at Middle Bank East, opposite Redcliff Point, during the study period.

(h) Inorganic Phosphate

The surface water values of inorganic phosphate near Redcliff Point (Station: Middle Bank East) were lower than values recorded for the bottom water (Table 5).

Analysis of the sea water samples was carried out by the South Australian Department of Services and Supply, Chemistry Division by the Single Solution method as described by Major *et al.* (1972).

Table 5: Mean Inorganic phosphate concentrations (µg at. P/l) at Middle Bank (Eastern Channel), upper Spencer Gulf (S.A. Department of Fisheries, unpublished data).

	Inorganic Phosphate Concentration (µg at. P/l)		
Sample	Mean	Standard Deviation	Sample Size
Surface	0.12	$\pm$0.122	36
Bottom	0.22	$\pm$0.270	36

Inorganic phosphate values are generally low in the South Australian gulfs (Rochford, 1975) and the surface values recorded during the Fisheries Branch Study ($\approx$0.1 µg at./l) are similar to those listed by Rochford.

2. Biological Aspects

The marine environment below high water mark may be separated into two broad zones:

(a) the intertidal zone, and

(b) the sublittoral zone.

The two zones provide a variety of habitats suitable for colonization and succession by many marine organisms and combined are a support system for an intricate food web.

(a) Intertidal zone

Tidal fluctuations are the prime cause of zonation of organisms in the intertidal region, and tidal fluctuations produce the clearest zonation where the tide range is greater and more regular and where sea conditions are calmest (Womersley & Thomas 1976).

The intertidal zone may be separated into three smaller zones:

(a) the supralittoral (or littoral fringe) zone,

(b) the eulittoral zone, and

(c) the sublittoral zone.

On the eastern side of the Gulf along the sandy beach shoreline between Redcliff Point and Mount Grainger, the supralittoral zone is absent and the upper eulittoral zone is marked by the drift of organic debris left by the receding tide.

Associated with the drift are small isopods, amphipods, bacteria and polychaete worms capable of breaking down the organic material into a form able to re-enter the food web.

The long sand-bar at the end of Redcliff Point projects out into the narrow basin of upper Spencer Gulf, and the east coast of upper Spencer Gulf north of Redcliff Point is more protected from wind and water movement than the coast between Redcliff Point and Mount Grainger. Consequently on the leeward side of Redcliff Point there is a series of extensive sandy-muddy intertidal flats severed by deep-water channels. In this area to the north of Redcliff Point the supralittoral zone is characterized by samphires (*Salicornia* and *Arthrocnemum* species) growing from where the lower stems may be covered by high tides to well above high tide level, but subject to high salt levels in the substrate.

The mangrove, *Avicennia marina* var. *australasica*, extends from the upper eulittoral zone into the supralittoral.

The mangroves not only provide nesting sites and shelter for the abundant and diverse avifauna but are associated with numerous other animals, e.g. molluscs *Bembicium auratum, Austrocochlea constricta, Cominella lineolata, C. eburnea, Salinator solida,* and the crustacean *Helograspus haswellianus*.

The mid-eulittoral zone both north of Redcliff Point and south-eastwards to Mount Grainger is characterized by many small mounds of sand and mud indicating the presence of a detrital feeding community of small bivalve molluscs, polychaetes, gastropods and crustaceans.

The lower eulittoral zone between Redcliff Point and Mount Grainger is colonized by a sparse community of *Zostera mucronata*. However, north of Redcliff Point the lower eulittoral zone is represented by two different communities. The seagrass, *Zostera mucronata,* has colonized the muddy areas, while the bivalve mollusc *Pinna bicolor* with the brown alga *Hormosira banksii* attached to the *Pinna* shells are the most common colonists of the sandy areas. In some areas the bivalve molluscs, *Austromytilus erosus* and *Malleus meridianus* have colonized the sandy flats in association with *Pinna bicolor*. Numerous polychaete worms, small crustaceans and small molluscs may be found on or just below the surface of both the sandy and muddy flats.

Near Redcliff Point, many of the lower eulittoral flats to the north do not slope gently down to sublittoral platforms colonized by *Posidonia* spp., instead the flats are severed by deep water channels possibly formed by strong tidal currents. The edges of these channels are almost vertical and may drop from 0 m to 8 m depth in less than a metre distance. In other areas the intertidal flats gradually slope down to sublittoral platforms that are usually colonized by several seagrass species.

(b) Sublittoral zone

Six sublittoral seagrass species are commonly recorded in the area; *Zostera mucronata, Heterozostera tasmanica, Amphibolis antarctica, Posidonia australis, P. sinuosa* and *Halophila ovalis.*

On the eastern shore of Spencer Gulf near Redcliff Point, *Zostera mucronata* extends from the intertidal region to 0.4 m depth where it is displaced by *Posidonia australis. Heterozostera tasmanica* grows usually in association with the *Posidonia* species, but near the lower limit of *P. sinuosa's* distribution, it has been noted in monospecific stands. *Amphibolis antarctica* is present on the sublittoral platforms from 0.8 m to 7.2 m deep below Low Water Mark.

Posidonia australis is the most common seagrass from Low Water Mark to less than 5 m depth and occurs in monospecific stands as well as in association with *Zostera mucronata, Amphibolis antarctica, Posidonia sinuosa* and *Heterozostera tasmanica.*

Posidonia sinuosa may be found in water less than 5 m deep but occurs in extensive monospecific stands between 5 m and 10 m depth throughout upper Spencer Gulf. This seagrass also occurs in association with *Heterozostera tasmanica, Amphibolis antarctica, Halophila ovalis* and *Posidonia australis*.

Halophila ovalis colonizes the sublittoral platform at the edge of the main channels usually between 10 m and 13 m depth and apart from being found in association with other seagrasses it is often found growing with the green alga, *Caulerpa cactoides*.

The channel bottom is characterized by large pebbles and coarse sand indicative of strong current flows. The bottom is almost barren, however a few red algae , *Laurencia brandenii, Neurophyllis aciculare, Dasya extensa,* and the ascidians *Sycoza pedunculata* and *Polycarpa pedunculata* are the most common benthic organisms.

CHAPTER THREE: THE COLLECTION SITES

A. Selection of the Study Sites

The decision by the South Australian Government to make available an area of land near Redcliff Point as a site on which to establish a petrochemical complex and the proposed location of the jetty, loading bay and effluent outfall from the industrial complex influenced the positioning of the study sites.

Three sites, A,B, and C were selected (Fig. 8). Two study sites were located near the proposed jetty and outfall; study site A to the north and study site B to the south. The third study site (C) was positioned outside of the range of the daily tidal transport from the possible outfall location. Hence site C was to be considered as a control study site for monitoring studies after the petrochemical complex was operating.

Preliminary surveys by the S.A. Department of Fisheries (1973, 1974) reported extensive stands of *Posidonia* near Redcliff Point, upper Spencer Gulf. A survey in this area (Johnson, unpublished data) showed that the epiflora of the sublittoral seagrasses, *Posidonia* and *Amphibolis* species, was more abundant and diverse than that of the intertidal seagrass *Zostera mucronata*. Therefore the study was confined to the epiflora of the most common sublittoral seagrass in the area, *Posidonia sinuosa,* and a study transect was established at each of the study sites;

(1) Transect A: 2 km south-west of Redcliff Point (approximately 2 km north-west of the proposed jetty),

(2) Transect B: 4.5 km south of Redcliff Point (approximately 2 km south-east of the proposed jetty) and

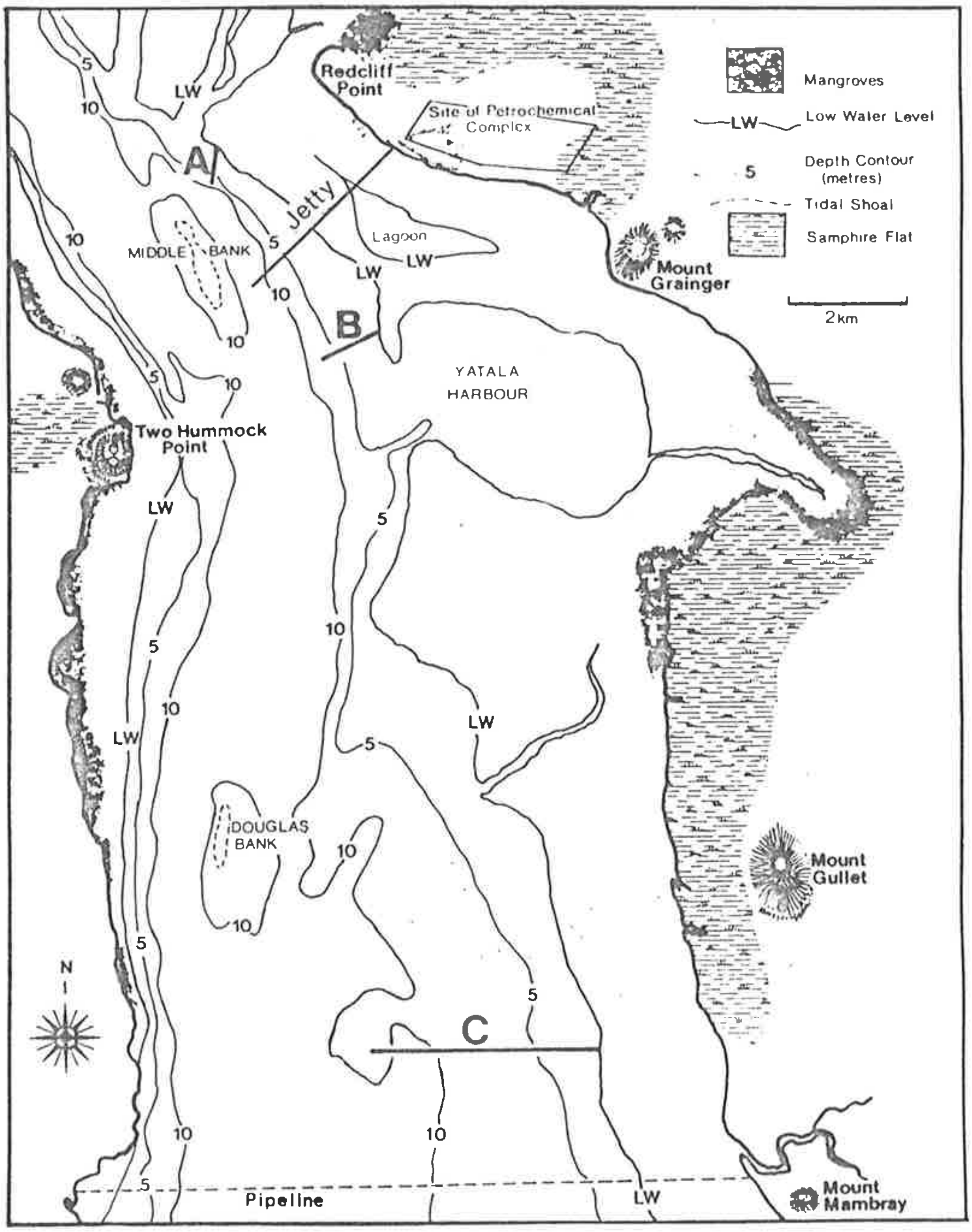

Fig. 8: Redcliff Point south to the submarine pipeline across upper Spencer Gulf, showing the location of the study sites A, B and C, in relation to the proposed siting of the petrochemical complex and the jetty.

(3) Transect C: 16.3 km south of Redcliff Point.

It was decided that the "erect" algal epiphytic community on the *Posidonia sinuosa* leaves should be monitored near the upper, middle and lower limits of the host species' depth range, so collection sites were selected at 2 m, 7 m, and 10 m depths below Low Water Mark.

B. Establishment of the Collection Sites

The bottom topographies of the three transects were first recorded from a Fisheries research vessel by a Furuno-FE502 echosounder; the tide height, chart speed, boat speed and sea conditions at each site were noted. The depth profiles (Fig. 9) were adjusted to Low Water Mark and the location of the 2 m, 7 m, and 10 m deep collection sites on each transect were determined. These sites were buoyed and permanent anchors and buoys were placed at the 2 m collection sites. The anchor for the 2 m buoy on each transect was a 45 kg concrete disc, with 0.5 of stainless steel chain set in the centre. A 5 m length of polypropylene rope attached the buoy to the chain. The anchor was buried in the sediment beneath the seagrass bed by a SCUBA diver. The buoys and their ropes at the 7 m and 10 m sites were removed after the establishment of the permanent sampling stations so they did not hinder shipping or commercial fishing activities in the area. After all collection sites on a transect were buoyed, a 150 m long lead line was fed out from the stern of the boat, so that the centrepoint of the line coincided with the buoy's anchor position. The lead line, which was at right angles to the line of the transect, was marked along its length at 5 m intervals and was anchored and buoyed at each end. At each 5 m interval a wooden stake 2 m x 2.5 cm x 2.5 cm was driven vertically, by a SCUBA diver using a hand-held pile driver, 1.2 m into the substrate. A 4 m

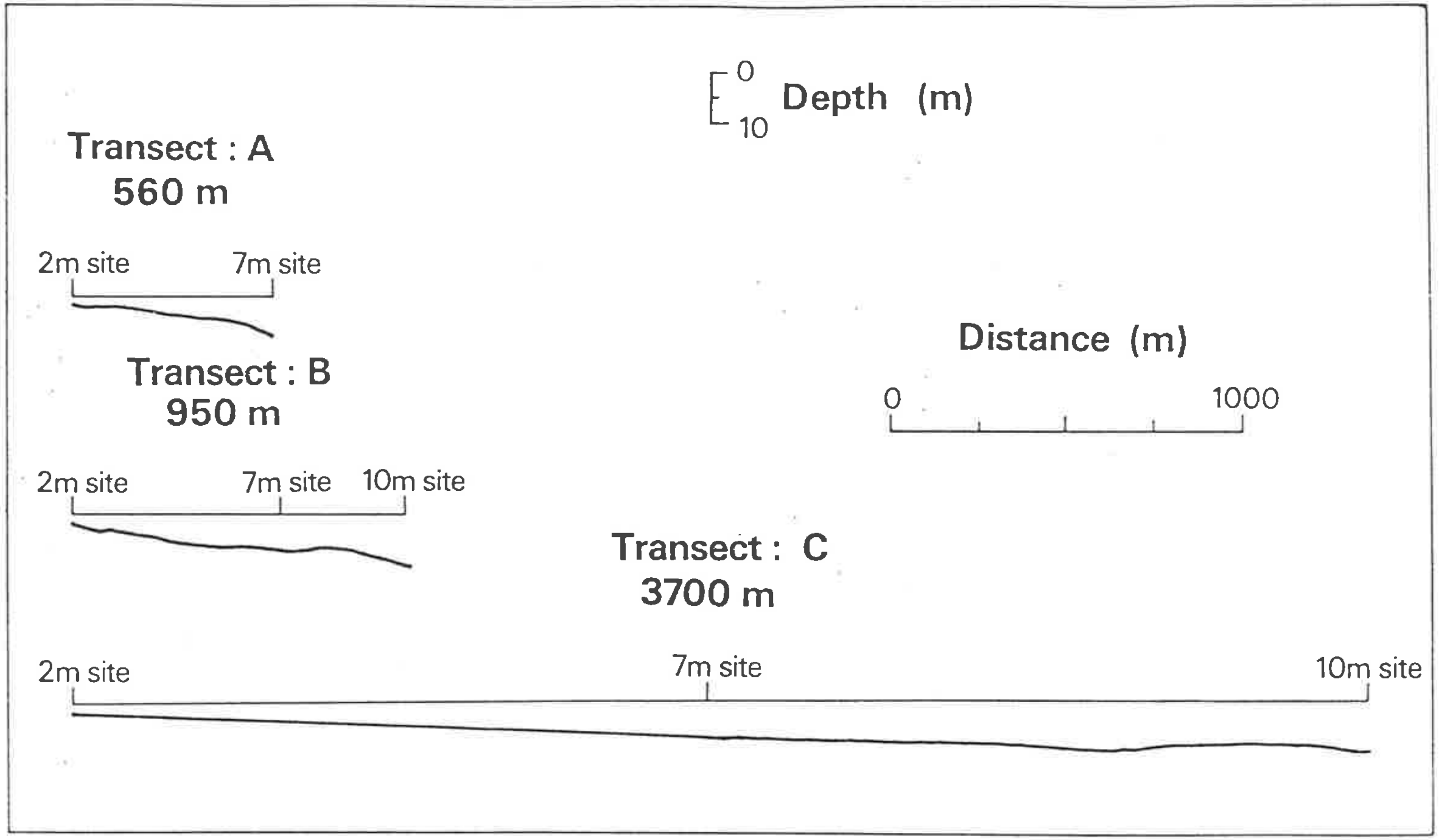

Fig. 9: Depth profiles of Transects A, B and C.

length of polypropylene tape was attached to each wooden stake after it had been placed in position. The centrepoint of the row of 30 wooden stakes, was marked by two (2 m) steel stakes driven into the substrate by the same method used on the wooden stakes. This whole procedure to establish three permanent sampling sites was repeated at each collection site. The permanent sampling sites were 75 m apart in a straight line perpendicular to the line of the study transect, one within 5 m of each end of the row of wooden stakes and the third around the centre-marking stakes.

Each study transect is described as a central permanent line, marked by landmarks on the shores of upper Spencer Gulf, running perpendicular to shore from Low Water Mark out beyond 10 m depth. At sites 2 m, 7 m and 10 m deep below Low Water Mark, along the transect, is a row of 30 wooden stakes, each 5 m apart, parallel to shore. The centre of each row of stakes is marked by two steel stakes. The shallowest collection site (2 m depth) on each transect was permanently buoyed.

It was discovered that the lower limit of the seagrass *Posidonia sinuosa* on Transect A was 8 m depth below Low Water Mark, hence the 10 m depth collection site and the corresponding sampling stations for this transect were not established.

C. Description of the Study Transects and the Collection Sites

1. Transect A

Transect A was located 2 km south-west of Redcliff Point and ran from Low Water Mark to 8 m depth along 189° from North (True). The seabed was of a gentle slope, 1 in 100, along the transect for 560 m between the 2 m and 7 m sites.

Cover of the seagrasses at each collection site on each transect was estimated visually by a SCUBA diver as a percentage cover of the seagrass leaves of each species over the substrate when viewed from vertically above.

Posidonia australis was the most common seagrass from Low Water Mark to 4 m depth. At 2 m depth there was 100% seagrass cover; *Posidonia sinuosa* and *Amphibolis antarctica* contributed 20% and 5% respectively, while *P. australis* accounted for the remaining 75%. Along the transect, between 3 m and 5 m depth, *P. sinuosa* became more common, *A. antarctica* disappeared and *P. australis* became less common. At 7 m depth *P. australis* was no longer present but *Heterozostera tasmanica* and *Halophila ovalis* were found in association with *P. sinuosa*, and the total seagrass percentage cover was 57%.

The seagrass community's depth limit was between 8 m and 9 m depth, therefore the 10 m deep collection site on this transect was not established.

2. Transect B

Transect B was 4.5 km south of Redcliff Point along a straight line joining Mount Grainger and Two Hummock Point at 245.5^{o} from North (True). The total length of the transect was 950 m with 590 m between the 2 m and 7 m deep sites and 360 m between the 7 m and 10 m deep sites. The slope of Transect B was 1 in 100.

From Low Water Mark to 4 m depth the most common seagrass was *Posidonia australis*. At the 2 m deep collection site, *P. australis*, *P. sinuosa* and *Amphibolis antarctica* contributed 70%, 25% and 5% respectively to a 100% seagrass cover. The abundance and cover of *Posidonia sinuosa* increased along the transect into deeper water and from 5 m depth it was the most common seagrass. The 7 m deep collection site was situated in a *P. sinuosa* community (94% cover) with patches of *P. australis*(5% cover) and *Heterozostera tasmanica* (1% cover). *P. australis* was rarely recorded greater than 7 m depth along this transect. The seagrass community became less dense towards the 10 m deep site and at 10 m depth the percentage cover of *P. sinuosa* and *H. tasmanica* was 66% and 4% respectively.

The lower limit of the seagrass bed was 11 m depth and patches of the green alga *Caulerpa cactoides* sparsely covered the seabed.

3. Transect C

Transect C was 16.3 km south of Redcliff Point, located by landmarks between Mount Gullet and Mount Mambray, running at 269° from North (True) commencing at Low Water Mark. The slope, 2 in 1000, of this 3700 m transect was less than those of Transects A and B.

Amphibolis antarctica, Posidonia australis and *Zostera mucronata* were the most common seagrasses in less than 2 m depth. *Z. mucronata* did not extend its distribution beyond 1.5 m depth and at the 2 m collection site the seagrass community comprised of *A. antarctica* (10% cover), *P. australis* (85% cover), *P. sinuosa* (4% cover) and *Heterozostera tasmanica* (1% cover). Along the transect into deeper water, *P. australis* and

A. antarctica became less abundant while *P. sinuosa* increased in abundance and cover. At the 7 m deep site, *P. australis*, *P. sinuosa* and *H. tasmanica* contributed 3%, 86% and 1% respectively to the total seagrass cover. The seabed along Transect C from the 7 m to the 10 m deep sites was colonized predominantly by *P. sinuosa* with patches of *H. tasmanica*. However, between 2700 m and 2900 m along the transect *H. tasmanica* was found as a monospecific stand of 75% cover. At the 10 m deep site these two seagrasses formed a mixed community of 83% total cover (Table 6).

Table 6: Total Percentage Seagrass Cover at Study Sites on Transects A, B and C, showing the percentage contribution by the 3 seagrass species, *Amphibolis antarctica, Posidonia australis* and *P. sinuosa*.

% Cover Seagrass Species

Transect	Depth	Amphibolis antarctica	Posidonia australis	Posidonia sinuosa	Other Seagrass	% Total Seagrass Cover
	2	5	75	20	-	100
A	7	-	-	49	8	57
	10	-	-	-	-	-
	2	5	70	25	-	100
B	7	-	5	94	1	100
	10	-	-	66	4	70
	2	10	85	4	1	100
C	7	-	3	86	1	90
	10	-	-	80	3	83

There was no rock substrate present along any of the transects. The larger bivalves, *Pinna bicolor, Pecten meridionalis, Katelysia scalarina, Malleus meridianus, Ostrea angasi* and *Equichlamys bifrons* provided a solid substrate for larger algae, *Haloplegma priessii, Asparagopsis armata, Sporochnus radiciformis, Laurencia brandenii, Coelarthrum muelleri, Jeannerettia pedicillata* and sessile fauna. Shepherd (S.A. Department of Fisheries, Report 1973) gave a brief list of the more common epizoic fauna of *Pinna bicolor (= P. dolobrata)* in the Redcliff Point region.

CHAPTER FOUR: METHODS

A. Relocation of the Study Sites and Collection of Samples

The study sites were visited at approximately six-weekly intervals from February 1975 to March 1977.

The line of the study transect was positioned by landmarks, but to increase efficiency in relocating the stakes, marker buoys were placed at the 2 m deep site on each transect. Buoys were not placed at the deeper study sites because of their possible hindrance to boating and fishing activities in upper Spencer Gulf. When the 2 m deep site was found, a SCUBA diver collected the seagrass samples at each of the three sampling stations. The row of stakes, with the tape attached, was used as an underwater guide by the diver to relocate each of the permanent sampling stations. At a sampling station the diver collected about ten handfuls of *Posidonia sinuosa,* including the leaf basal-sheaths*, and placed these in a labelled plastic bag. Having completed the 2 m depth collection site and returned the samples to the boat, the diver was ready to relocate the 7 m and 10 m deep collection sites (if present) on the transect.

The diver was towed by a boat along the line of the transect, and using a manta-board he was able to sled across the sea-bottom, just above the seagrass bed. On siting the row of wooden stakes at 7 m depth, the diver dropped a lead weight (1½ kg) alongside the stakes. The weight was attached to a small (10 cm diam.) orange and white buoy by a nylon cord which unfurled and allowed the buoy to float to the surface. A coloured buoy was used for easier location on the surface from the boat on rough days when "white-water" made it difficult to find white buoys. The diver continued to be towed along the line of the transect until the 10 m deep site was

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*Sampled areas were avoided in following collections.

located and buoyed in a similar manner.

At the 7 m and 10 m deep sites the seagrass samples were collected by a SCUBA diver in the same manner as at the 2 m deep site.

The samples were retained in the labelled plastic bag and preserved in a 5% formaldehyde and 95% seawater mixture on return to the shore. The samples were packed in black plastic barrels and transported to the laboratory for sorting and microscopical examination.

The collections at all study areas were completed within 2 days, and if weather and sea conditions permitted, in one day.

B. Sample Selection

The preserved samples of seagrass were washed in water and the whole leaves of *Posidonia sinuosa* removed. This was repeated for each sub-sample. All of the whole leaves from each of the sample areas at a collection site were pooled. The leaf length of at least fifty of the longest leaves were recorded.

After the first collection, February 1975, it was necessary to determine a suitable number of leaves that should be examined to estimate the total number of algal epiphytic species represented at a sample site. The cumulative number of algal epiphytic species versus the cumulative number of *P. sinuosa* leaves, which represented a progressive increase in sample area, was plotted for the 7 m deep site on Transect B. The graph showed that after microscopical examination of 10 leaves in the sample, 24 (83%) out of a total of 29 algal species had been recorded. Table 7 shows similar results were recorded for the other collection sites.

Table 7: Cumulative Number of Algal Epiphytic Species recorded on 10, 20, 30 and 40 *Posidonia* leaves examined from samples collected at each of eight permanent sampling sites in February 1975.

	Collection Site	Number of *Posidonia* leaves examined 10	20	30	40
Cumulative Number	A2 m	20	20	21	21
of Algal Epiphytic	A7 m	25	26	31	31
Species on the	B2 m	25	25	28	32
Posidonia leaves	B7 m	24	25	29	29
at each Collection	B10 m	24	27	28	28
Site	C2 m	20	23	25	25
	C7 m	22	24	26	27
	C10 m	25	25	26	26

The results showed that a sample of forty leaves would give an accurate estimate of the total number of algal species present in the epiphytic community of the *Posidonia* leaves. Although presence and absence data were relatively simple to record for a sample size of forty leaves, the time required to examine and record the species' density for this sample size was not available during the period of the study. A sample of the nine longest leaves was selected to estimate the density of the algal species.

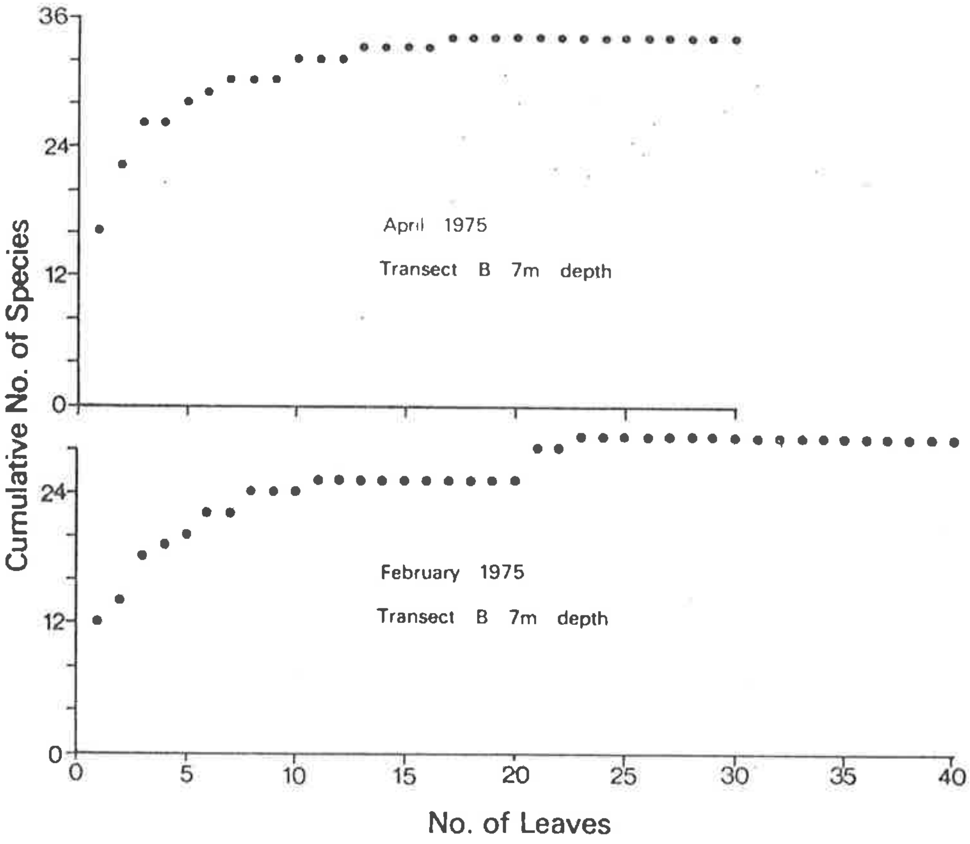

Fig. 10: Species - area graphs for the algal epiphytic community on the distal one-third of *Posidonia sinuosa* leaves at Transect B, 7 m depth, Feb. 1975 and Apr. 1975.

Only the distal one-third of whole *Posidonia* leaf blades were microscopically examined so estimates of species' density were restricted to the climax community on the leaf sample at each site.

A second graph of the cumulative number of algal epiphytic species versus the cumulative number of *P. sinuosa* leaves for the 7 m deep collection on Transect B in April 1975 was drawn, both to check the results of the February collection and to examine the effect on the estimate of algal species in the community by reducing the leaf sample size. It was considered on the results of both the February and April 1975 species-area graphs (fig. 10) that minimal loss of information on the species in the algal epiphytic community would occur if the sample size was reduced to the thirty longest leaves from each collection site.

Summarizing, the leaf subsamples from each depth were pooled and the length of the fifty longest leaves was recorded. From this sample, the thirty longest leaves were selected (in the February 1975 collections, the forty longest leaves were chosen) for microscopical examination of the occurrence of the algal epiphytes on the distal one-third of the leaf blade. The density of each of the algal epiphytes was estimated from a sample of the nine longest leaves in each sample of fifty leaves. Estimating this parameter for each species was more time consuming than recording the presence or absence of each epiphytic species, and with the time available between sampling periods, the number of leaves that could be examined microscopically was restricted.

C. Examination of the Sample

1. Estimating the height of the Standing Crop of Seagrass

The *Posidonia* leaf length measurements recorded during the sample selection were used as an estimate of the height of the standing crop at each site. The sample mean

$$\bar{X} = \frac{\sum_{i=1}^{n} X}{n}$$

and the standard deviation $s = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}$ were calculated for each sample.

2. The algal epiphytic species

The algae, excluding the crustose corallines, diatoms, blue-green algae, and the minute mat-like brown algae, present on the distal one-third of the thirty longest whole leaf blades were identified and recorded. Algal material for Voucher slides was stained in 1% aniline blue, washed, acidified in 1N hydrochloric acid, and mounted in 50-80% Karo syrup preserved with phenol. Occasionally the more fragile algae e.g. *Anotrichium* spp., *Amoenothamnion* sp., *Bryopsis* sp., *Giffordia* sp. were mounted directly in a mixture of 20% Karo, aniline blue and hydrochloric acid (20:1:1).

3. Indices used in Collecting the Data

(a) Frequency

In this study, Frequency is defined as the percentage of leaves (sample size = 30, except in Feb. 1975 when the sample size = 40) on which an individual algal species was noted to occur, using the distal one-third of the *Posidonia* leaf.

(b) Density Index

The Density Index is an estimate of the number of plants or clumps of plants of an individual algal species recorded on a leaf surface area of 50 cm^2.

To obtain the density index for each seagrass leaf blade, the distal one-third of the *Posidonia* leaf was cut into 35 mm lengths. These leaf segments were examined microscopically and an estimate of the number of individuals of each species for each segment was recorded. These density values for a particular species on all segments were totalled to give a total leaf density value for that species. If the species was present on a leaf segment (35 mm) the density value assigned to that species was as indicated in the following table.

Density Value	Estimated Number of Individuals or Clumps of a Species
0.4	3
1	5
2	10
3	15
4	20
5	25
Plus 1 for each additional 5 individuals	

The total leaf density value of a species was converted from that for the leaf surface area examined to an Density Index for that species for a standard leaf surface area of 50 cm^2.

(c) The Size Index

The value of the size index may be between 1 and 5, where the value 1 is assigned to the smallest individuals of a species and 5 is assigned to the largest individuals of that species. The size index assigned is that of the majority of individuals for that species on all leaf surfaces examined in each seagrass collection.

4. Recording the Indices

Each sample of *Posidonia sinuosa* was examined microscopically and data on frequency, density value, size index and reproductive state of the algal epiphyte species were recorded.

Density index and total algal density were estimated from density values noted for each algal epiphyte's occurrence on the distal one-third of the nine longest leaf blades in the seagrass sample.

Frequency, the size index, and the reproductive state of each algal epiphytic species was determined from the plants recorded on the distal one-third of the thirty longest whole leaf blades of *Posidonia sinuosa* in the sample.

CHAPTER FIVE: THE HOST PLANT: *Posidonia sinuosa*

Posidonia sinuosa forms extensive subtidal meadows in upper Spencer Gulf. These meadows may be either monospecific or in association with other seagrasses. *P. sinuosa* sets buds in May and June and commences flowering in mid-August. The flowers are held on a peduncle approximately 10 cm above the substrate but they remain cryptic beneath the leaf canopy. Ripe fruits are released from October through to January, floating for a few days before the fleshy pericarp splits to release the seed. Seed setting has not been observed in the study areas.

At each of the study transects, the heights of the standing crop of *Posidonia sinuosa* recorded throughout the study period of February 1975 to March 1977 were averaged and the results are shown in Table 8.

Table 8: The averaged height of the standing crop (mm) of *P. sinuosa* at the collection sites during February 1975 to March 1977. (Standard Error of the Mean in Brackets).

[N = 850]	Average Height of Standing Crop (mm)		
	Collection Site		
	2 m	7 m	10 m
A	531 (± 3)	609 (± 4)	-
B	577 (± 3)	648 (± 4)	693 (± 4)
C	557 (± 3)	568 (± 3)	586 (± 3)

There was an increase in the average height of the *Posidonia* standing crop with an increase in the depth of the collection site. This is especially evident on Transects A and B and less marked on Transect C.

At Transects A and B there was an increase in the height of the *Posidonia* standing crop during the spring of 1975 and 1976 with a decline during the following summers of 1976 and 1977. The results of Transect C do not show such marked trends, although the maximum standing crops recorded were in late spring to early summer both in 1975/76 and 1976/77 (Figs. 11, 12 and 13).

Seasonal fluctuations in seagrass leaf growth have been reported for *P. oceanica* in the Mediterranean. Molinier & Zevaco (1962) studied the growth rythm of this species, and recognised three phases; a resting stage during the autumn and early winter followed by a period of rapid growth during winter into spring, with the third phase being a growth decrease during summer.

The subtropical seagrass from the Gulf of Mexico, *Thalassia testudinum*, a seagrass of similar leaf morphology to *P. sinuosa*, has shown seasonal variations in average leaf length (Zieman 1975). Cambridge (1975) reported from Western Australia that the appearance of *P. australis* flower stalks in autumn (April) corresponded to a time of lowered standing crop with shorter leaves and an increased production of new leaves, and marked seasonal differences in leaf blade production, 5.5 g dry wt $m^{-2}day^{-1}$ in summer and 2.7 g dry wt $m^{-2}day^{-1}$ in winter, have been recorded for *P. australis* at the entrance to Chinaman Creek near Redcliff Point, Spencer Gulf (West & Larkum 1979). However the values recorded for the average height of the standing crop of *P. sinuosa* did not show a significant change with season, although trends comparable to the results of Cambridge (1975) and West and Larkum (1979) could be recognized.

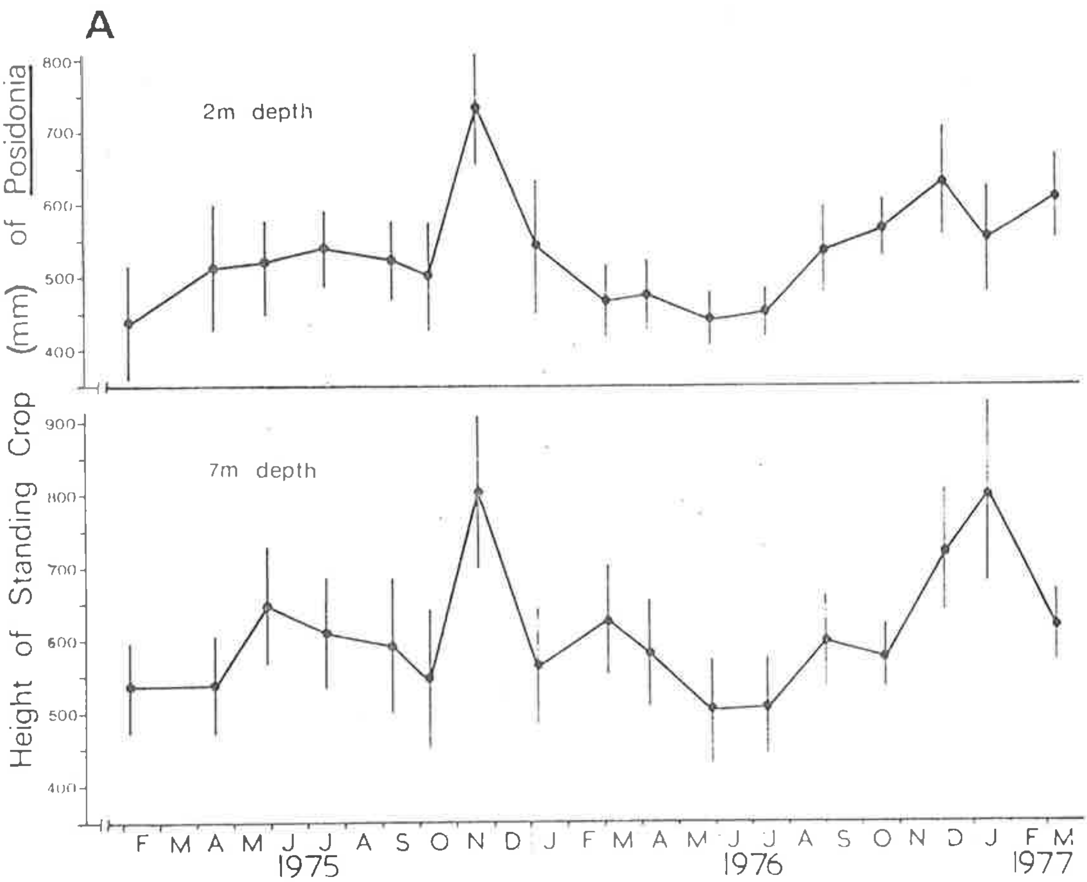

Fig. 11: The average height of the standing crop of *Posidonia sinuosa* estimated from the length of the 50 longest leaves in each sample at the collection sites on the Transect A between February 1975 and March 1977.

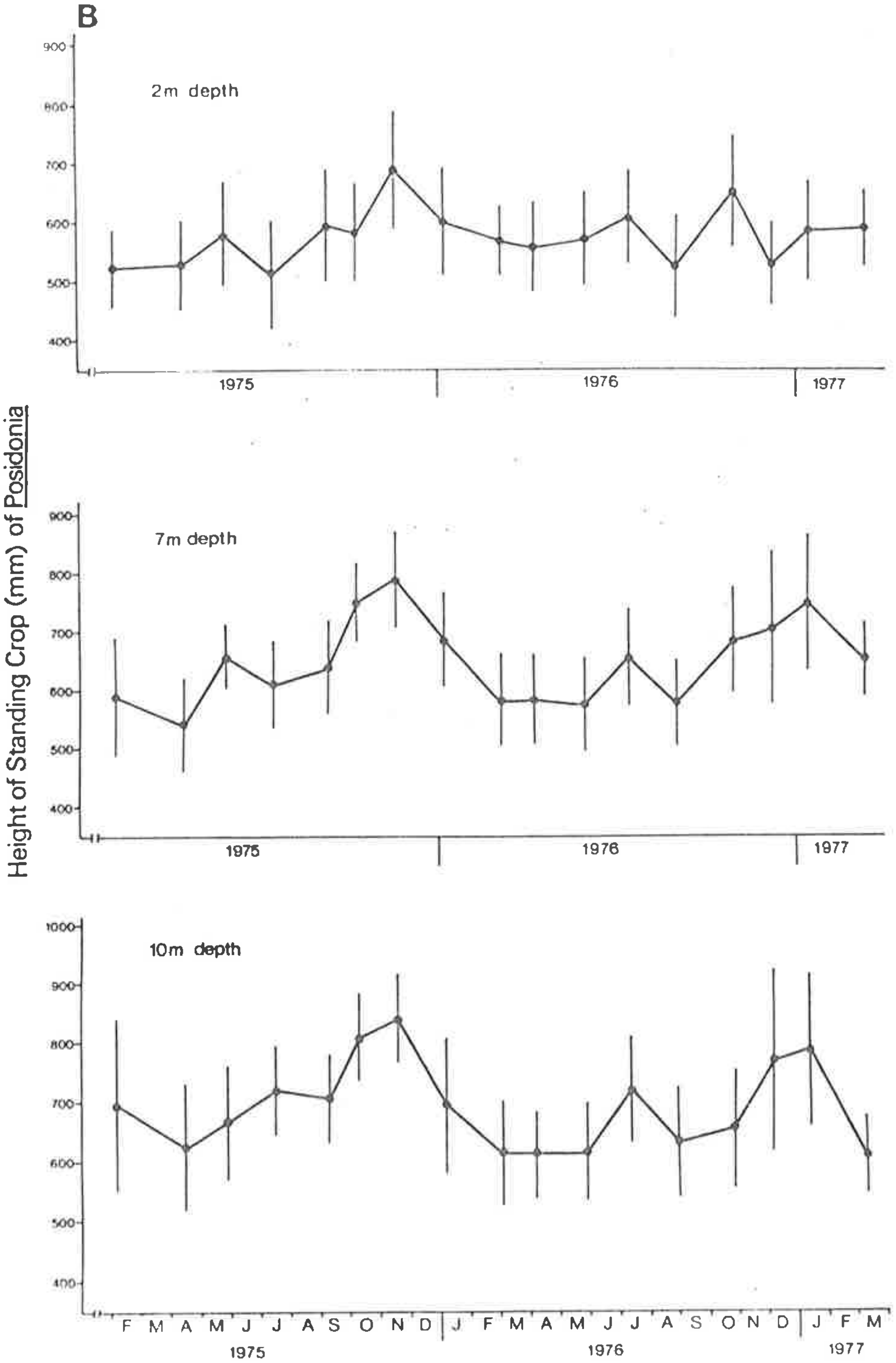

Fig. 12: The average height of the standing crop of *Posidonia sinuosa* estimated from the length of the 50 longest leaves in each sample at the collection sites on the Transect B between February 1975 and March 1977.

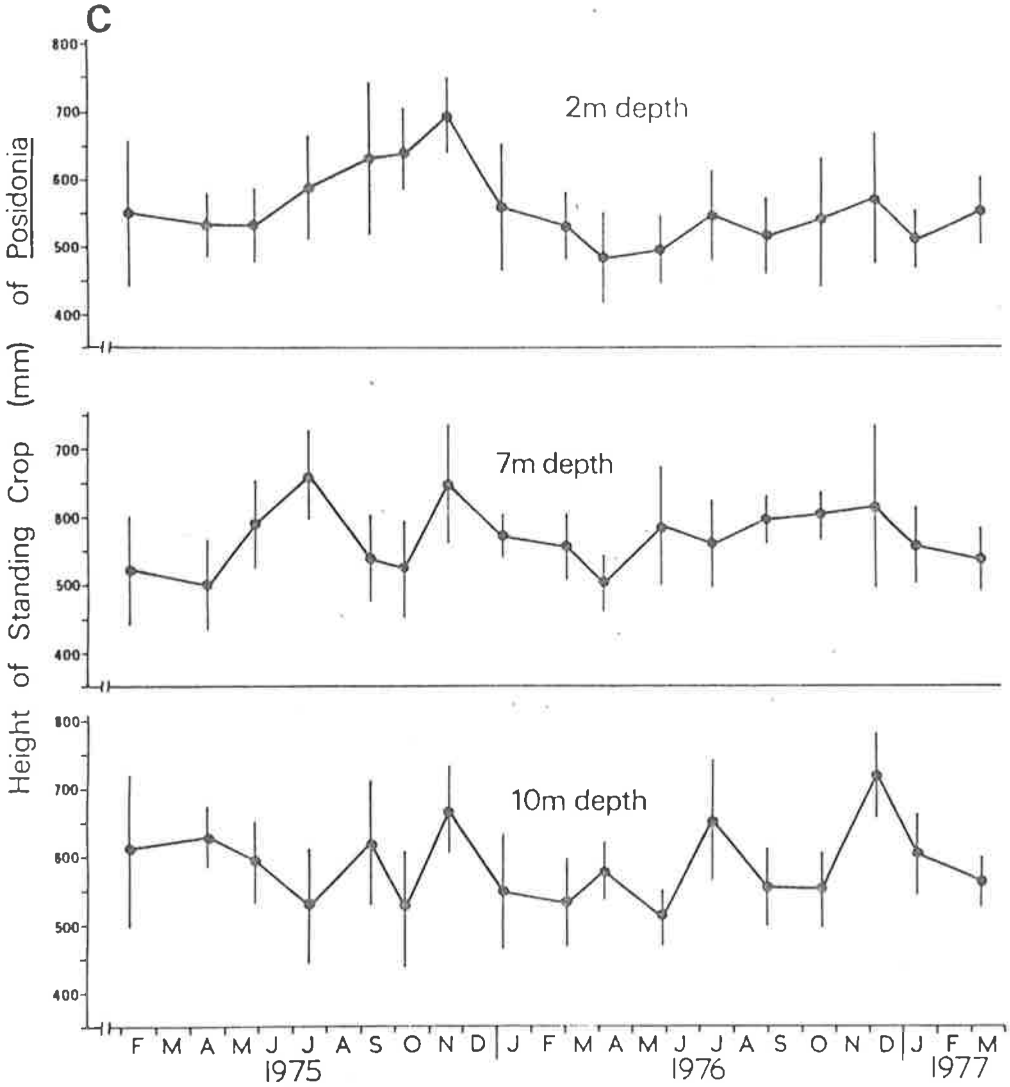

Fig. 13: The average height of the standing crop of *Posidonia sinuosa* estimated from the length of the 50 longest leaves in each sample at the collection sites on the Transect C between February 1975 and March 1977.

S.A. Shepherd, (S.A. Dept. of Fisheries) is presently investigating leaf elongation rates in *P. sinuosa* in southern Australian waters. In mid-summer 1980 he estimated that the average leaf elongation for *P. sinuosa* leaves up to 30 cm long marked near Tipara Reef, Spencer Gulf, is approximately 5 mm day^{-1}. However he and Kirkman have commented that older leaves possibly have a slower elongation rate (Personal communication). Therefore assuming the average leaf elongation rate of *P. sinuosa* near Redcliff Point is 4 mm day^{-1}, then according to the average leaf lengths (standing crops) listed in Table 8 the microscopically examined leaves are between four and six months old. This assumption agrees with the estimate by West & Larkum for *P. australis* of 2.8 leaf crops per year.

CHAPTER SIX: RESULTS: THE ALGAL EPIHYTE SPECIES

The Algae associated with the *Posidonia sinuosa* beds

Along the eastern shore of upper Spencer Gulf between Redcliff Point and the entrance to Yatala Harbour there were some small areas of subtidal rock substrate. However in the vicinity of the study transects there were no rocky areas and the larger bivalves, *Pinna bicolor (P. dolobrata)*, *Pecten meridionalis*, *Katelysia scalarina*, *Malleus meridianus*, *Ostrea angasi* and *Equichlamys bifrons* provided a solid substrate on which the larger algae, *Haloplegma priessianum*, *Asparagopsis armata*, *Sporochnus radiciformis*, *Dasya extensa*, *Gloiosaccion brownii*, *Laurencia brandenii*, *Coelarthrum muelleri*, *Jeannerettia pedicellata*, *Caulocystis uvifera*, *Protokützingia australasica* and *Neurophyllis aciculare* attached. Some of these species were rarely found on *Posidonia sinuosa*. The most common algae in the study areas were those epiphytic on the seagrasses, and between February 1975 and March 1977 samples of *Posidonia sinuosa* were collected at approximately six-weekly intervals to record the algal species attached to the *P. sinuosa* leaf blades.

Excluding the *Chrysophyta*, *Cyanophyta*, the encrusting coralline algae of the *Rhodophyta* and the minute mat-forming *Phaeophyta*, a total of 52 algal species were recorded on *Posidonia sinuosa* leaf blades.

List of algal species recorded:

Chlorophyta

- *Bryopsis plumosa* (Hudson) C. Agardh
- *Cladophora fascicularis* (Mertens) Kuetzing
- *Chaetomorpha aerea* (Dillwyn) Kuetzing
- *Enteromorpha intestinalis* (Linnaeus) Link

Phaeophyta

Asperococcus bullosus Lamouroux ADU50489

**Castagnea epiphytica* Bailey sp. nov.

**Caulocystis uvifera* (C. Agardh) Areschoug

**Giffordia mitchelliae* (Harvey) Hamel

**Giraudya robusta* Skinner and Womersley sp. nov.

Pachydictyon polycladum (Kuetzing) Womersley ADU50504, 50505

Sphacelaria biradiata Askenasy ADU 50485

Sphacelaria cirrosa (Roth) C. Agardh ADU50486, 50503

Sphacelaria furcigera Kuetzing ADU50487

Sporochnus radiciformis (Turner) C. Agardh ADU50478

Rhodophyta

Amoenothamnion planktonicum Wollaston ADU 50495

Anotrichium tenue (C. Agardh) Naegeli ADU50480

Anotrichium sp. ADU50475, 50476, 50477

Antithamnion divergens (J. Agardh) J. Agardh ADU50481, 50482, 50488

Asparagopsis armata Harvey ADU50515

**Audouinella* sp.

Centrocerasclavulatum (C. Agardh) Montagne ADU50479

Ceramium cliftonianum J. Agardh ADU50500, 47991, 47992

Ceramium macilentum J. Agardh ADU50498

Ceramium puberulum Sonder ADU50497, 50499

Ceramium shepherdii Womersley ADU50501

Champia zostericola (Harvey) Reedman and Womersley ADU50509

Chondria dasyphylla (Woodward) C. Agardh ADU50496,50510

**Corallina* sp.

**Crouania* sp.

Dasya sp.1 ADU50464, 50465, 50466, 50467

Dasya sp.2 ADU50468, 50469, 50470

Dictymenia harveyana Sonder ADU50512

**Dipterosiphonia* aff. dendritica

**Gattya pinnella* Harvey

Gloiosaccion brownii Harvey ADU50313, 50514

**Griffithsia monilis* Harvey

Herposiphonia sp.1 ADU50471, 50473

Herposiphonia sp.2 ADU50474

**Hypnea musciformis* (Wulfun) Lamouroux

**Jania micrarthrodia* Lamouroux

Jeannerettia pedicellata (Harvey) Papenfuss ADU50507, 50516, 50517

Laurencia forsteri (Mertens ex Turner) Greville ADU50490, 50491, 50492

**Lomentaria* sp.

**Metagoniolithon chara* var. *chara* (Lamarck) Ducker

Platysiphonia miniata (C. Agardh) Boergesen ADU50483, 50484

**Polysiphonia amphibolis* Womersley

**Polysiphonia decipiens* Montagne

**Polysiphonia infestans* Harvey

Protokützingia australasica (Montagne) Falkenberg ADU50493, 50494

**Ptilocladia australis* (Harvey) Wollaston

Spyridia tasmanica (Kuetzing) J. Agardh ADU50502, 50506

**Thaumatella*

Representative slides and/or herbarium sheets have been lodged at ADU.

The following species were recorded rarely and were considered as "irregular transient species" on the *P. sinuosa* leaf blades:

Chaetomorpha aerea

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*Herbarium numbers not yet allocated.

Enteromorpha intestinalis

Sporochnus radiciformis

Amoenothamnion planktonicum

Anotrichium sp.

Asparagopsis armata

Dictymenia harveyana

Dipterosiphonia aff. dendritica

Gattya pinnella

Herposiphonia sp.2

Thaumatella sp.

Both the frequencies and the density indices were recorded for most of the species to ascertain whether a presence or absence parameter (frequency) indicated the true population changes as shown by the density indices. Although a correlation coefficient could be calculated to determine the linearity of the relationship between the two parameters for each of the species/species groups, the graphs of the results for both parameters for each of the species/species groups gave a visual indication of the reliability of using frequency data only.

The Frequency and Density Index data on the algal species for seagrass samples collected between February 1975 and March 1977 are shown in Figures 14 to 87 and a comprehensive list of data for all collections and "erect" algal species is deposited in the S.A. Department of Fisheries, Data Bank. The size indices attributed to the epiphytic algal species and the occurrence of fertile plants are presented in Tables 9 to 42.

Chlorophyta

1. *Bryopsis plumosa* (Fig. 14; Table 9)

The species was not common as an epiphyte in the Redcliff Point area although its occurrence was regularly recorded during the late summer and autumn (Fig. 14) and was considered to be a summer-autumn species (Jan.-May). *Bryopsis* was more commonly recorded at the 2 m deep sites on all transects than at the deeper sites. Fertile plants of this species were not observed during the study (Table 9).

There was a good correlation between frequency and density index values and the population trends could be shown by recording only the frequency data.

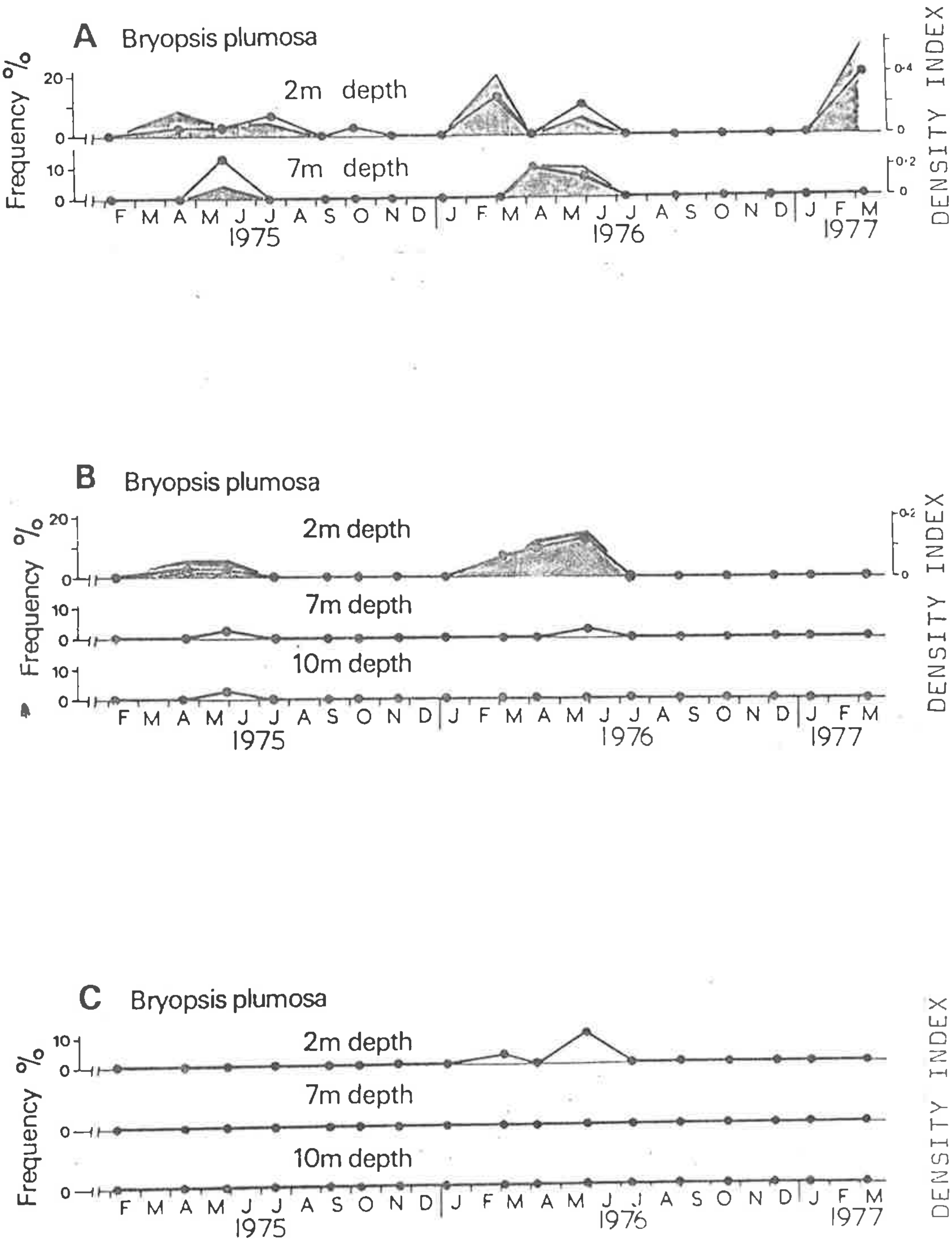


Fig. 14: Percentage frequency (solid line) and Density Index (shaded area) Values for *Bryopsis plumosa* on the Transects A, B and C.

Table 9: Size indices and reproductive plants recorded for *Bryopsis plumosa* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION 1975 F	A	M	J	S	O	N	1976 J	M	A	M	J	S	O	D	1977 J	M	S	1978 J
A2 m	Size	–	3	1	2	–	3	–	–	2	–	3	–	–	–	–	–	2	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	–	–	3	–	–	–	–	–	–	3	3	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
B2 m	Size	–	3	1	–	–	–	–	–	2	3	4	–	–	–	–	–	–	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B7 m	Size	–	1	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B10 m	Size	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C2 m	Size	–	–	–	–	–	–	–	–	2	–	4	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

2. *Cladophora fascicularis* (Figs. 15,16; Table 10)

The autumn-winter species (Apr.-Aug.) had a seasonal peak in density and frequency in autumn with the peak occasionally extending into winter (Fig. 15,16,17). Frequency data correlated well with population changes in the species. There was not a seasonal pattern to the occurrence of fertile plants (Table 10).

On Transects B and C, *Cladophora* showed no depth preference, however on Transect A the species is generally more abundant at the 2 m deep site.

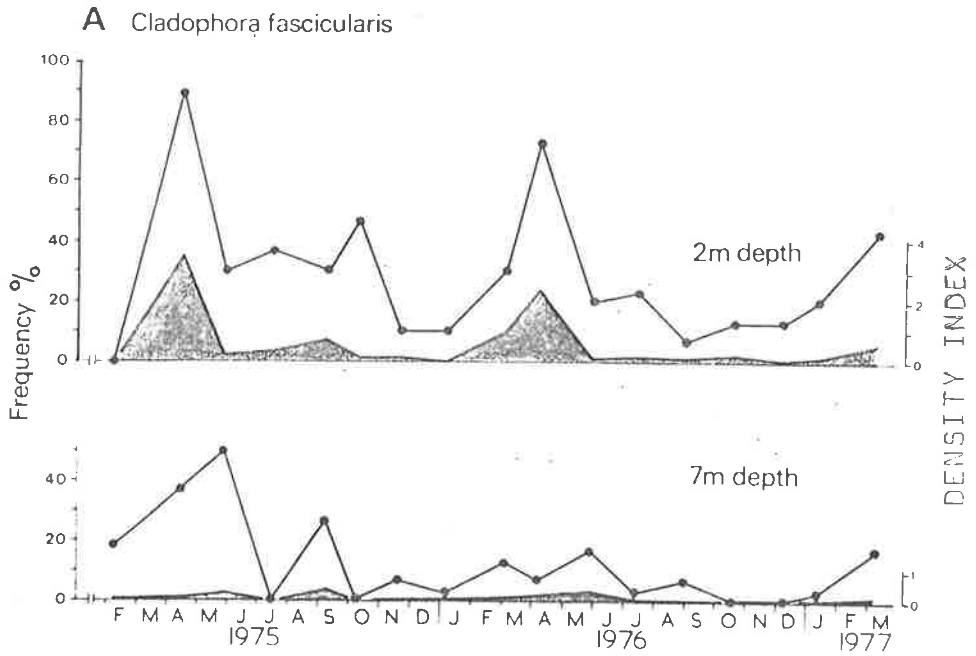


Fig. 15: Percentage frequency (solid line) and Density Index (shaded area) Values for *Cladophora fascicularis* on the Transect A.

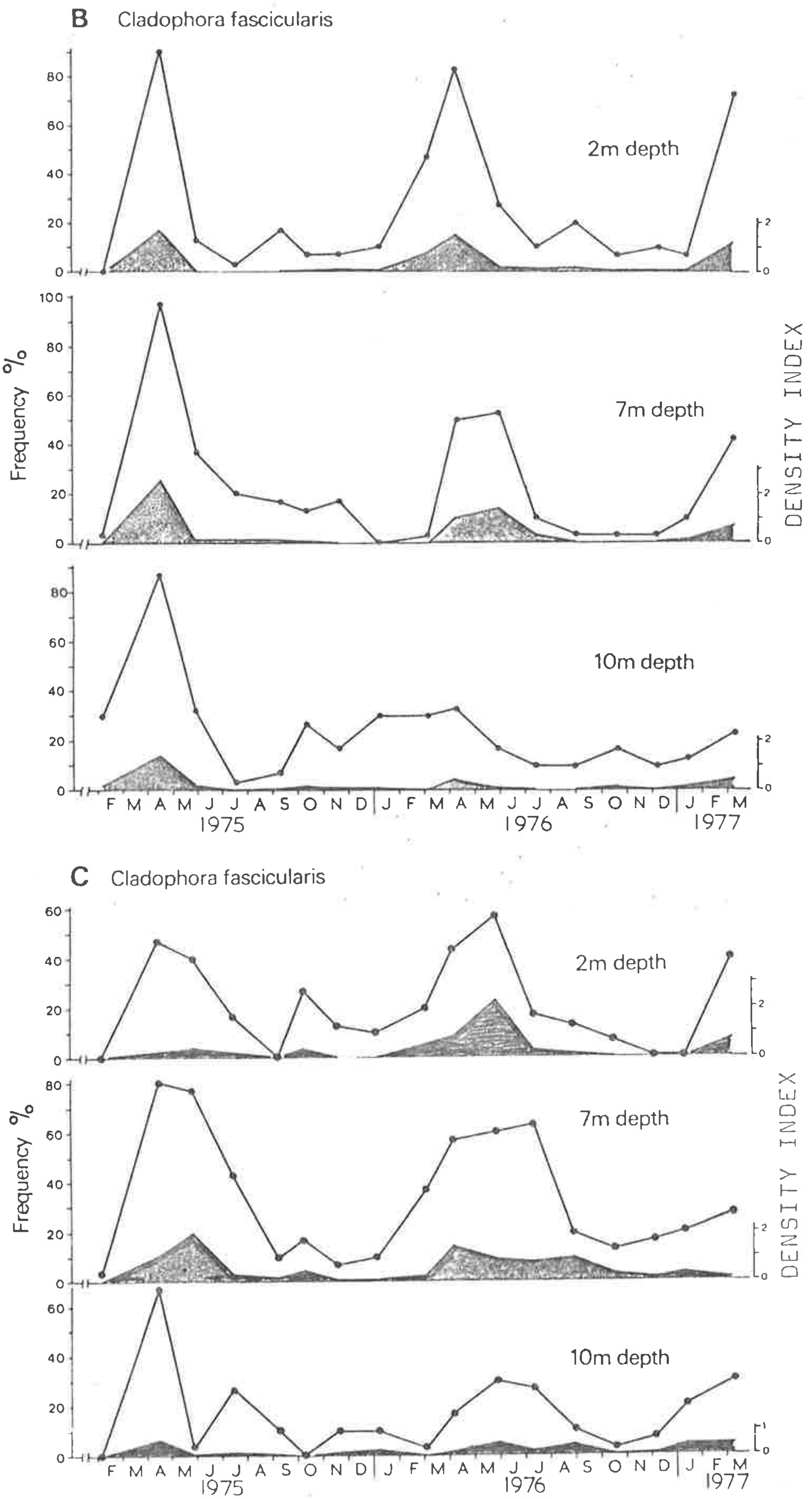


Fig. 16: Percentage frequency (solid line) and Density Index (shaded area) Values for *Cladophora fascicularis* on the Transects B and C.

Table 10: Size indices and reproductive plants recorded for *Cladophora fascicularis* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	2	3	3	3	3	4	1	2	3	4	3	2	4	3	2	4	3	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	Z	–	–	Z	–	X
A7 m	Size	1	3	4	–	3	–	4	4	2	3	4	3	3	–	–	2	2	3	X
	Repr.	–	Z	–	–	–	–	–	–	–	–	Z	–	–	–	–	–	–	–	X
B2 m	Size	–	2	4	1	3	4	3	2	2	4	4	2	2	1	3	2	3	2	5
	Repr.	–	–	–	–	–	–	Z	–	–	Z	–	–	–	–	–	–	–	–	–
B7 m	Size	3	3	4	3	3	3	2	–	3	2	3	3	3	3	1	4	2	4	4
	Repr.	–	–	–	–	–	–	–	–	–	–	–	Z	Z	–	–	–	–	–	–
B10 m	Size	2	3	4	3	2	2	2	4	4	2	2	3	3	2	2	2	2	3	4
	Repr.	–	–	Z	Z	–	Z	–	–	–	Z	–	Z	Z	Z	–	–	–	Z	–
C2 m	Size	–	3	3	4	–	3	1	2	4	2	4	3	3	2	–	–	4	–	X
	Repr.	–	–	–	–	–	–	–	–	Z	–	–	–	–	–	–	–	–	–	X
C7 m	Size	3	3	5	5	2	3	2	2	3	3	3	4	3	2	2	3	3	3	X
	Repr.	–	–	Z	–	–	–	–	–	–	–	Z	Z	–	–	–	–	–	–	X
C10 m	Size	–	4	3	4	3	–	2	4	1	3	4	3	4	1	3	4	3	5	X
	Repr.	–	Z	–	Z	–	–	–	–	–	–	–	Z	–	–	–	–	–	–	X

Phaeophyta

3. Asperococcus bullosus (Figs. 17,18; Table 11)

Asperococcus bullosus was an autumn-winter (May-Sep.) species. Results showed that the frequency data correlated well with population changes in the species. It was absent from the study sites from mid-spring to the beginning of autumn, and reached a peak of density and frequency in mid to late winter (Figs. 17,18). On Transect A, *Asperococcus* was more abundant at the 2 m deep site than the 7 m site, however on Transects B and C the species was most abundant at the deepest sites.

The size indices showed that the *Asperococcus* plants increased in size from the beginning of autumn until the end of winter (Table 11), when the plants became less common on the *Posidonia* leaf blades.

Plants with sori were recorded throughout the period that *Asperococcus bullosus* was noted on *Posidonia sinuosa*.

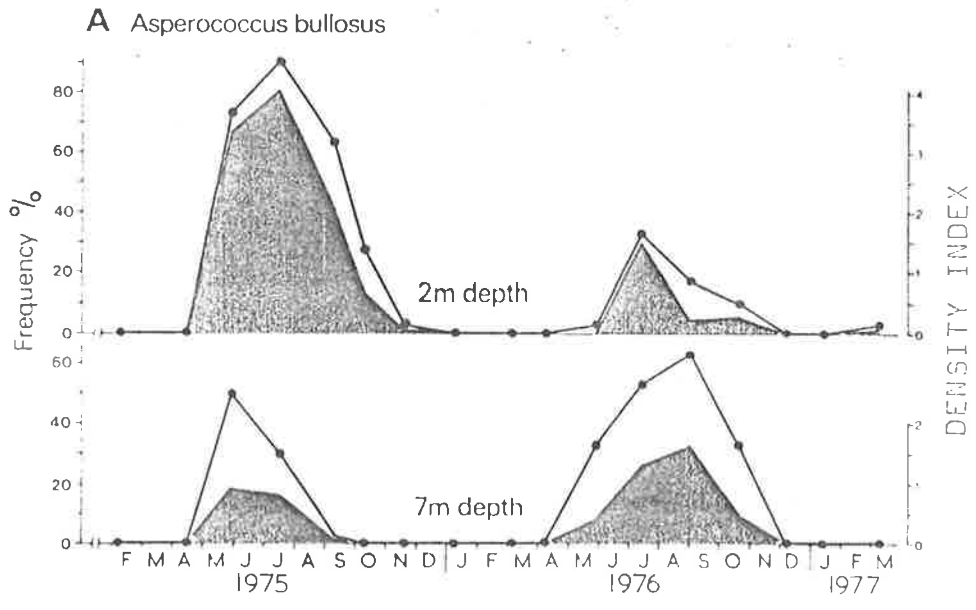
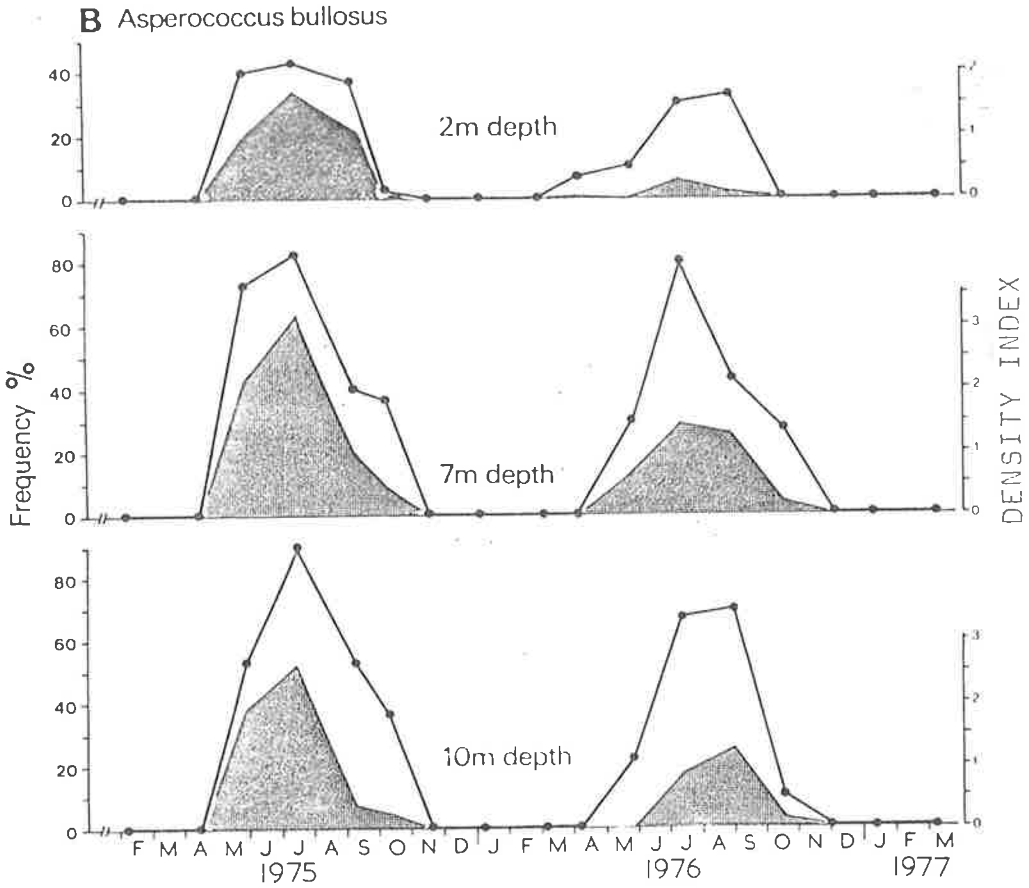


Fig. 17: Percentage frequency (solid line) and Density Index (shaded area) Values for *Asperococcus bullosus* on the Transect A.



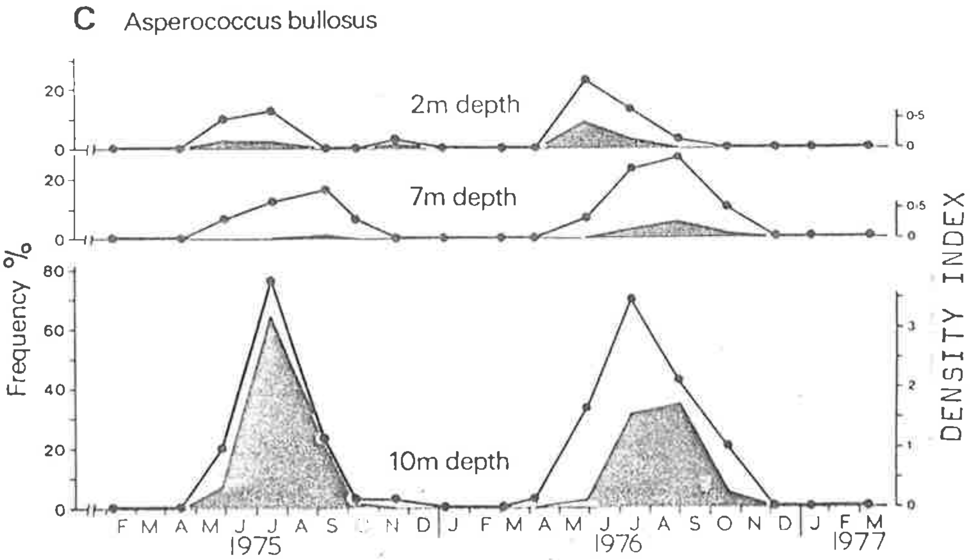


Fig. 18: Percentage frequency (solid line) and Density Index (shaded area) Values for *Asperococcus bullosus* on the Transects B and C.

Table 11: Size indices and reproductive plants recorded for *Asperococcus bullosus* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION 1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	–	2	3	3	4	4	–	–	–	3	4	5	5	–	–	1	4	X
	Repr.	–	–	S	S	S	S	S	–	–	–	–	S	S	S	–	–	–	S	X
A7 m	Size	–	–	1	2	2	–	–	–	–	–	2	4	5	5	–	–	–	4	X
	Repr.	–	–	S	S	S	–	–	–	–	–	S	S	S	S	–	–	–	S	X
B2 m	Size	–	–	2	2	3	3	–	–	–	1	3	3	2	–	–	–	–	–	4
	Repr.	–	–	S	S	S	S	–	–	–	–	–	S	S	–	–	–	–	–	–
B7 m	Size	–	–	2	2	3	4	–	–	–	–	2	3	4	5	–	–	–	4	2
	Repr.	–	–	S	S	S	S	–	–	–	–	S	S	S	S	–	–	–	S	S
B10 m	Size	–	–	2	2	3	4	–	–	–	–	2	3	4	3	–	–	–	4	2
	Repr.	–	–	S	S	S	S	–	–	–	–	S	S	S	S	–	–	–	S	S
C2 m	Size	–	–	2	2	–	–	4	–	–	–	1	2	2	–	–	–	–	3	X
	Repr.	–	–	–	S	–	–	S	–	–	–	S	S	S	–	–	–	–	S	X
C7 m	Size	–	–	2	3	4	4	–	–	–	–	2	3	4	5	–	–	–	4	X
	Repr.	–	–	–	S	S	S	–	–	–	–	S	S	S	S	–	–	–	S	X
C10m	Size	–	–	2	2	2	3	5	–	–	2	3	3	4	3	–	–	–	3	X
	Repr.	–	–	–	S	S	S	S	–	–	–	S	S	S	S	–	–	–	S	X

4. *Castagnea epiphytica* (Figs. 19,20; Table 12)

There was a good correlation between the frequency and density indices for this species. *Castagnea* was a non-seasonal species (Figs. 19, 20) although the size indices suggested that the species settled on the leaves at the end of winter through early spring (Table 12). The plants reached their maximum size the following autumn.

Castagnea epiphytica was more dense at the 2 m deep sites on all transects. Fertile plants of this species were not observed during the study (Table 12).

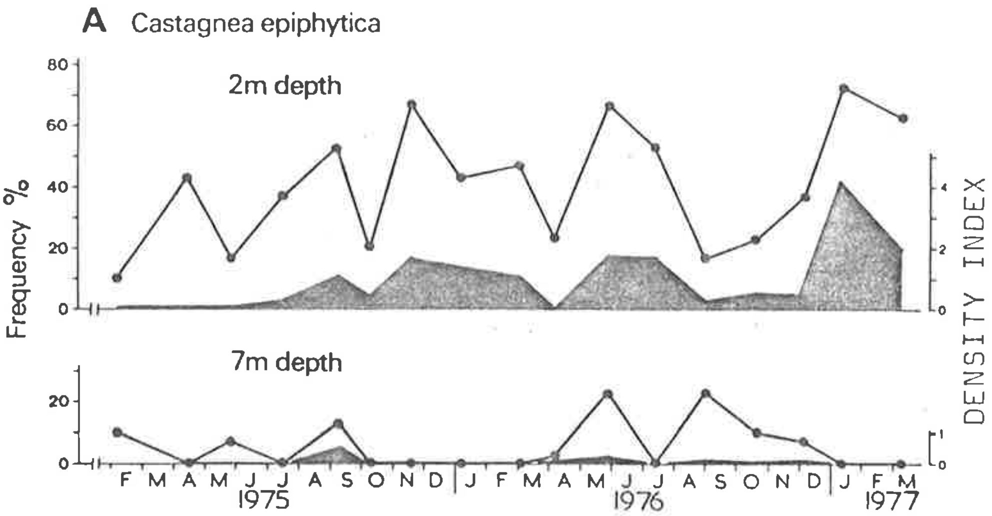


Fig. 19: Percentage frequency (solid line) and Density Index (shaded area) Values for *Castagnea epiphytica* on the Transect A.

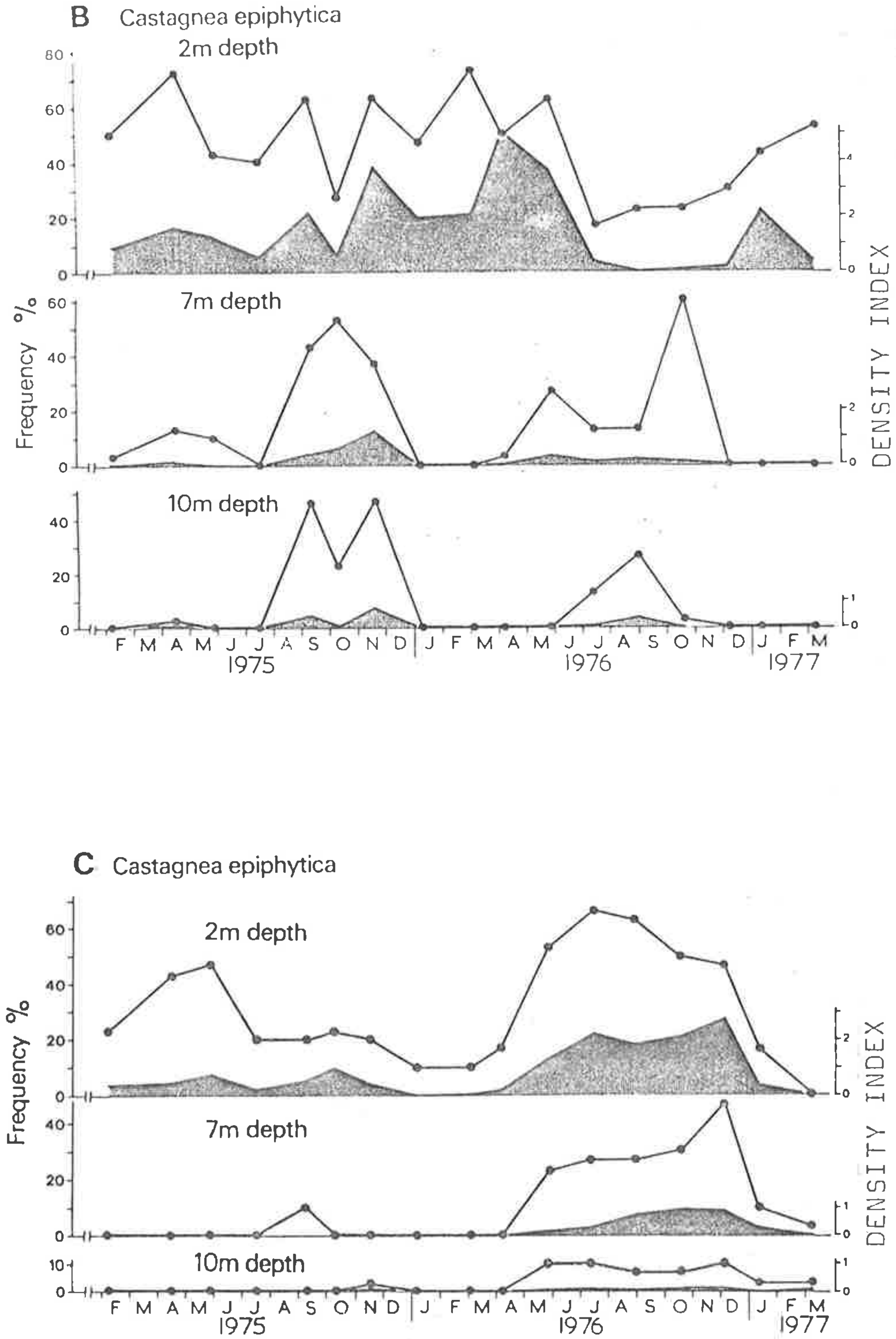


Fig. 20: Percentage frequency (solid line) and Density Index (shaded area) Values for *Castagnea epiphytica* on the Transects B and C.

Table 12: Size indices and reproductive plants recorded for *Castagnea epiphytica* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	2	2	3	3	2	2	1	1	2	3	4	3	2	1	1	3	4	2	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
A7 m	Size	3	–	3	–	1	–	–	–	–	2	3	–	1	2	2	–	–	1	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
B2 m	Size	2	3	3	3	2	2	1	1	2	1	2	3	2	1	1	3	4	2	1
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B7 m	Size	2	2	3	–	2	1	2	–	–	3	3	2	2	1	–	–	–	1	1
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B10 m	Size	–	2	–	–	1	1	1	–	–	–	–	3	3	1	–	–	–	2	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C2 m	Size	2	3	2	3	1	2	1	1	3	1	2	4	2	1	1	2	–	2	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	–	–	–	–	2	–	–	–	–	–	4	2	4	1	1	2	3	1	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	–	–	–	–	–	–	2	–	–	–	1	2	3	1	2	1	1	2	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

5. *Giffordia mitchelliae* (Figs. 21,22,23; Table 13)

Frequency data only were recorded for *Giffordia* because the habit of the species made it almost impossible to determine individual plants or clumps of plants.

There was a peak in the frequency of *Giffordia* in the autumn to winter months (May-Aug.) with a low frequency usually observed in mid-summer (Figs. 21,22,23), characteristic of an autumn-winter species. Fertile plants were generally recorded when the largest plants were observed; from autumn to spring (Table 13). The frequency data did not indicate a depth selection along any transect by this species.

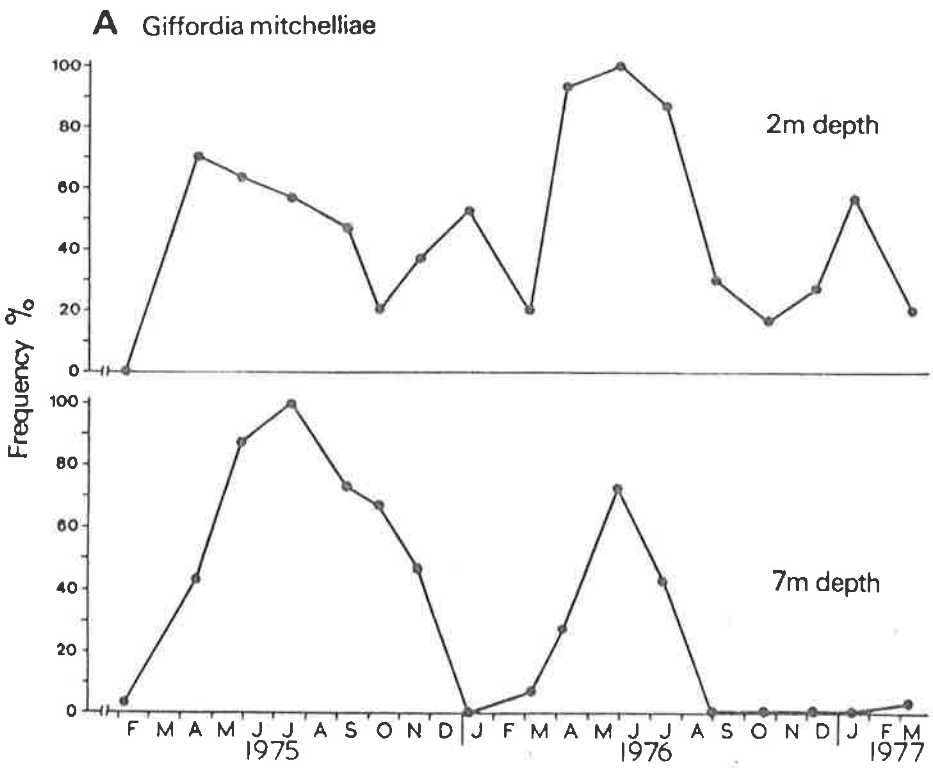


Fig. 21: Percentage frequency for *Giffordia mitchelliae* on the Transect A.

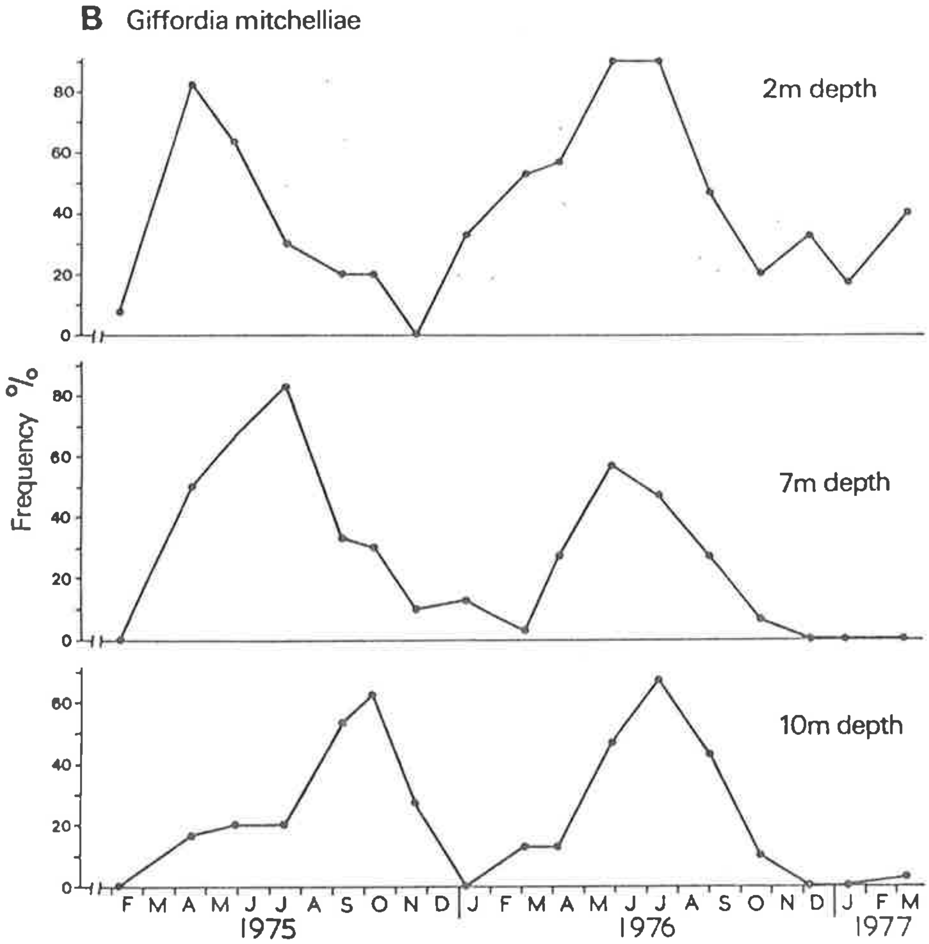


Fig. 22: Percentage frequency for *Giffordia mitchelliae* on the Transect B.

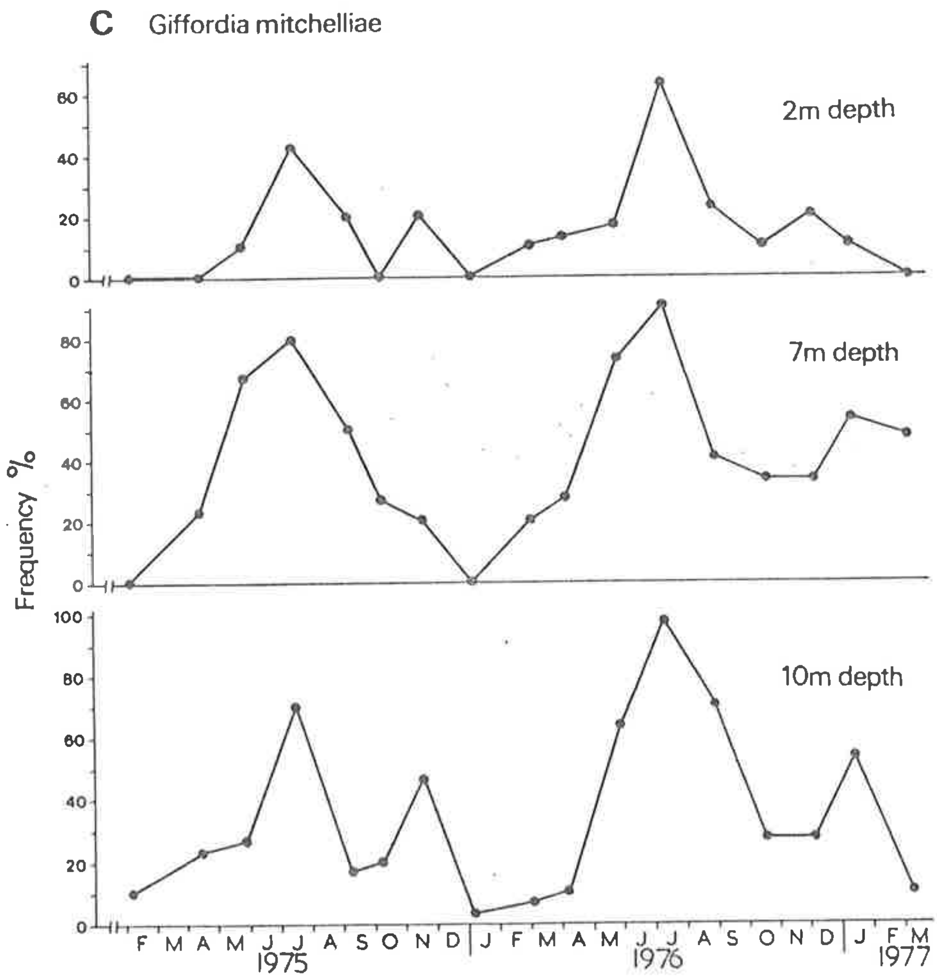


Fig. 23: Percentage frequency for *Giffordia mitchelliae* on the Transect C.

Table 13: Size indices and reproductive plants recorded for *Giffordia mitchelliae* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	1	2	3	3	2	1	2	2	2	5	5	4	3	2	2	4	2	X
	Repr.	–	–	–	–	sp	–	–	–	sp	–	sp	–	–	–	–	sp	–	–	X
A7 m	Size	2	1	2	2	2	3	1	–	1	2	3	3	–	–	–	–	2	4	X
	Repr.	–	–	–	sp	sp	sp	–	–	–	–	sp	–	–	–	–	–	–	sp	X
B2 m	Size	2	2	2	2	3	2	–	1	1	1	2	4	3	2	2	1	2	3	3
	Repr.	–	–	–	–	–	–	–	sp	sp	–	sp	–	–	–	–	–	–	–	–
B7 m	Size	–	2	3	2	3	3	1	2	1	2	2	2	2	3	–	–	–	4	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	sp	–	–	–	–	–	–	–
B10 m	Size	–	2	2	2	4	2	1	–	1	2	2	3	4	3	–	–	2	4	2
	Repr.	–	–	–	–	–	–	–	–	–	sp	–	–	–	–	–	–	–	–	–
C2 m	Size	2	–	2	3	–	1	1	–	1	2	2	4	3	2	2	2	–	4	X
	Repr.	–	–	–	sp	sp	–	–	–	–	–	–	–	sp	–	–	–	–	sp	C
C7 m	Size	–	2	2	3	3	2	2	–	1	1	4	4	4	2	2	2	2	3	X
	Repr.	–	–	–	sp	sp	sp	–	–	–	–	–	sp	sp	sp	–	–	–	sp	X
C10 m	Size	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	1	2	3	X
	Repr.	–	–	–	sp	–	–	–	–	–	–	–	–	sp	sp	–	–	–	–	X

6. *Giraudya robusta* (Figs. 24,25; Table 14)

Giraudya robusta was a non-seasonal species and on the Transects A and B was more dense at the 2 m deep sites than at the 7 m and 10 m deep sites. On the Transect C there was little difference in the density of the species at the three collection sites, although *Giraudya* is more often recorded at the shallowest site (Figs. 24,25). Also fertile plants on this transect were more commonly noted at the 2 m deep site (Table 14).

On the Transects A and B the density indices showed that a large population increase of the species occurred at the 2 m deep sites in the winter of 1976; this feature was less obvious at the Transect C.

There was a good correlation between the frequency and density index data, although the "bloom" of winter 1976 did not show the same sharp increase in the frequency data as in the density indices for that period.

The average size of the plants of *Giraudya robusta* on the *Posidonia* leaves from autumn through to early spring was larger than that noted during the summer (Table 14).

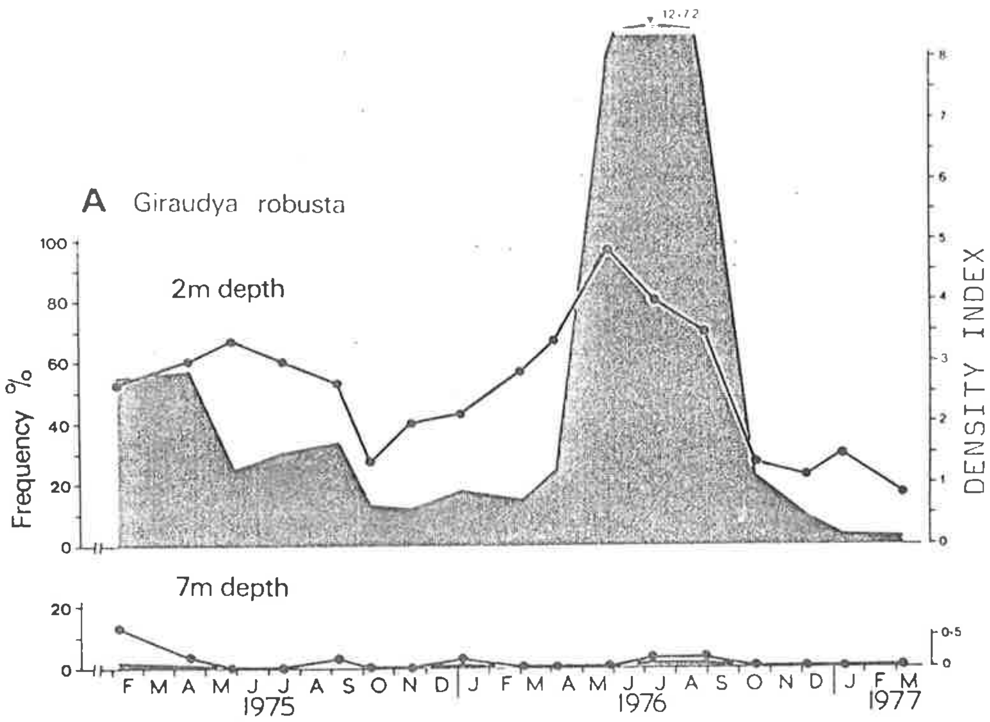


Fig. 24: Percentage frequency (solid line) and Density Index (shaded area) Values for *Giraudya robusta* on the Transect A.

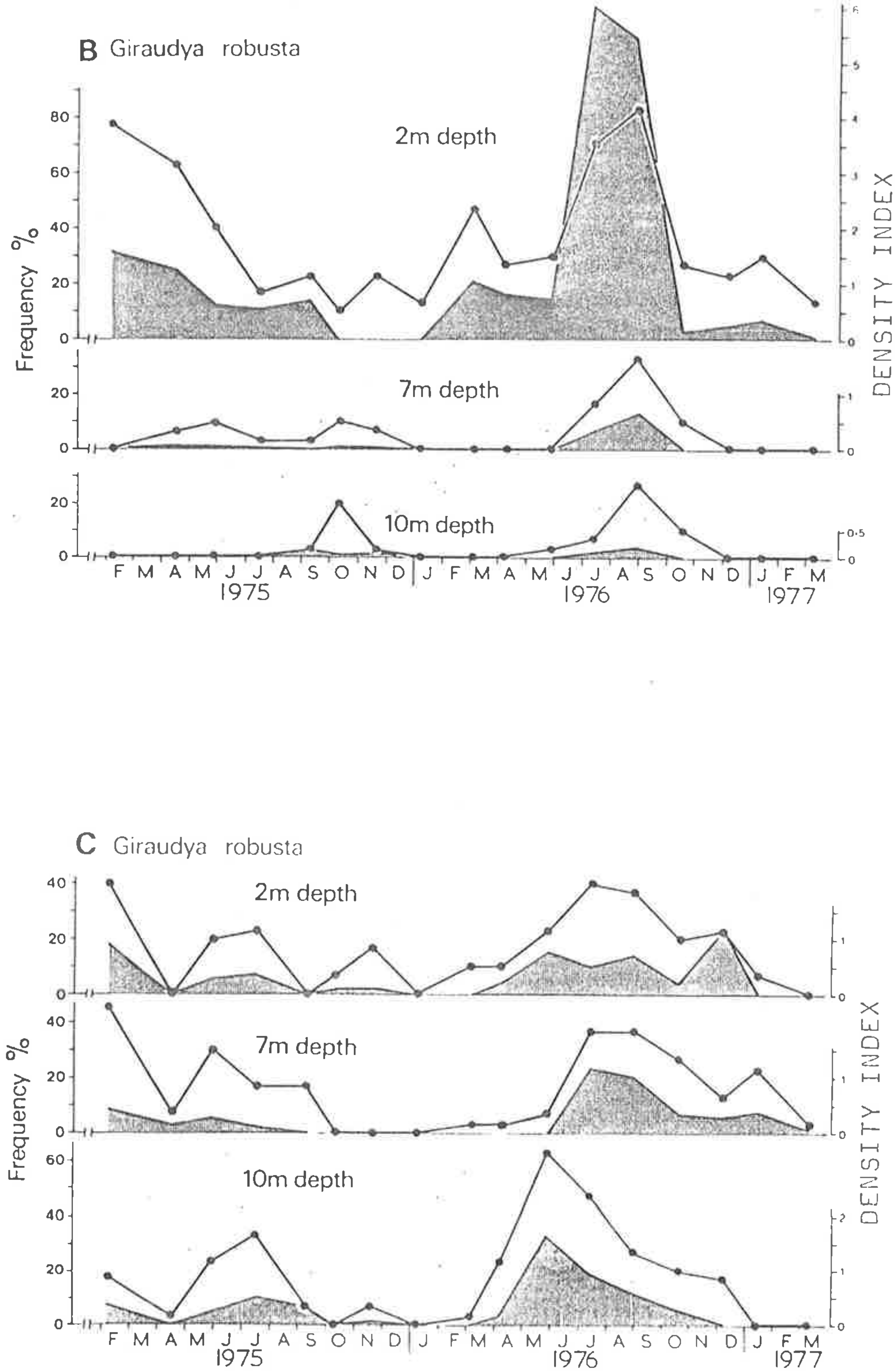


Fig. 25: Percentage frequency (solid line) and Density Index (shaded area) Values for *Giraudya robusta* on the Transects B and C.

Table 14: Size indices and reproductive plants recorded for *Giraudya robusta* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																				
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	3	4	3	3	3	2	1	2	2	3	4	4	5	3	2	2	2	4	X
	Repr.	–	sp	sp	–	–	–	sp	–	–	–	–	sp	sp	sp	–	–	–	sp	X
A7 m	Size	2	2	–	–	4	–	–	1	–	–	–	2	2	–	–	–	–	4	X
	Repr.	sp	–	–	–	–	–	–	–	–	–	–	sp	–	–	–	–	–	–	X
B2 m	Size	2	3	4	3	2	2	2	1	2	3	4	4	3	3	2	2	3	3	4
	Repr.	sp	sp	sp	–	–	–	–	–	sp	–	sp	–	–	sp	–	–	–	–	sp
B7 m	Size	–	2	4	2	2	2	2	–	–	–	–	2	3	4	–	–	–	3	3
	Repr.	–	sp	–	–	–	–	–	–	–	–	–	–	sp	sp	–	–	–	–	sp
B10 m	Size	–	–	–	–	2	2	2	–	–	–	2	2	3	3	–	–	–	4	–
	Repr.	–	–	–	–	sp	–	–	–	–	–	–	–	–	sp	–	–	–	–	–
C2m	Size	2	–	2	3	–	1	1	–	1	2	2	4	3	2	2	2	–	4	X
	Repr.	sp	–	sp	–	–	–	–	–	sp	sp	sp	sp	sp	sp	–	–	–	sp	X
C7 m	Size	–	2	2	3	3	2	2	–	1	1	4	4	4	2	2	2	2	3	X
	Repr.	sp	sp	–	–	sp	–	–	–	–	–	–	sp	sp	–	sp	–	–	–	X
C10 m	Size	2	2	4	3	4	–	2	–	1	3	3	2	4	3	2	–	–	4	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	sp	–	–	–	–	–	X

7. *Pachydictyon polycladum* (Figs. 26,27,28; Table 15)

There was a good correlation between the changes in the frequency data and the changes in the density indices, showing that frequency was a suitable parameter by which to follow population trends in this species.

On the Transects A and C *Pachydictyon* was more dense at the 7 m and 10 m deep sites, while on the Transect B the species was less dense at these collection sites than at the 2 m deep site (Figs. 26,27,28). *P. polycladum* showed a decline in density in late winter through to spring (Aug.-Nov) followed by an increase in density through the summer (Dec.-Mar.) reaching a peak in density in autumn and early winter. This was grouped as a summer-winter species. The smallest plants of the species were more often present in spring, while the largest plants were present in autumn which was also when fertile plants were most commonly noted (Table 15).

Evidence of grazing, especially in autumn when the species was most dense on the *Posidonia* leaf blades, was also recorded.

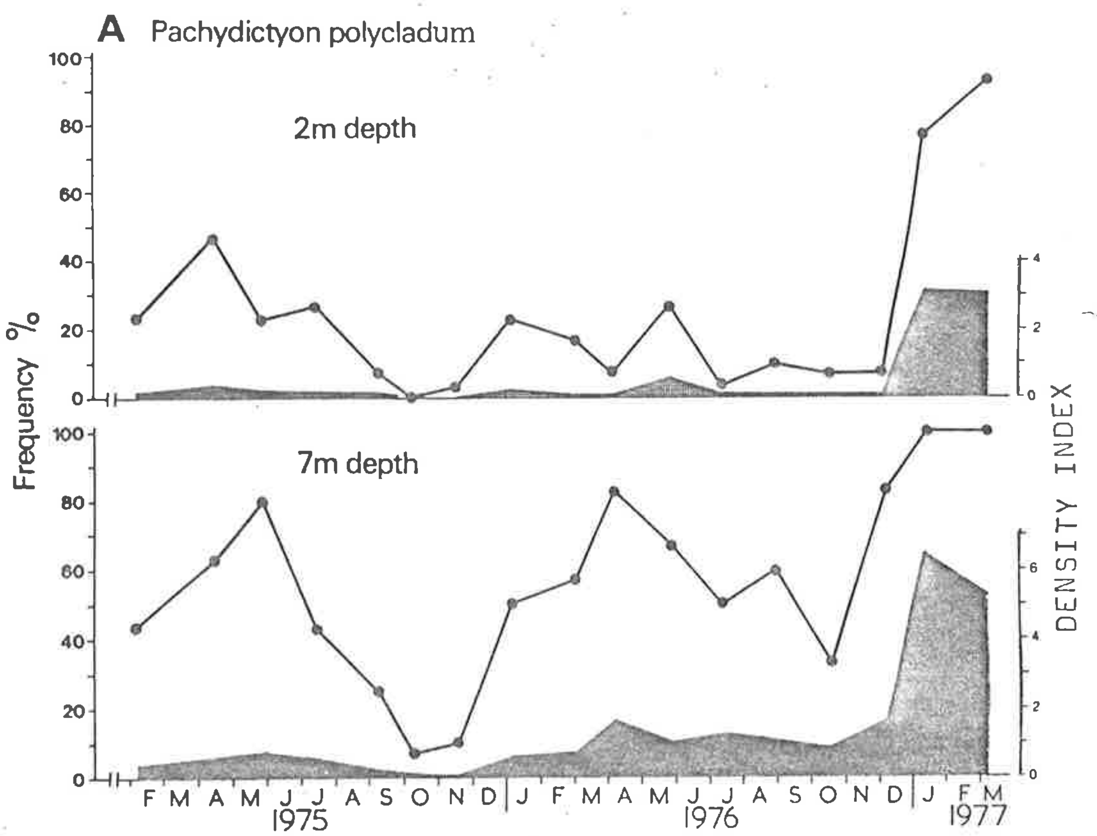


Fig. 26: Percentage frequency (solid line) and Density Index (shaded area) Values for *Pachydictyon polycladum* on the Transect A.

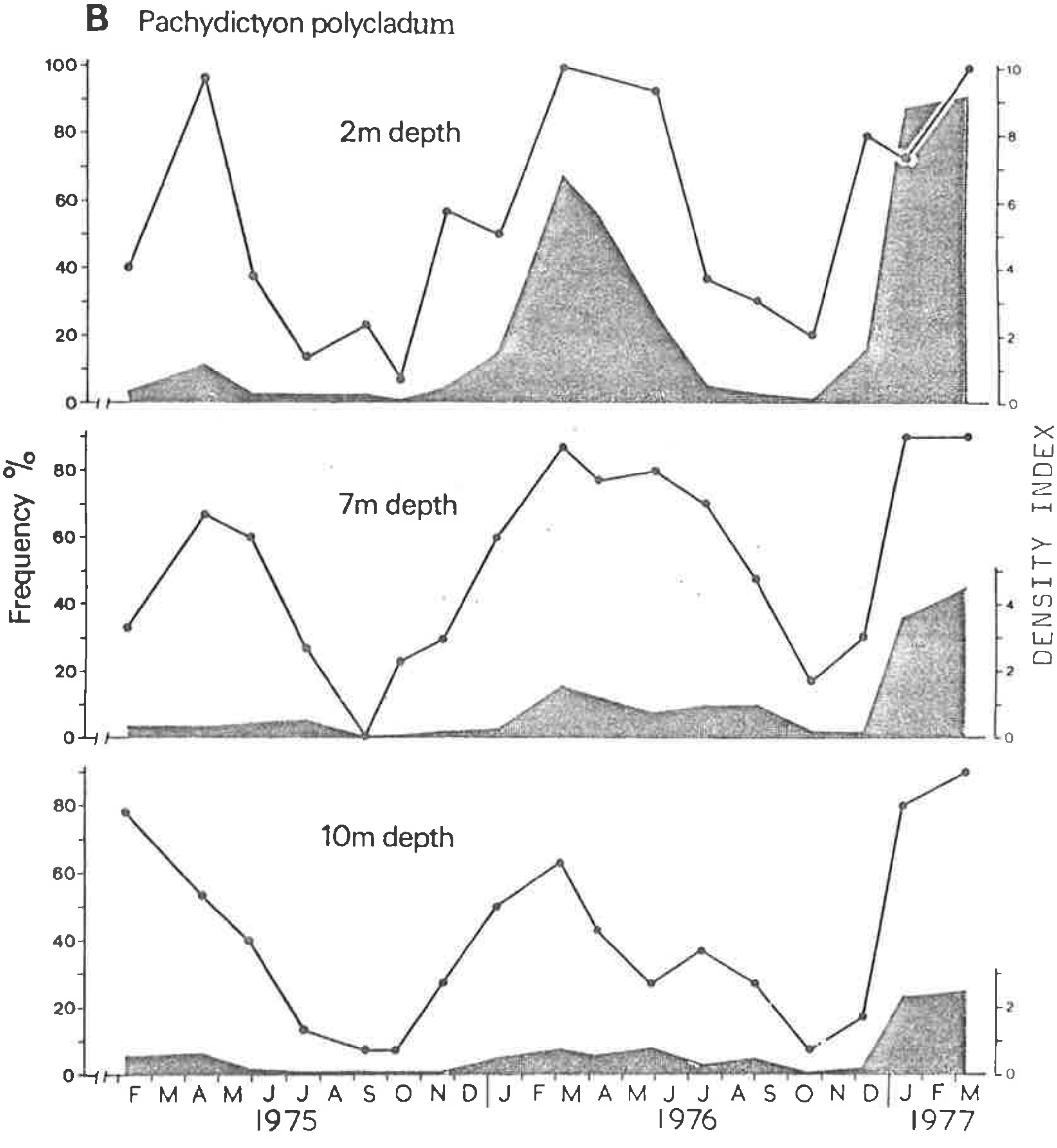


Fig. 27: Percentage frequency (solid line) and Density Index (shaded area) Values for *Pachydictyon polycladum* on the Transect B.

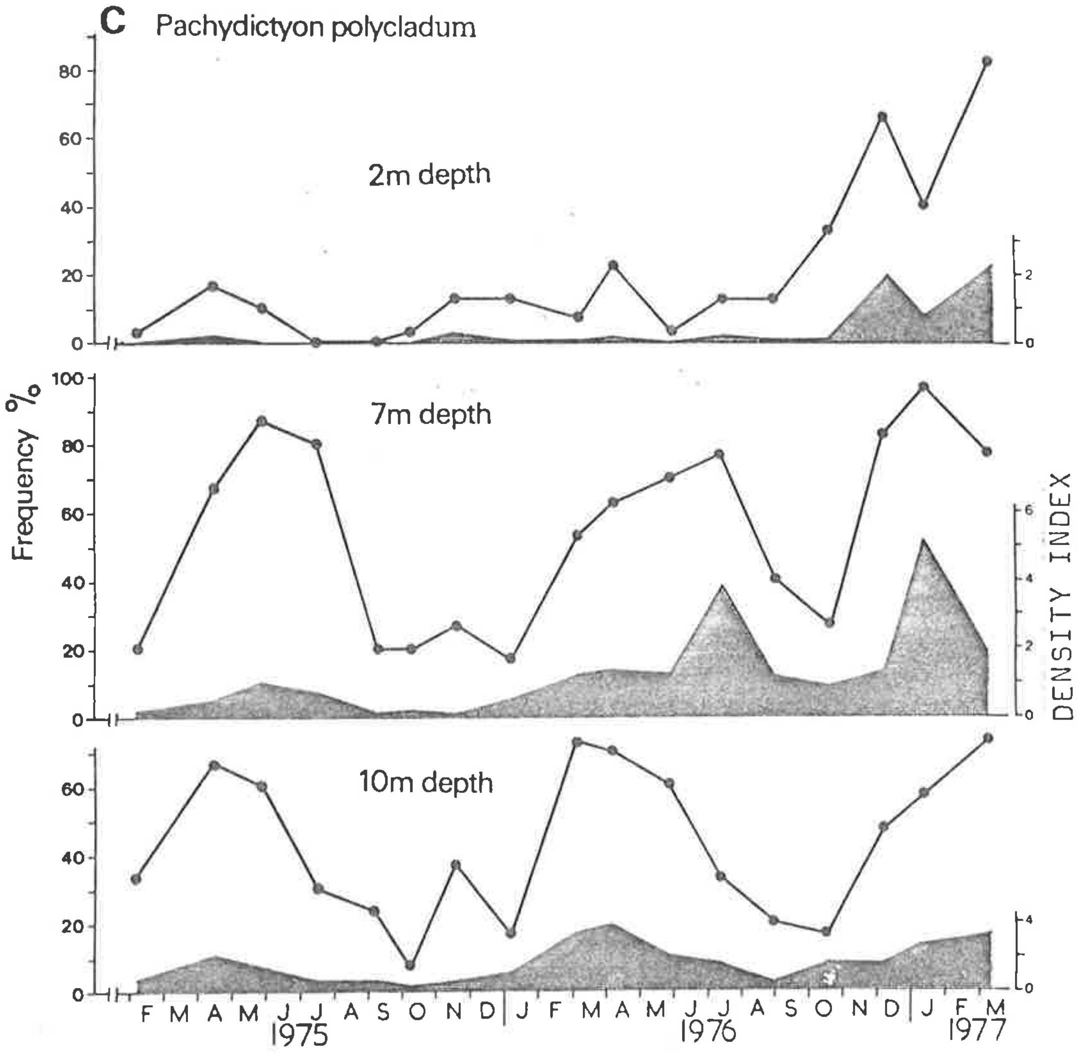


Fig. 28: Percentage frequency (solid line) and Density Index (shaded area) Values for *Pachydictyon polycladum* on the Transect C.

Table 15: Size indices and reproductive plants recorded for *Pachydictyon polycladum* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	3	4	3	3	2	–	1	2	2	2	2	2	2	1	2	2	3	2	X
	Repr.	–	–	–	–	–	–	–	–	–	S	–	–	–	–	–	S	S	–	X
A7 m	Size	2	3	4	5	3	2	1	2	3	4	5	4	2	1	1	2	3	1	X
	Repr.	–	–	–	S	S	–	–	–	–	S	–	–	–	–	–	S	–	–	X
B2 m	Size	2	4	3	2	2	3	1	3	3	4	3	2	1	2	1	3	4	1	4
	Repr.	–	–	–	–	–	–	–	S	S	S	S	–	–	–	S	S	S	–	S
B7 m	Size	2	4	5	3	–	2	1	2	3	3	3	2	2	1	1	4	3	2	2
	Repr.	–	S	S	S	–	–	–	S	S	–	–	S	–	S	S	S	S	–	S
B10 m	Size	2	4	4	4	2	2	1	2	3	2	2	2	2	1	1	2	3	2	2
	Repr.	–	–	S	–	–	–	–	–	–	S	S	–	–	–	–	–	S	–	–
C2 m	Size	2	3	2	–	–	5	1	2	3	2	4	1	2	1	1	2	3	–	X
	Repr.	–	S	–	–	–	–	–	–	–	S	–	–	–	–	–	–	S	–	X
C7 m	Size	2	3	3	3	3	4	1	2	2	3	2	2	3	1	1	3	3	1	X
	Repr.	–	S	S	S	–	–	–	–	–	S	S	S	–	–	S	–	S	–	X
C10 m	Size	2	3	2	3	2	2	2	2	2	3	2	3	2	1	2	2	2	2	X
	Repr.	–	–	S	S	S	–	–	–	–	–	S	S	S	S	–	–	–	S	X

8. *Sphacelaria* spp. (Figs. 29,30,31)

Sphacelaria biradiata, S. cirrosa and *S. furcigera* were recorded together as a *Sphacelaria* species group.

The frequency data for this species group did not indicate any changes in the population size during the study, although irregular changes did occur. Thus frequency was not a satisfactory parameter for monitoring *Sphacelaria* spp. population changes. The group did not show a seasonal trend and was always common as an epiphyte on the seagrass leaves. There was little difference in the density of the species group at the 2 m and 7 m sites on the Transect A. However, on the Transect B, *Sphacelaria* spp. was most abundant at the 2 m deep site, while on the Transect C the species group was least dense at this collection site (Figs. 29,30,31).

Fertile plants were more common at the shallow water sites than at the deep water sites (Table 16).

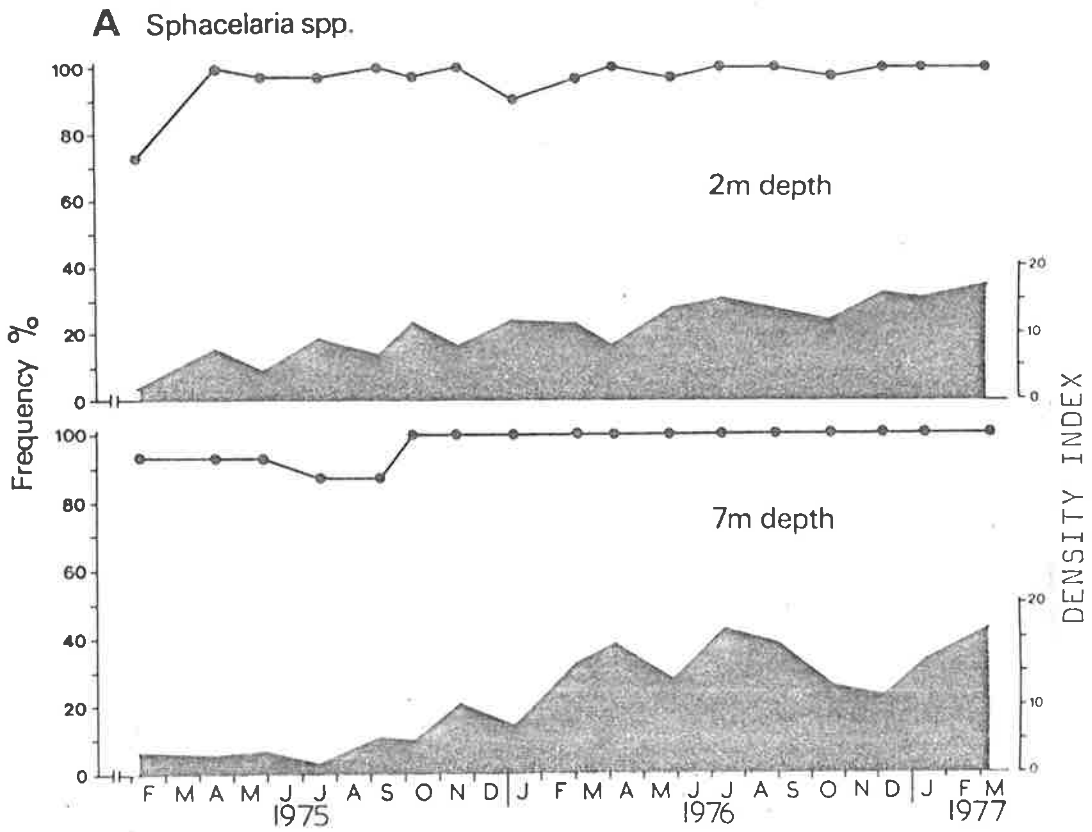


Fig. 29: Percentage frequency (solid line) and Density Index (shaded area) Values for *Sphacelaria* spp. on the Transect A.

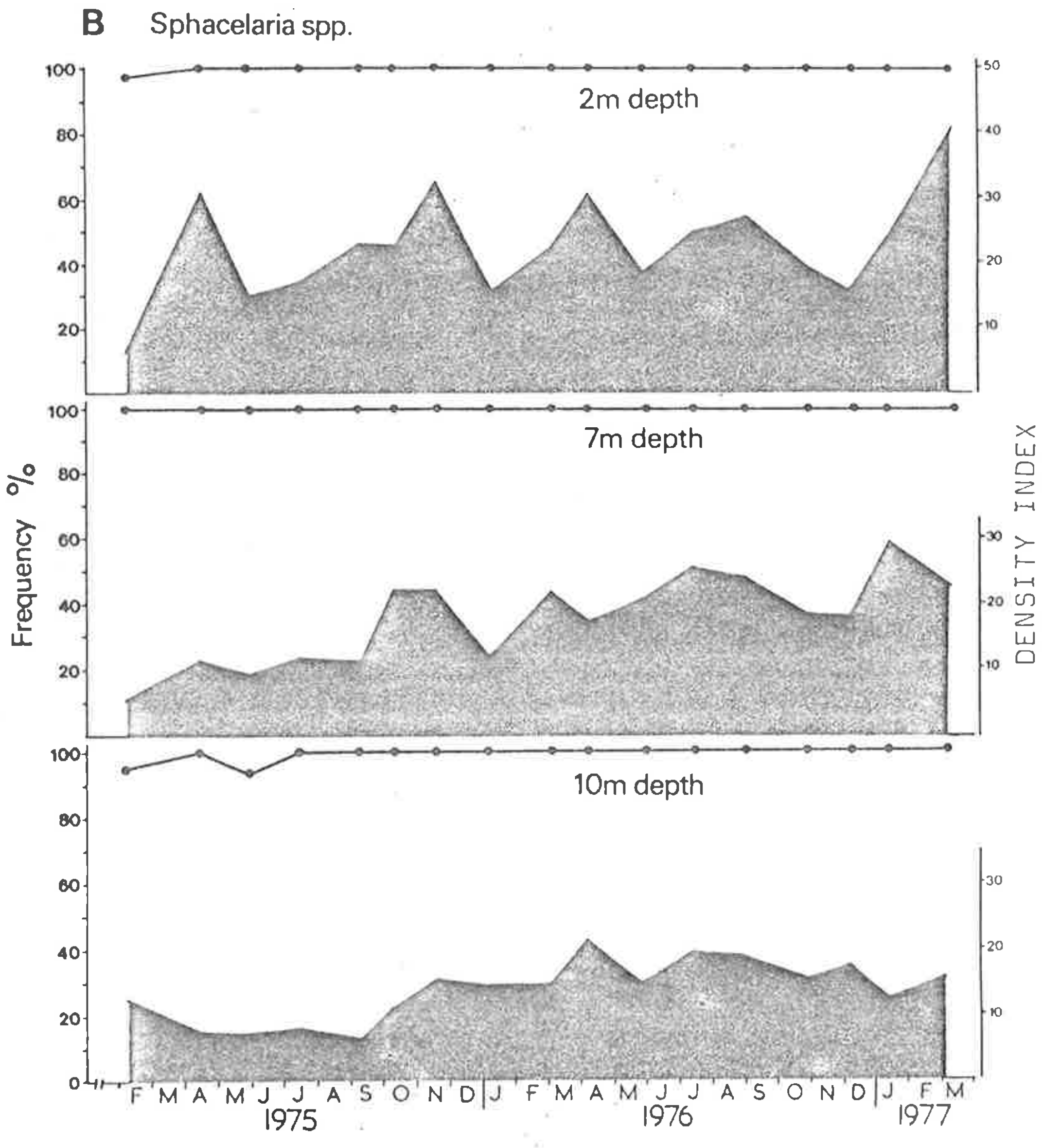


Fig. 30: Percentage frequency (solid line) and Density Index (shaded area) Values for *Sphacelaria* spp. on the Transect B.

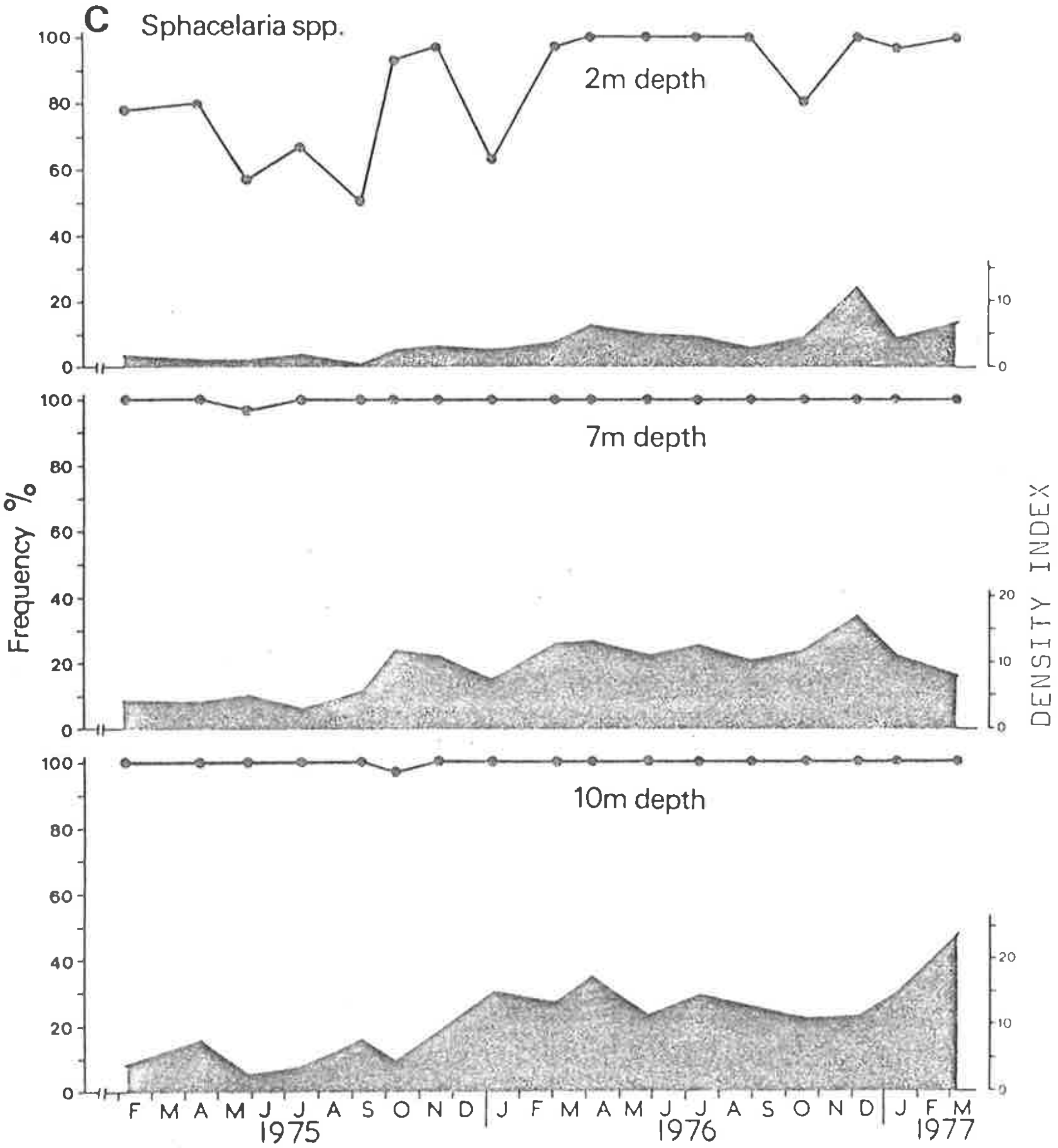


Fig. 31: Percentage frequency (solid line) and Density Index (shaded area) Values for *Sphacelaria* spp. on the Transect C.

Table 16: Size indices and reproductive plants recorded for *Sphacelaria* spp. during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	2	2	2	2	3	3	1	2	1	3	3	3	2	2	2	1	3	3	X
	Repr.	–	–	p	p	p	–	p	–	–	p	p	p	–	p	–	p	–	p	X
A7 m	Size	2	2	3	3	2	1	1	2	2	3	3	3	2	1	2	2	3	2	X
	Repr.	–	–	–	p	p	–	–	–	–	–	–	p	–	–	–	–	p	–	X
B2 m	Size	2	2	4	3	3	3	2	2	2	1	2	2	2	2	2	4	3	2	3
	Repr.	p	p	p	p	p	–	–	sp	p	–	p	–	–	–	–	–	p	–	p
B7 m	Size	2	3	3	3	3	3	2	2	2	2	3	3	4	2	1	1	2	4	2
	Repr.	–	p	p	p	p	p	p	p	–	–	p	p	–	p	–	–	p	–	–
B10 m	Size	2	2	3	3	3	3	2	1	2	2	2	3	4	3	3	1	1	3	2
	Repr.	–	–	–	–	–	–	p	–	–	–	–	p	p	–	p	–	–	p	p
C2 m	Size	2	3	2	2	2	2	1	1	1	2	1	2	2	1	1	2	2	2	X
	Repr.	p	–	p	p	p	–	–	–	–	p	p	–	p	–	–	–	–	p	X
C7 m	Size	2	2	2	3	2	3	1	2	2	2	2	2	3	1	2	2	2	1	X
	Repr.	p	–	p	–	–	–	p	–	–	p	–	p	p	–	–	–	–	–	X
C10 m	Size	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	4	4	X
	Repr.	–	–	–	p	–	–	–	–	–	–	–	–	p	–	p	–	–	–	X

Rhodophyta

9. *Anotrichium tenue* (Figs. 32, 33; Table 17)

There was a good correlation between frequency and abundance index data indicating that frequency was a satisfactory parameter for following population changes in this species.

Anotrichium was least common at the 10 m deep sites on Transects B and C, and although recorded more often at the 7 m deep site than at the 2 m deep site on Transect A, there was little difference in the abundance of this species at these two sites (Figs. 32,33). Generally the largest plants of this species were noted at the shallow water sites.

Anotrichium tenue was most often recorded on *Posidonia* during summer to autumn and this was also when fertile plants were noted (summer-autumn species). No fertile plants were recorded at the deepest sites (Table 17).

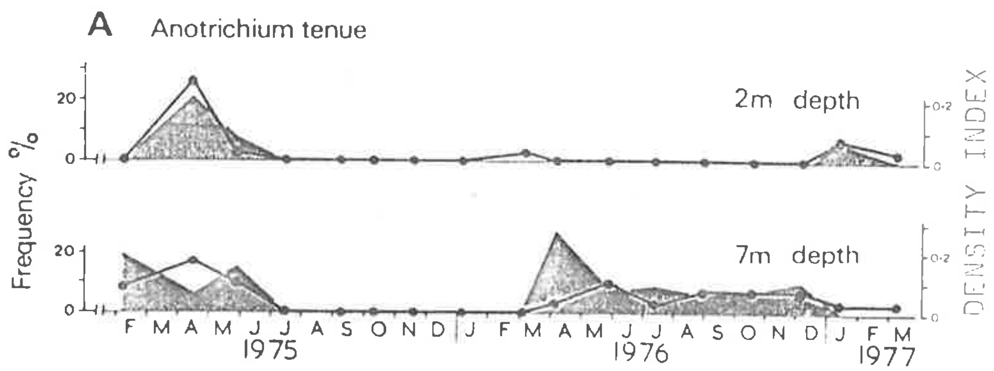


Fig. 32: Percentage frequency (solid line) and Density Index (shaded area) Values for *Anotrichium tenue* on the Transect A.

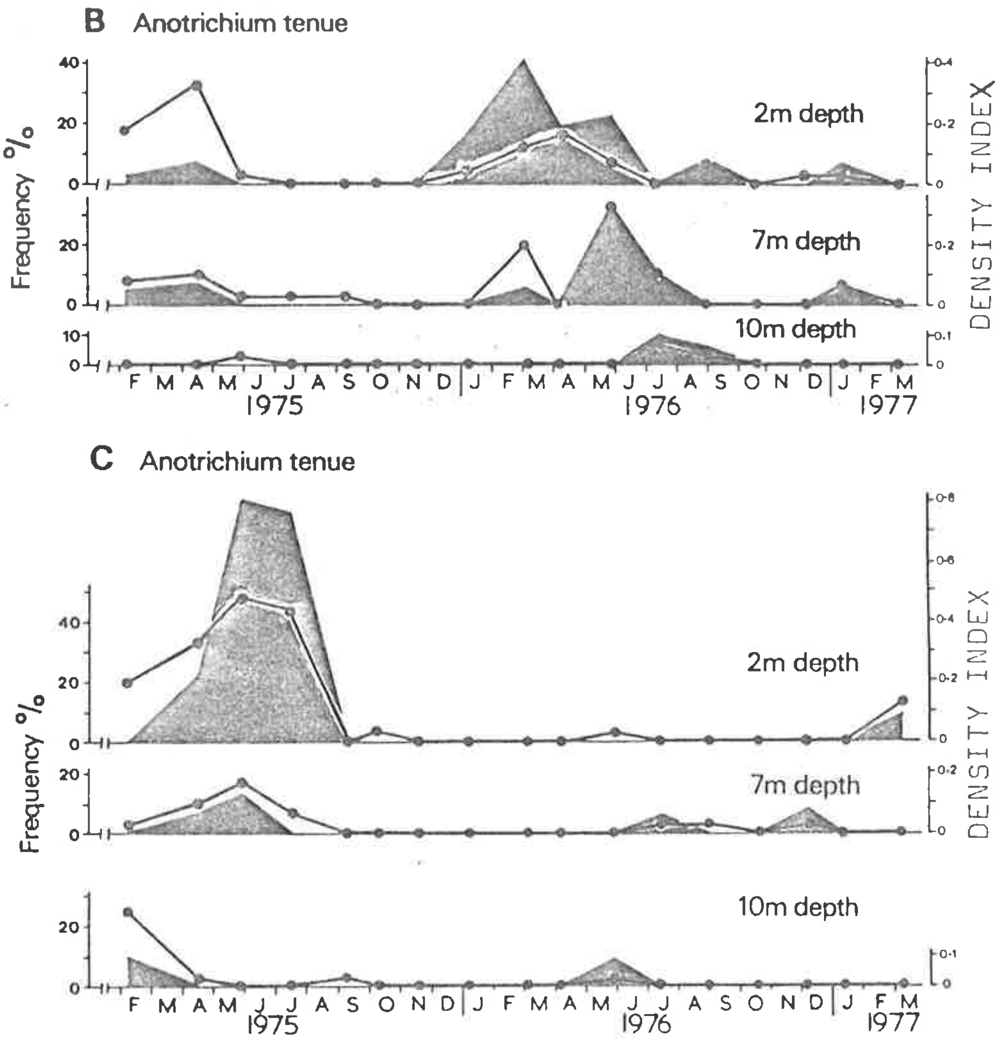


Fig. 33: Percentage frequency (solid line) and Density Index (shaded area) Values for *Anotrichium tenue* on the Transects B.

Table 17: Size indices and reproductive plants recorded for *Anotrichium tenue* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION 1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	2	1	–	–	–	–	–	1	–	–	–	–	–	–	1	2	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	3	3	4	–	–	–	–	–	–	2	3	3	2	1	–	3	2	–	X
	Repr.	–	–	m	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
B2 m	Size	3	4	5	–	–	–	–	2	2	3	4	–	5	–	2	1	–	–	5
	Repr.	–	f	m	–	–	–	–	f	⊕m	–	–	–	–	–	–	–	–	–	f
B7 m	Size	2	2	1	1	1	–	–	–	2	–	3	2	–	–	–	5	–	3	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B10 m	Size	–	–	2	–	–	–	–	–	–	–	–	2	2	–	–	–	–	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C2 m	Size	3	3	4	3	–	3	–	–	–	–	3	–	–	–	–	–	4	–	X
	Repr.	–	–	m	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	3	3	3	5	–	–	–	–	–	–	–	3	4	–	2	–	–	–	X
	Repr.	–	–	m	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	3	3	–	–	3	–	–	–	–	–	3	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

10. *Antithamnion divergens* (Figs. 34,35,36; Table 18)

Only at the 7 m depth, on the Transect A, did *Antithamnion* display a marked seasonality, nevertheless frequency data at all sites did reflect the population trends shown by the density indices.

Antithamnion divergens was more dense at the deep water sites and at these deeper sites on Transects A and B the species' density declined during the spring and early summer months (Sep.-Jan) (Figs. 34,35,36). The largest plants were recorded through autumn to early spring (Table 18) and during this period fertile plants were most often recorded. Overall *Antithamnion* was a non-seasonal epiphyte and was present on the seagrass leaves throughout most of the study period.

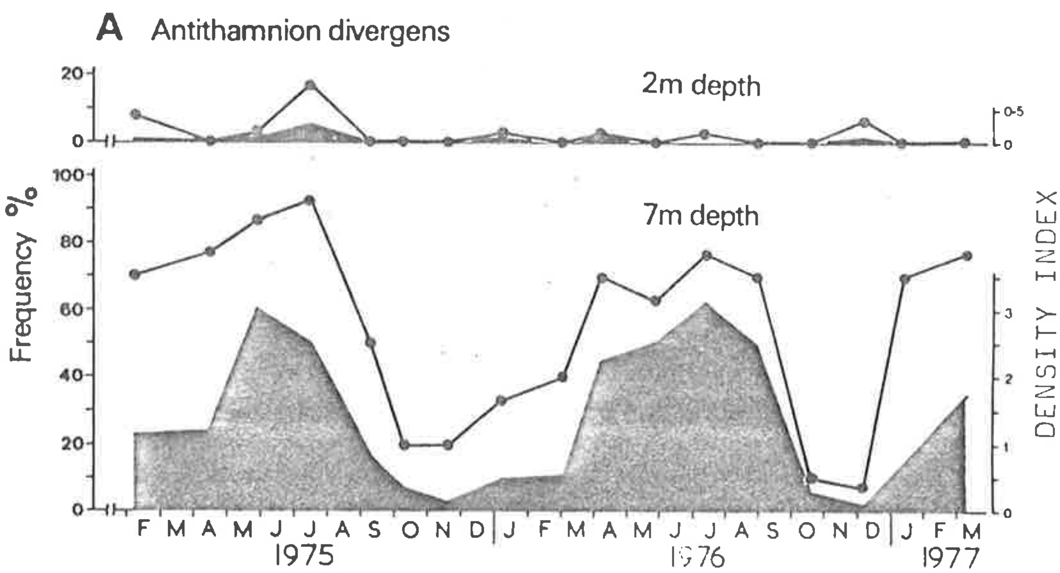


Fig. 34: Percentage frequency (solid line) and Density Index (shaded area) Values for *Antithamnion divergens* on the Transect A.

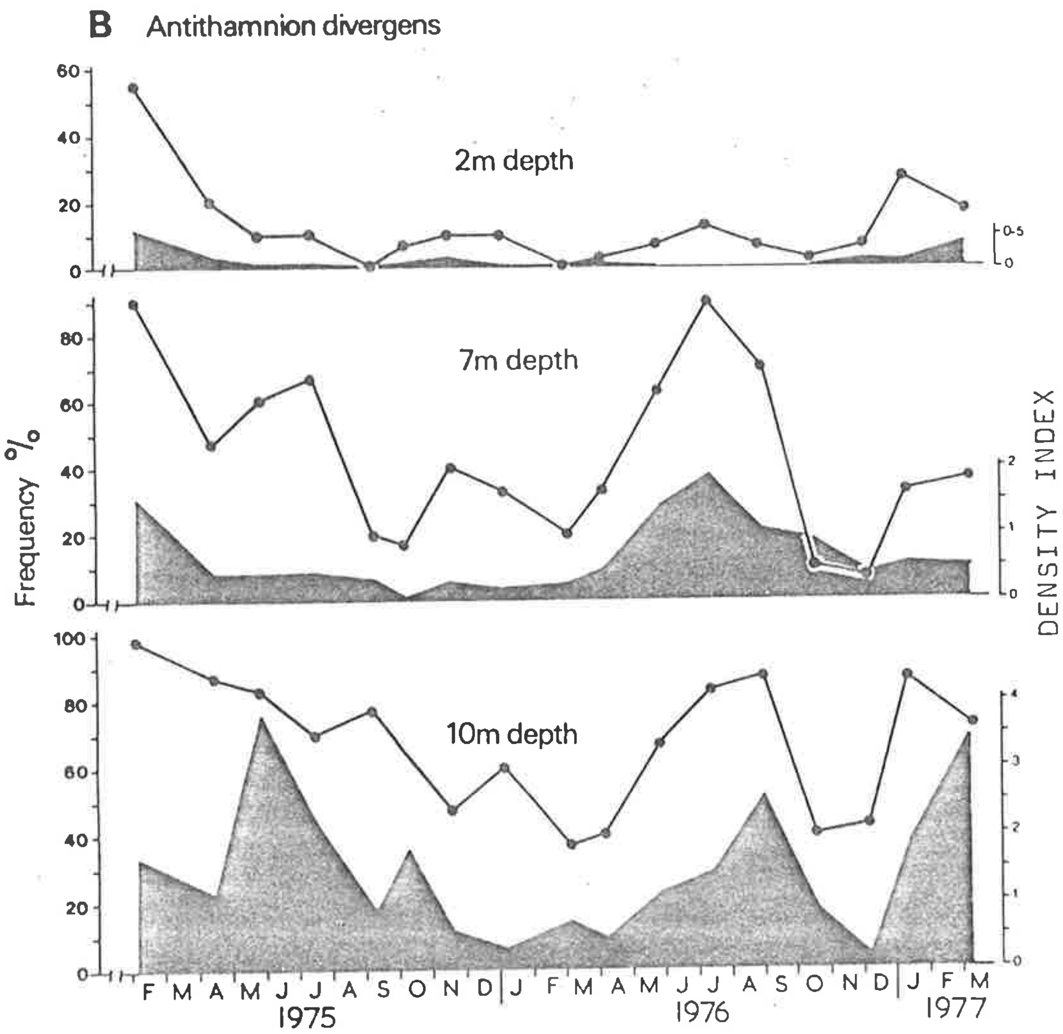


Fig. 35: Percentage frequency (solid line) and Density Index shaded area) Values for *Antithamnion divergens*, on the Transect B.

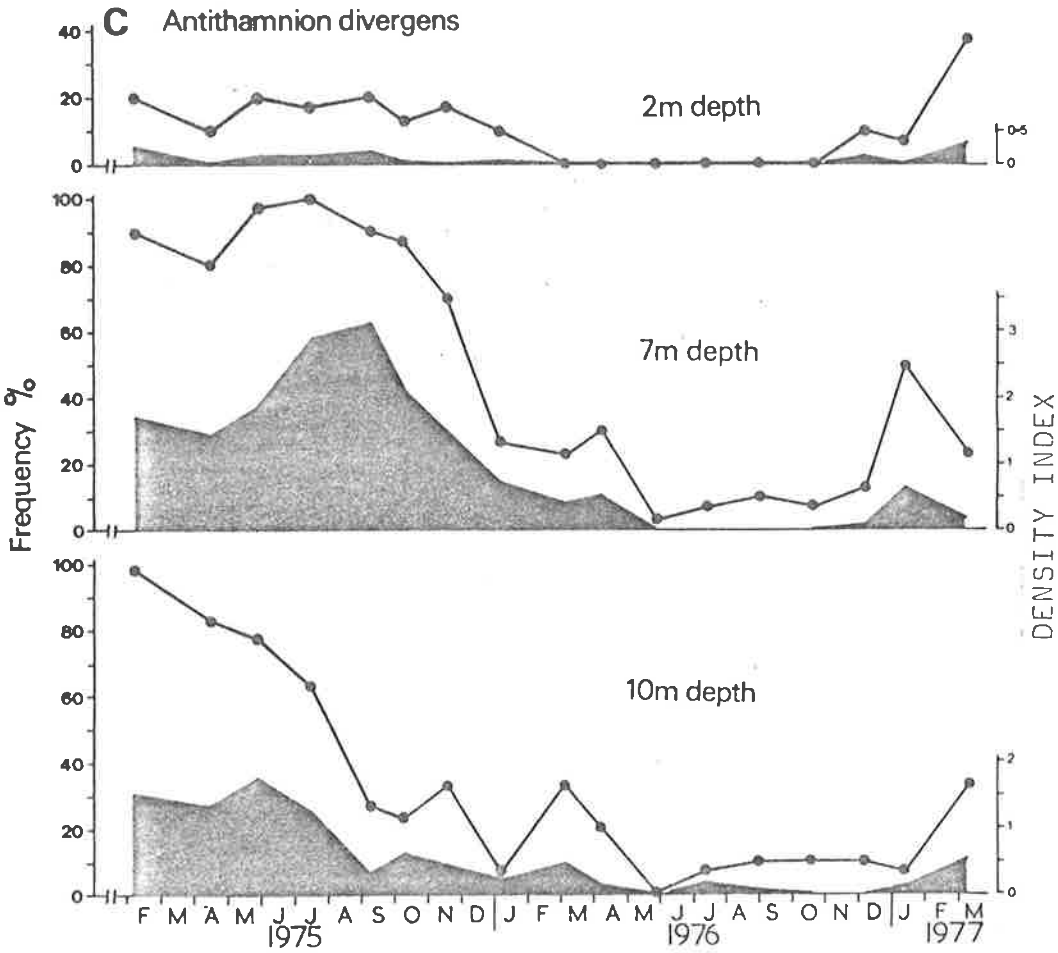


Fig. 36: Percentage frequency (solid line) and Density Index (shaded area) Values for *Antithamnion divergens*, on the Transect C.

Table 18: Size indices and reproductive plants recorded for *Antithamnion divergens* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																	
		1975							1976								1976			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	1	–	3	3	–	–	–	1	–	2	–	2	–	–	2	–	–	1	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	2	3	4	4	3	2	1	2	3	4	4	4	3	2	1	2	2	3	X
	Repr.	–	f⊕m	f⊕	f⊕	–	f	–	–	–	f⊕m	f⊕	f⊕	–	–	–	f	f	–	X
B2 m	Size	2	3	3	1	–	3	1	2	–	3	4	1	1	2	3	1	3	1	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	⊕	–	–	–	–
B7 m	Size	3	3	3	4	3	3	2	2	2	2	3	3	3	2	1	3	2	3	3
	Repr.	–	f⊕m	⊕	m	–	–	–	–	–	f⊕	f	–	–	–	–	–	⊕	–	f
B10 m	Size	2	2	3	3	3	3	1	2	2	2	2	3	3	4	2	3	3	3	4
	Repr.	–	–	f⊕m	f⊕	m	f	⊕	–	–	f	f⊕	–	–	–	⊕	f⊕	⊕	–	f
C2 m	Size	2	3	3	3	3	3	1	1	–	–	–	–	–	–	1	2	3	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	2	3	3	4	4	3	2	2	1	3	3	3	4	3	2	1	3	2	X
	Repr.	–	–	–	f	f	–	–	–	–	–	–	–	f	–	–	–	–	–	X
C10 m	Size	3	3	3	3	2	2	2	1	2	3	–	3	2	2	2	3	2	3	X
	Repr.	⊕	–	–	f	f	–	–	–	⊕	–	–	f	–	–	–	⊕	⊕	–	X

11. *Audouinella* sp. (Figs. 37,38; Table 19)

Audouinella sp. was a summer-autumn species (Feb.-Apr.). At all study sites, except Transect C, 2 m depth, *Audouinella* had a peak of density and frequency around mid-autumn (April) while a low density and a corresponding low frequency were recorded from mid-winter to mid-spring (Jul.-Oct.)(Figs. 37,38). At Transect C, 2 m depth, no seasonal pattern was observed.

On Transects A and B, *Audouinella* sp. was more abundant at the 2 m deep sites than at the 7 m and 10 m deep sites, however on Transect C the species was least abundant at the 2 m deep collection site (Figs. 37,38).

Fertile plants with monosporangia were rarely recorded (Table 19).

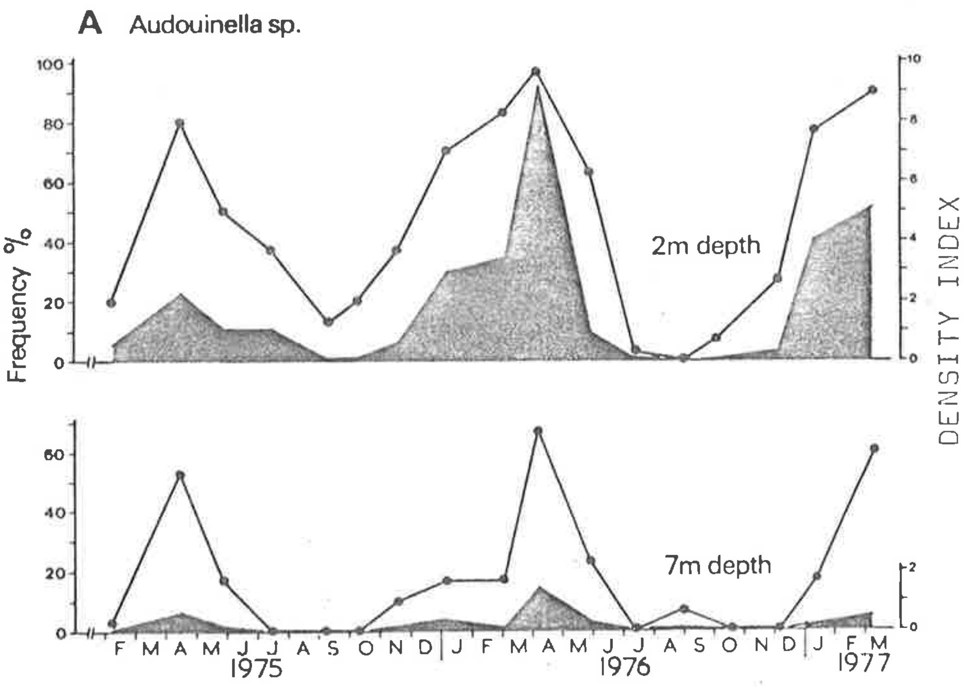


Fig. 37: Percentage frequency (solid line) and Density Index (shaded area) Values for *Audouinella* sp. on the Transect A.

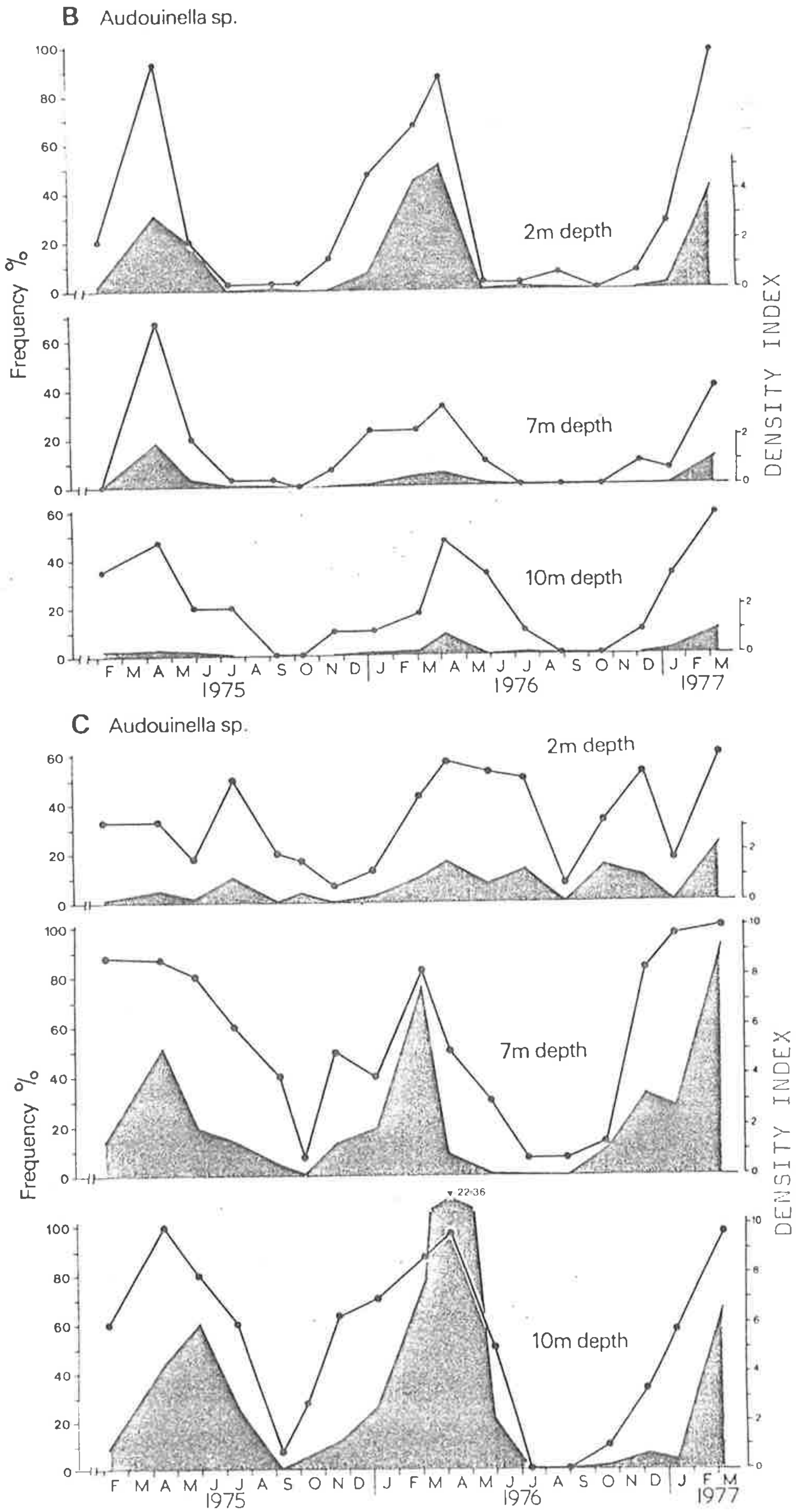


Fig. 38: Percentage frequency (solid line) and Density Index (shaded area) Values for *Audouinella* sp. on the Transects B and C.

Table 19: Size indices and reproductive plants recorded for *Audouinella* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	3	3	3	3	3	3	2	3	3	3	3	2	–	2	3	2	3	3	X
	Repr.	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	3	4	4	–	–	–	2	3	3	4	4	–	1	–	–	2	2	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
B2 m	Size	2	3	5	5	5	5	2	3	3	3	4	1	2	–	2	2	4	–	3
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B7 m	Size	–	4	4	3	3	–	1	2	3	2	2	–	–	–	1	2	2	–	2
	Repr.	–	–	0	–	–	–	–	0	–	–	–	–	–	–	–	–	–	–	–
B10 m	Size	2	3	3	2	–	–	2	3	2	2	4	2	–	–	2	3	4	3	5
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C2 m	Size	3	3	3	3	2	3	1	3	3	3	1	2	2	1	1	3	3	2	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	2	3	5	5	3	3	2	2	4	3	2	2	4	2	2	3	3	2	X
	Repr.	–	–	0	–	–	0	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	3	3	4	3	1	3	2	3	3	3	2	–	–	1	2	2	3	1	X
	Repr.	–	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

12. *Centroceras clavulatum* (Figs. 39,40; Table 20)

This species was most abundant at the 7 m deep collection sites. Both the frequency and density index data showed that *Centroceras* was almost absent, if not absent, from the *Posidonia* leaves during the spring (Sep.-Nov.) (Figs. 39,40). Therefore, this species was placed in the summer-winter species category.

Fertile plants were rarely recorded during the study period (Table 20).

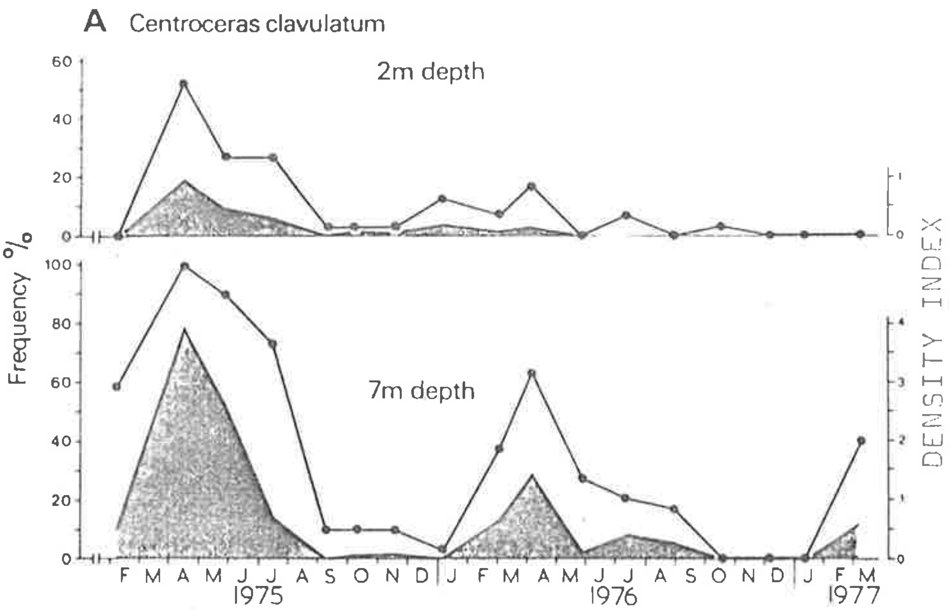


Fig. 39: Percentage frequency (solid line) and Density Index (shaded area) Values for *Centroceras clavulatum* on the Transect A.

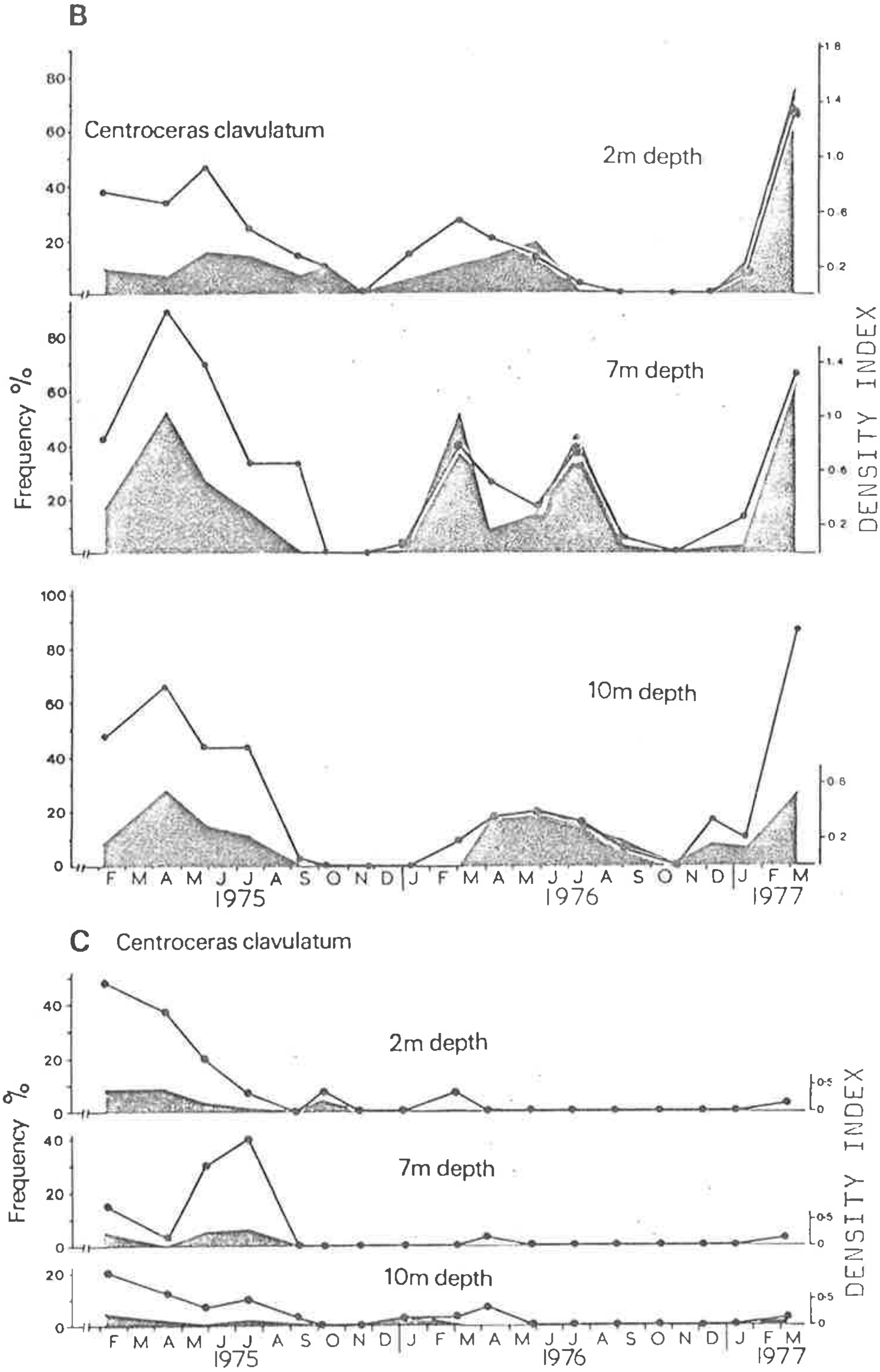


Fig. 40: Percentage frequency (solid line) and Density Index (shaded area) Values for *Centroceras clavulatum* on the Transects B and C.

Table 20: Size indices and reproductive plants recorded for *Centroceras clavulatum* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITES	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	2	2	3	3	1	1	2	1	1	–	3	–	1	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	3	3	3	3	3	2	1	2	2	3	3	2	2	–	–	–	3	3	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
B2 m	Size	2	3	2	2	2	3	–	1	1	2	3	2	–	–	–	2	3	1	4
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	⊕	–	–	–
B7 m	Size	3	3	2	3	2	–	–	2	2	1	2	3	2	–	1	3	2	4	4
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	f⊕	–	–
B10 m	Size	2	3	3	3	3	–	–	–	3	3	2	3	2	–	2	2	4	3	3
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C2 m	Size	3	2	2	5	–	2	–	–	2	–	–	–	–	–	–	–	2	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	3	2	3	2	–	–	–	–	–	2	–	–	–	–	–	–	2	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	3	3	3	2	2	–	–	2	1	2	–	–	–	–	–	–	3	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

13. *Ceramium puberulum* (Figs, 41,42,43; Table 21)

The frequency data did reflect the general population changes indicated by the density indices.

Ceramium puberulum showed no seasonal trend at any of the study sites (Figs. 41,42,43) although the size indices (Table 21) suggested that the species reached its maximum size during autumn to winter (Apr.-Sep.) and a new settlement of spores occurred on the leaves that were collected in spring. The plants were more abundant on the *Posidonia* leaves at the shallow water sites on all transects and fertile plants were recorded throughout the year.

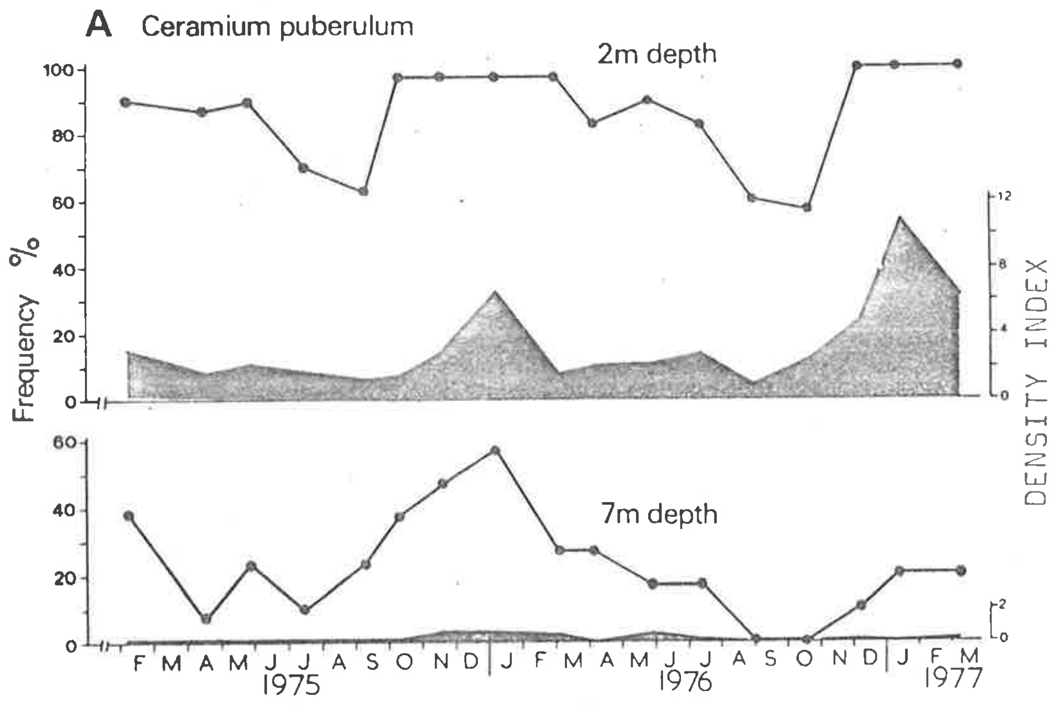


Fig. 41: Percentage frequency (solid line) and Density Index (shaded area) Values for *Ceramium puberulum* on the Transect A.

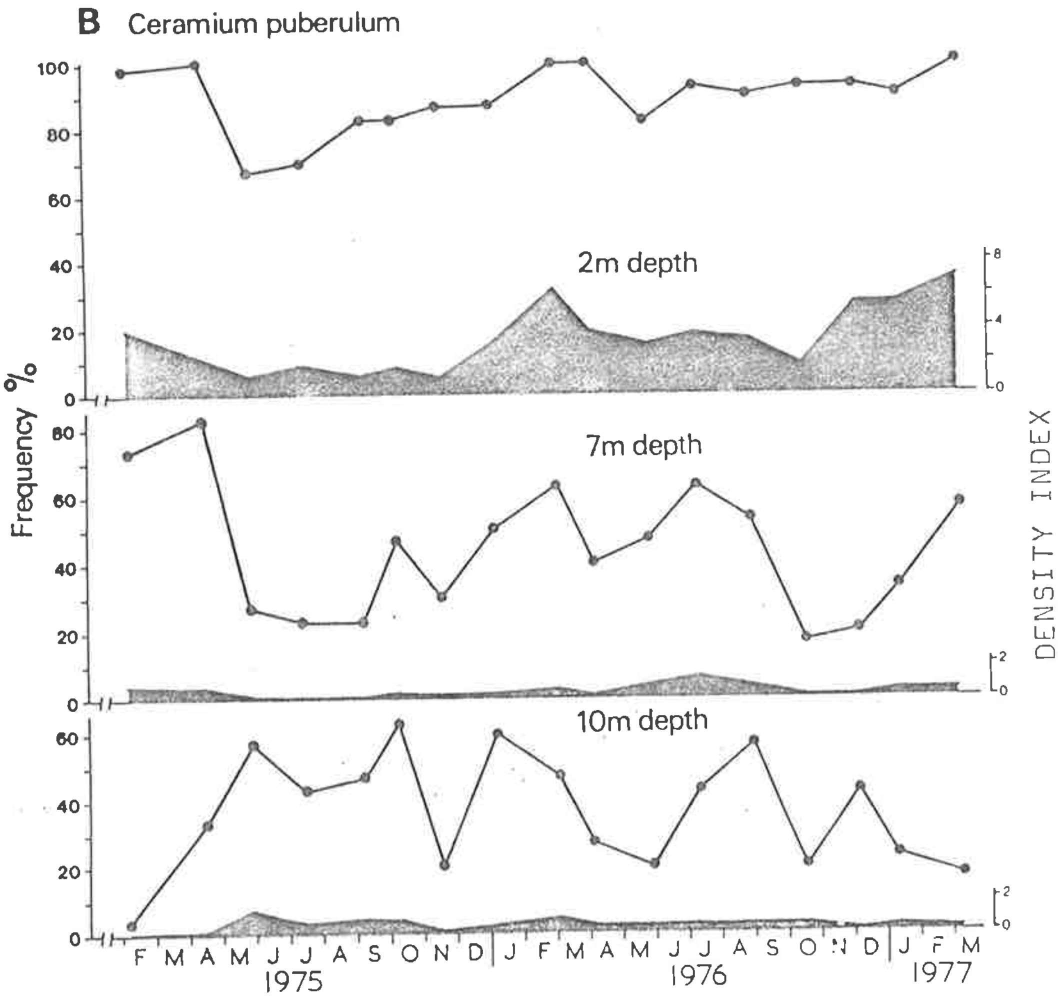


Fig. 42: Percentage frequency (solid line) and Density Index (shaded area) Values for *Ceramium puberulum* on the Transect B.

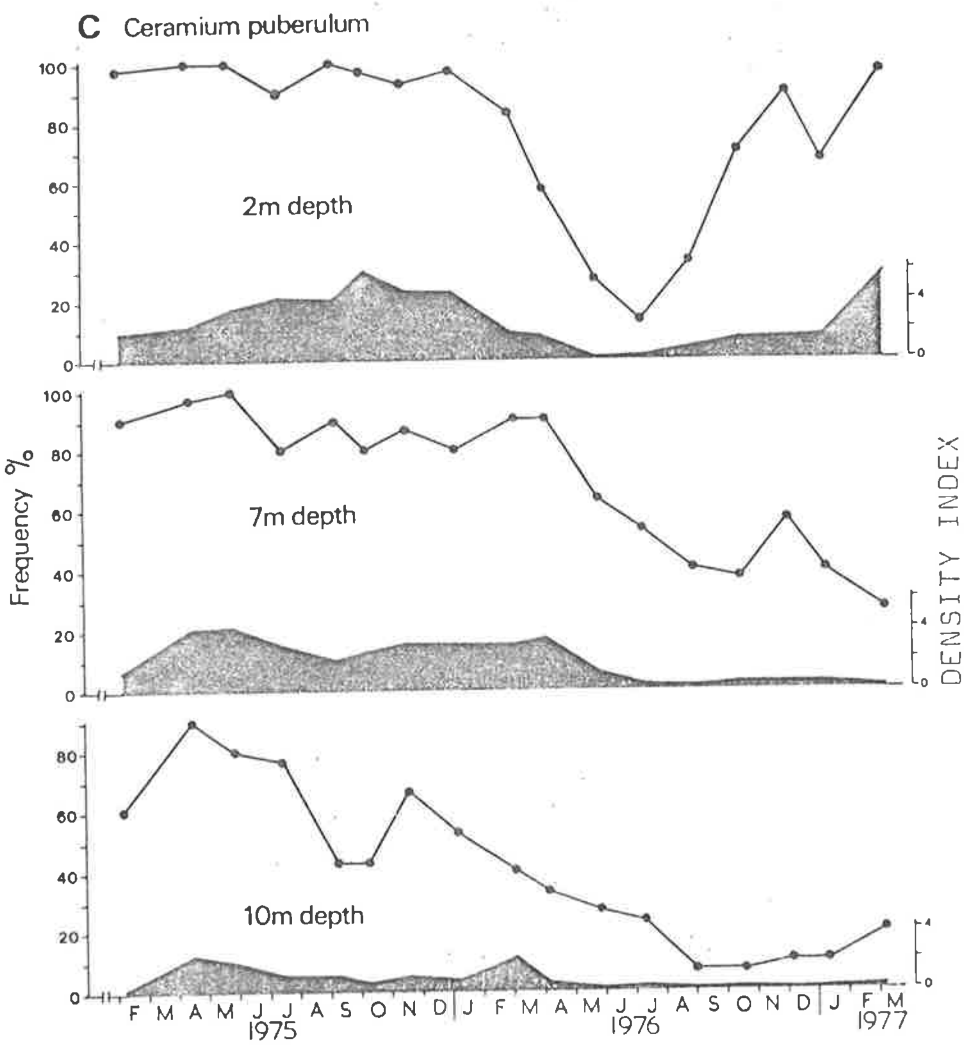


Fig. 43: Percentage frequency (solid line) and Density Index (shaded area) Values for *Ceramium puberulum* on the Transect C.

Table 21: Size indices and reproductive plants recorded for *Ceramium puberulum* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	3	2	3	4	3	3	1	2	2	2	3	4	3	3	3	3	2	3	X
	Repr.	–	⊕	fm	f⊕	f⊕	f⊕	⊕	–	–	f⊕m	f⊕	–	f⊕	–	f	f⊕m	–	f	X
A7 m	Size	2	3	4	4	1	1	1	1	2	2	2	4	–	–	2	2	2	1	X
	Repr.	–	–	–	–	–	f	f	–	–	–	–	–	–	–	–	f	–	–	X
B2 m	Size	3	3	4	2	3	3	2	1	2	2	3	3	3	1	2	2	3	3	4
	Repr.	f	–	f⊕	m	m	f⊕	f	f⊕m	–	f⊕	f⊕	f⊕	f⊕m	⊕m	f⊕	f⊕m	f⊕	fm	f⊕m
B7 m	Size	2	2	3	2	2	3	1	1	2	2	3	3	3	1	1	2	2	4	3
	Repr.	–	⊕	–	–	–	–	–	–	–	–	f	–	fm	–	–	f	⊕	⊕	f⊕
B10 m	Size	1	2	3	2	3	3	1	2	2	2	2	3	3	1	1	2	3	4	3
	Repr.	–	⊕	fm	–	f⊕	–	–	f	m	f⊕	–	–	m	–	⊕	f	–	–	f⊕
C2 m	Size	2	2	3	4	2	3	1	2	2	2	3	3	3	1	2	2	2	3	X
	Repr.	f⊕m	⊕	f⊕m	⊕m	f⊕	f⊕m	–	–	–	m	–	–	⊕	–	f⊕	–	f	f⊕	X
C7 m	Size	2	3	5	4	3	2	2	2	2	3	2	3	4	1	1	3	2	1	X
	Repr.	–	⊕	f⊕	f⊕	f⊕	–	f⊕	⊕	–	f⊕m	–	–	–	–	–	–	f	–	X
C10 m	Size	2	2	2	3	1	1	2	2	2	3	2	2	2	2	2	2	3	4	X
	Repr.	⊕	–	⊕	f⊕m	–	–	⊕	–	f⊕	⊕	⊕	–	⊕	–	⊕	–	–	–	X

14. *Ceramium shepherdii* (Figs. 44,45; Table 22)

On the Transects A and B, the frequencies and density indices showed that *Ceramium shepherdii* was a marked summer-winter species (Dec.-July) (Figs. 44,45). The size indices also showed that the plants reached their maximum size in autumn (Apr.-May) before their decline in size at the end of winter (Table 22). On the Transect C, *Ceramium shepherdii* was much less common than at the other transects and was a non-seasonal species which did not show a depth preference. There was good correlation between frequencies and density indices for the species at all collection sites.

Ceramium shepherdii was more abundant at the deeper sites of the Transects A and B, and fertile plants were observed through summer and autumn.

On the basis of the results for Transects A and B, *Ceramium shepherdii* was considered a summer-winter species near Redcliff Point.

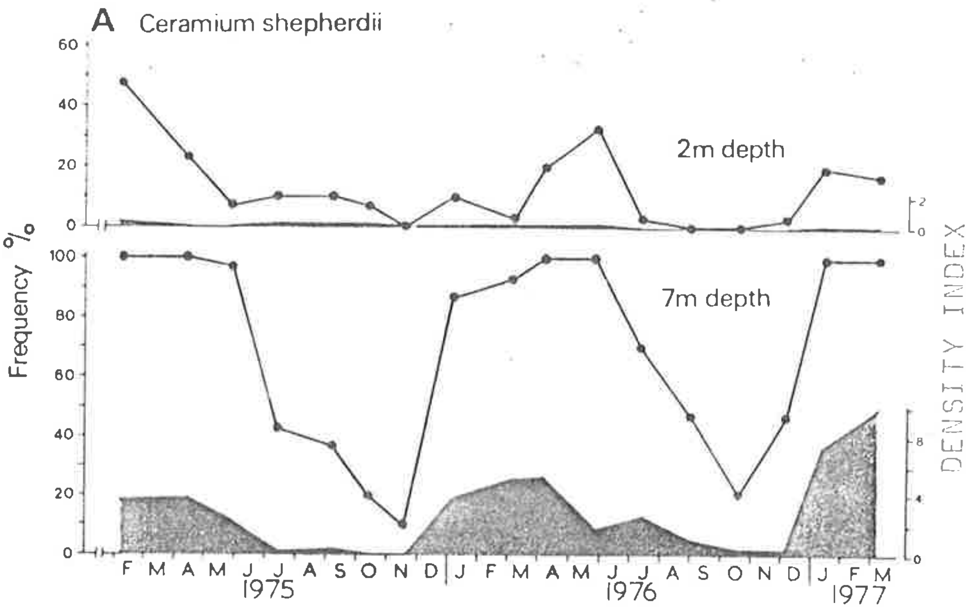


Fig. 44: Percentage frequency (solid line) and Density Index (shaded area) Values for *Ceramium shepherdii* on the Transect A.

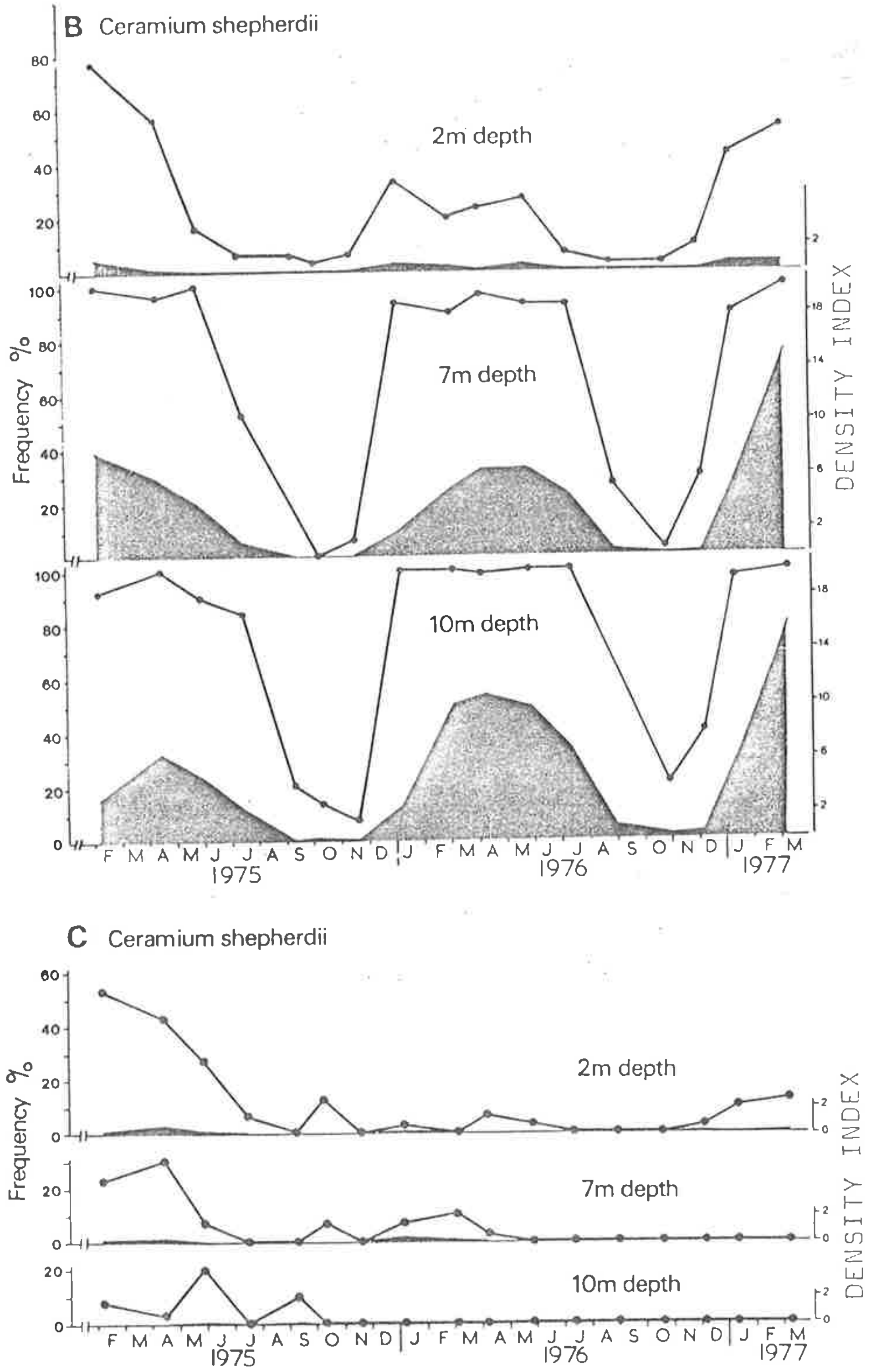


Fig. 45: Percentage frequency (solid line) and Density Index (shaded area) Values for *Ceramium shepherdii* on the Transects B and C.

Table 22: Size indices and reproductive plants recorded for *Ceramium shepherdii* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION 1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	3	3	2	2	2	2	–	1	1	2	2	2	–	–	1	1	1	2	X
	Repr.	⊕	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	3	3	4	5	2	2	1	1	3	3	3	3	1	1	1	2	3	1	X
	Repr.	fm	–	–	f⊕	–	–	–	–	f	f⊕	–	–	–	–	–	f	–	–	X
B2 m	Size	2	3	2	1	2	2	2	2	1	1	2	2	1	1	1	1	1	2	2
	Repr.	–	–	–	–	–	–	m	–	–	–	–	–	–	–	–	–	f	–	–
B7 m	Size	2	3	3	3	2	–	2	2	3	2	4	3	3	1	1	3	3	4	3
	Repr.	f	f	f	–	–	–	–	f	f	⊕	f⊕	m	–	–	–	f	f⊕m	–	–
B10 m	Size	3	4	3	2	2	2	2	2	2	2	3	4	3	1	1	2	2	3	2
	Repr.	f⊕m	fm	f⊕	–	–	–	–	f	f	f⊕m	m	–	–	–	⊕	f⊕m	f⊕m	–	–
C2 m	Size	2	2	2	3	–	2	–	2	–	2	1	–	–	–	1	2	3	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	2	3	2	–	–	2	–	2	1	3	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	⊕	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	2	3	2	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

15. *Champia zostericola* (Figs. 46,47; Table 23)

Champia zostericola was a non-seasonal species, indicated by both the frequencies and the density indices. There was a good correlation between changes in the frequencies and the density indices. The species was most abundant at the shallow water sites on Transects A, B and C (Figs. 46,47) and fertile plants were present throughout the year at these sites on the Transects A and B. At the Transect C, 2 m depth site, *Champia* was absent in the collections from March to July 1976, however fertile plants were present at most other collections (Table 23).

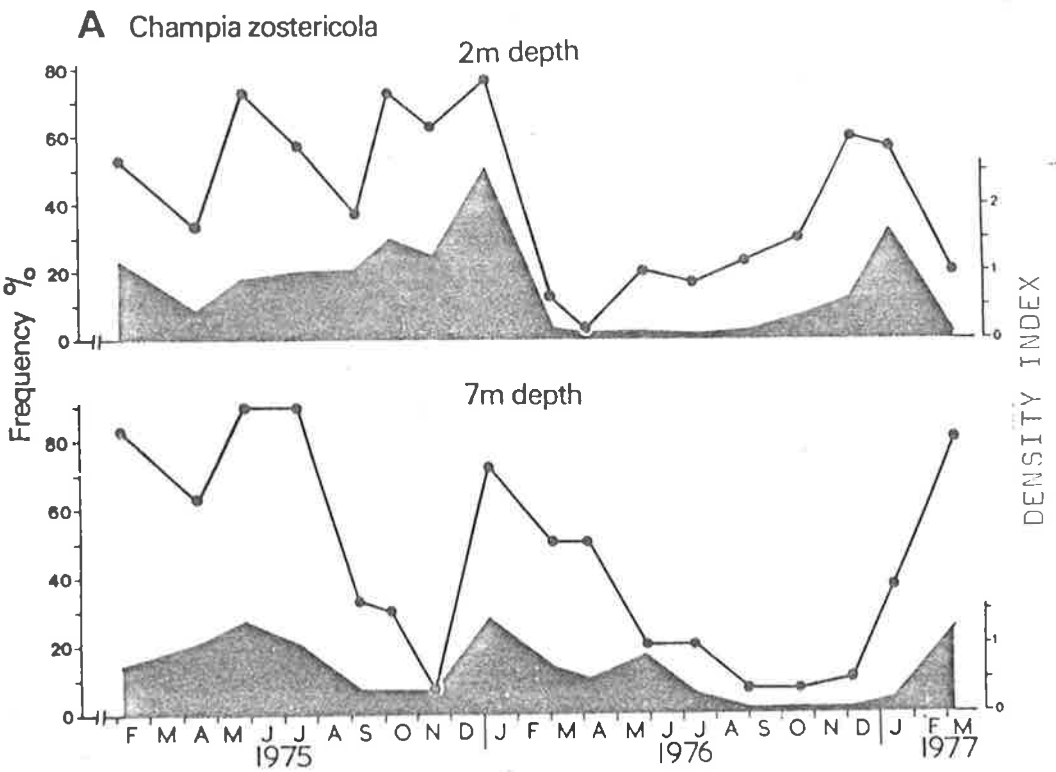


Fig. 46: Percentage frequency (solid line) and Density Index (shaded area) Values for *Champia zostericola* on the Transect A.

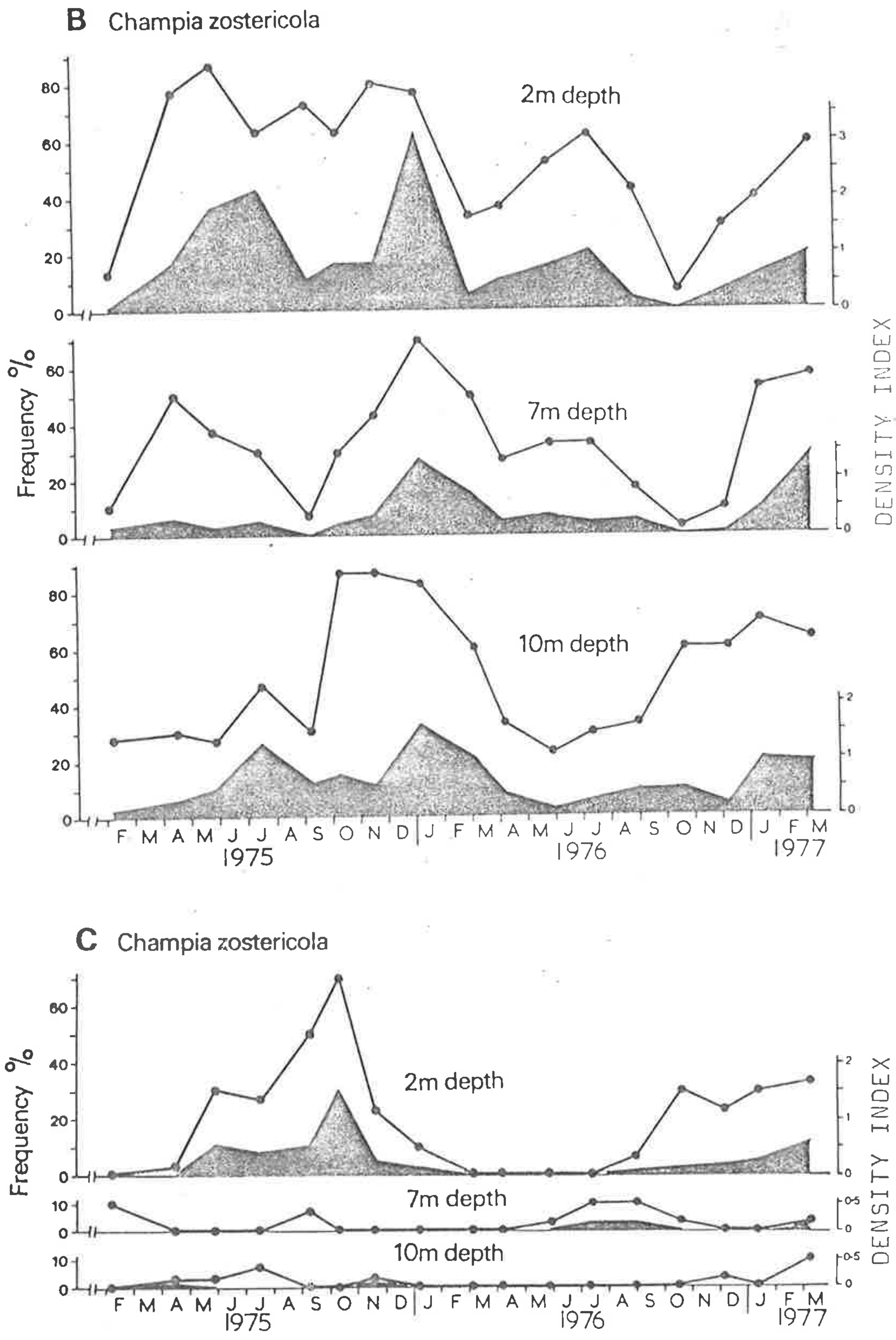


Fig. 47: Percentage frequency (solid line) and Density Index (shaded area) Values for *Champia zostericola* on the Transects B and C.

Table 23: Size indices and reproductive plants recorded for *Champia zostericola* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTIONS																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	3	3	2	3	2	3	1	2	1	4	1	3	2	3	2	2	2	3	X
	Repr.	–	⊕	f⊕	f	f	f⊕m	⊕m	fm	–	f	f	f	f⊕	fm	–	f⊕	⊕	⊕	X
A7 m	Size	1	2	3	4	2	2	1	2	1	2	2	3	2	2	2	1	3	2	X
	Repr.	–	–	f⊕m	f⊕m	⊕	–	–	m	m	–	–	–	–	–	–	–	–	–	X
B2 m	Size	2	3	3	2	3	2	1	2	1	2	2	2	2	1	2	2	2	2	3
	Repr.	–	f⊕m	f⊕	–	f	⊕	⊕	f⊕m	–	f⊕	⊕	f	⊕m	–	fm	f	f	⊕	f⊕m
B7 m	Size	3	3	2	2	2	2	1	2	1	2	1	1	2	2	2	3	2	2	3
	Repr.	–	–	f⊕	–	–	f	–	f	⊕	–	⊕	⊕m	–	–	–	fm	⊕	–	⊕
B10 m	Size	2	2	2	2	3	2	1	1	1	1	1	1	1	1	3	3	2	2	2
	Repr.	–	⊕	m	–	–	⊕	⊕	f⊕	⊕	–	–	–	–	–	⊕	f⊕	⊕	–	f⊕m
C2 m	Size	–	3	2	3	2	2	1	1	–	–	–	–	2	1	2	2	3	2	X
	Repr.	–	⊕	⊕m	m	–	⊕	–	–	–	–	–	–	–	f	m	⊕	–	–	X
C7 m	Size	3	–	–	–	2	–	–	–	–	–	2	1	3	1	–	–	3	2	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	⊕	–	–	–	–	–	X
C10 m	Size	–	3	1	2	–	–	1	–	–	–	–	–	–	–	2	–	2	–	X
	Repr.	–	⊕	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

16. *Chondria dasyphylla* (Fig. 48; Table 24)

This species was not common on *P. sinuosa* leaves, nevertheless there was a good correlation between the frequencies and density indices (Fig. 48). It displayed no seasonal trend nor a preference for a particular depth of study site.

Fertile plants were recorded on the Transects A and C only (Table 24).

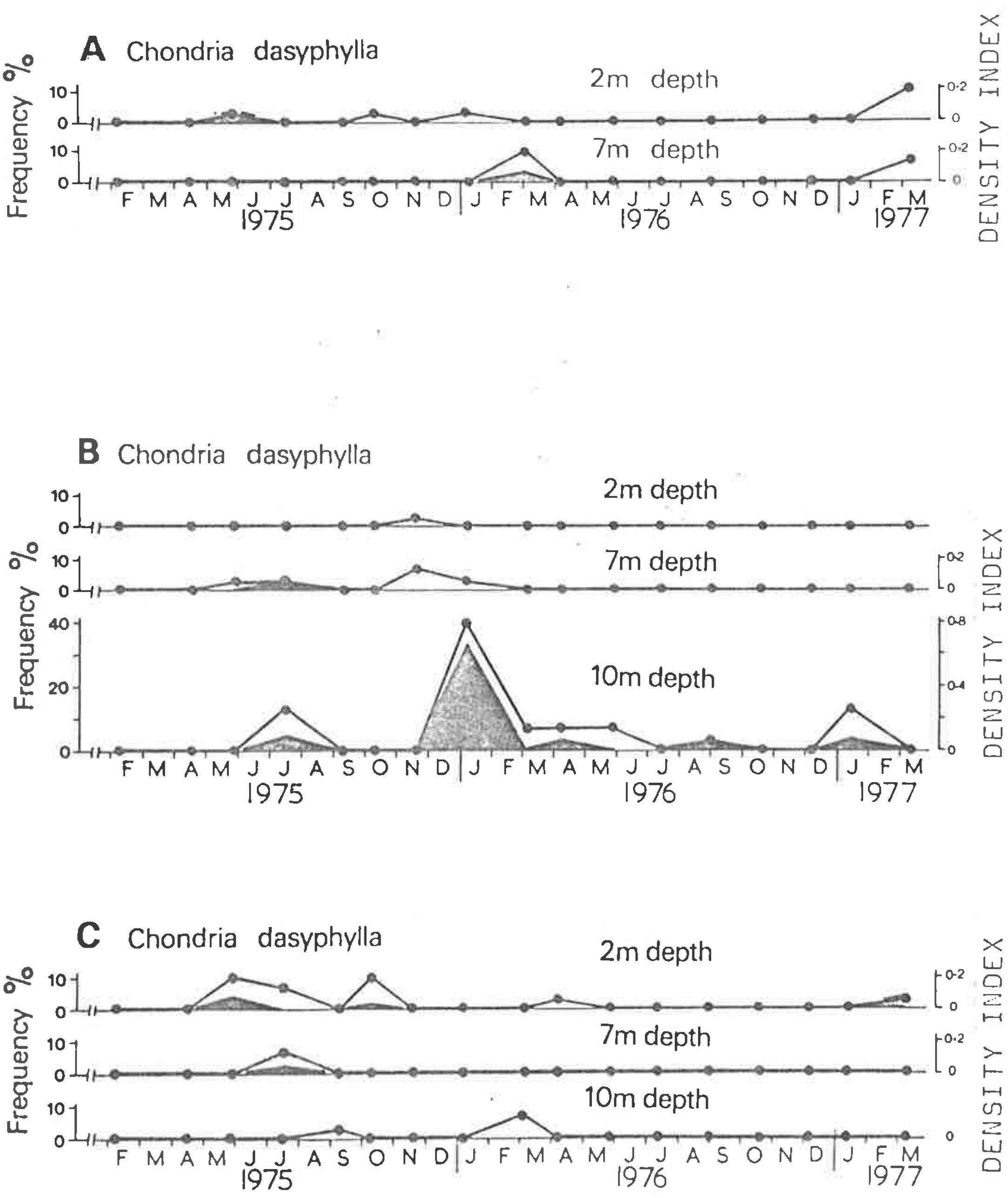


Fig. 48: Percentage frequency (solid line) and Density Index (shaded area) Values for *Chondria dasyphylla*, on the Transects A, B and C.

Table 24: Size indices and reproductive plants recorded for *Chondria dasyphylla* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																				
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	–	5	–	–	5	–	2	–	–	–	–	–	–	–	–	3	–	X
	Repr.	–	–	⊕	–	–	–	–	–	–	–	–	–	–	–	–	–	⊕	–	X
A7 m	Size	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	4	–	X
	Repr.	–	–	–	–	–	–	–	–	f	–	–	–	–	–	–	–	–	–	X
B2 m	Size	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B7 m	Size	–	–	2	2	–	–	2	3	–	–	–	–	–	–	–	–	–	–	5
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B10 m	Size	–	–	–	2	–	–	–	4	2	2	2	–	3	–	–	3	–	–	2
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C2 m	Size	–	–	5	3	–	3	–	–	–	2	–	–	–	–	–	–	3	–	X
	Repr.	–	–	⊕	f	–	⊕	–	–	–	–	–	–	–	–	–	–	⊕	–	X
C7 m	Size	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	–	–	–	–	4	–	–	–	2	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

17. Corallina sp. (Fig. 49; Table 25)

This non-seasonal species was most abundant at the 2 m deep collection sites on all transects. Changes in density correlated with the changes in frequency (Fig. 49). Fertile plants were recorded at the shallow water sites only (Table 25) on each transect.

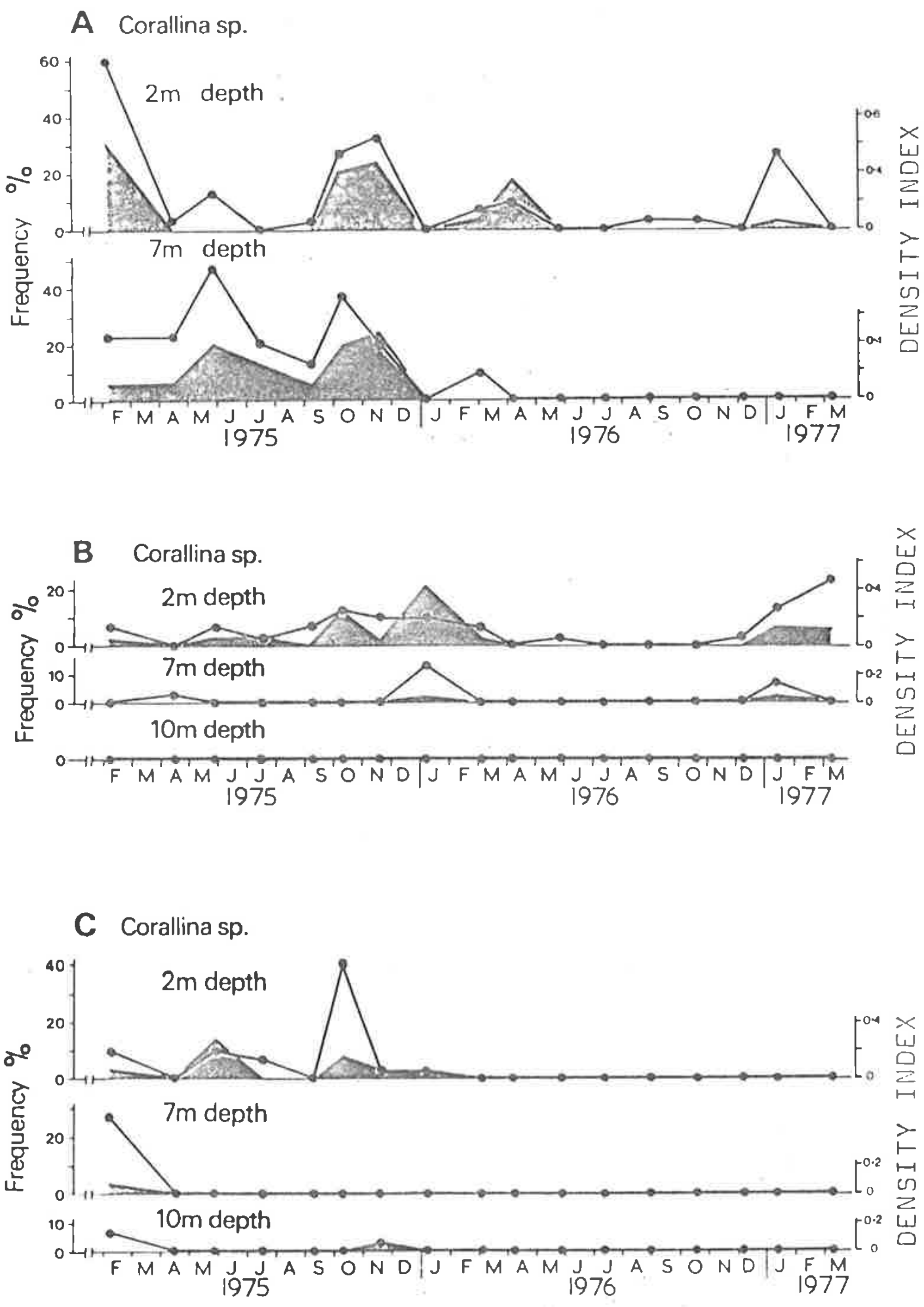


Fig. 49: Percentage frequency (solid line) and Density Index (shaded area) Values for *Corallina* sp. on the Transects A, B and C.

Table 25: Size indices and reproductive plants recorded for *Corallina* sp. during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SIZE	INDEX	COLLECTION 1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	2	4	3	–	4	3	2	–	4	3	–	–	3	2	–	3	–	3	X
	Repr.	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	X
A7 m	Size	3	2	2	2	3	3	2	–	4	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
B2 m	Size	3	–	4	4	2	2	2	4	2	–	2	–	–	–	3	1	3	–	–
	Repr.	–	–	+	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–
B7 m	Size	–	2	–	–	–	–	–	1	–	–	–	–	–	–	–	3	–	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B10 m	Size	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C2 m	Size	3	–	3	4	–	3	1	2	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	2	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

18. *Crouania sp.* (Fig. 50; Table 26)

Crouania displayed neither a seasonal trend nor a preference for a particular depth site but there was good correlation between frequencies and density indices. The species was least abundant on the Transect C (Fig. 50).

Fertile plants were rare and were not observed on the Transect C (Table 26) during the study.

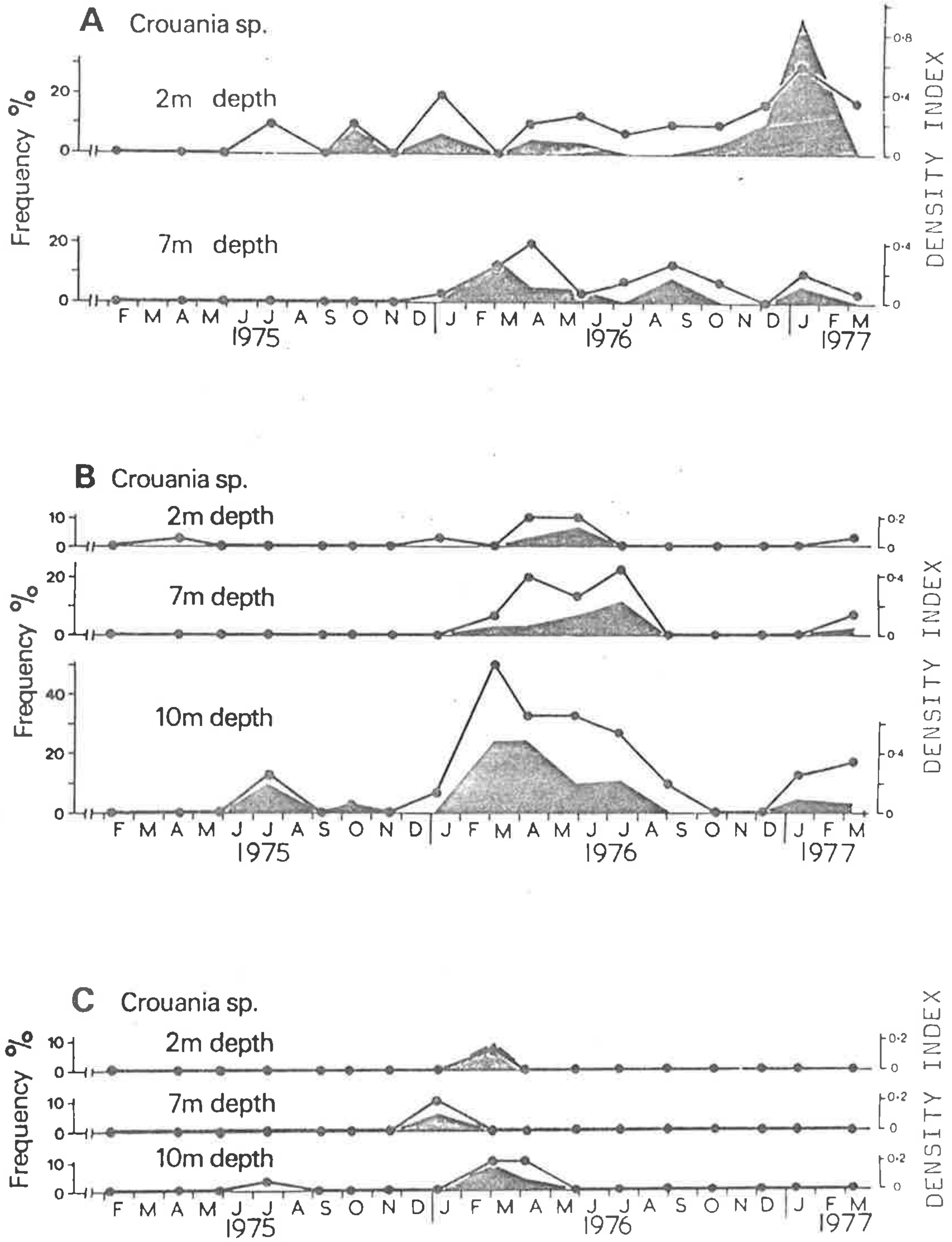


Fig. 50: Percentage frequency (solid line) and Density Index (shaded area) Values for *Crouania* sp. on the Transects A, B and C.

Table 26: Size indices and reproductive plants recorded for *Cronania* sp. during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																			
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	–	–	2	–	3	–	2	–	2	2	2	3	3	2	3	3	2	X
	Repr.	–	–	–	–	–	f	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	–	–	–	–	–	–	–	2	4	3	2	2	1	2	–	1	2	1	X
	Repr.	–	–	–	–	–	–	–	–	–	f⊕	–	–	–	–	–	f	–	–	X
B2 m	Size	–	3	–	–	–	–	–	2	–	1	2	–	–	–	–	–	1	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B7 m	Size	–	–	–	–	–	–	–	–	3	3	4	4	–	–	–	–	2	3	4
	Repr.	–	–	–	–	–	–	–	–	–	f	–	–	–	–	–	–	–	–	–
B10 m	Size	–	–	–	2	–	3	–	3	3	3	2	3	3	–	–	3	2	5	4
	Repr.	–	–	–	–	–	–	–	–	⊕	f	–	–	–	–	–	–	–	–	f
C2 m	Size	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	–	–	–	3	–	–	–	–	3	3	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

19. *Dasya* species group (Figs. 51,52,53; Table 27)

Two unidentified *Dasya* species were grouped together. The species were least abundant at the 2 m deep sites. The *Dasya* spp. attained their peak density, maximum frequency (Figs. 51,52,53) and their maximum average size during autumn (Mar.-May) (Table 27). Fertile plants were more common at this time. The species have a marked decrease in abundance and frequency during spring (Sep.-Nov.). Figures 51,52,53 show the good correlation between frequencies and density indices.

The *Dasya* species group was a summer-winter (Jan.-Aug.) species; this was indicated by both, the frequency and density index data.

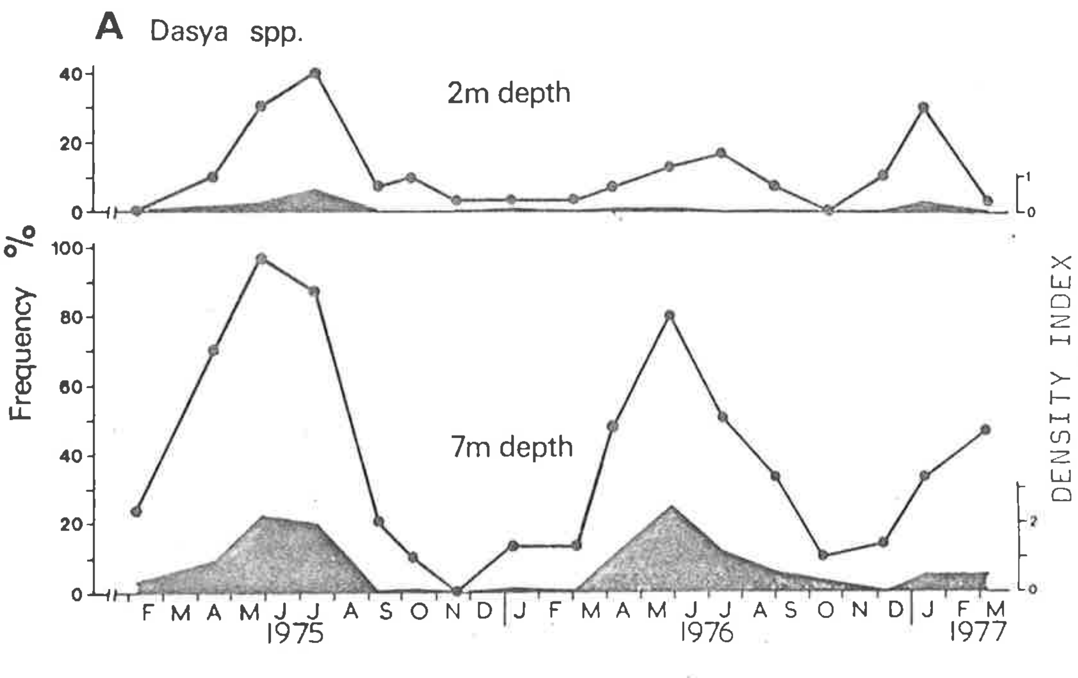


Fig. 51: Percentage frequency (solid line) and Density Index (shaded area) Values for *Dasya* spp. on the Transect A.

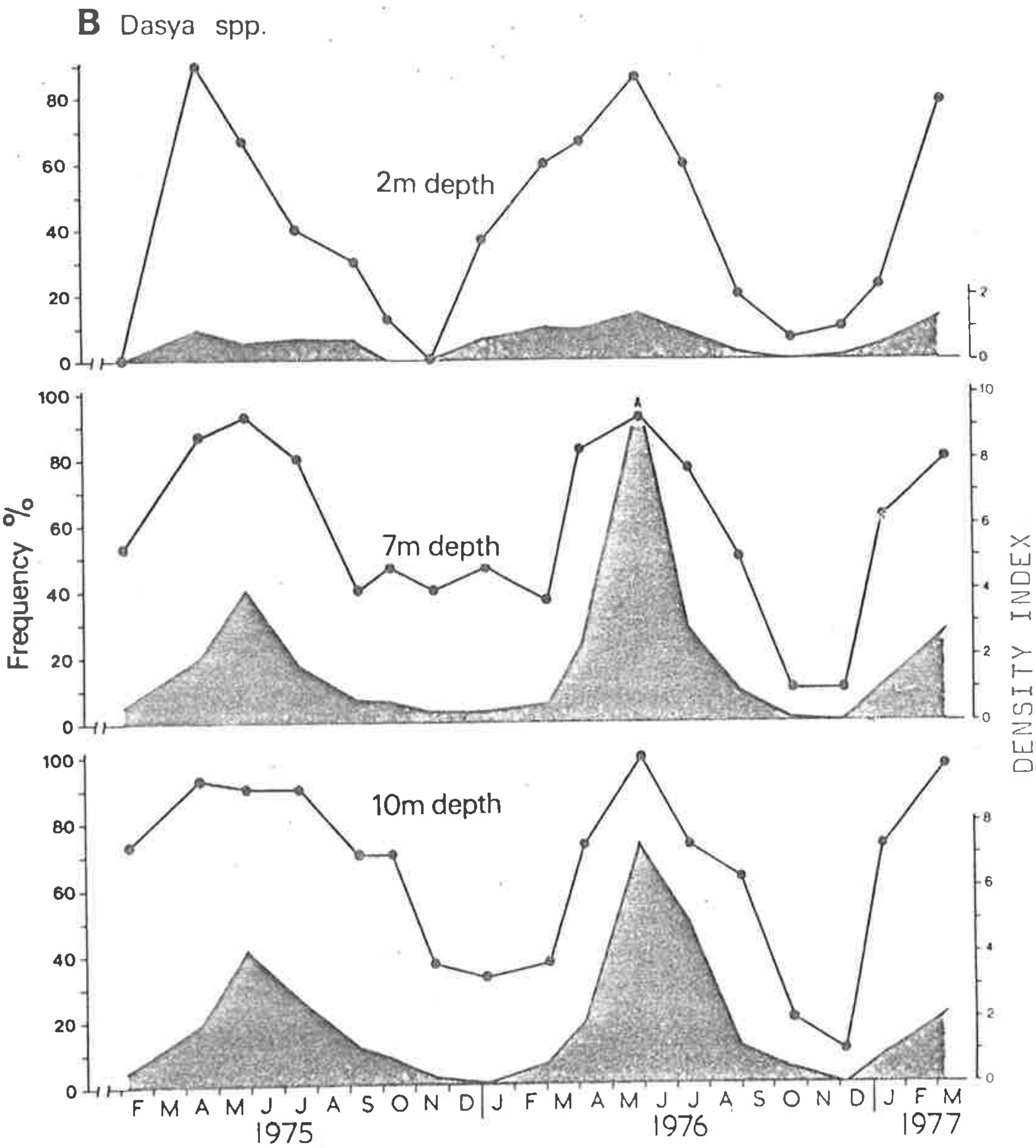


Fig. 52: Percentage frequency (solid line) and Density Index (shaded area) Values for *Dasya* spp. on the Transect B.

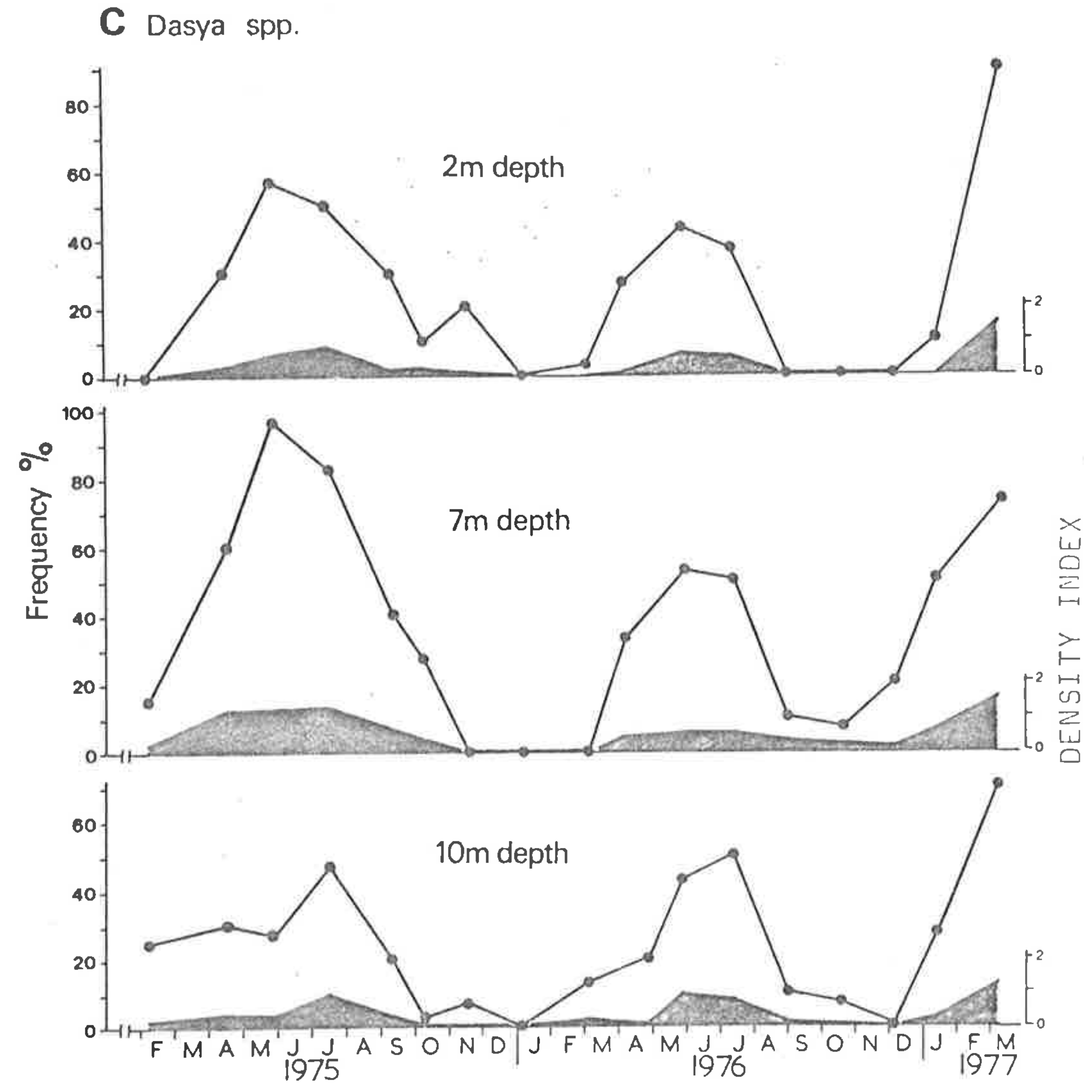


Fig. 53: Percentage frequency (solid line) and Density Index (shaded area) Values for *Dasya* spp. on the Transect C.

Table 27: Size indices and reproductive plants recorded for *Dasya* spp. during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																			
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	4	2	2	2	2	3	3	3	4	4	2	1	–	2	3	3	2	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	fm	–	–	X
A7 m	Size	2	3	3	2	2	3	–	2	2	2	3	2	2	2	2	3	2	2	X
	Repr.	f	–	m	–	–	–	–	–	–	–	–	–	–	–	–	–	f⊕	–	X
B2 m	Size	–	3	2	2	2	1	–	2	2	2	2	3	1	1	1	2	2	1	2
	Repr.	–	m	–	–	–	–	–	f⊕m	m	f	⊕	–	–	–	–	f⊕	⊕	–	f
B7 m	Size	3	3	3	3	2	3	2	3	2	2	4	3	3	2	1	4	2	4	2
	Repr.	f⊕m	⊕m	f⊕m	–	–	⊕m	–	–	⊕	⊕	f⊕m	–	–	–	–	f⊕m	⊕m	f⊕m	–
B10 m	Size	2	3	4	3	2	2	2	2	2	2	3	4	3	1	3	2	3	3	3
	Repr.	⊕m	⊕	f⊕m	–	m	⊕	–	f⊕	⊕	fm	fm	m	f	f	m	f⊕m	f⊕	f⊕m	m
C2 m	Size	–	2	3	3	2	3	1	–	2	2	5	4	–	–	–	1	3	2	X
	Repr.	–	–	f	–	–	m	–	–	–	–	f⊕	fm	–	–	–	–	f	–	X
C7 m	Size	2	3	2	2	2	3	–	–	–	2	3	4	3	2	2	2	2	1	X
	Repr.	–	–	f	–	–	–	–	–	–	f⊕	f⊕	fm	–	–	–	–	m	–	X
C10 m	Size	2	3	4	2	2	3	2	–	3	2	4	3	3	1	–	3	2	3	X
	Repr.	m	⊕	–	–	–	–	–	–	–	–	f⊕m	f⊕	–	–	–	f	m	–	X

20. *Gloiosaccion brownii* (Fig. 54; Table 28)

Population changes were indicated by the frequency data as well as by the density indices. The species displayed seasonal abundance changes at the 10 m deep site on the Transect B only. At this site, *Gloiosaccion brownii* had a peak density and a corresponding peak in frequency in late winter (Aug.-Sep.) while the lowest abundance occurred during the summer (Dec.-Feb.) (Fig. 54). On the Transects A and B the species was more dense on *P. sinuosa* in the deeper water than at the shallow study sites, while on the Transect C, *G. brownii* was only recorded at the 2 m deep site (Table 28). This was a non-seasonal species.

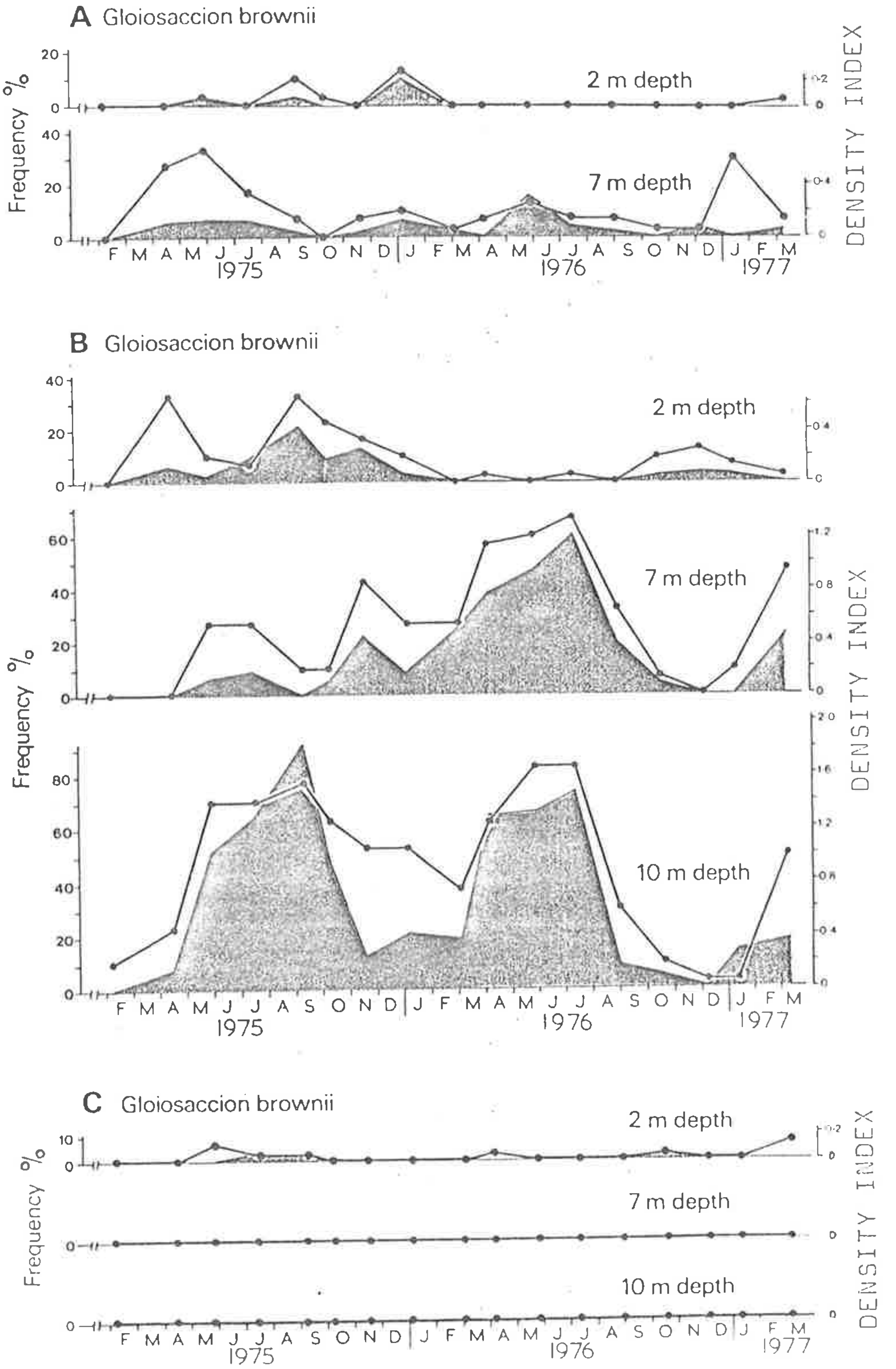


Fig. 54: Percentage frequency (solid line) and Density Index (shaded area) Values for *Gloiosaccion brownii* on the Transects A, B and C.

Table 28: Size indices and reproductive plants recorded for *Gloiosaccion brownii* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	CORRECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	–	4	–	1	2	–	2	–	–	–	–	–	–	–	–	2	2	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	–	3	3	4	3	–	1	2	2	3	3	1	2	2	2	3	2	2	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	f⊖	–	–	X
B2 m	Size	–	2	4	2	2	2	2	1	–	2	–	3	–	2	2	2	1	2	3
	Repr.	–	–	⊖	–	–	–	–	–	–	–	–	–	–	f	–	–	–	–	f
B7 m	Size	–	4	–	3	2	2	2	2	3	2	3	2	3	1	–	2	2	3	4
	Repr.	–	–	⊖	–	–	–	–	–	–	f	f⊖	–	–	–	–	–	f⊖	f	f⊖
B10 m	Size	2	3	3	2	3	2	1	2	1	3	3	2	2	1	2	3	2	2	4
	Repr.	–	–	⊖	f⊖	f⊖	⊖	–	f⊖	–	–	f⊖	⊖	–	–	–	⊖	⊖	f	f⊖
C2 m	Size	–	–	3	3	–	1	–	–	–	1	–	–	–	1	–	–	3	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

21. *Griffithsia monilis* (Figs. 55,56; Table 29)

Griffithsia was recorded at all sites throughout the study period. This species had no seasonal trend. There was no apparent preference for this species to occur at a particular depth (Figs. 55,56). The frequency data reflected the general population changes indicated by the density indices. Fertile plants were recorded at most times of the year (Table 29).

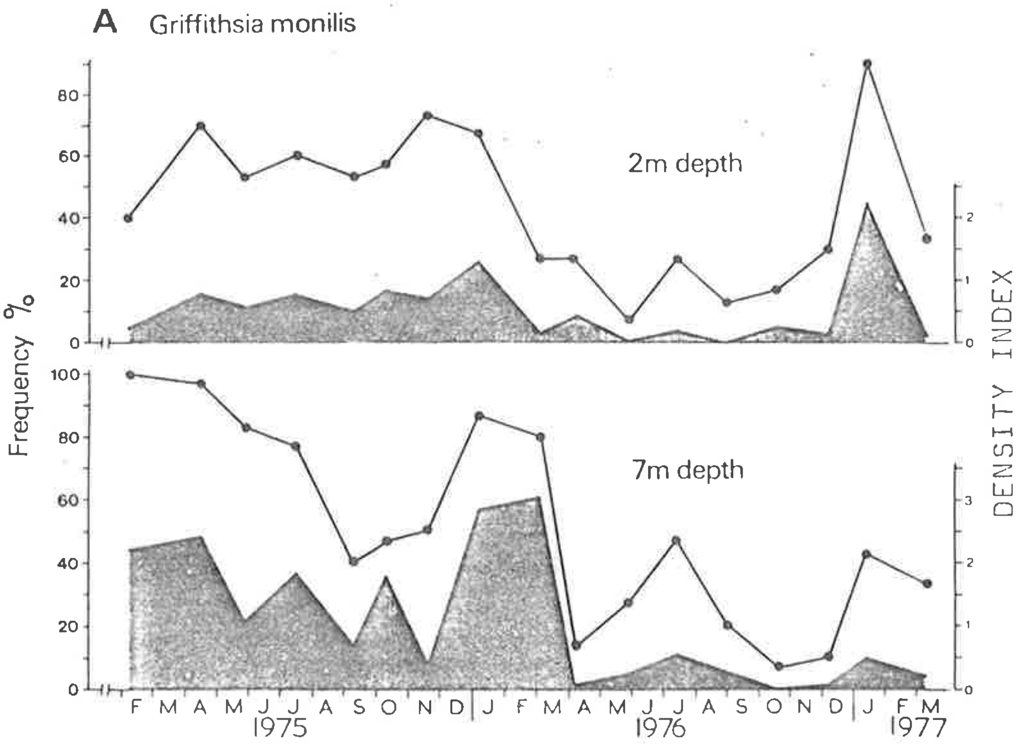
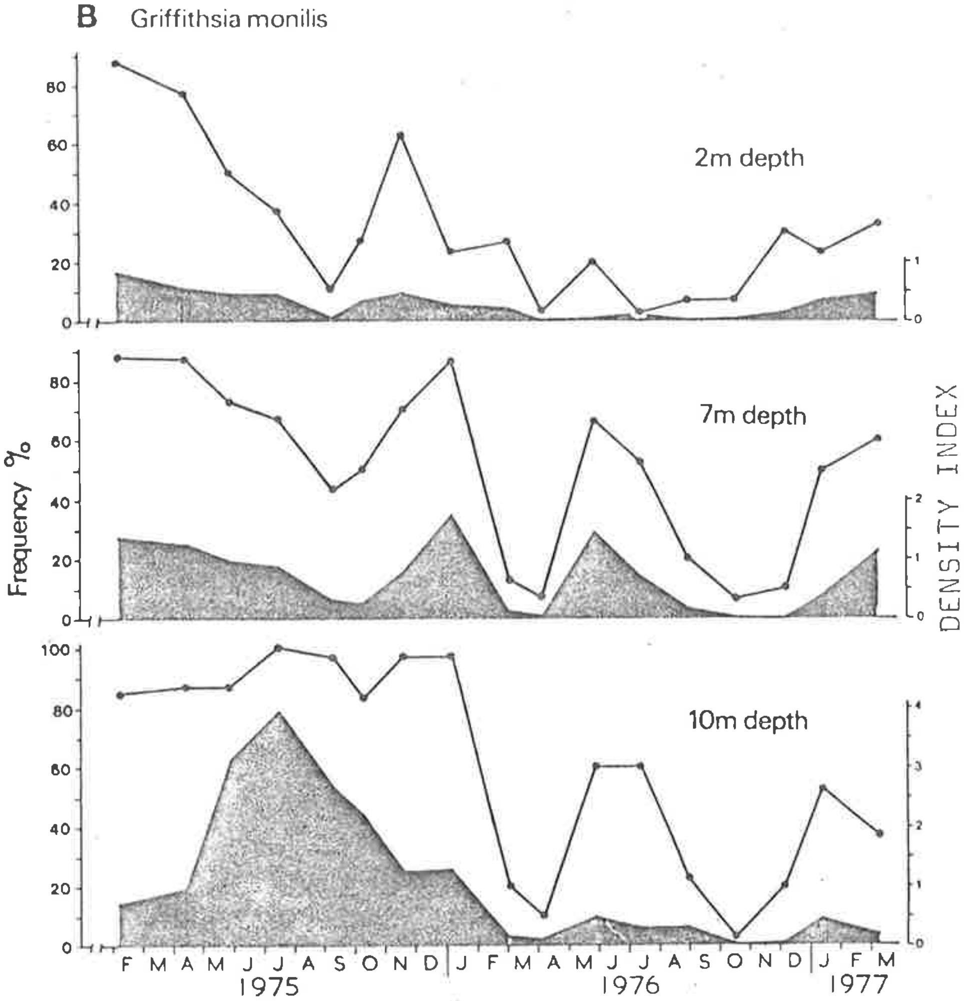


Fig. 55: Percentage frequency (solid line) and Density Index (shaded area) Values for *Griffithsia monilis* on the Transect A.



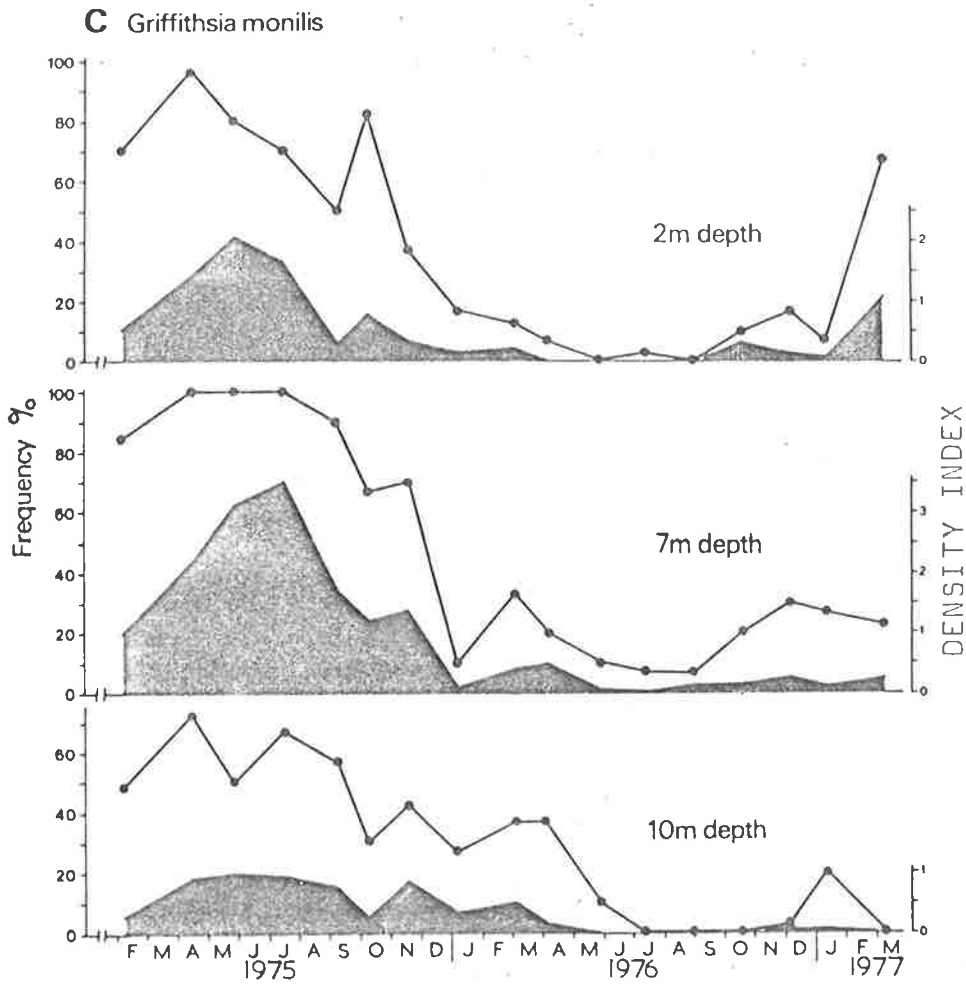


Fig. 56: Percentage frequency (solid line) and Density Index (shaded area) Values for *Griffithsia monilis* on the Transects B and C.

Table 29: Size indices and reproductive plants recorded for *Griffithsia monilis* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION 1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	4	4	2	2	3	2	1	2	2	2	2	3	2	2	3	2	2	3	X
	Repr.	–	fm	⊕m	–	m	–	m	m	–	⊕m	–	–	–	–	–	m	–	⊕f	X
A7 m	Size	–	3	3	4	3	–	1	2	2	3	3	1	2	2	2	3	2	2	X
	Repr.	–	–	f	–	–	m	–	⊕m	m	–	–	–	–	–	–	⊕m	–	–	X
B2 m	Size	2	2	3	3	1	2	2	2	3	3	2	2	1	1	1	2	2	1	3
	Repr.	–	f	m	–	–	m	m	–	m	–	–	–	–	–	–	–	⊕	–	–
B7 m	Size	2	3	4	3	3	3	1	2	1	3	4	3	3	2	1	3	3	3	4
	Repr.	–	–	f⊕m	⊕m	⊕m	⊕m	fm	f⊕m	–	–	fm	–	–	–	–	⊕m	m	⊕m	f⊕m
B10 m	Size	3	3	3	3	4	3	1	2	1	1	2	3	2	2	2	2	4	3	5
	Repr.	–	–	f⊕m	–	f⊕m	⊕m	⊕m	f⊕m	–	–	f⊕m	–	–	–	m	–	⊕	⊕m	f⊕m
C2 m	Size	3	3	4	2	3	2	1	3	2	2	–	2	–	1	1	2	2	–	X
	Repr.	⊕	–	f⊕m	f⊕m	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	2	3	4	3	3	2	2	2	2	2	2	2	4	3	2	3	3	3	X
	Repr.	–	–	f⊕m	f⊕m	m	⊕m	m	–	–	–	–	–	–	⊕	f	–	m	f⊕	X
C10 m	Size	3	3	3	3	1	2	1	2	2	3	1	–	–	–	2	1	–	3	X
	Repr.	–	–	f⊕m	f	⊕	–	m	m	–	–	–	–	–	–	–	f⊕	–	–	X

22. *Herposiphonia* sp. 1 (Figs. 57,58,59; Table 30)

This was a non-seasonal species as shown by both, the frequencies and the density indices (Figs. 57,58,59). The size indices (Table 30) showed that smaller plants of this species were more common in the spring collections (Sep.-Nov.) and the larger plants were observed in the following autumn and through the early winter collections.

On the Transects A and B, *Herposiphonia* sp. 1 was more abundant at the deeper water sites, but this trend was not evident on Transect C.

Figures 57,58 and 59 show that there was a good correlation between frequency changes and density index changes during the study.

Fertile plants occurred throughout the year, with male plants being less common than female and tetrasporangiate plants (Table 30).

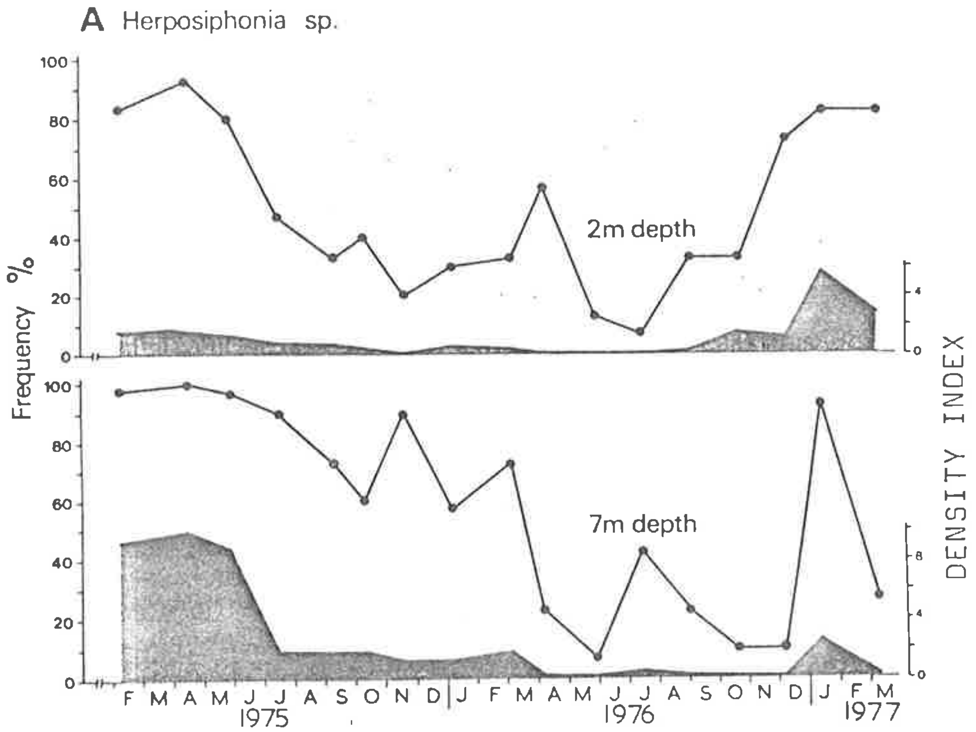


Fig. 57: Percentage frequency (solid line) and Density Index (shaded area) Values for *Herposiphonia* sp. 1 on the Transect A.

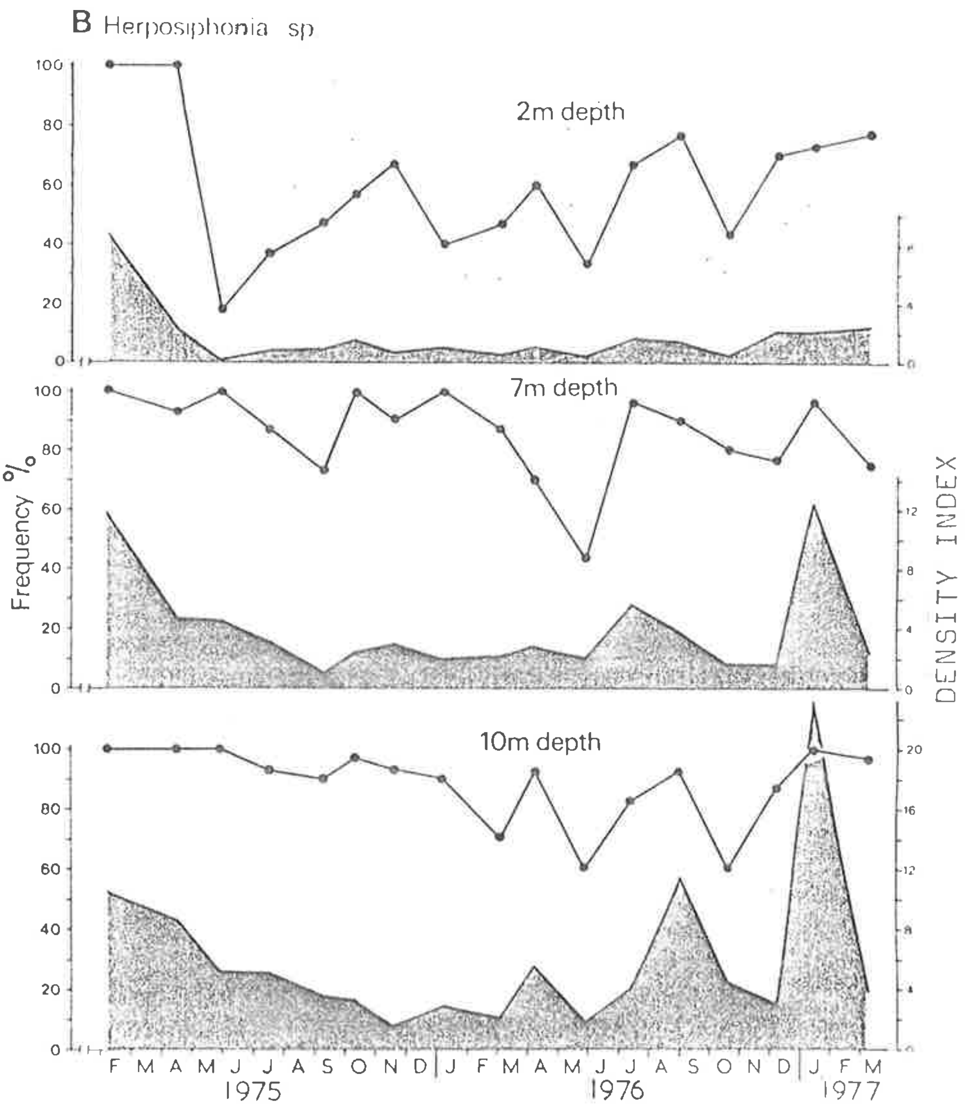


Fig. 58: Percentage frequency (solid line) and Density Index (shaded area) Values for *Herposiphonia* sp. 1 on the Transect B.

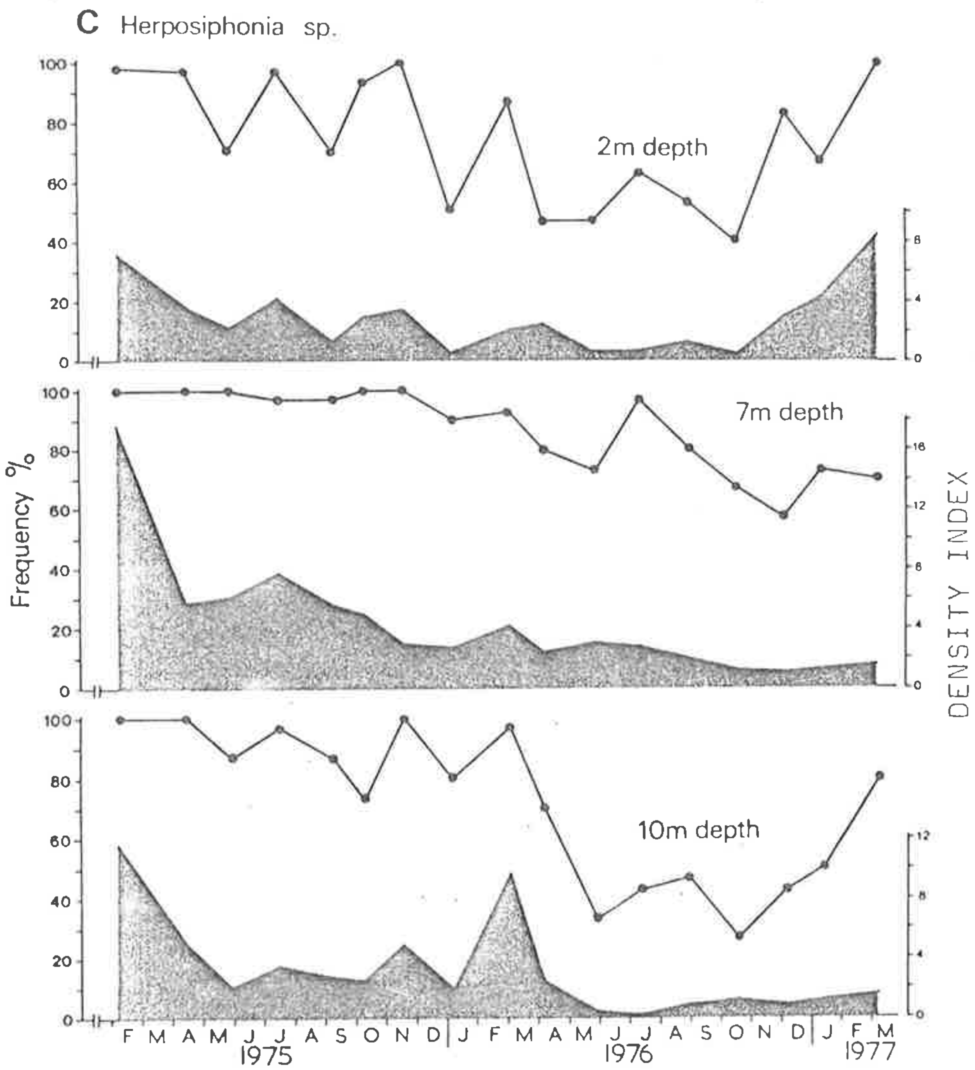


Fig. 59: Percentage frequency (solid line) and Density Index (shaded area) Values for *Herposiphonia* sp. 1 on the Transect C.

Table 30: Size indices and reproductive plants roecorded for *Herposiphonia* sp. 1. during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	4	3	2	3	2	2	1	3	2	2	2	3	1	3	3	4	2	2	X
	Repr.	⊕	–	–	f	–	f	–	f	f	f	⊕	–	–	f⊕	f⊕	f⊕	f⊕	–	X
A7 m	Size	2	2	3	3	2	2	1	1	1	4	4	3	2	1	1	2	3	1	X
	Repr.	–	–	–	⊕	⊕	–	–	–	–	f⊕	–	–	–	–	–	f⊕	f⊕	–	X
B2 m	Size	2	2	1	2	2	2	1	2	1	3	3	3	1	1	1	2	2	1	3
	Repr.	f	–	–	–	–	–	–	f⊕	f⊕	f⊕	f⊕	f	–	–	f	–	⊕	–	f
B7 m	Size	2	3	2	3	2	2	2	2	2	2	4	3	2	2	1	2	2	4	3
	Repr.	–	f	f⊕	–	–	f	f⊕	f⊕	f	f⊕	f	f	f	f⊕	f⊕	f	f	–	f
B10 m	Size	1	2	3	2	3	3	1	2	2	2	2	4	3	3	2	2	2	4	3
	Repr.	–	–	f	–	–	fm	f	fm	f	f	–	f	f	f	f	f	f	f⊕	–
C2 m	Size	2	3	3	3	2	2	1	2	2	2	3	5	3	1	1	1	3	2	X
	Repr.	f⊕	–	–	fm	–	f	–	m	f	f	–	f⊕	f⊕	–	f	–	f⊕	f⊕	X
C7 m	Size	2	3	3	4	4	3	2	1	3	3	3	4	4	1	2	3	2	1	X
	Repr.	⊕	–	f	f	fm	–	–	f	f⊕	f	f	f	–	–	–	–	f	–	X
C10 m	Size	2	2	2	3	3	2	2	2	3	3	4	3	3	1	1	3	3	5	X
	Repr.	f	–	⊕	–	f⊕	⊕	f	f	f⊕	f	–	–	f⊕	–	–	f	f⊕	f⊕	X

23. Hypnea musciformis (Figs. 60,61; Table 31)

Hypnea musciformis was a summer-winter species. The frequencies generally indicated the same population changes as the density indices, although during 1975 at the Transect A, 2m deep site, the correlation between the two parameters was low.

Hypnea did not show a strong seasonal change in density although it had a low density during the spring at all study sites, except on the Transect A, 2 m depth (Fig. 63). Fertile plants were not common but were most often noted at the deeper sites (Table 31). *Hypnea musciformis* was also more abundant at the deeper than the shallow sites.

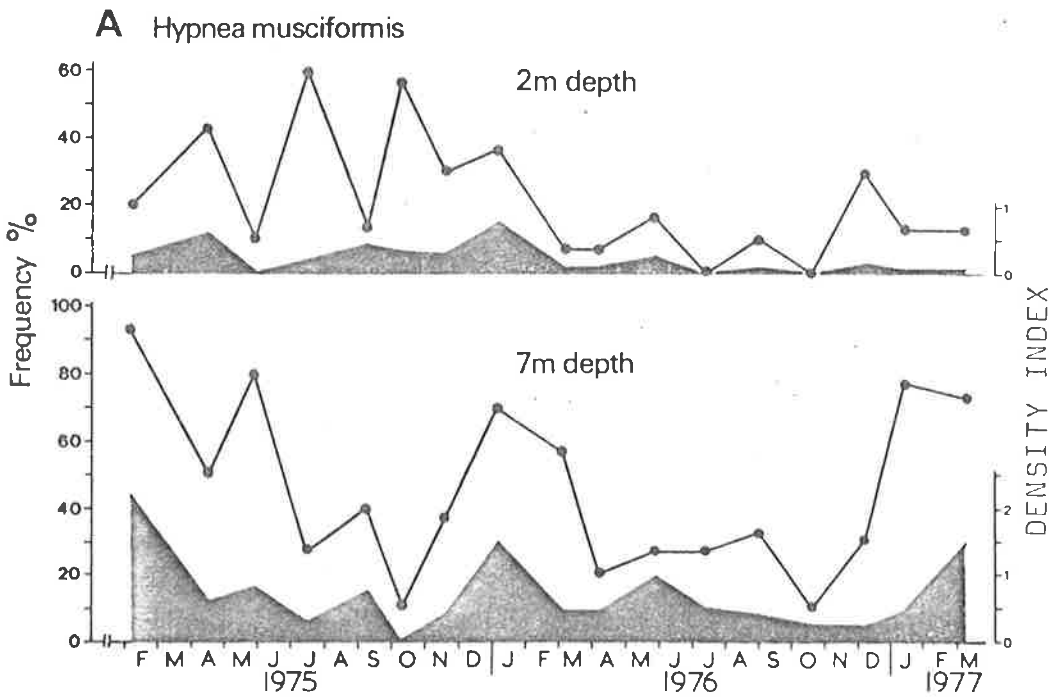


Fig. 60: Percentage frequency (solid line) and Density Index (shaded area) Values for *Hypnea musciformis* on the Transect A.

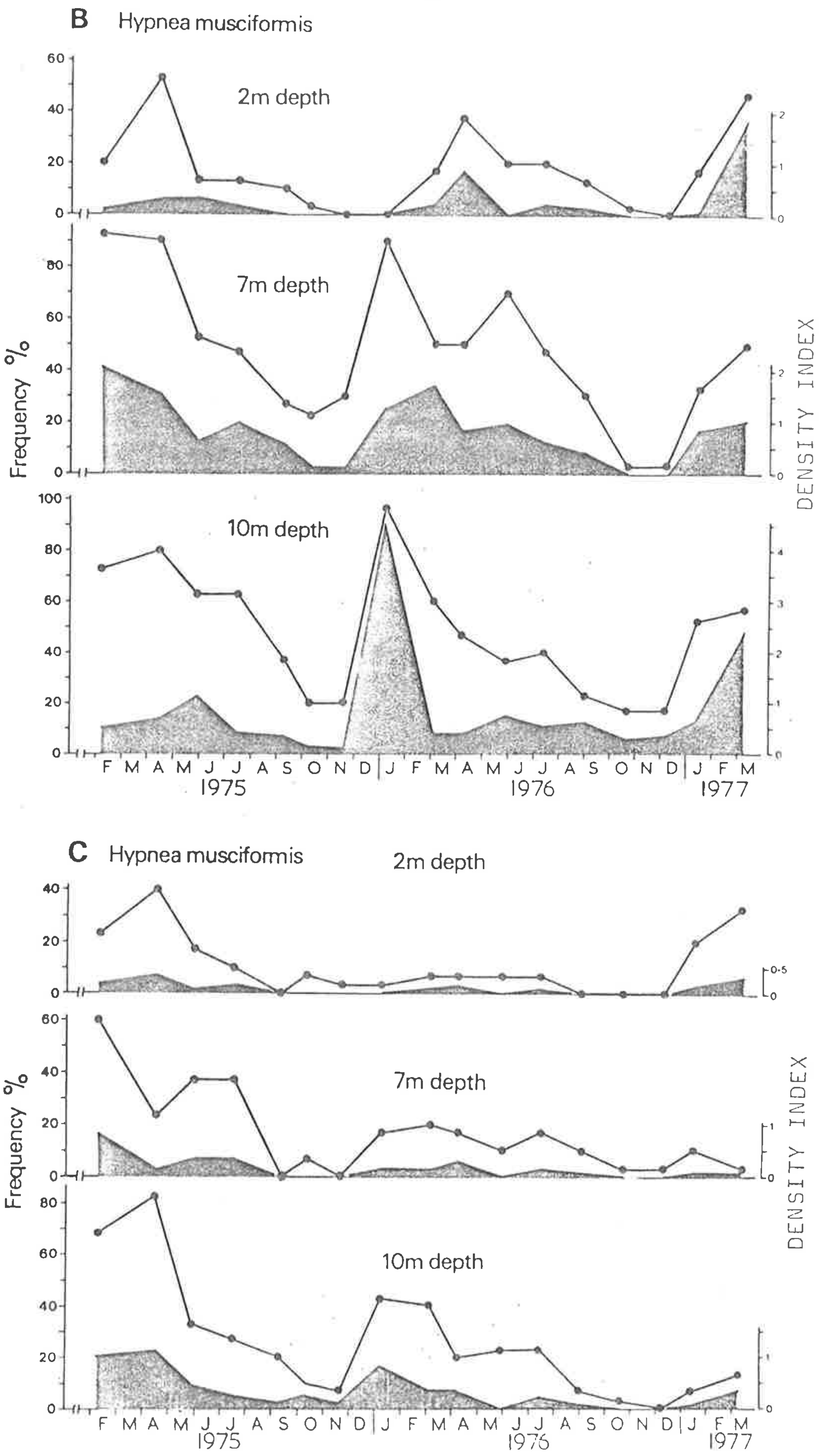


Fig. 61: Percentage frequency (solid line) and Density Index (shaded area) Values for *Hypnea musciformis* on the Transects B and C.

Table 31: Size indices and reproductive plants recorded for *Hypnea musciformis* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																				
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	3	2	2	2	3	3	2	2	2	2	2	–	3	–	4	2	2	3	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	1	2	2	3	4	4	3	2	3	3	3	3	2	2	2	3	2	4	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	⊕	–	–	X
B2 m	Size	2	3	2	2	3	1	–	–	2	3	3	3	3	1	–	3	4	1	2
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	f	–	–
B7 m	Size	2	3	2	2	3	3	2	2	3	3	4	4	4	3	3	3	3	3	5
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B10 m	Size	2	1	2	3	2	3	3	2	3	1	3	4	5	5	4	5	4	3	5
	Repr.	–	–	–	–	f	⊕	–	–	⊕	–	–	–	–	–	⊕	⊕	–	–	–
C2 m	Size	3	4	3	3	–	3	2	1	1	3	1	2	–	–	–	3	4	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	3	4	3	5	–	2	–	4	3	5	3	1	3	2	3	2	3	5	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	⊕	–	–	–	X
C10 m	Size	3	3	2	2	2	2	2	2	2	3	1	3	3	4	–	4	2	4	X
	Repr.	–	–	–	f	–	f	–	–	–	–	–	–	–	–	–	–	–	–	X

24. *Jania micrarthrodia* (Figs. 62,63,64; Table 32)

The articulated coralline alga, *Jania micrarthrodia*, was generally found more abundantly at the shallow site, especially on the Transect C (Figs. 62,63,64).

Jania was a common epiphyte on *P. sinuosa* as shown by both, the density indices and the frequencies; however, many of the population changes that occurred were not reflected by the frequencies.

This was a non-seasonal species and fertile plants were recorded throughout the study (Table 32).

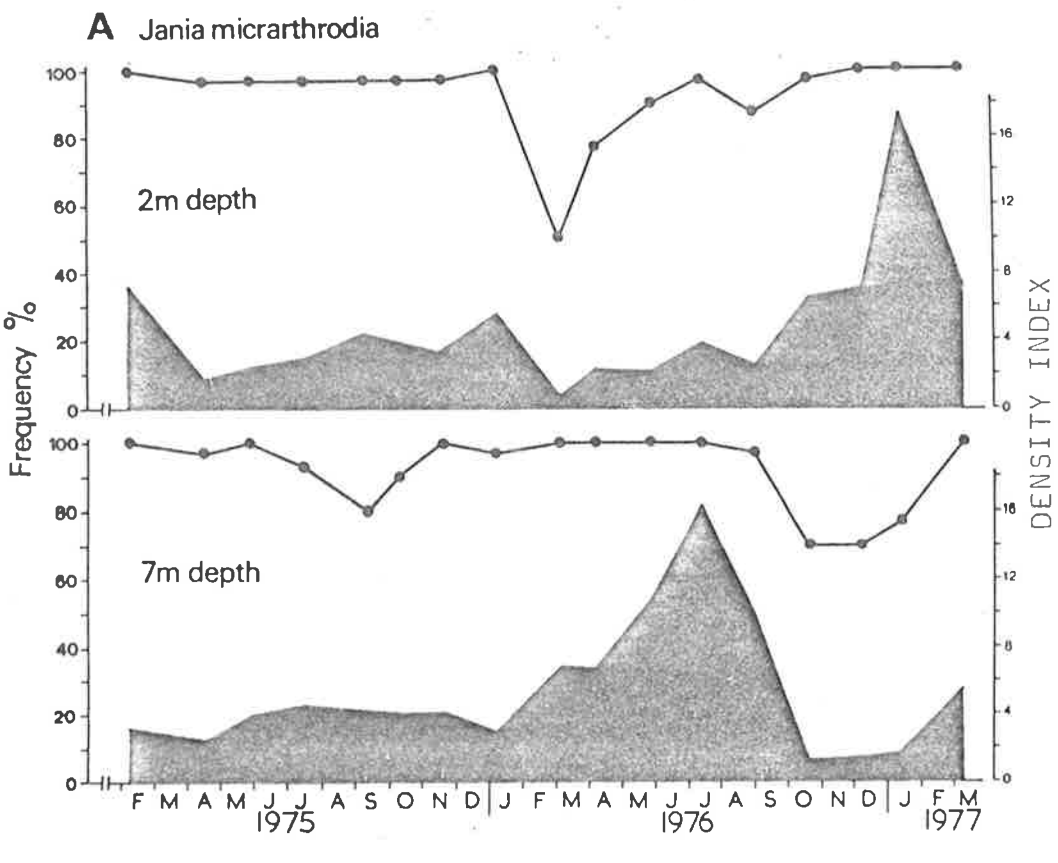


Fig. 62: Percentage frequency (solid line) and Density Index (shaded area) Values for *Jania micrarthrodia* on the Transect A.

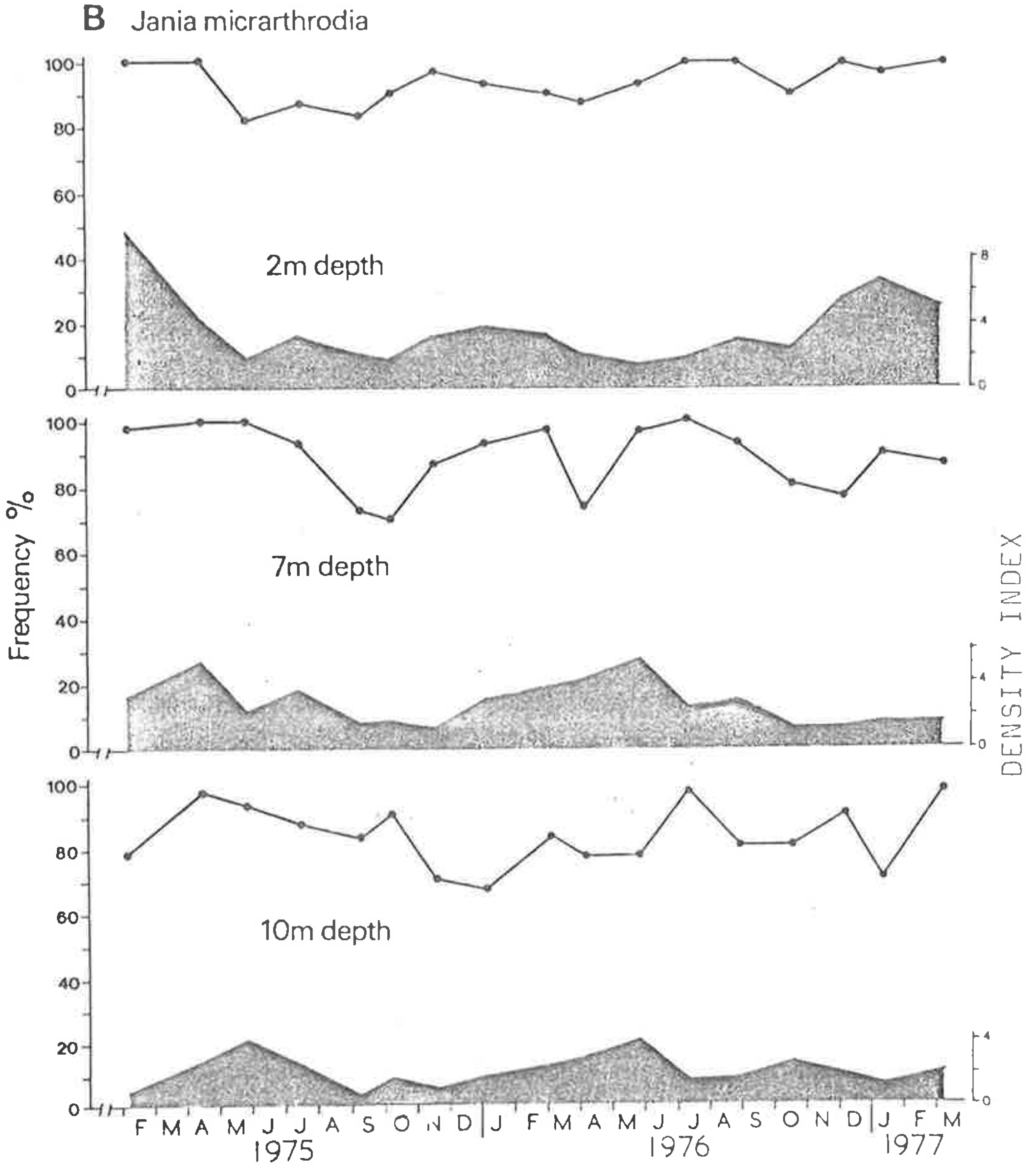


Fig. 63: Percentage frequency (solid line) and Density Index (shaded area) Values for *Jania micrarthrodia* on the Transect B.

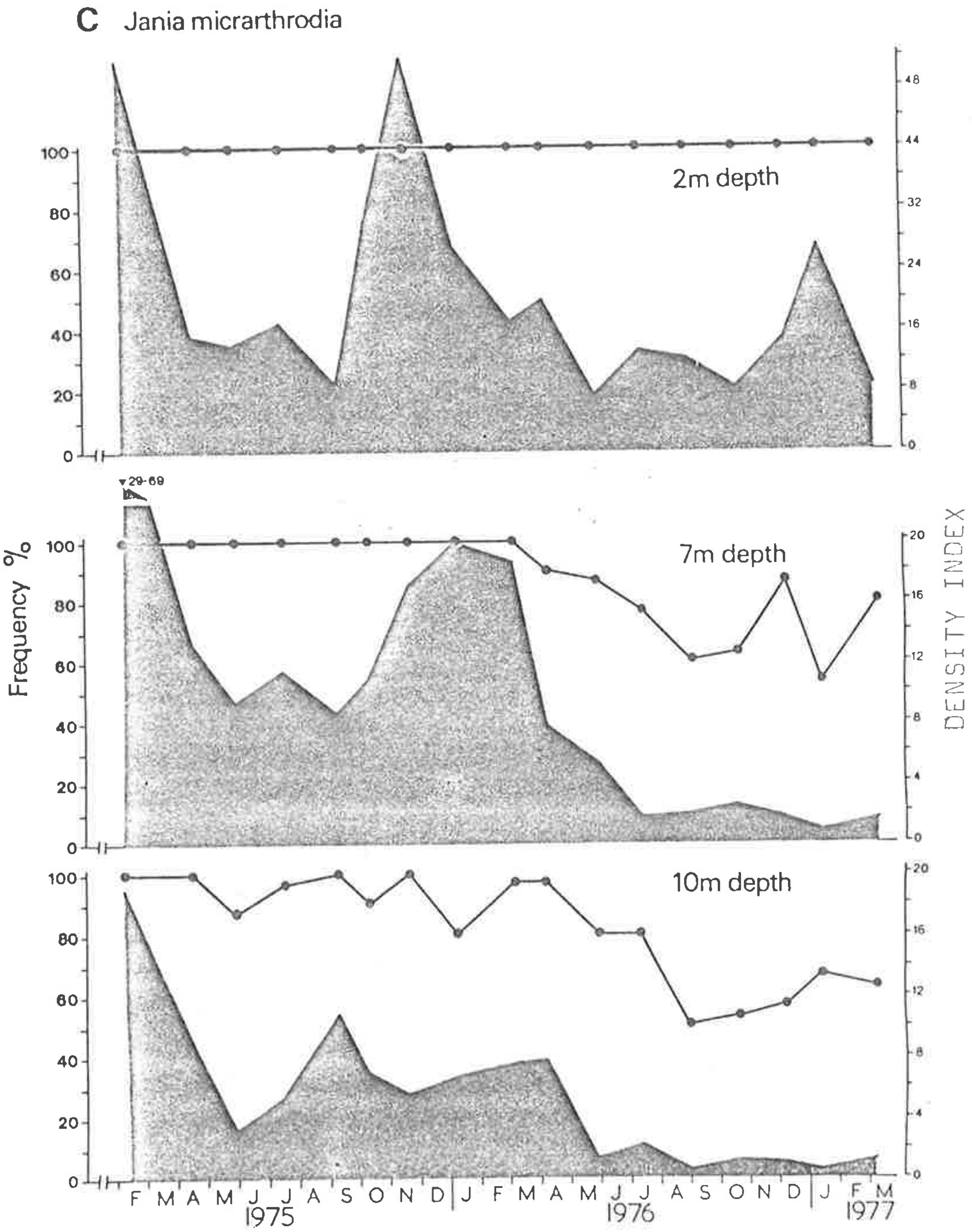


Fig. 64: Percentage frequency (solid line) and Density Index (shaded area) Values for *Jania micrarthrodia* on the Transect C.

Note the different Density Index scale at 2 m depth.

Table 32: Size indices and reproductive plants recorded for *Jania micrarthrodia* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION 1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	1	1	2	2	3	3	1	2	2	2	2	2	2	1	3	2	3	3	X
	Repr.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	X
A7 m	Size	2	2	2	3	3	2	1	1	2	3	4	5	2	1	2	2	3	3	X
	Repr.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	X
B2 m	Size	2	2	2	2	2	3	2	2	2	1	1	2	2	2	2	2	3	2	2
	Repr.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	–
B7 m	Size	2	3	2	2	2	3	1	3	2	2	3	3	3	2	2	2	2	2	4
	Repr.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	–
B10 m	Size	2	2	3	3	2	3	2	2	2	2	3	3	3	1	2	3	4	2	5
	Repr.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
C2 m	Size	2	3	3	4	3	4	2	2	2	2	2	2	2	2	2	2	3	2	X
	Repr.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	X
C7 m	Size	2	3	2	3	2	3	2	2	2	2	2	1	3	2	2	2	2	2	X
	Repr.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	X
C10 m	Size	2	2	3	2	3	2	2	3	2	2	2	2	3	2	2	2	2	2	X
	Repr.	+	–	+	+	+	+	+	+	+	+	+	+	+	+	+	–	+	+	X

25. *Jeannerettia pedicellata* (Figs. 65,66; Table 33)

There was a good correlation between the frequency and density index data for this species, and both showed that *Jeannerettia pedicellata* was a summer species.

The abundance data and the size indices data indicated (Table 33) that *Jeannerettia* spores settled out on the *Posidonia* leaves in winter and spring. During the spring through to the summer the plants gradually increased in size reaching their maximum at the end of summer-early autumn (Mar.-Apr.). The species attained a peak of density in mid-summer (January) of each year (Figs. 65, 66) and is most abundant at the deepest collection sites.

Only one reproductive plant was recorded during the study (Table 33).

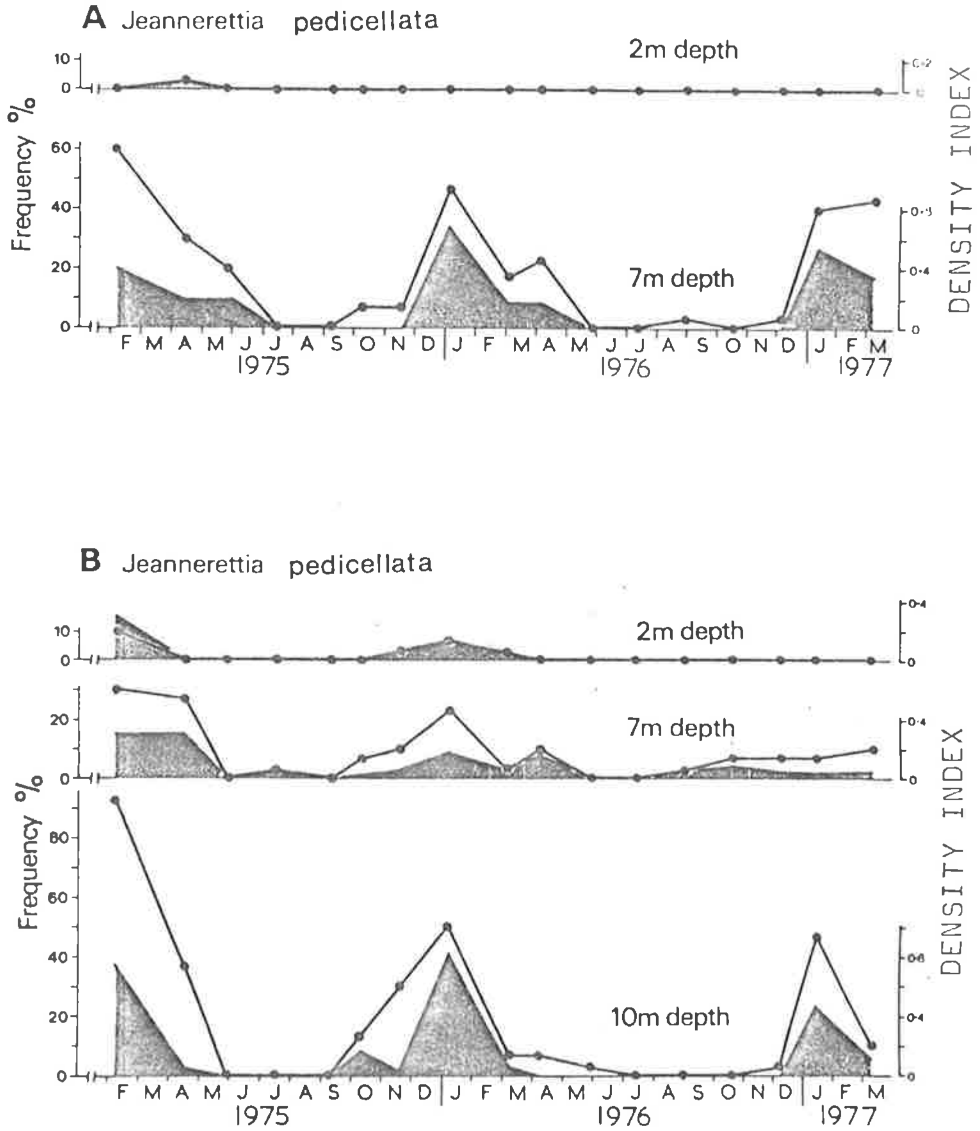


Fig. 65: Percentage frequency (solid line) and Density Index (shaded area) Values for *Jeannerettia pedicellata* on the Transects A and B.

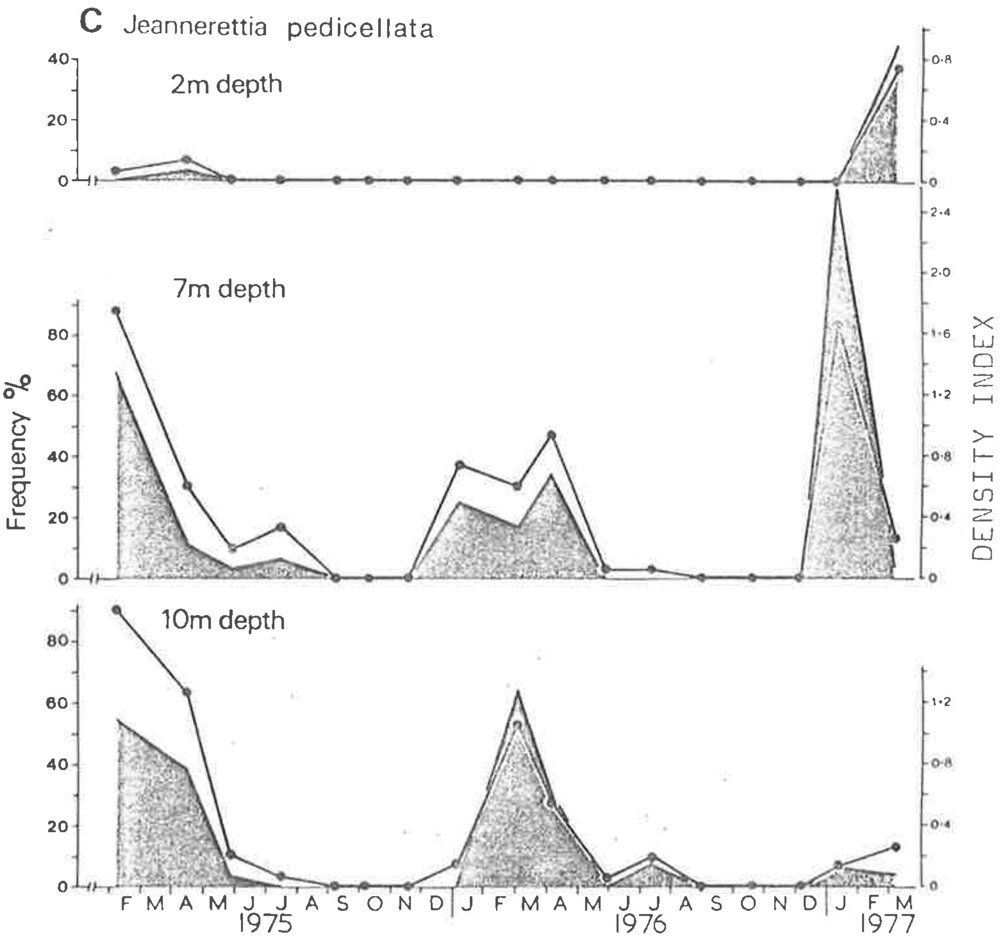


Fig. 66: Percentage frequency (solid line) and Density Index (shaded area) Values for *Jeannerettia pedicellata* on the Transect C.

Table 33: Size indices and reproductive plants recorded for *Jeannerettia pedicillata* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	2	4	5	–	–	1	1	2	5	4	–	–	1	–	2	3	4	1	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
B2 m	Size	2	–	–	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B7 m	Size	2	3	–	5	–	1	2	3	3	5	–	–	1	1	1	3	1	1	5
	Repr.	–	–	–	–	–	–	f	–	–	–	–	–	–	–	–	–	–	–	–
B10 m	Size	2	4	–	–	–	2	2	2	3	2	5	–	–	–	3	3	4	–	4
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C2 m	Size	2	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	2	3	3	4	–	–	–	2	2	2	4	3	–	–	–	3	3	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	2	4	4	1	–	–	–	2	4	1	1	3	–	–	–	2	2	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

26. *Laurencia forsteri* (Figs. 67,68,69; Table 34)

At the 7 m and 10 m deep study sites *Laurencia forsteri* displayed a peak in density in autumn (Apr.-May) with a corresponding low the following spring (Sep.-Oct.). Therefore, at the deeper water sites *Laurencia* was labelled as a summer-winter species (Dec.-Aug.), but at the 2 m deep sites it was non-seasonal, although it was often more abundant at these sites than at the 7 m and 10 m deep sites (Figs. 67,68,69).

There was a good correlation between the trends and changes recorded in the frequency data and the trend and changes recorded in the density index data.

Fertile plants occurred at all study sites throughout most of the study period (Table 34).

Evidence of grazing upon some of the *Laurencia* plants was also recorded.

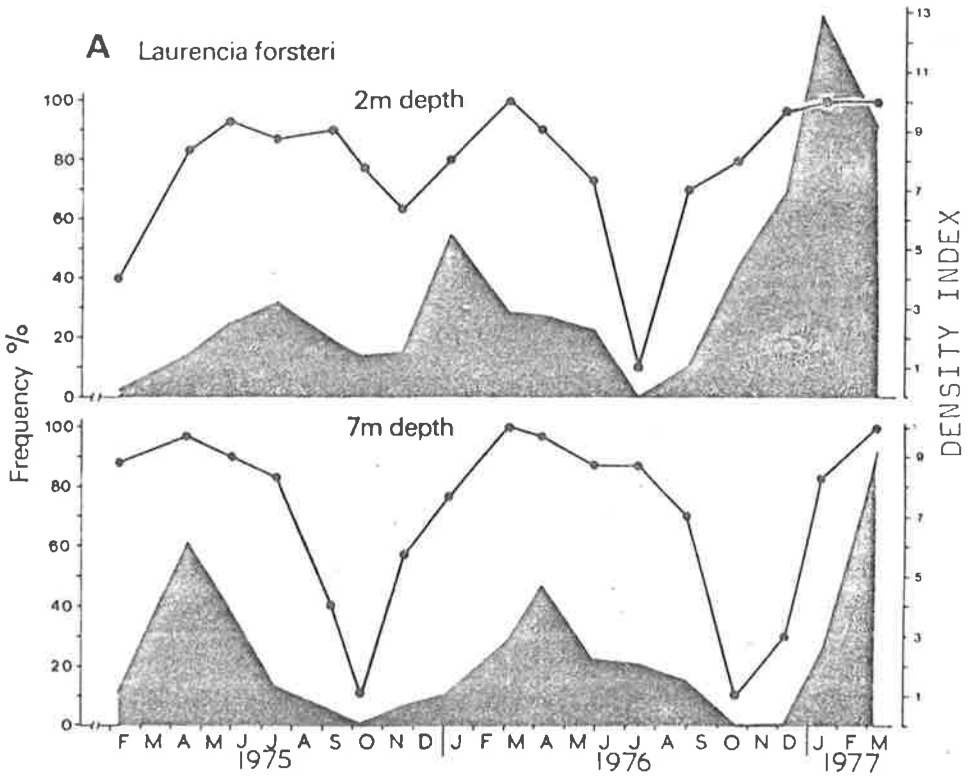


Fig. 67: Percentage frequency (solid line) and Density Index (shaded area) Values for *Laurencia forsteri* on the Transect A.

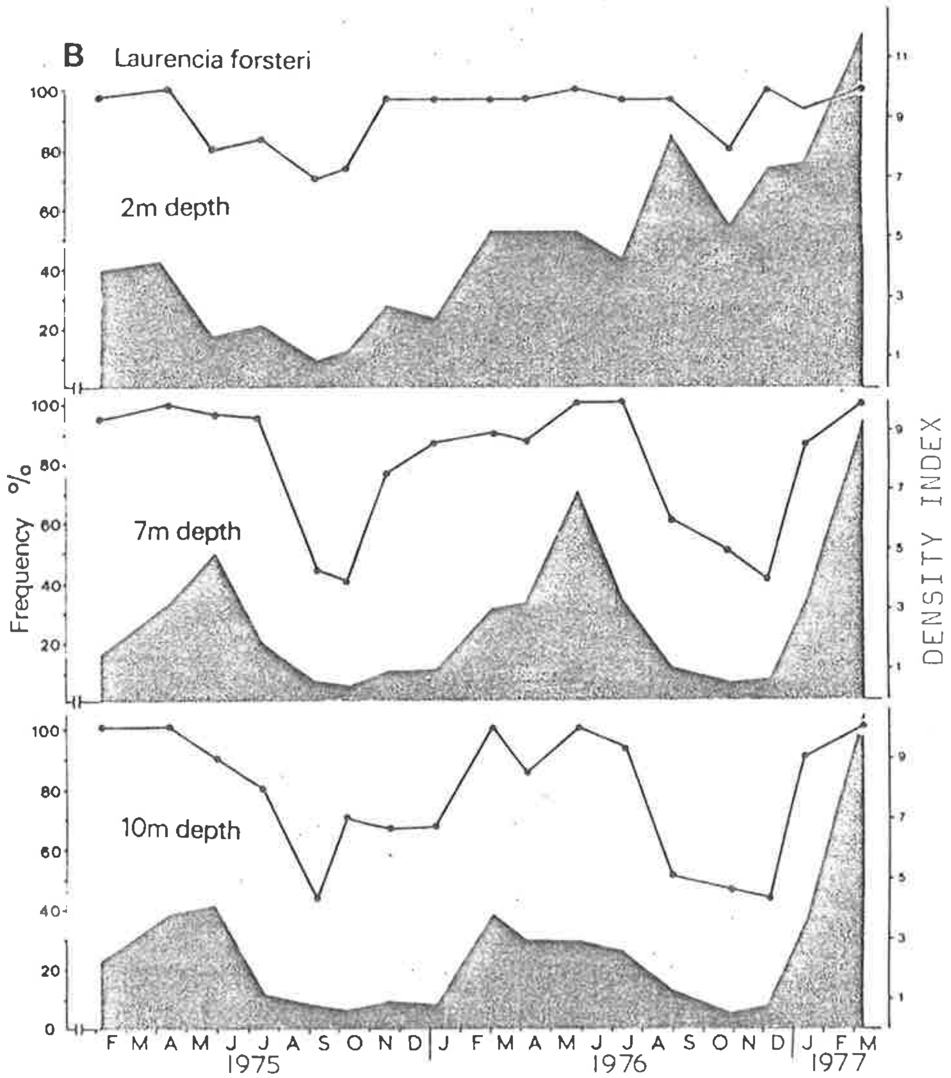


Fig. 68: Percentage frequency (solid line) and Density Index (shaded area) Values for *Laurencia forsteri* on the Transect B.

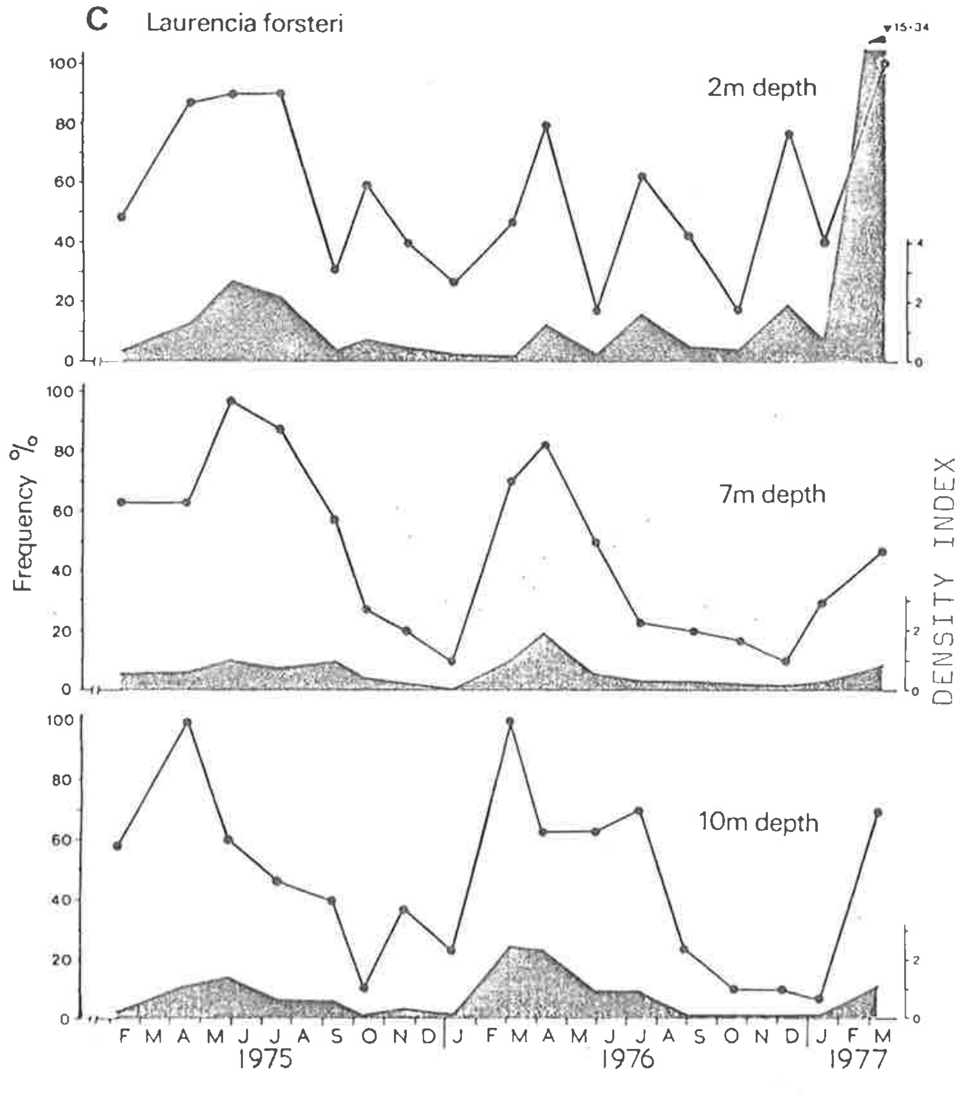


Fig. 69: Percentage frequency (solid line) and Density Index (shaded area) Values for *Laurencia forsteri* on the Transect C.

Table 34: Size indices and reproductive plants recorded for *Laurencia forsteri* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	2	2	2	2	3	1	1	2	2	2	2	2	2	1	2	2	4	2	X
	Repr.	–	⊕	–	f	fm	f⊕	–	⊕	–	⊕	f⊕	–	f	–	f⊕	f⊕	⊕	–	X
A7 m	Size	2	2	2	2	2	1	1	1	3	3	3	2	2	2	2	2	3	3	X
	Repr.	–	–	–	–	f⊕	⊕	–	⊕	f⊕	f⊕	–	–	–	–	–	f⊕m	f⊕	–	X
B2 m	Size	2	3	2	2	2	2	2	2	3	2	2	1	3	1	2	3	4	2	4
	Repr.	⊕m	–	–	–	–	f	m	⊕	f⊕	f⊕	–	⊕	m	–	f⊕	f⊕	f⊕	–	f⊕m
B7 m	Size	2	2	3	2	2	2	1	2	3	2	4	3	2	2	1	3	2	3	3
	Repr.	–	⊕m	f⊕m	–	–	–	⊕	f	f⊕m	⊕	f⊕	f⊕	m	–	f	f⊕	f⊕	–	f⊕
B10 m	Size	1	1	2	2	2	3	1	2	2	1	4	4	1	1	1	2	4	2	4
	Repr.	–	–	f⊕m	–	–	–	–	–	⊕	f	f⊕m	f	–	–	–	f⊕	⊕	–	fm
C2 m	Size	2	2	3	2	2	2	1	1	1	2	2	4	3	1	1	2	3	3	X
	Repr.	⊕	–	f⊕m	fm	–	–	–	–	⊕	⊕	–	–	f	–	–	–	f⊕	–	X
C7 m	Size	2	2	1	3	2	3	1	2	1	2	2	1	2	2	2	2	3	2	X
	Repr.	⊕	⊕	–	f	⊕	–	–	–	–	–	⊕	⊕	–	–	–	–	⊕	–	X
C10 m	Size	3	2	2	2	2	1	1	2	2	2	1	3	2	2	2	1	2	3	X
	Repr.	f	–	f⊕m	f⊕	⊕	–	–	–	⊕	f⊕m	f⊕m	⊕	–	–	–	–	⊕	–	X

27. *Lomentaria* sp. (Figs. 70,71; Table 35)

Lomentaria was a non-seasonal species. Although a summer-winter (Jan.-Aug.) seasonal cycle could be recognized on the Transect B at 7 m and 10 m depth, there was no indication of such trends at the other study sites (Figs. 70,71). There was no pattern to the occurrence of fertile plants nor did the size indices show seasonal changes in average plant size (Table 35).

On the Transect B, *Lomentaria* was more commonly recorded at the deeper sites, while on the other transects the species was more common at the shallow sites (Fig. 71).

There was a good correlation between the frequency data and the changes in the density indices.

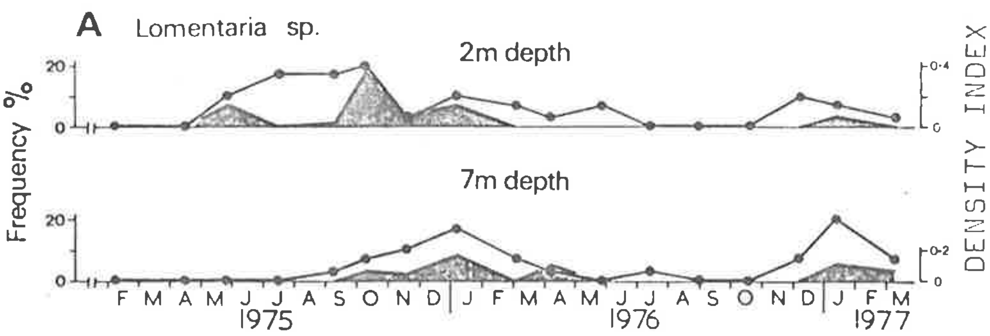
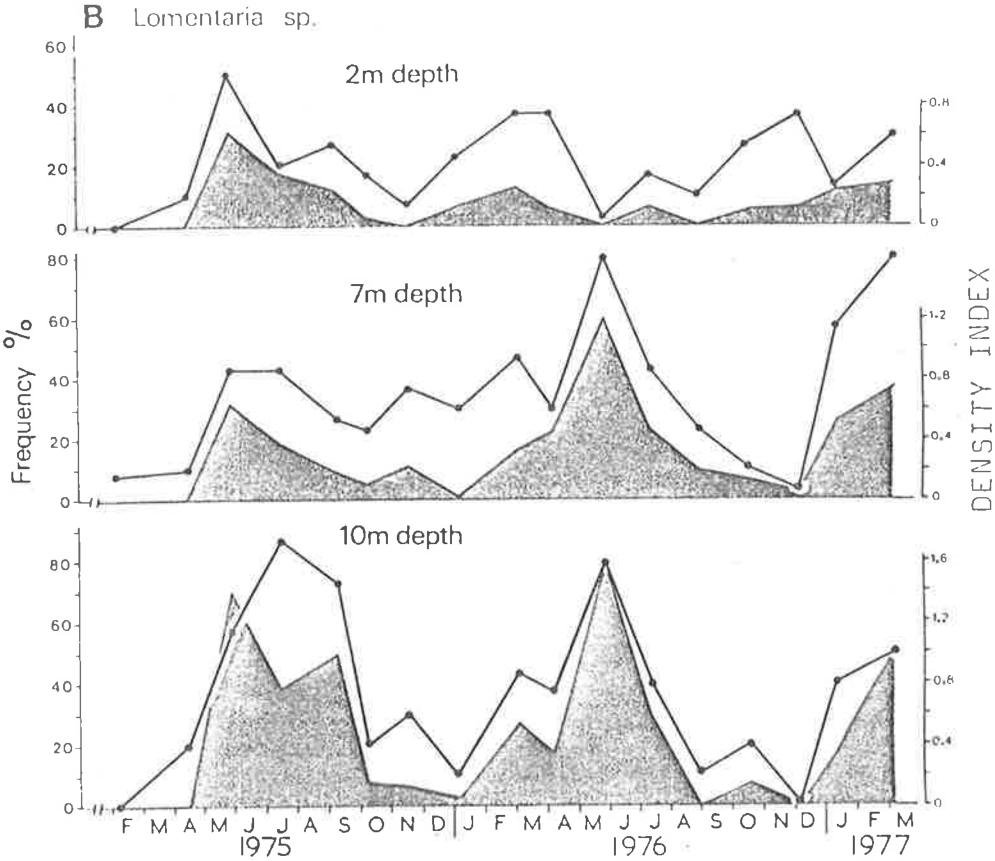


Fig. 70: Percentage frequency (solid line) and Density Index (shaded area) Values for *Lomentaria* sp. on the Transect A.



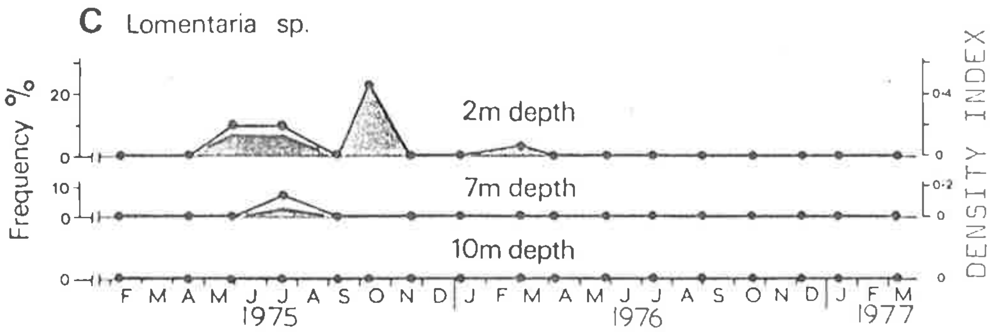


Fig. 71: Percentage frequency (solid line) and Density Index (shaded area) Values for *Lomentaria* sp. on the Transects B and C.

Table 35: Size indices and reproductive plants recorded for *Lomentaria* sp. during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	–	4	1	3	2	1	2	2	3	2	–	–	–	2	2	2	2	X
	Repr.	–	–	⊕	–	f⊕	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	–	–	–	–	–	3	3	1	2	2	–	3	–	–	1	2	3	–	X
	Repr.	–	–	–	–	–	⊕	⊕	–	⊕	–	–	–	–	–	–	–	–	–	X
B2 m	Size	–	3	3	2	3	3	1	1	2	2	2	2	1	2	2	1	2	1	4
	Repr.	–	–	f⊕	f	–	–	–	–	–	f	–	–	f	f	f⊕	–	–	–	–
B7 m	Size	1	2	3	2	3	3	2	2	2	2	3	2	2	2	2	3	2	3	3
	Repr.	–	–	⊕	–	–	⊕	f⊕	f	–	f⊕	f⊕	–	–	–	–	⊕	f⊕	⊕	⊕
B10 m	Size	–	2	2	2	3	3	2	3	2	2	2	2	2	3	–	2	3	4	4
	Repr.	–	f	⊕	–	f⊕	f	f⊕	–	⊕	f	f⊕	–	f	–	–	⊕	f⊕	f⊕	f
C2 m	Size	–	–	5	3	–	3	–	–	3	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	⊕m	⊕	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

28. *Metagoniolithon chara* var *chara* (Fig. 72; Table 36)

Metagoniolithon was a non-seasonal species and its population changes noted in the density indices were also reflected in the frequency data. This articulated coralline alga was noted to be more abundant at the 2 m deep sites on all transects (Fig. 75). Fertile plants were rarely observed during the study (Table 36).

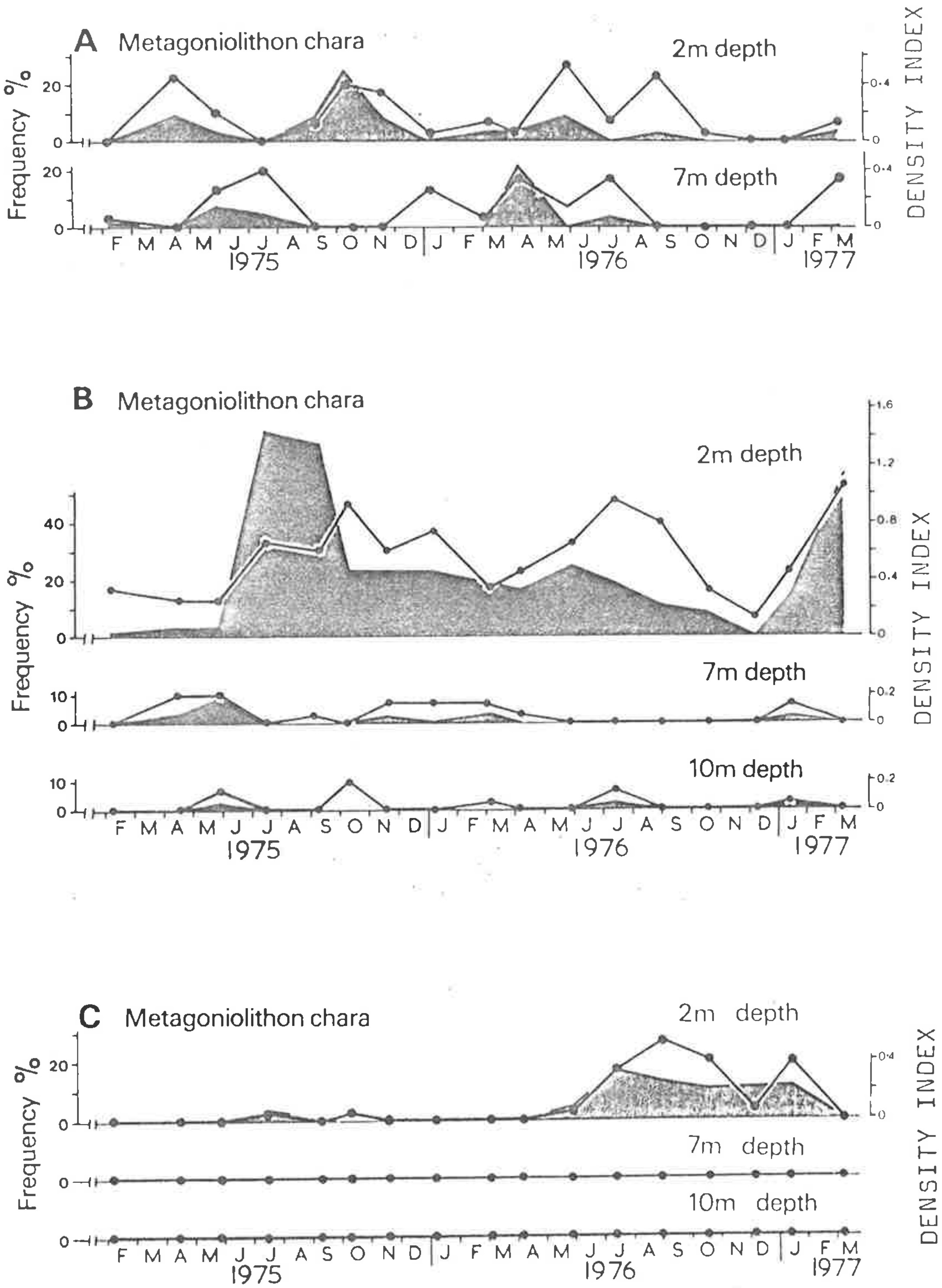


Fig. 72: Percentage frequency (solid line) and Density Index (shaded area) Values for *Metagoniolithon chara* on the Transects A, B and C.

Table 36: Size indices and reproductive plants recorded for *Metagoniolithon chara* var. *chara* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	2	3	–	3	3	2	2	3	5	3	3	3	2	–	–	2	3	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	3	–	3	4	–	–	–	3	4	4	4	5	–	–	–	–	3	4	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
B2 m	Size	4	3	2	2	4	3	3	2	1	3	3	2	3	3	2	2	4	2	4
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–
B7 m	Size	–	3	3	–	2	–	3	2	1	3	–	–	–	–	–	1	–	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B10 m	Size	–	–	4	–	–	4	–	–	1	–	–	5	–	–	–	3	–	–	4
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C2 m	Size	–	–	–	3	–	4	–	–	–	–	3	4	3	3	3	3	–	4	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

29. *Platysiphonia miniata* (Figs. 73,74; Table 37)

This was a summer-winter species (Dec.-Aug.) with the species reaching a peak density during the summer and/or autumn and regularly having its lowest density during spring. There was a good correlation between frequency and density index data indicating that frequency was a satisfactory parameter for following population changes in this species.

Platysiphonia was least abundant at the shallow sites (Figs. 73, 74). Fertile plants were more often recorded at the deeper sites (Table 37).

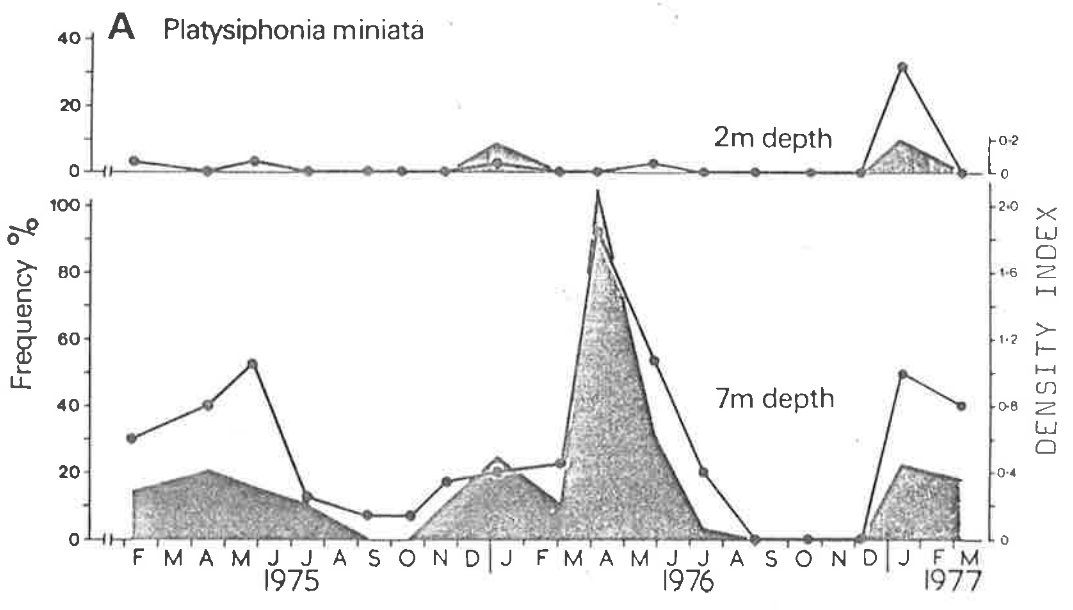


Fig. 73: Percentage frequency (solid line) and Density Index (shaded area) Values for *Platysiphonia miniata* on the Transect A.

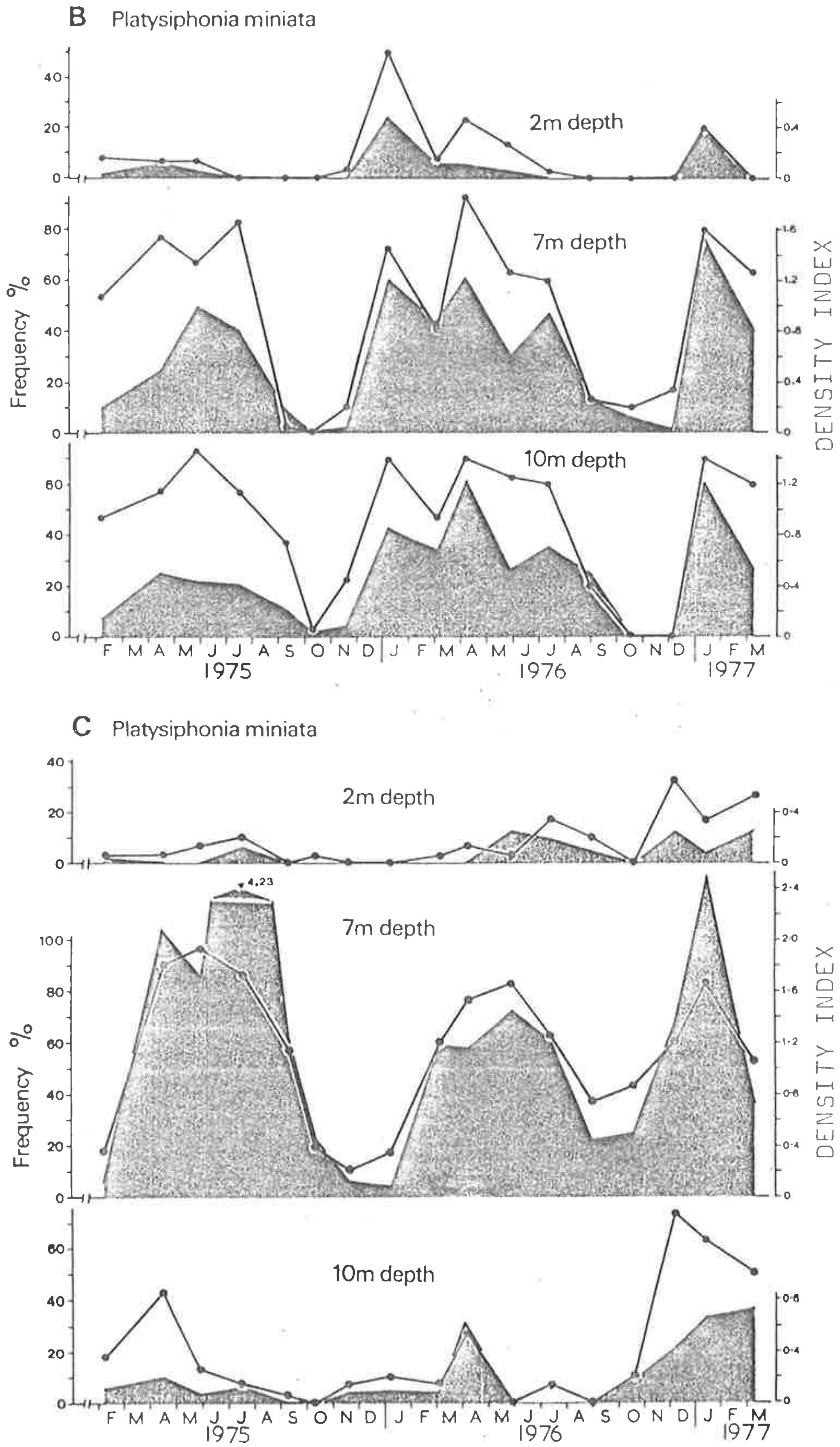


Fig. 74: Percentage frequency (solid line) and Density Index (shaded area) Values for *Platysiphonia miniata* on the Transects B and C.

Table 37: Size indices and reproductive plants recorded for *Platysiphonia miniata* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	3	–	4	–	–	–	–	1	–	–	3	–	–	–	–	2	–	1	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	3	4	4	5	5	1	2	3	4	3	3	4	–	–	–	2	2	4	X
	Repr.	f	–	⊕m	–	–	–	⊕	–	⊕	f⊕	–	–	–	–	–	m	f	–	X
B2 m	Size	3	4	3	–	–	–	1	2	2	3	3	2	–	–	–	2	–	–	–
	Repr.	–	–	–	–	–	–	–	f⊕	–	–	–	–	–	–	–	⊕	–	–	–
B7 m	Size	3	3	4	3	2	–	1	2	2	3	4	3	2	2	2	3	1	4	3
	Repr.	fm	⊕m	⊕	–	⊕	–	–	f	–	f⊕	⊕	–	–	–	⊕	m	f⊕	–	–
B10 m	Size	2	3	3	2	2	3	1	1	1	3	2	3	3	–	–	1	2	3	5
	Repr.	–	⊕	⊕m	–	–	–	–	f⊕m	–	f⊕m	f⊕	fm	–	–	–	f	–	–	f⊕
C2 m	Size	3	4	3	3	–	1	–	–	3	3	3	2	4	–	3	3	3	4	X
	Repr.	–	–	–	–	–	–	–	–	m	–	–	–	–	–	⊕	–	⊕	–	X
C7 m	Size	3	4	3	3	2	3	1	2	2	3	3	3	3	2	3	4	3	2	X
	Repr.	–	–	f⊕m	–	–	–	–	m	f⊕m	f⊕m	⊕m	f⊕m	–	–	–	f⊕	f	–	X
C10 m	Size	3	4	2	3	4	–	1	3	1	3	–	3	–	2	3	2	3	4	X
	Repr.	⊕	f	⊕m	–	–	–	–	f	–	⊕m	–	–	–	–	⊕	–	f⊕m	–	X

30. Polysiphonia spp. (Figs. 75,76,77; Table 38)

The *Polysiphonia* species group comprised *Polysiphonia amphibolis* and *P. infestans*.

The *Polysiphonia* species group was at its greatest density during autumn through the winter (Apr.-Aug.) and its lowest density occurred in spring (Sep.-Nov.). The frequency data showed the same population trends. The species group was least dense at the 2 m site on all transects (Figs. 75,76,77). Small individuals of *Polysiphonia* spp. were recorded on the samples collected through spring and increased in size during the summer samples reaching their maximum in the autumn samples before the decline of the population towards the end of winter (Table 38). This species group was placed in the summer-winter species category.

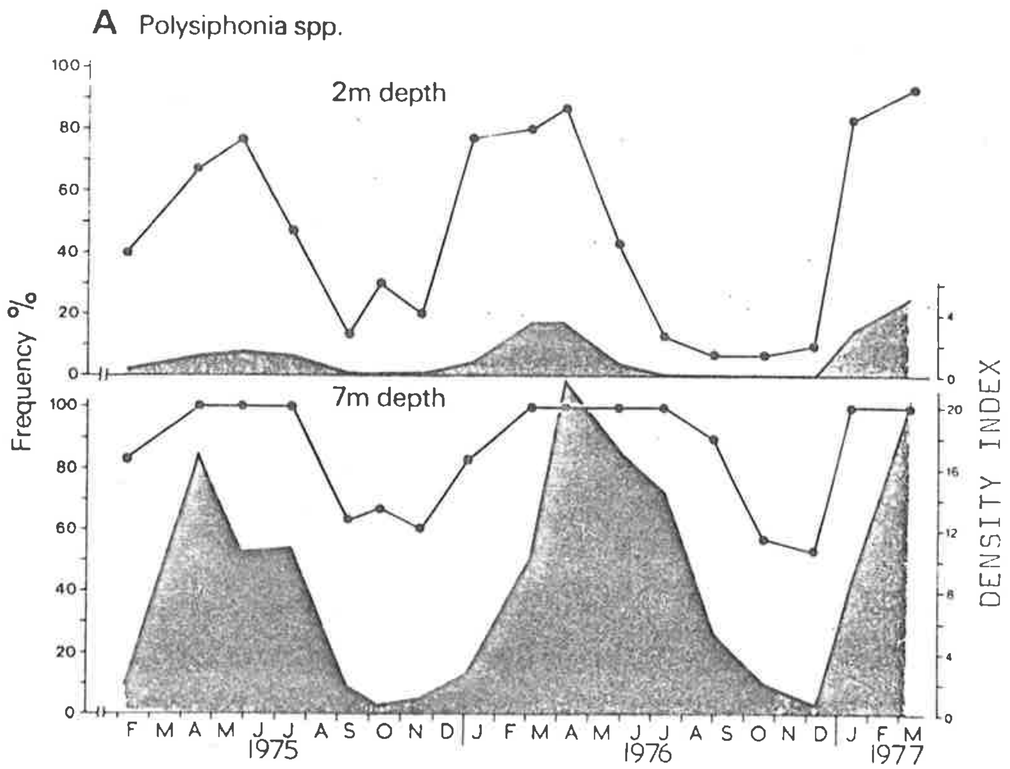


Fig. 75: Percentage frequency (solid line) and Density Index (shaded area) Values for *Polysiphonia* spp. on the Transect A.

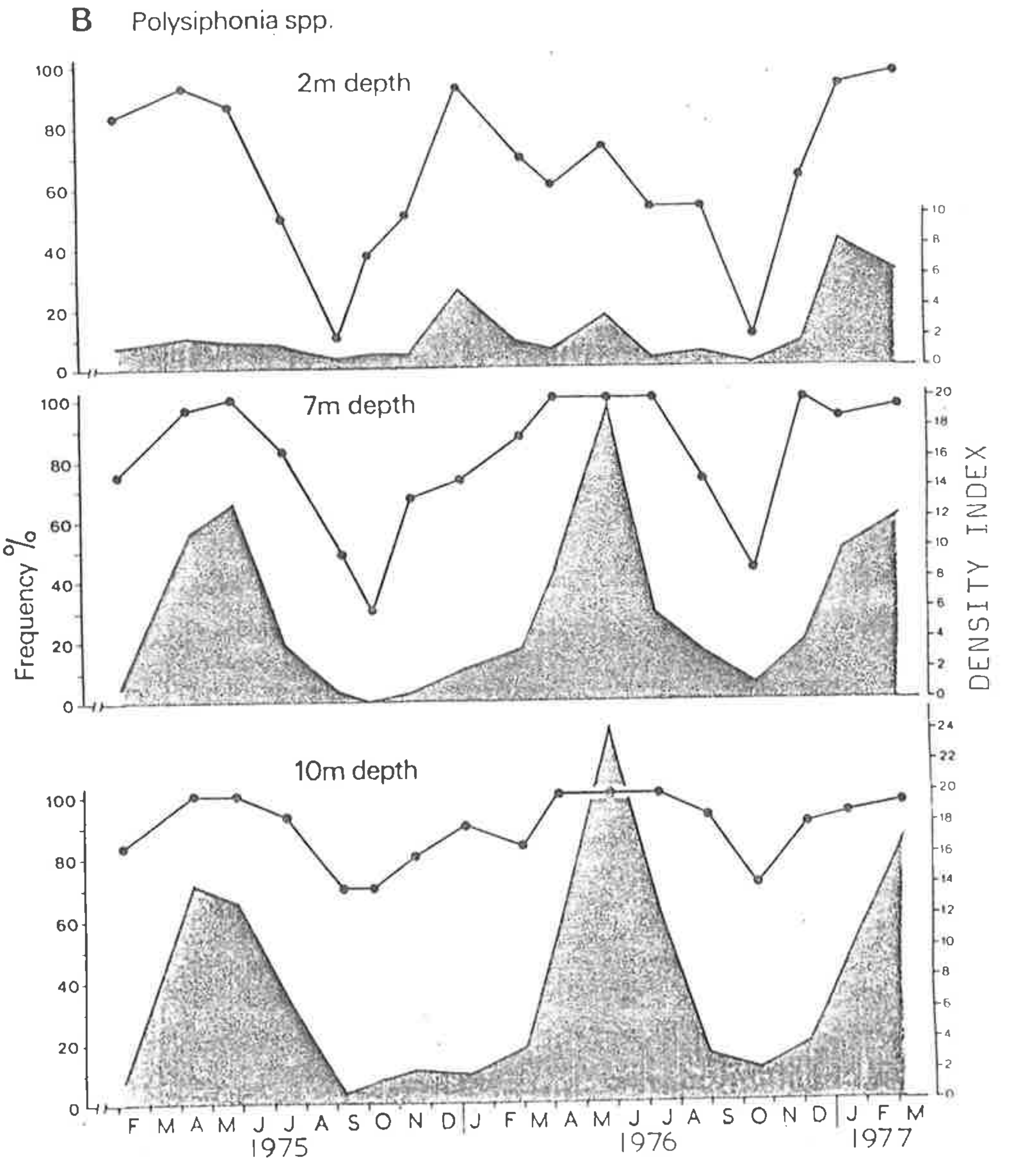


Fig. 76: Percentage frequency (solid line) and Density Index (shaded area) Values for *Polysiphonia* spp. on the Transect B.

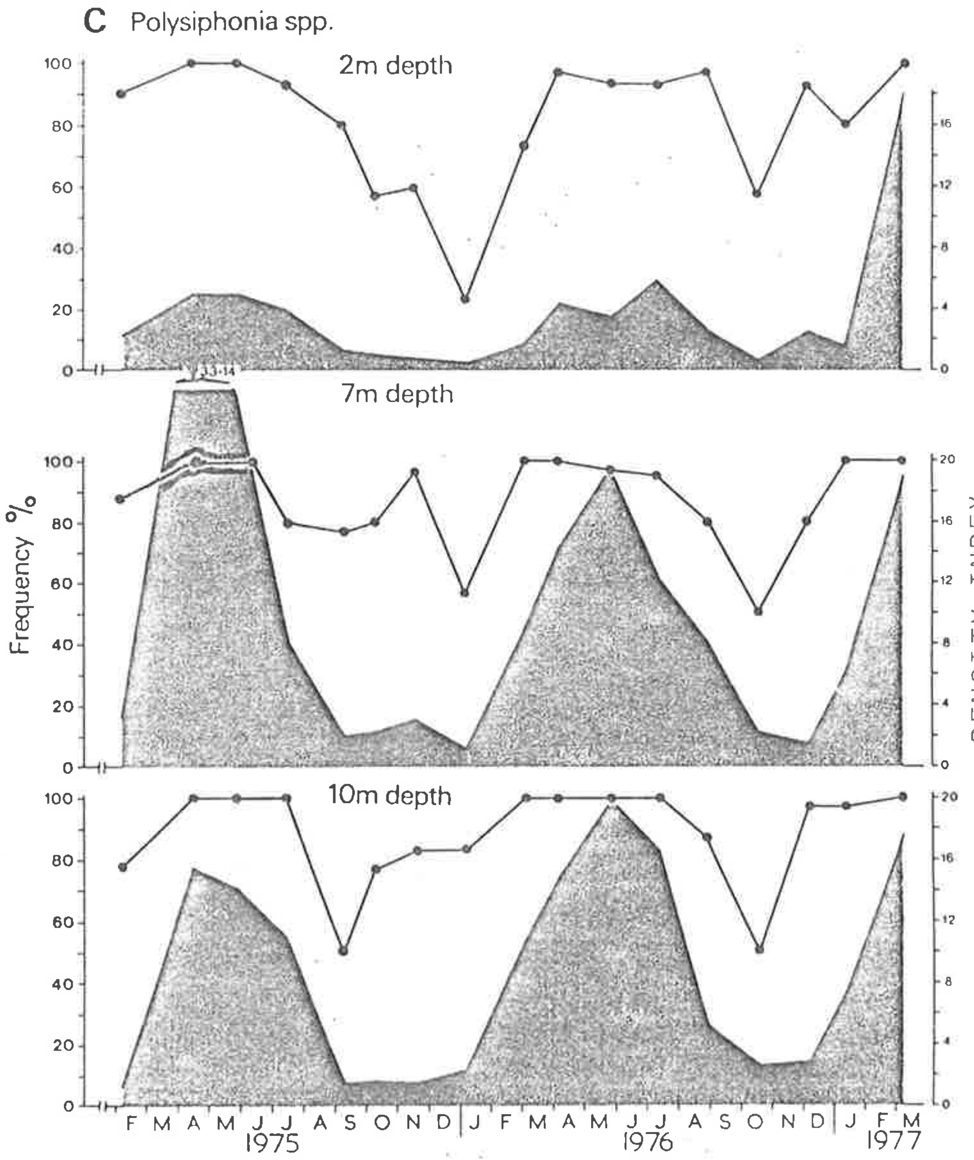


Fig. 77: Percentage frequency (solid line) and Density Index (shaded area) Values for *Polysiphonia* spp. on the Transect C.

Table 38: Size indices and reproductive plants recorded for *Polysiphonia* spp. during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	1	2	3	2	2	1	1	2	1	2	2	2	1	1	1	2	2	1	X
	Repr.	f	f	–	–	–	–	f	f	f	f⊕m	f	–	–	–	–	f	f⊕	–	X
A7 m	Size	2	2	3	4	3	3	1	1	2	3	4	2	2	2	2	2	2	1	X
	Repr.	–	–	–	f⊕	⊕	⊕	–	–	f	f⊕	–	–	–	–	–	f	f	–	X
B2 m	Size	1	2	2	2	1	1	1	2	1	3	3	1	1	1	1	1	1	1	3
	Repr.	–	f	f	–	–	–	–	f	–	f	f	–	–	–	–	–	–	–	–
B7 m	Size	1	2	3	2	2	2	1	1	2	2	4	2	2	1	1	2	1	2	3
	Repr.	m	–	–	–	–	–	–	–	–	f	f	–	–	⊕	–	f⊕	–	f	f⊕
B10 m	Size	2	3	4	2	2	2	1	1	2	2	3	4	2	2	1	1	2	2	2
	Repr.	–	–	f⊕	f	–	–	–	f	f	f⊕	f⊕	fm	–	–	–	f	–	–	f⊕
C2 m	Size	1	3	3	2	2	2	1	1	1	2	2	2	2	1	1	1	2	2	X
	Repr.	–	–	–	–	–	–	f	–	–	⊕	f⊕	–	–	–	–	–	f	–	X
C7 m	Size	2	2	4	3	2	2	1	1	2	3	4	2	3	1	1	3	2	1	X
	Repr.	f⊕	f⊕	f⊕	–	–	–	–	–	f	f⊕	f	–	–	–	f	f	f	–	X
C10 m	Size	2	3	3	2	2	1	1	1	3	2	3	3	1	1	2	1	3	2	X
	Repr.	f	f	f⊕	f⊕m	–	–	–	–	f	f⊕m	f⊕	–	–	⊕	–	f	f	–	X

31. *Polysiphonia decipiens* (Figs. 78,79,80)

This *Polysiphonia* species was recorded as a separate taxon from the other *Polysiphonia* spp. in this epiphyte study.
P. decipiens was a non-seasonal species and did not have a marked difference in its density at the different depths of the study sites on any of the transects (Figs. 78,79,80), these features were indicated by both, the frequencies and the density indices.

Fertile plants occurred irregularly throughout the study period and thus no reproductive seasonal cycle was observed. Female plants were most commonly recorded (Table 39).

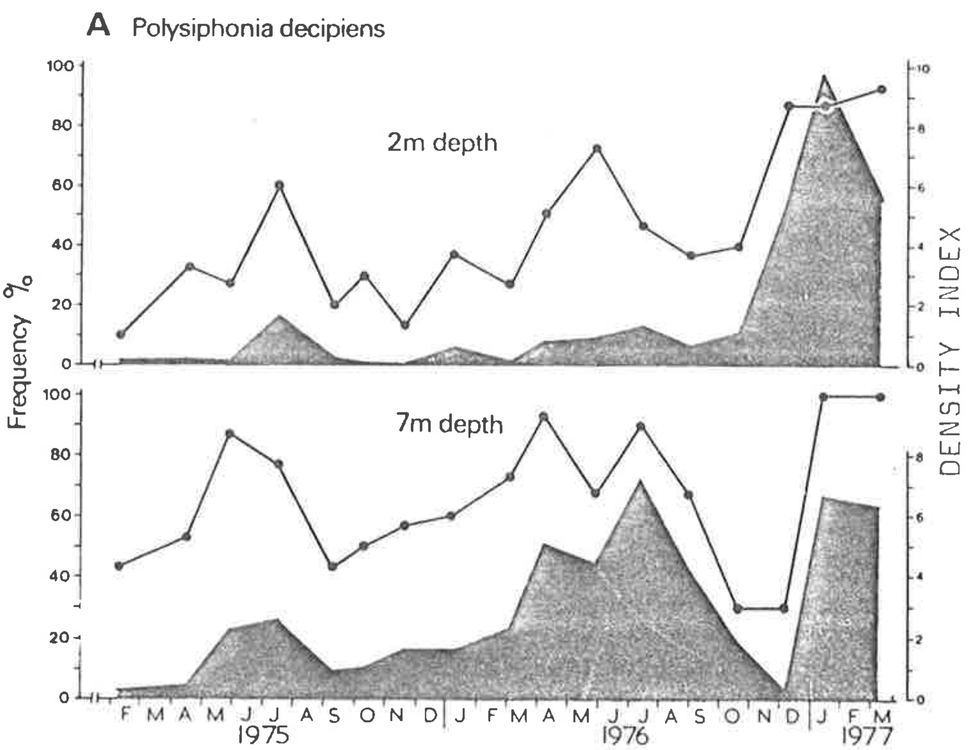


Fig. 78: Percentage frequency (solid line) and Density Index (shaded area) Values for *Polysiphonia decipiens* on the Transect A.

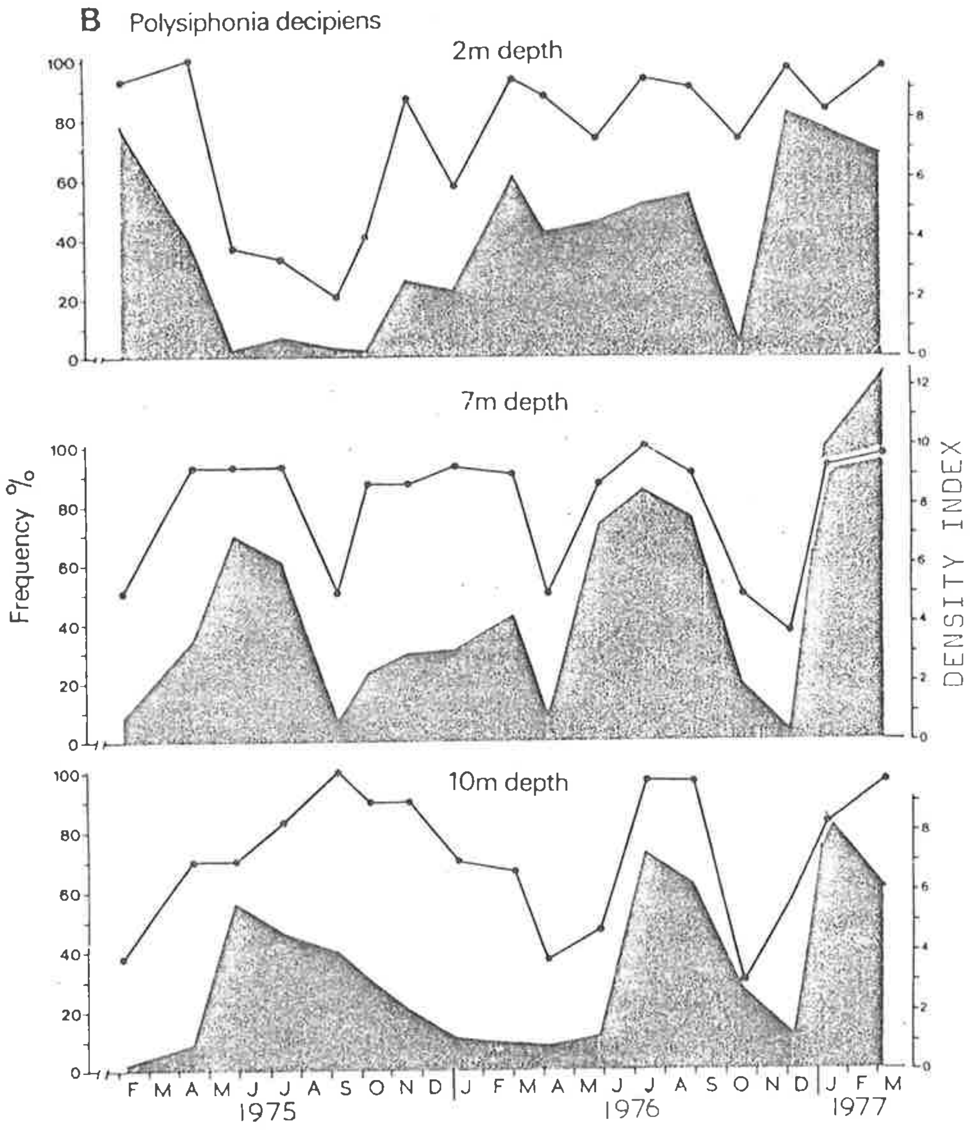


Fig. 79: Percentage frequency (solid line) and Density Index (shaded area) Values for *Polysiphonia decipiens* on the Transect B.

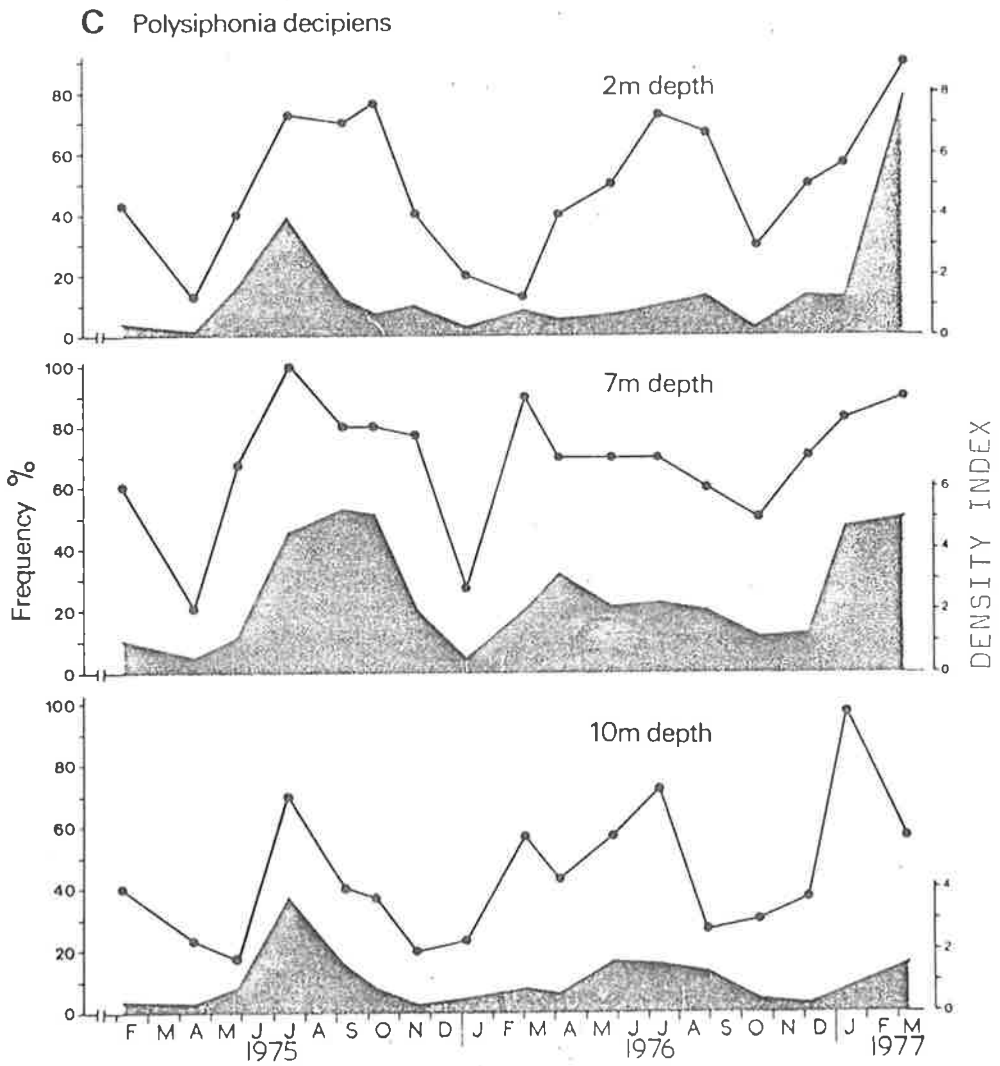


Fig. 80: Percentage frequency (solid line) and Density Index (shaded area) Values for *Polysiphonia decipiens* on the Transect C.

Table 39: Size indices and reproductive plants recorded for *Polysiphonia decipiens* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	2	2	3	3	2	3	2	2	1	2	3	2	2	1	2	3	3	1	X
	Repr.	⊕	–	f	–	–	m	–	f⊕	f	f⊕m	f	–	–	–	f⊕	f	f⊕	–	X
A7 m	Size	2	2	4	4	4	2	1	2	2	3	4	4	2	2	2	2	2	1	X
	Repr.	–	–	f	f⊕	–	–	m	f	–	–	f⊕	–	–	–	–	f	⊕	–	X
B2 m	Size	2	3	2	2	3	2	2	2	2	3	3	3	3	1	2	2	2	3	3
	Repr.	–	–	f	–	–	–	f	f	f	f⊕	f⊕	–	–	f	f⊕	fm	f	f	f
B7 m	Size	1	3	3	3	2	3	2	2	3	2	3	4	3	1	1	3	2	5	4
	Repr.	–	f	f	f⊕	–	f	f	f⊕	f	f	f	f	f	⊕	–	fm	–	f	f⊕
B10 m	Size	2	2	3	3	2	3	2	2	2	2	3	3	3	2	3	2	3	4	3
	Repr.	–	–	fm	f	–	–	f	f	–	f	f	f	–	–	f⊕	f	f	f	f⊕
C2 m	Size	2	4	4	3	1	2	1	2	2	2	2	5	3	1	1	1	3	1	X
	Repr.	–	–	f	–	–	–	–	⊕	⊕	f	–	f	m	–	–	–	f	m	X
C7 m	Size	2	4	3	3	2	2	1	1	1	3	2	4	4	1	2	2	3	1	X
	Repr.	⊕	⊕	–	–	f	f⊕	f⊕	–	–	fm	f⊕m	–	–	⊕	–	f	–	–	X
C10 m	Size	2	4	4	3	2	2	2	2	2	2	3	4	4	1	2	2	2	3	X
	Repr.	⊕	–	f	f	–	⊕	–	f	–	f	–	f⊕	–	–	–	f⊕	f⊕	⊕	X

32. *Protokützingia australasica* (Figs. 81,82; Table 40)

There was a good correlation between the frequency data and the density indices. This was a summer species with a peak in its density in January and was generally absent from the study sites during the cooler months of the year. On all the transects *P. australasica* was more dense at the deep water sites than at the 2 m deep sites (Figs. 81,82). No fertile plants were recorded on *Posidonia sinuosa* during the study (Table 40).

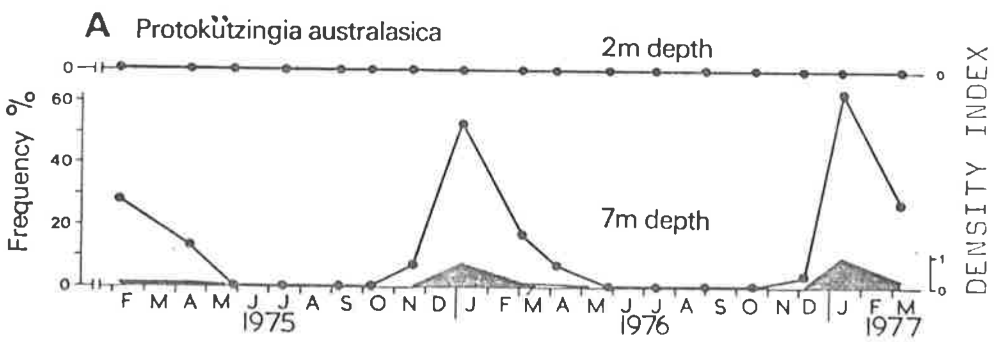
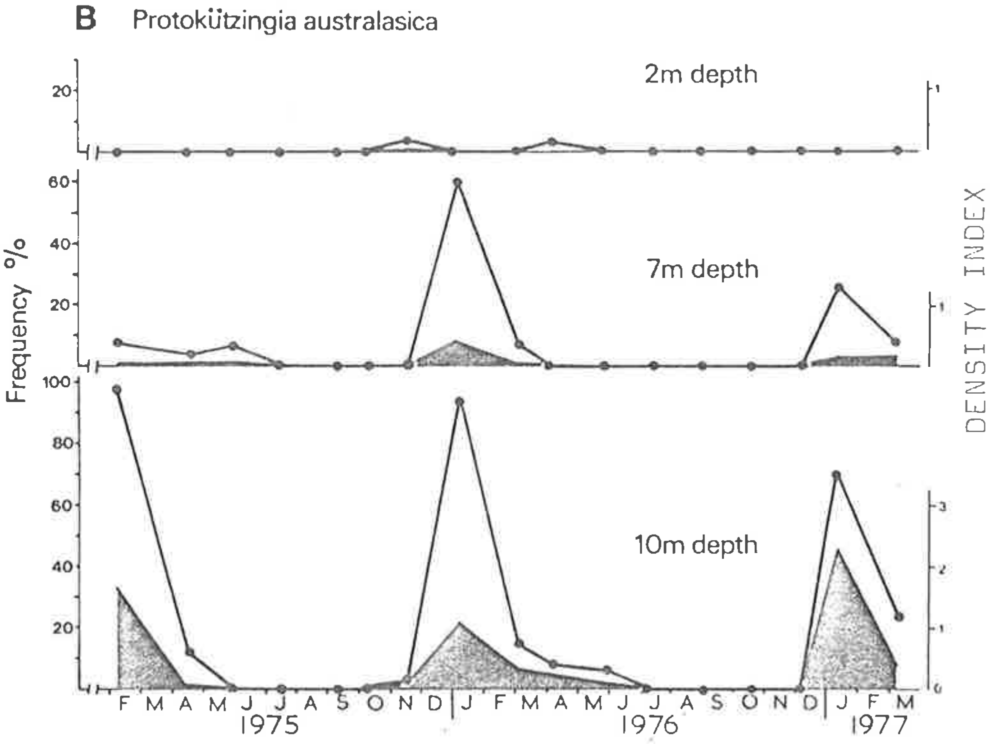


Fig. 81: Percentage frequency (solid line) and Density Index (shaded area) Values for *Protokützingia australasica* on the Transect A.



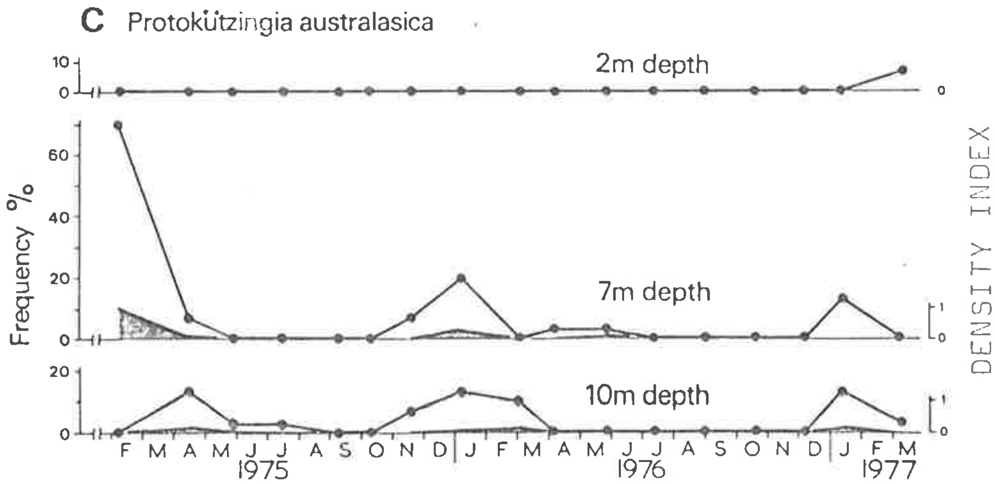


Fig. 82: Percentage frequency (solid line) and Density Index (shaded area) Values for *Protokützingia australasica* on the Transects B and C.

Table 40: Size indices and reproductive plants recorded for *Protokützingia australasica* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																	
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	2	4	–	–	–	–	–	1	2	4	5	–	–	–	1	2	2	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
B2 m	Size	–	–	–	–	–	–	1	–	–	3	–	–	–	–	–	–	–	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B7 m	Size	2	4	4	–	–	–	–	2	3	–	–	–	–	–	–	2	3	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B10 m	Size	2	5	–	–	–	–	1	2	2	4	5	–	–	–	–	2	3	–	–
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C2 m	Size	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	2	4	–	–	–	–	5	2	–	2	1	–	–	–	–	3	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	–	5	5	4	–	–	1	2	5	–	–	–	–	–	–	1	5	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

33. *Ptilocladia australis* (Figs. 83,84; Table 41)

There was a good correlation between the frequency data and the density indices. On the Transects A and B, *Ptilocladia australis* was found more abundantly at the deep sites than at the 2 m deep sites, however, on the Transect C the species was most abundant at the 2 m deep site. At the deeper site on the Transects A and B the species showed a seasonal decline in density and frequency in the spring (Sep.-Nov.) and maximum abundance in late autumn or early winter (May-Jul.) (Figs. 83,84) and therefore was a summer-winter species at these sites. Fertile plants on these two transects were more common through the autumn and winter than in spring and summer (Table 41). *P. australis* showed no regular seasonal density changes at the study sites on the Transect C.

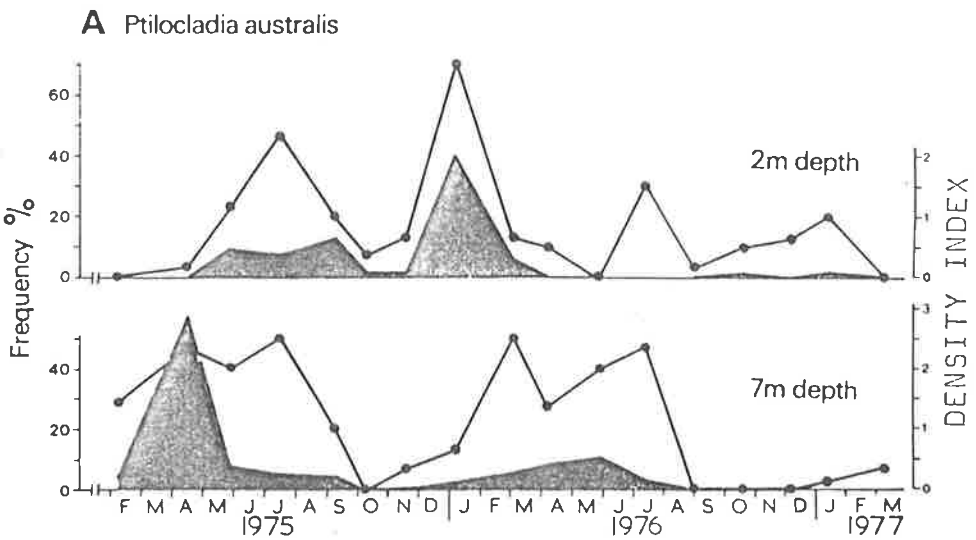
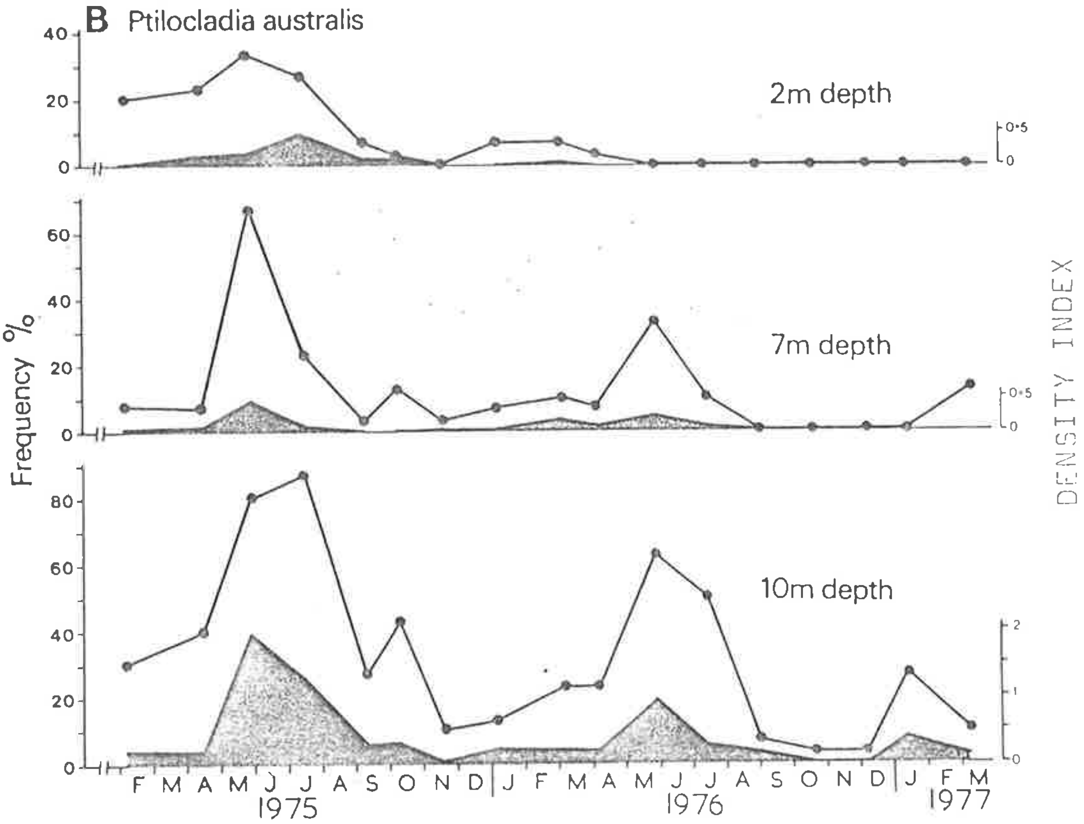


Fig. 83: Percentage frequency (solid line) and Density Index (shaded area) Values for *Ptilocladia australis* on the Transect A.



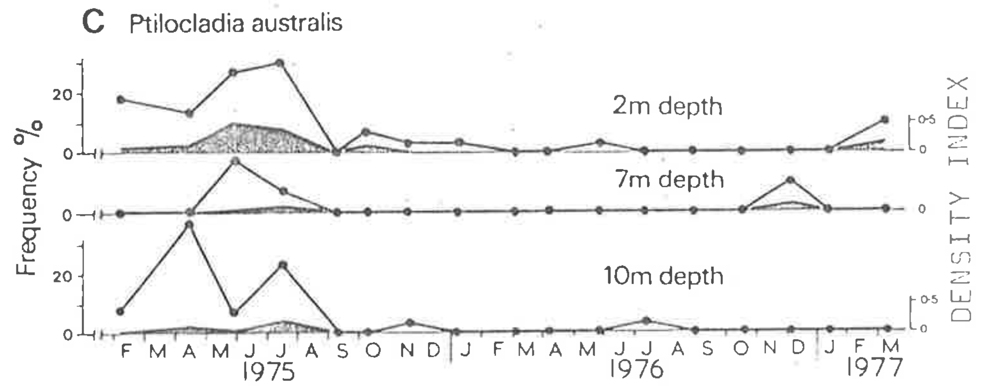


Fig. 84: Percentage frequency (solid line) and Density Index (shaded area) Values for *Ptilocladia australis* on the Transects B and C.

Table 41: Size indices and reproductive plants recorded for *Ptilocladia australis* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	–	2	3	4	2	1	1	4	1	3	–	2	3	1	2	3	–	3	X
	Repr.	–	–	f	⊕	f	–	–	–	f	–	–	–	–	–	–	f	–	f	X
A7 m	Size	3	3	4	2	3	–	1	2	3	4	4	3	–	–	–	4	2	1	X
	Repr.	–	⊕	f⊕	–	–	–	–	–	–	⊕	f	f	–	–	–	–	–	–	X
B2 m	Size	2	2	4	3	3	4	–	3	3	2	–	–	–	–	–	–	–	–	3
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B7 m	Size	2	2	5	3	2	3	2	4	3	3	4	4	–	–	–	–	3	2	3
	Repr.	–	–	f	–	–	–	–	–	–	–	f	–	–	–	–	–	–	–	f
B10 m	Size	3	3	3	4	4	3	1	4	3	2	4	3	4	1	3	5	3	4	4
	Repr.	–	–	f	f	–	f	–	–	–	⊕	f⊕	–	–	–	–	f	–	–	f⊕
C2 m	Size	3	4	4	4	–	4	1	1	–	–	1	–	–	–	–	–	2	–	X
	Repr.	–	–	f	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	–	–	5	1	–	–	–	–	–	–	–	–	–	–	3	–	–	–	X
	Repr.	–	–	–	⊕	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C10 m	Size	3	4	1	4	–	–	3	–	–	–	–	4	–	–	–	–	–	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X

34. *Spyridia tasmanica* (Figs. 85,86,87; Table 42)

Spyridia tasmanica was much more abundant at the 7 m and 10 m sites than at the 2 m deep sites. At these deeper sites the species displayed a summer-winter seasonal cycle. The density indices showed that the species had a peak in density in summer (Dec.-Feb) and a low the following spring (Sep.-Nov.). (Figs. 85, 86,87).

A *Spyridia* "bloom" occurred in the summer of 1975 according to the density indices. Athough there was a good correlation between the frequency and the density index data, the frequencies did not indicate as marked a population change for this summer period as did the density indices.

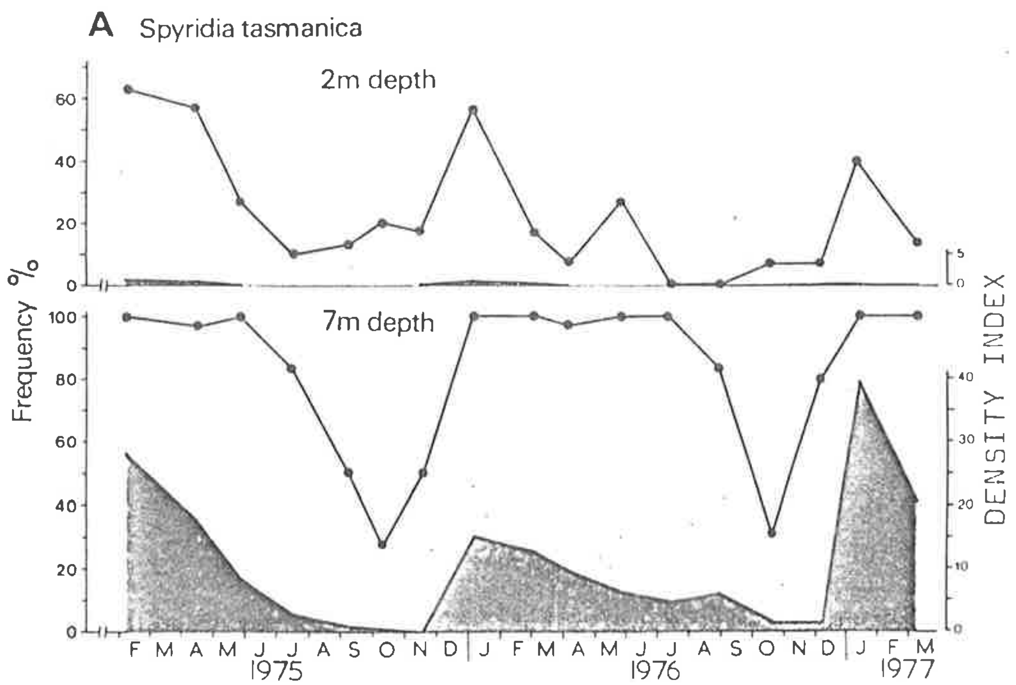


Fig. 85: Percentage frequency (solid line) and Density Index (shaded area) Values for *Spyridia tasmanica* on the Transect A.

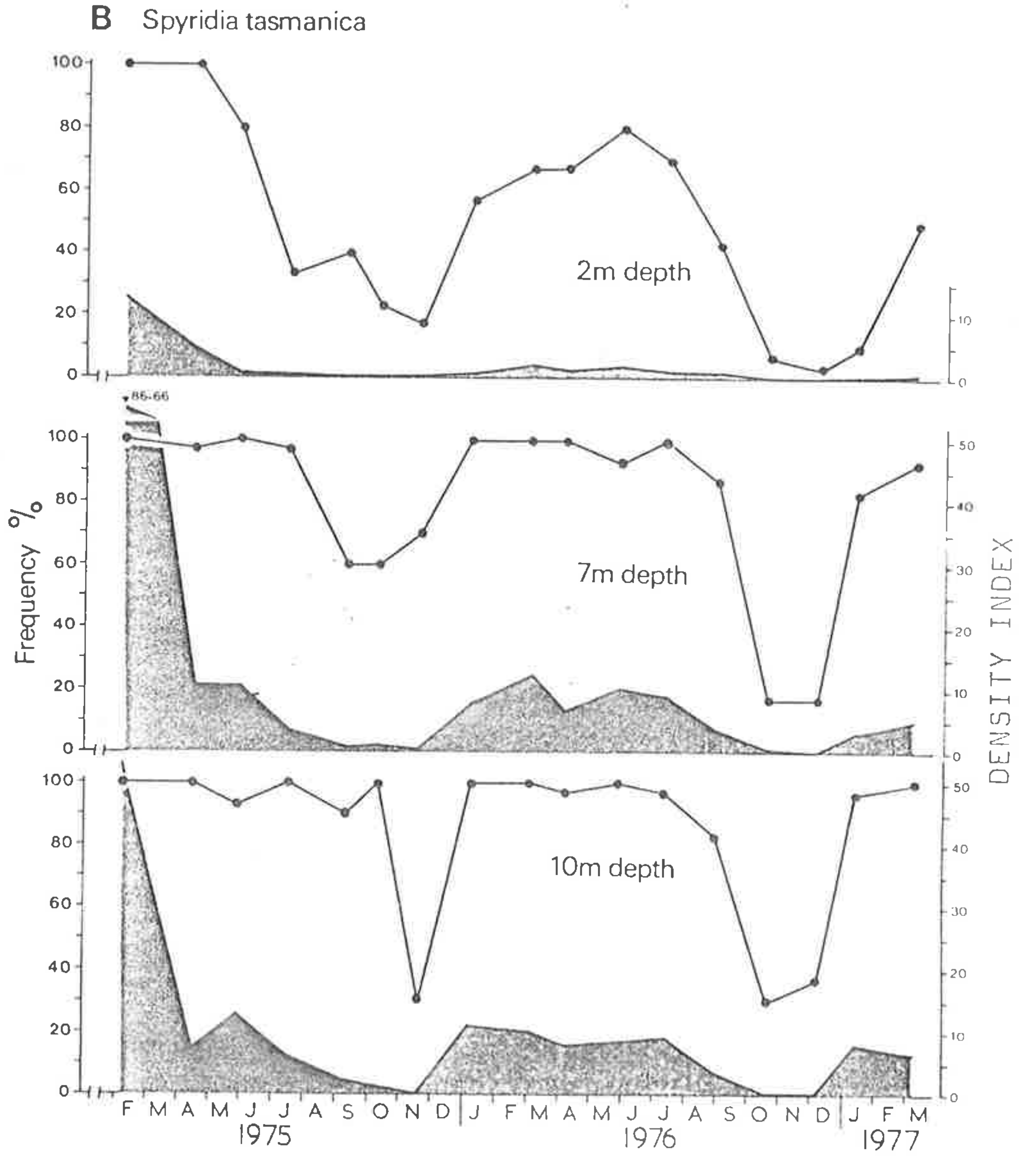


Fig. 86: Percentage frequency (solid line) and Density Index (shaded area) Values for *Spyridia tasmanica* on the Transect B.

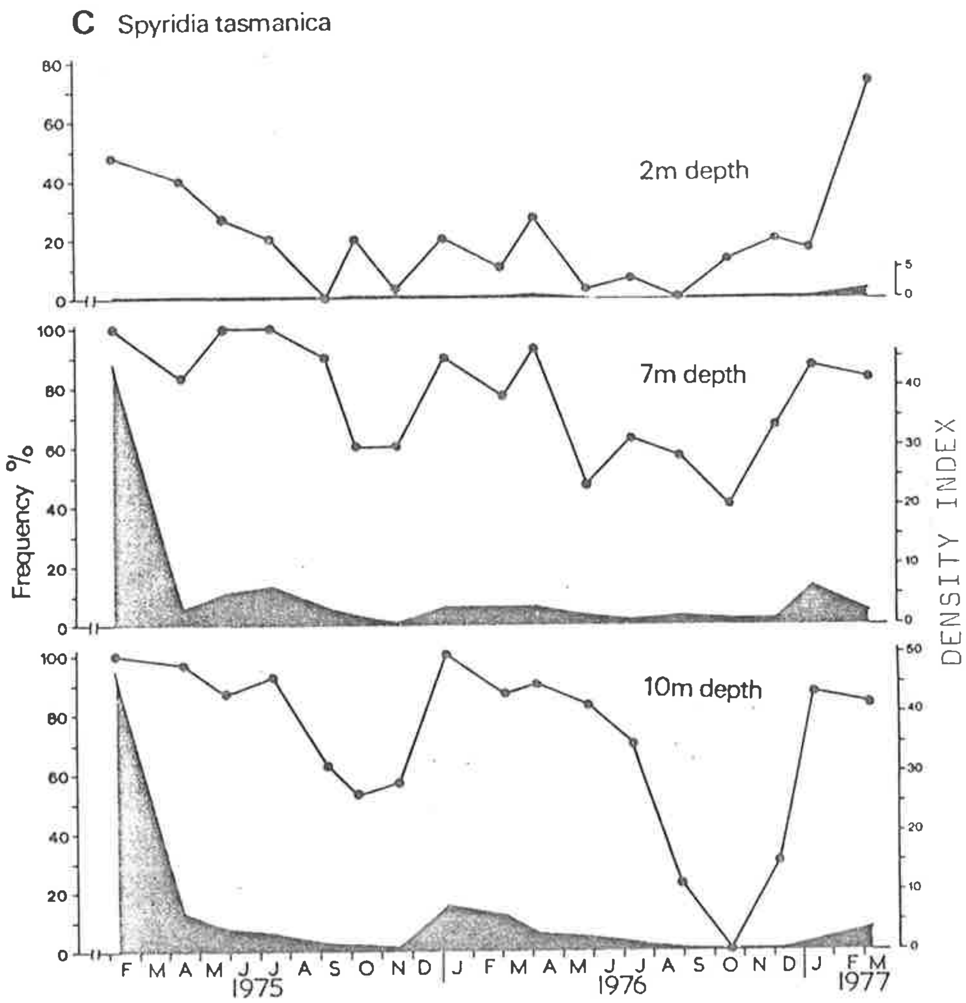


Fig. 87: Percentage frequency (solid line) and Density Index (shaded area) Values for *Spyridia tasmanica* on the Transect C.

Table 42: Size indices and reproductive plants recorded for *Spyridia tasmanica* during Feb. 1975 to June 1978 at eight permanent study sites in upper Spencer Gulf.

SITE	INDEX	COLLECTION																		
		1975							1976								1977			1978
		F	A	M	J	S	O	N	J	M	A	M	J	S	O	D	J	M	S	J
A2 m	Size	1	2	2	2	3	2	1	2	1	2	2	–	–	1	1	2	1	2	X
	Repr.	f⊕	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
A7 m	Size	2	3	3	5	5	3	2	1	2	2	3	5	5	1	1	3	2	4	X
	Repr.	–	–	–	–	–	–	–	m	–	fm	–	–	–	–	–	m	–	–	X
B2 m	Size	2	2	2	2	2	2	1	1	2	1	2	3	3	1	2	1	2	3	3
	Repr.	–	f⊕	–	–	–	–	–	–	–	m	fm	m	–	–	–	–	⊕m	–	–
B7 m	Size	2	2	3	2	2	3	2	2	3	2	4	3	4	1	1	3	2	5	4
	Repr.	–	–	f	–	–	–	–	f	⊕m	–	–	f	m	–	–	fm	m	–	f
B10 m	Size	2	3	4	3	2	3	1	2	2	3	2	4	4	3	2	2	2	3	3
	Repr.	–	–	f	–	–	m	–	–	f⊕m	⊕	f	–	–	–	⊕	f⊕m	m	–	–
C2 m	Size	2	2	2	2	–	2	1	2	2	3	2	3	–	1	2	2	2	–	X
	Repr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
C7 m	Size	2	3	3	4	3	3	2	2	2	3	3	3	3	1	2	2	2	2	X
	Repr.	–	–	–	–	–	–	–	–	–	f	–	–	–	–	–	–	–	–	X
C10 m	Size	2	3	2	2	5	2	2	2	2	3	2	3	3	–	2	1	2	3	X
	Repr.	–	–	–	f	f⊕	–	–	–	–	–	–	–	–	–	–	–	–	–	X

CHAPTER SEVEN: DISCUSSION - THE ALGAL EPIPHYTES

A. The Epiphytic Algae

As Feldman (1937) found for marine algae in the Mediterranean, the epiphytic algae on *Posidonia sinuosa* belong to three different groups,

(a) a felt-like coating of minute species; diatoms and phaeophytes,

(b) the encrusting calcareous species, and

(c) the larger more or less "erect" species.

This study is primarily concerned with the third group. 53 species in 42 genera of "erect" algal epiphytes were recorded on *Posidonia sinuosa* in upper Spencer Gulf. Many of these genera were in common with those recorded in other studies:

(i) 19 such genera on *Thalassia testudinum* in Florida (Humm 1964),

(ii) 19 on *Posidonia oceanica* in the Mediterranean (Van der Ben 1971),

(iii) 14 on *Zostera marina* in North Carolina, U.S.A. (Brauner 1975),

(iv) 18 on seagrasses in Florida (Ballantine & Humm 1975),

(v) 26 on *Amphibolis* spp. in southern Australia (Ducker et al. 1977), and

(vi) 24 on seagrasses in eastern Australia (May et al. 1978).

Apart from the "irregular transient species" listed in Chapter Six, the data on the 34 individual species or species groups indicate that on the basis of seasonal behaviour, there are two main categories, each with similar numbers of species, i.e. a non-seasonal category and a seasonal category. Humm (1964) and Ducker et al. (1977) recognized on the basis of seasonal behaviour two distinctive algal groups on *Thalassia testudinum* and *Amphibolis* species respectively; a constant year-round component of the epiphytic flora and a second group which reflected the vegetation of the local environment. However, from the information collected in this study about the seasonal behaviour of the individual species, several smaller and better defined categories were recognized.

(a) Non-seasonal Epiphytic Species

The non-seasonal group was separated into two categories, a year round component and an irregular component of the epiphytic flora.

(1) The species that formed a year round component of the epiphytic flora included *Sphacelaria* spp., *Antithamnion divergens*, *Ceramium puberulum*, *Champia zostericola*, *Griffithsia monilis*, *Herposiphonia* sp. 1, *Jania micrarthrodia* and *Polysiphonia decipiens*.

(2) The species that were not a year round component of the epiphytic flora but their occurrence did not appear to be regulated by seasonal factors included *Castagnea epiphytica*, *Giraudya robusta*, *Chondria dasyphylla*, *Corallina* sp., *Crouania* sp., *Gloiosaccion brownii*, *Lomentaria* sp., *Metagoniolithon chara* var. *chara* These species had an irregular occurrence and may be common epiphytes but did not appear to be chance occurrences as in the case of the irregular transient species.

Giraudya robusta, even though it was present throughout the study at the 2 m deep sites on the three transects, occurred irregularly at the other five sites and therefore was included within this group rather than being described as a year round component of the epiphytic flora. Similarly, *Lomentaria* sp. although it was present all year round on the Transect B, occurred irregularly at the study sites on the Transects A and C; it was therefore included within this group.

(b) Seasonal Epiphytic Species

Seasonal species were assigned to one of 4 categories; summer, summer-autumn, autumn-winter, and summer-winter, according to the season(s) in which their population responded with continued development from juvenile stages to vegetative and reproductive maturity followed by initiation of senescence of the majority of the population. The inclusion of young stages should provide a more accurate and meaningful evaluation of the development requirements of the species than if only the period of thallus maturity is represented. The presence during part of the year of the recognizable form of a species must be a condition for a seasonal species, although they were probably represented in the community during their apparent adverse season by spores, zygotes, germlings or dormant juveniles.

(1) The summer species, *Jeannerettia pedicellata* and *Protokützingia australasica*, showed a peak in frequency and density during the summer with a decline in population levels in autumn, and were absent from collections from the mid-autumn to the mid-spring months (Apr. - Oct.).

(2) The summer-autumn species, *Bryopsis plumosa, Anotrichium tenue* and *Audouinella* sp., showed a peak in frequency and density during the summer and/or autumn months and were mostly absent from the collections during the winter and spring months.

(3) The autumn-winter species, *Cladophora fascicularis*, *Asperococcus bullosus* and *Giffordia mitchelliae,* had a peak frequency and density during autumn and winter (May - Aug.). There was usually an increase in frequency and density during the autumn (Apr. - May) and a decline in the species occurrence in late winter (Aug. - Sep.), with a noticeable absence of the species during spring and summer (late Sep. - Feb.).

(4) The summer-winter species, *Pachydictyon polycladum, Centroceras clavulatum, Ceramium shepherdii, Dasya* spp., *Hypnea musciformis, Laurencia forsteri, Platysiphonia miniata, Polysiphonia* spp.*, *Ptilocladia australis* and *Spyridia tasmanica,* characteristically had low frequencies and density indices during the spring (Sep. - Nov.).

May et al. (1978) mentioned that *Champia zostericola* demonstrated two peaks in frequency, one in late autumn - early winter and the second in late spring - early summer. However in upper Spencer Gulf no epiphytic species' frequencies were recorded as showing this effect. They also reported that some species highest frequency occurred over one season, analogous to the summer species in this study, while the frequency of others

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* *Polysiphonia* spp. comprised of *P. amphibolis* and *P. infestans.*

remained high for six months of the year (the autumn-winter species in this study). Also in their study another group of algal epiphytes were common throughout the year but showed a decline in frequency during late winter, corresponding with the summer-winter species in this study.

B. Indicator Species

The aim of the study was to collect baseline information on the algal epiphyte species of *Posidonia sinuosa* such that it would be useful in biological monitoring studies for measuring environmental modifications based on indicator-species systems and/or community structure. Therefore not only the selection of indicator species, but also the establishment of common changes and trends within the epiphytic species on the three transects, was important in the development of future biological monitoring studies in the Redcliff Point area.

The differences in the observed seasonal trends in the epiphytic species at study site C in relation to seasonal trends observed at the other study sites have been mentioned in Chapter Six, nevertheless there were also strong similarities and both the seasonal and depth distribution trends of most of the algal epiphytic species recorded along a particular transect were an indication of the trends that would be recorded at the other two transects. Of the 34 species or species groupsexamined, 21 of these (62%) showed the same seasonal cycles and depth distributions at the three study sites. The Transects A and B had 28 (82%) species/species groups which were similar, while the Transects A and C, and B and C had 23 (68%) and 24 (70%) species/species groups that showed the same trends.

The epiphytic species were more likely to show differences between the transects in the occurrence of the algae along a depth gradient, therefore water depth was probably less important in determining the occurrence of the algae than other environmental factors which alter with the seasons. Of the 13 species or species groups which did not show the same trends along the three transects, 11 of these were differences in the density trend of the species along a depth gradient, 1 was related to a difference in seasonal trend while the remaining species showed differences in both the seasonal and depth relationships recorded.

So having established that the three transects were quite similar and that the majority of "erect" epiphytes showed the same trends at these three sites then the selection of indicator species was appropriate. The indicator species system is based on the idea that the presence of a given species indicates a certain quality of the environment where it lives or regularly occurs, whereas the absence of this species indicates another environmental quality. The characteristics usually sought in indicator species are that they be present throughout all or most of the year, easily recognized and identified, fairly common and that their seasonal variation be slight or well defined. It is also advantageous to know the response of the species to the pollutant(s) that is to be monitored. Some species are good indicators of different seasonal factors but because of their seasonal nature are of limited value as an indicator species during their period of absence. In this study *Asperococcus bullosus, Giffordia mitchelliae* and *Cladophora fascicularis* were characteristically present in collections made between April and October while

Jeannerettia pedicellata and *Protokutzingia australasica* were present in collections made between November and March inclusive and by grouping these species with the summer-winter species an effective monitoring base might be established, but the species that are probably most useful as possible indicator species are those which occurred reasonably frequently and showed little variation between season and year. Therefore the algal epiphyte species which occurred on 33% or more of the leaf-blades from a total of 4 160 *Posidonia* leaf-blades examined from all samples collected between February 1975 and March 1977 were listed (Table 43), and a comparative list determined by the summation of the Density Index Values for the same period (Table 44). Both lists recorded the same fourteen species although not in the same order.

Table 43: The fourteen most common species as determined by the presence and absence data for the species on 4 160 *Posidonia* leaf-blades collected between February 1975 and March 1977.

Species Number (RANK)	Algal Epiphyte Species	Total No. of leaves on which present	Frequency %	Seasonality	Depth Distribution from the Frequency Data
1	*Sphacelaria* spp.	4 026	97	Non-seasonal	On Transect C, least common at the shallow site. No trend on Transects A and B.
2	*Jania micrarthrodia*	3 759	90	Non-seasonal	On Transect C, most common at the shallow site. No trend on Transects A and B.
3	*Polysiphonia* spp.	3 236	78	Summer-Winter	Least common at the shallow sites

Table 43 (Cont'd)

Species Number (RANK)	Algal Epiphyte Species	Total No. of leaves on which present	Frequency %	Seasonality	Depth Distribution from the Frequency Data
4	*Herposiphonia* sp.	3 004	72	Non-seasonal	On Transect C, least common at the deepest sites. On Transects A and B least common at the shallow site.
5	*Laurencia forsteri*	2 868	69	Non-seasonal at the shallow sites. Summer-Winter	Most common at the shallow sites.
6	*Spyridia tasmanica*	2 562	62	Summer-Winter	Least common at the shallow sites.
7	*Polysiphonia decipiens*	2 442	59	Non-seasonal	No trend. Most common at the 7 m deep site
8	*Ceramium puberulum*	2 437	59	Non-seasonal	Most common at the shallow sites. Least common at the deepest sites.
9	*Griffithsia monilis*	1 828	44	Non-seasonal	On Transect C, least common at the deepest site. On Transects A and B, least common at the shallow site.
10	*Pachydictyon polycladum*	1 777	43	Summer-Winter	On Transects A and C, least common at the shallow site. On Transect B least common at the deepest site.

Table 43 (Cont'd)

Species Number (RANK)	Algal Epiphyte Species	Total No. of leaves on which present	Frequency %	Seasonality	Depth Distribution from the Frequency Data
11	*Dasya* spp.	1 539	37	Summer-Winter	Least common at the shallow sites.
12	*Antithamnion divergens*	1 440	35	Non-Seasonal	Least common at the shallow sites.
13	*Audouinella* sp.	1 400	34	Summer-Autumn	On Transect C, most common at the deepest site. On Transects A and B, most common at the shallow site.
14	*Ceramium shepherdii*	1 364	33	Summer-Winter	On Transect C, least common at the deepest site. On Transects A and B, least common at the shallow site.

Table 44: The fourteen most dense algal epiphyte species on *Posidonia sinuosa* as determined by the Density Index Values summed for the period February 1975 to March 1977.

Species Number (RANK)	Species	Total Density Index Value	Species Number (RANK) according to Frequency Data
1	*Sphacelaria* spp.	1 416	1
2	*Jania micrarthrodia*	931	2
3	*Polysiphonia* spp.	817	3
4	*Spyridia tasmanica*	720	6
5	*Herposiphonia* sp.	437	4
6	*Polysiphonia decipiens*	354	7
7	*Laurencia forsteri*	329	5
8	*Ceramium puberulum*	225	8
9	*Ceramium shepherdii*	204	14
10	*Audouinella* sp.	171	13
11	*Pachydictyon polycladum*	137	10
12	*Dasya* spp.	106	11
13	*Antithamnion divergens*	90	12
14	*Griffithsia monilis*	89	9

The frequencies of these fourteen species at each collection site were examined for marked differences in their occurrence between the Transects A, B and C. *Sphacelaria* spp., *Jania micrarthrodia*, *Polysiphonia* spp., *Herposiphonia* sp. 1, *Spyridia tasmanica*, *Ceramium puberulum*, *Griffithsia monilis*, *Pachydictyon polycladum* and *Antithamnion divergens* showed only small differences, but the results for *Laurencia forsteri* and *Ceramium shepherdii* indicated that these species were much less common on the Transect C than on the other two transects, while *Polysiphonia decipiens* and *Dasya* spp. were much more common on the Transect B than on the other transects. Finally, *Audouinella* sp. was most common on the Transect C.

The density index values for these fourteen species indicated that for *Polysiphonia* spp.*, *Herposiphonia* sp. 1, *Ceramium puberulum*, *Griffithsia monilis*, *Pachydictyon polycladum* and *Antithamnion divergens*, there was little difference in the density of these species at the three transects, while *Sphacelaria* spp., *Polysiphonia decipiens* and *Dasya* spp. were all more abundant on the Transect B than on the other transects. *Laurencia forsteri*, *Spyridia tasmanica* and *Ceramium shepherdii* were all low in abundance at the Transect C compared with their densities on the Transects A and B. *Jania micrarthrodia* and *Audouinella* sp. were more dense at the sites on the Transect C than at the corresponding sites on the other transects.

However because of the seasonal and annual variation in the lower ranking species in the lists in Tables 43 and 44 it was decided to select the "indicator species" from the eight algal species that occurred on more than 50% of the total *Posidonia* leaves. *Polysiphonia* spp. and *Spyridia tasmanica* at all collection sites and *Laurencia forsteri* at the 7 m and 10 m deep sites displayed a summer-winter seasonal cycle, thus the most common species which were non-seasonal were:-

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* *Polysiphonia* spp. comprised of *P. amphibolis* and *P. infestans*.

Sphacelaria spp.,

Jania micrarthrodia

Herposiphonia sp. 1,

Polysiphonia decipiens and

Ceramium puberulum

The mean frequencies and mean density indices for each of these non-seasonal species at all collections are presented in Table 45. These means provide baseline data upon which future comparisons may be made. Further frequent observations on these species at the study sites, co-ordinated with laboratory studies to examine factors controlling their life cycles, should provide a better knowledge of the variability of the species occurrence and their suitability as an indicator species. It is also suggested that the thermal tolerance and the susceptability of these species to effluents of a range of concentrations of caustic soda and ethylene dichloride[1] would allow better assessment of these small algae as indicator species for environmental modifications caused by a petrochemical complex if one were established near Redcliff Point.

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1 The design of the petrochemical complex is such that it is proposed to have a thermal outfall for seawater used during cooling processes in the plant. The main products to be shipped from the site by marine vessels are caustic soda and ethylene dichloride.

Table 45: Mean Frequency and Mean Density Index at each collection site for the 5 most common non-seasonal algal algal epiphytes on *P. sinuosa* near Redcliff Point, upper Spencer Gulf.

SPECIES	PARAMETER	A 2m		A 7m		B 2m		B 7m		B 10m		C 2m		C 7m		C 10m	
		Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
Sphacelaria spp.	Frequency	29.0	1.9	29.9	1.4	29.9	0.2	30.0	0.00	29.8	0.7	25.7	5.2	29.5	0.9	29.5	1.7
	Density Index	10.70	4.4	11.1	7.0	22.90	8.3	17.96	6.6	13.60	4.5	3.79	2.8	10.70	5.8	10.90	5.5
Jania micrarthrodia	Frequency	27.8	3.8	27.9	3.1	28.2	1.9	26.5	3.0	24.9	2.9	30.0	0.00	26.4	4.8	24.6	5.4
	Density Index	4.80	3.8	5.55	4.0	3.65	2.1	2.76	1.4	2.17	1.0	20.43	13.6	10.15	8.6	4.28	4.8
Herposiphonia sp.1	Frequency	14.9	8.4	17.2	10.4	17.8	6.8	25.8	4.4	26.6	3.9	22.2	6.4	26.0	4.3	21.6	7.5
	Density Index	1.15	1.4	2.49	3.4	1.69	1.9	3.98	3.3	5.96	5.3	2.92	2.3	4.42	3.9	3.13	3.2
Polysiphonia decipiens	Frequency	13.3	8.1	19.7	6.9	22.1	7.8	23.88	5.9	21.6	7.0	13.7	7.6	20.5	6.3	12.5	5.6
	Density Index	1.73	2.8	2.91	2.3	3.92	2.9	4.19	2.8	3.33	2.6	1.39	1.9	2.58	1.7	1.00	0.8
Ceramium puberulum	Frequency	25.8	4.4	6.5	4.7	26.8	3.0	13.2	5.9	11.4	5.3	23.1	8.5	21.2	7.1	11.8	7.7
	Density Index	2.72	1.5	0.27	0.2	3.29	1.9	0.48	0.3	0.51	0.4	2.72	1.9	1.98	1.5	0.74	0.7

C. Frequency and Density Index

An important consideration in developing a sampling procedure in ecological studies is the evaluation of the effort required to gain a unit of information.

Frequency is usually the easiest of the quantitative measures to determine (Greig-Smith 1964) and it requires little time to record presence or absence of an epiphytic species on a leaf. Density index is a more time consuming parameter to measure and consequently the number of leaves, i.e. the sample size, that could be examined within a given time is much less than if only the frequencies of the species were being recorded. However, at the beginning of this study it was not known if the changes in frequency of a species in the leaf samples over a period of time truly represented population density changes of that species over the same period. In order to evaluate the amount of information that may be obtained from the frequency data in surveys of this type, the density index for each of 33 species or species groups was also recorded at each collection. Only frequency data were recorded for *Giffordia mitchelliae*. The density index of a species was an estimate of the species' density and was defined as a measure of the number of individuals of that species on a unit leaf surface area.

Information on the average size of the plants of a species and the presence or absence of reproductive plants of a species in each sample throughout the study aided in determination of the seasonality of the species.

Sphacelaria spp. and *Jania micrarthroda*, the two most common "erect" epiphytic species present throughout the study, showed little or no correlation between the frequency and density index parameters. Their common occurrence on the leaves at all times (often 100% frequency) made it difficult to assess changes in their population densities. Thus the density indices not only showed that there were fluctuations in the density of the species' populations during the study, but also that their density varied at the different study sites. The frequencies did not allow one to recognize these features of the species population although they did accurately indicate the non-seasonality of these species.

There were good correlations between the frequencies and density indices in the remaining 31 species or species groups and the changes in population size recorded by the density indices were also reflected in the changes in the frequencies. Except for 5 species *(Pachydictyon polycladum, Jeannerettia pedicellata, Laurencia forsteri, Polysiphonia* spp., and *Spyridia tasmanica*) the frequency results of the species also indicated any disparities in the species population density related to the depth of the collection site.

Table 46 compares the properties of the frequency and density index parameters as they generally applied to the "erect" algal epiphytes in this study.

Table 46: Comparison of the properties of Frequency data and Density Indices for the "erect" algal epiphytes of *Posidonia sinuosa*.

	Frequency	Density Index
Average time taken to examine each leaf	3-5 mins	15-20 mins
Sample size (no. of leaves)	30	9
Presence or absence data	Yes	Yes
Density estimate	No	Yes
Trends in species population size corresponding with the depth of the collection site	Yes	Yes
Seasonal trends in population size at a collection site	Yes	Yes

From Table 46 it can be seen that frequency data provided almost as much information as the density indices for much less recording time and effort. This was because many species were represented by plants that were difficult to identify as individuals because of clumping or development of rhizoidal structures, so frequency of occurrence of the species should be preferred to recording the density of individuals.

CHAPTER EIGHT: THE ALGAL EPIPHYTIC COMMUNITY

Plants and animals generally distribute themselves or are distributed widely by various means, and different locations having similar conditions and resources are often occupied by biological communities recognizably the same or similar. A biological community, being dependent on the conditions and resources of its location, may change if these change. These resource changes may be natural or artificial. It is important to examine the natural changes in a community so a better assessment of changes caused by man-induced factors can be made. In this study, changes in environmental conditions have been attributed as the causal agents for changes in the density, frequency, size and reproductive state of individual epiphytic algal species of *Posidonia sinuosa*. These changes also cause changes in the composition of the community, and community composition and diversity can be extremely sensitive biological indices of environmental change (Warren 1971, p. 347).

A. Total Density Value Changes

To assess if there were changes in the density of the epiphytic community with different seasons, the Total Density Values (Figs. 88, 89 and 90) determined by summing the density indices of all the algal species recorded on a standardized leaf surface area of 50 cm^2 from the distal one-third of the *Posidonia sinuosa* leaf blade were calculated.

Transect A

On the Transect A at 2 m depth, the Total Density Values recorded during the study were variable, and at this collection site the minimum Total Density Value of 23.0 was recorded in November 1975, and the maximum value recorded in January 1977, was 94.4. A seasonal increase and decline of Total Density Values was evident at the 7 m deep site (Fig. 88). The

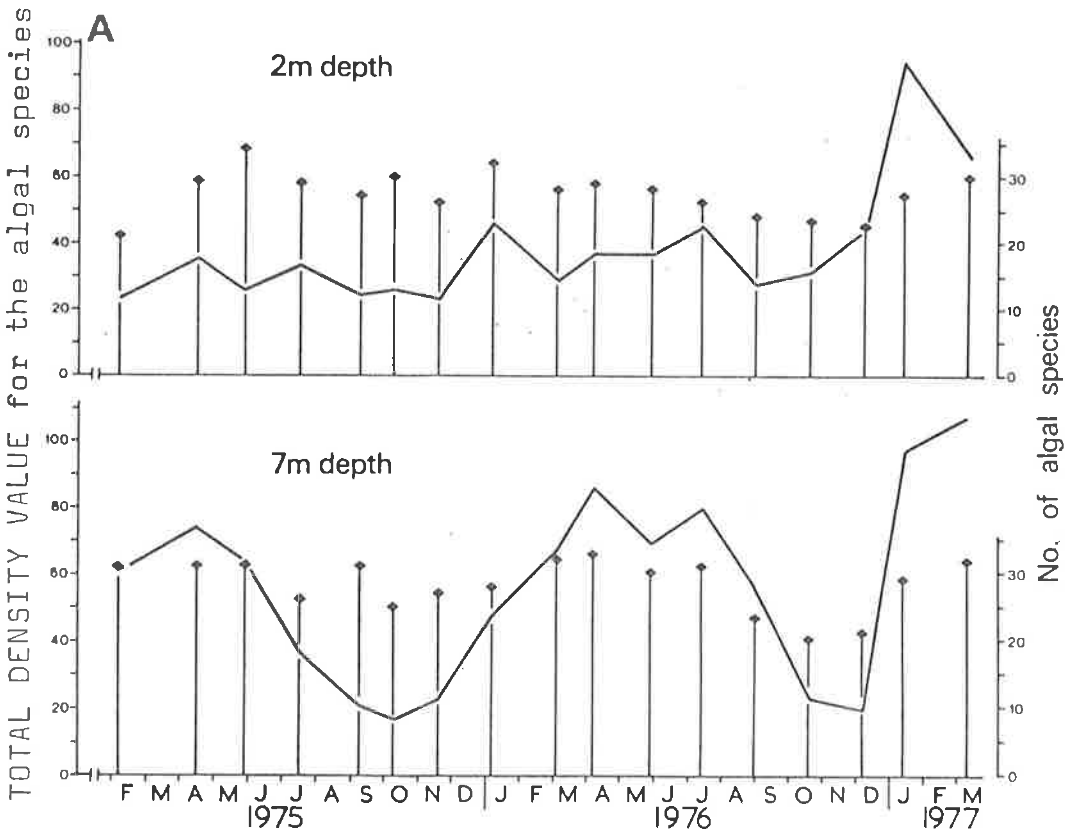

Fig. 88: The Total Density Values (solid line) and the Number of "erect" algal species (diamonds) recorded in *Posidonia sinuosa* samples at 2 m and 7 m depths on the Transect A Between Feb. 1975 and Mar. 1979.

density of the epiphytic algae was greatest in late summer to autumn (March-April) and least during spring and early summer (October-December). The minimum density values recorded from one year to the next were less variable than the maximum density values (Table 47).

Table 47: The maxima and minima Total Density Values and the month in which they were recorded for the 7 m deep collection site on the Transect A.

Transect A

Period		Min^m Value	Max^m Value
	7 m deep Collection Site		
Feb. - June 1975	Month Density Value	Not Applicable	Apr. 73.7
July 1975 - June 1976	Month Density Value	October 16.7	Apr. 85.9
July 1976 - March 1977	Month Density Value	Dec. 18.5	Mar. 107.1

Although there was a seasonal change in the density of algae at the 7 m deep collection site, there was not a corresponding difference in the number of algal species recorded in the collections. The decrease in algal epiphytic species in spring 1976 compared with the autumns of 1975, 1976 and 1977 was not significant. The average number of algal species recorded per collection at the 2 m and 7 m deep sites was 27 and 28, respectively.

Transect B

The Total Density Values of the algal epiphytic community of *P. sinuosa* at collection sites on the Transect B showed a seasonal increase and decline (Fig. 89) and the seasonal changes in Total Density Values were more

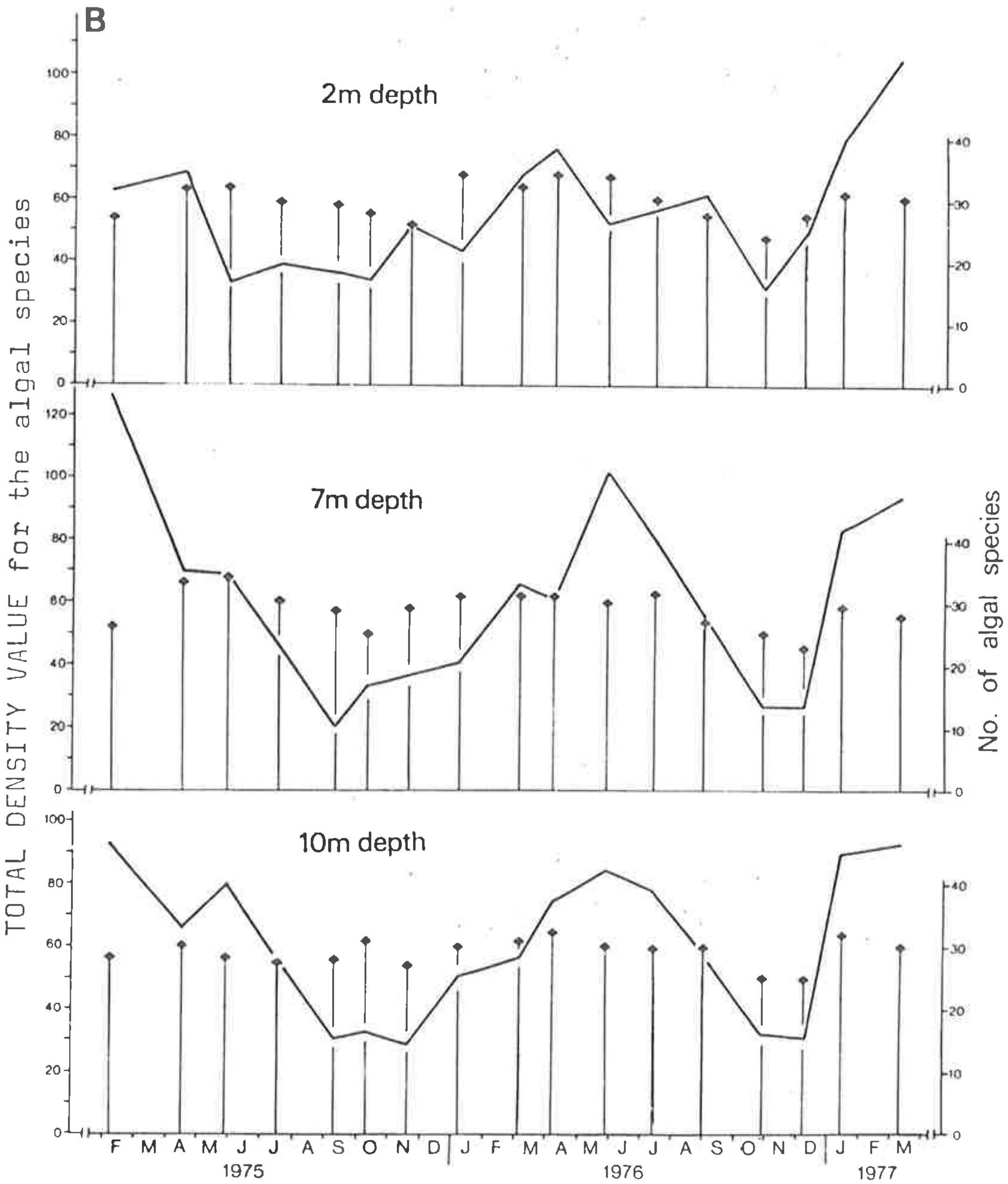

Fig. 89: The Total Density Values (solid line) and the Number of "erect" algal species (diamonds) recorded in *Posidonia sinuosa* samples at 2 m, 7 m and 10 m depths on the Transect B.

recognizable at the 7 m and 10 m deep sites. The maximum density value of algae at the 2 m, 7 m and 10 m deep sites occurred in late summer to autumn (February-May) while the minimum density value was recorded during spring or early summer (September-December) (Table 48). The minima recorded in the seasonal cycles were less variable than the corresponding maxima.

Table 48: The maxima and minima Total Density Values and the month in which they were recorded for the 2 m, 7 m and 10 m deep collection sites on the Transect B.

Transect B

Period		Min^m Value	Max^m Value
	2 m deep Collection Site		
Feb - June 1975	Month Density Value	Not Applicable	Apr. 68.5
July 1975 - June 1976	Month Density Value	Oct. 34.4	Apr. 76.6
July 1976 - Mar. 1977	Month Density Value	Oct. 31.6	Mar. 106.0
	7 m deep Collection Site		
Feb. - June 1975	Month Density Value	Not Applicable	Feb. 126.6
July 1975 - June 1976	Month Density Value	Sept. 20.7	May 102.4
July 1976 - Mar. 1977	Month Density Value	Oct. 27.2	Mar. 93.9
	10 m deep Collection Site		
Feb. - June 1975	Month Density Value	Not Applicable	Feb. 93.1
July 1975 - June 1976	Month Density Value	Nov. 28.6	May 84.5
July 1976 - Mar. 1977	Month Density Value	Dec. 30.9	Mar. 93.6

There is no seasonal change in the number of algal epiphytic species on the *P. sinuosa* leaves and the average numbers of algal species at the 2 m, 7 m and 10 m deep sites were 30, 29 and 30 respectively.

Transect C

A seasonal increase and decline in the Total Density Values of the epiphytic algae was recognizable at all collection sites, but was more evident at the 7 m and 10 m deep sites than at the shallowest site (Fig. 90).

The maximum density of algae occurred in mid-summer to mid-autumn (February -April) at the 7 m and 10 m deep sites during late spring and summer (November-March) at the 2 m deep site (Table 49).

Table 49: The maxima and minima Total Density Values and the month in which they were recorded for the 2m, 7 m and 10 m deep collection sites on the Transect C.

Transect C

Period		Min^{m} Value	Max^{m} Value
	2 m deep Collection Site		
Feb.-June 1975	Month Density Value	Not Applicable	Feb. 75.7
July 1975 -June 1976	Month Density Value	Sep. 20.1	Nov. 68.7
July 1976 -Mar. 1977	Month Density Value	Oct. 21.4	Mar. 86.2
	7 m deep Collection Site		
Feb.-June 1975	Month Density Value	Not Applicable	Feb. 111.2
July 1975 -June 1976	Month Density Value	Sept. 41.0	Mar 65.4
July 1976 - Mar. 1977	Month Density Value	Dec. 32.5	Mar. 55.4

Table 49 (Cont'd)

Transect C

Period		Min^m Value	Max^m Value
	10 m deep Collection Site		
Feb.-June 1975	Month Density Value	Not Applicable	Feb. 92.1
July 1976 -June 1976	Month Density Value	Oct. 20.8	Apr. 76.4
July 1976 -Mar. 1977	Month Density Value	Oct. 18.0	Mar. 63.0

The minimum density of algae at all collection sites on the Transect C and the minimum Total Density Values recorded from one year to the next were less variable at each of the collection sites than the corresponding maximum Total Density Values.

There was no significant change in the average number of algal species recorded at each collection site throughout the year unlike the Total Density Values. The average numbers of algal species at the 2 m, 7 m and 10 m deep sites (25, 24 and 23, respectively) were not significantly different.

B. Chlorophyta, Phaeophyta and Rhodophyta Changes

To examine more closely the structural changes in the community the percentage abundance of the total number of species of each of the *Chlorophyta, Phaeophyta* and *Rhodophyta* in the algal epiphytic community at eight collection sites during the study period were investigated (Figs. 91-98).

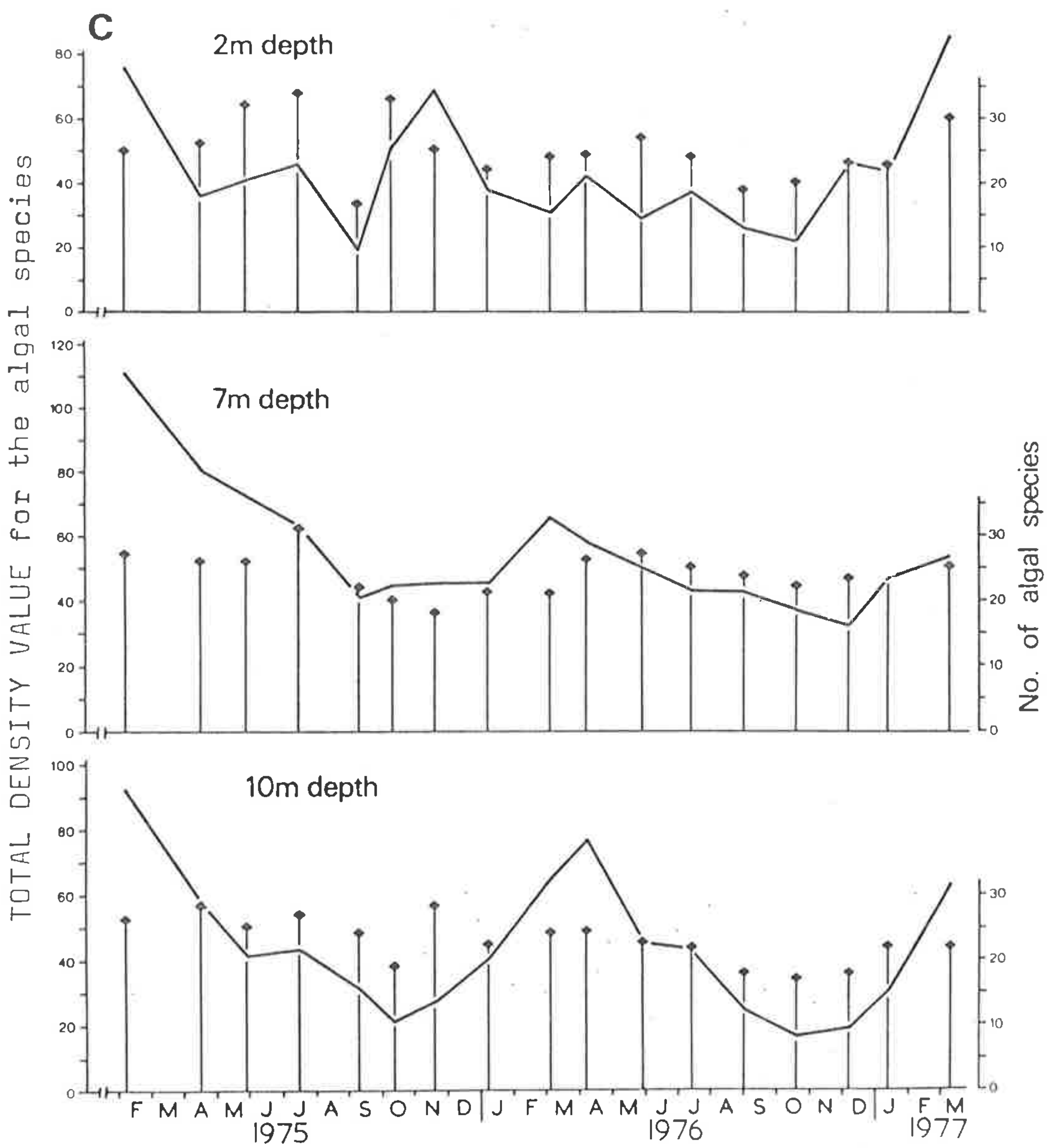

Fig. 90: The Total Density Values (solid line) and the Number of "erect" algal species (diamonds) recorded in *Posidonia sinuosa* samples at 2 m, 7 m and 10 m depths on the Transect C.

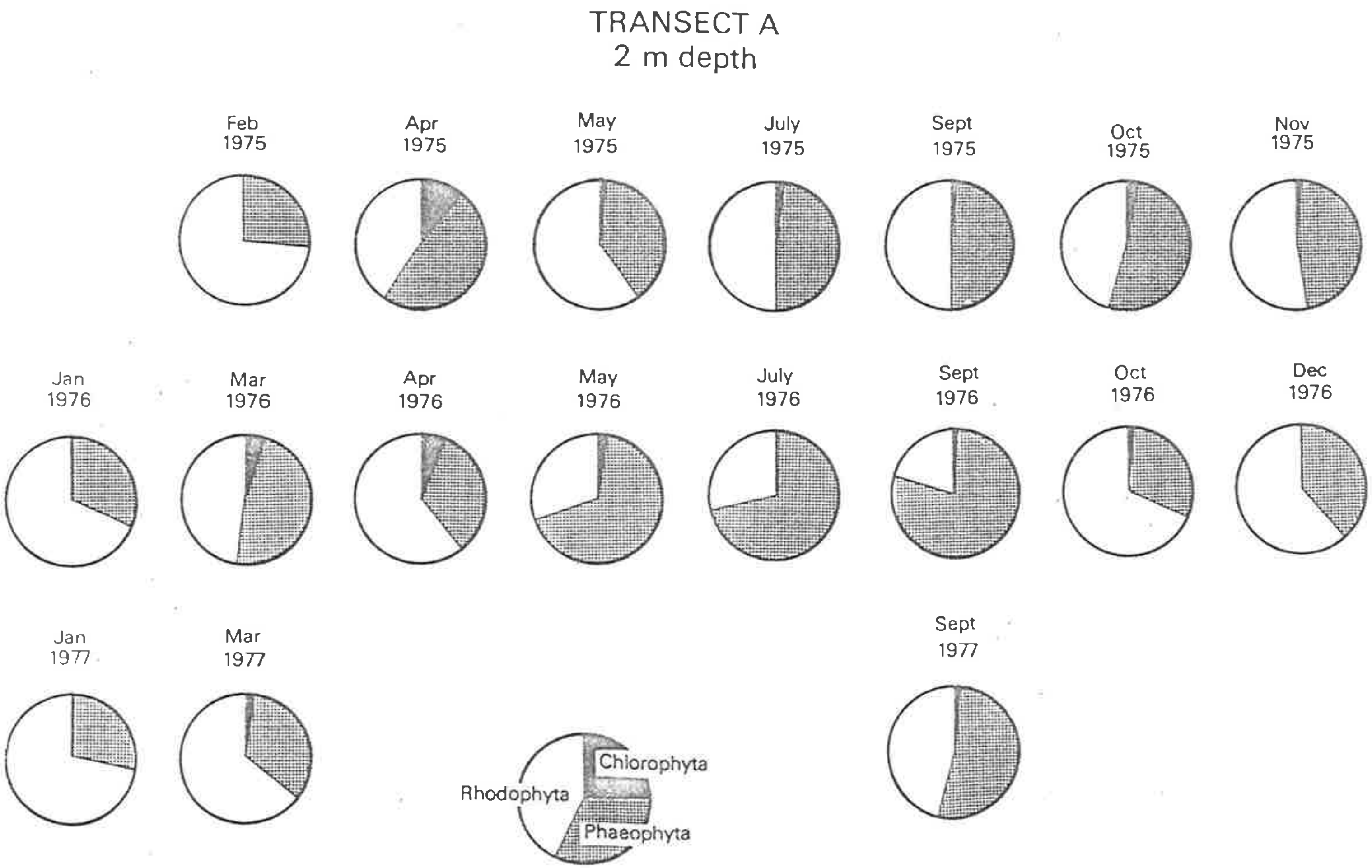

Fig. 91: Percentage abundance of Chlorophyta, Phaeophyta and Rhodophyta in the epiphytic community of *Posidonia sinuosa* at 2 m depth on Transect A.

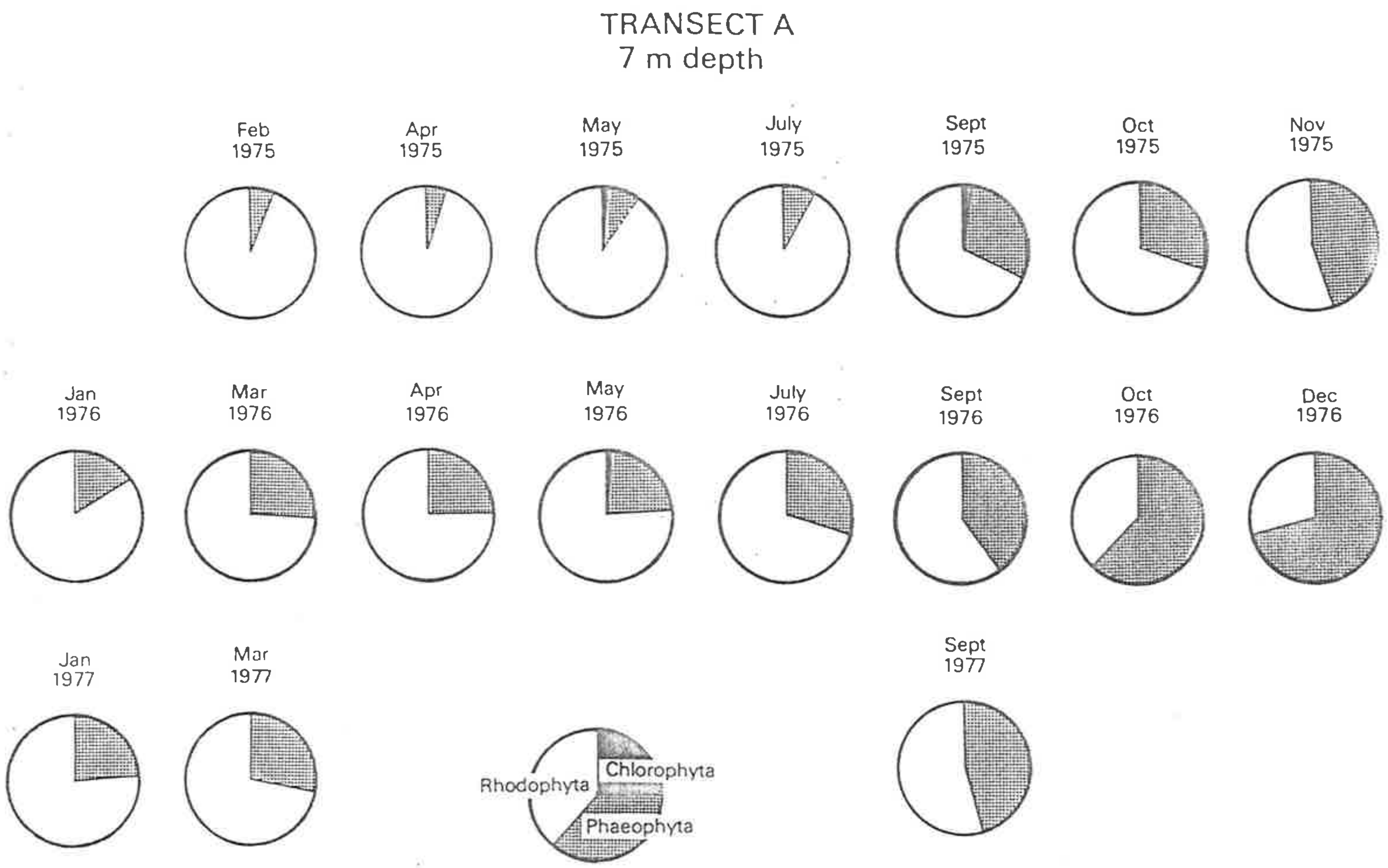

Fig. 92: Percentage abundance of Chlorophyta, Phaeophyta and Rhodophyta in the epiphytic community of *Posidonia sinuosa* at the 7 m depth on Transect A.

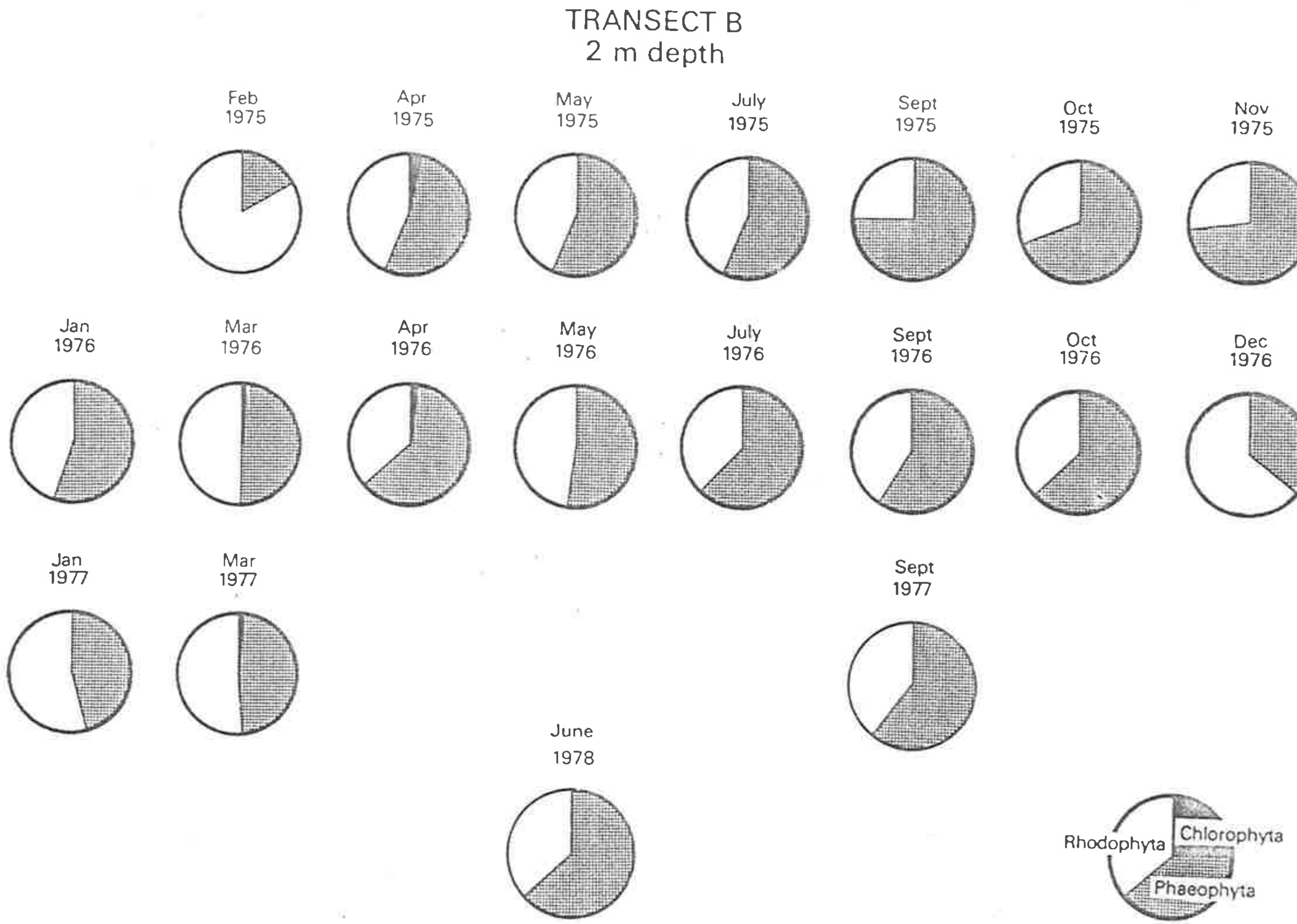

Fig. 93: Percentage abundance of Chlorophyta, Phaeophyta and Rhodophyta in the epiphytic community of *Posidonia sinuosa* at 2 m depth on Transect B.

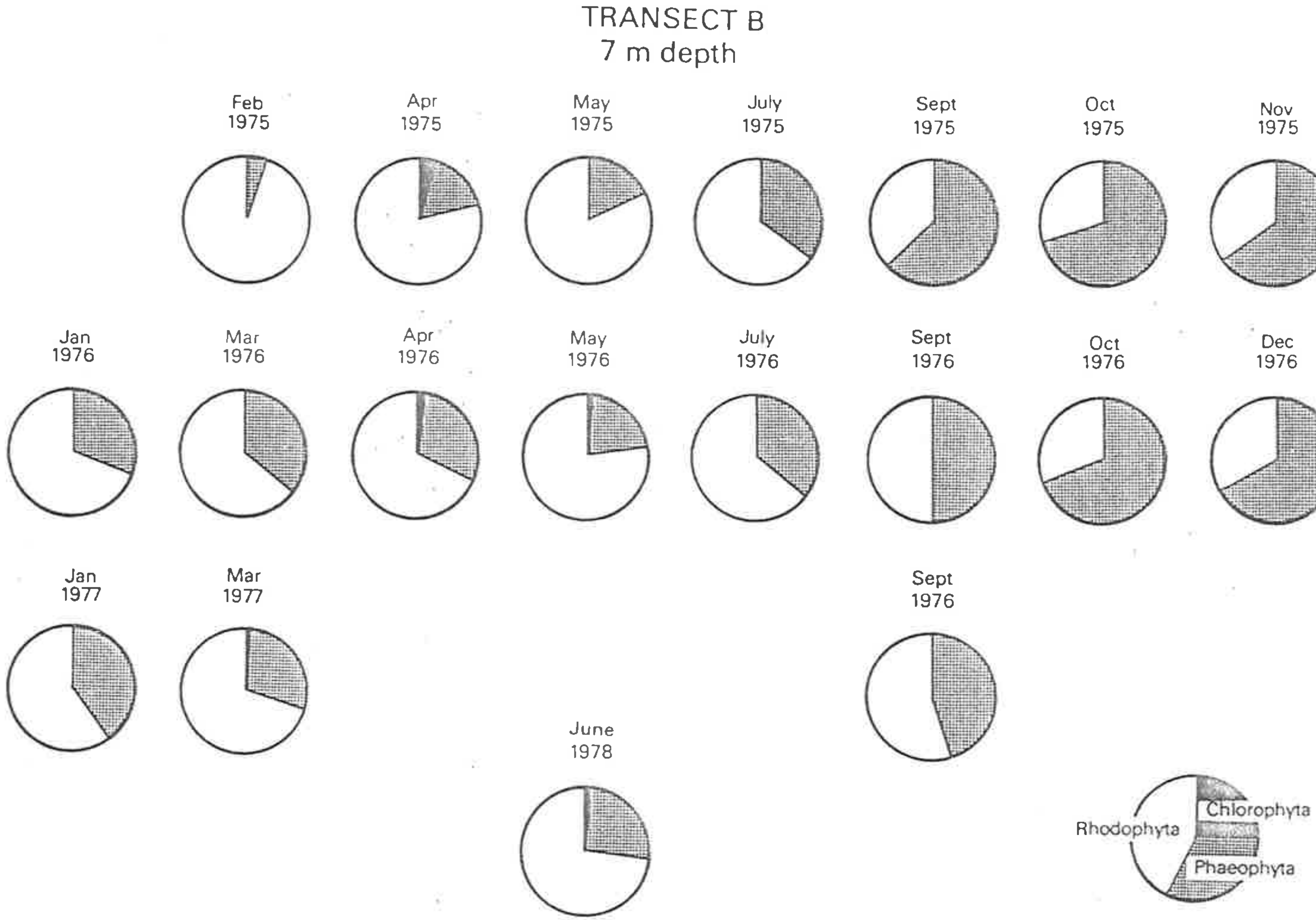

Fig. 94: Percentage abundance of Chlorophyta, Phaeophyta and Rhodophyta in the epiphytic community of *Posidonia sinuosa* at 7 m depth on Transect B.

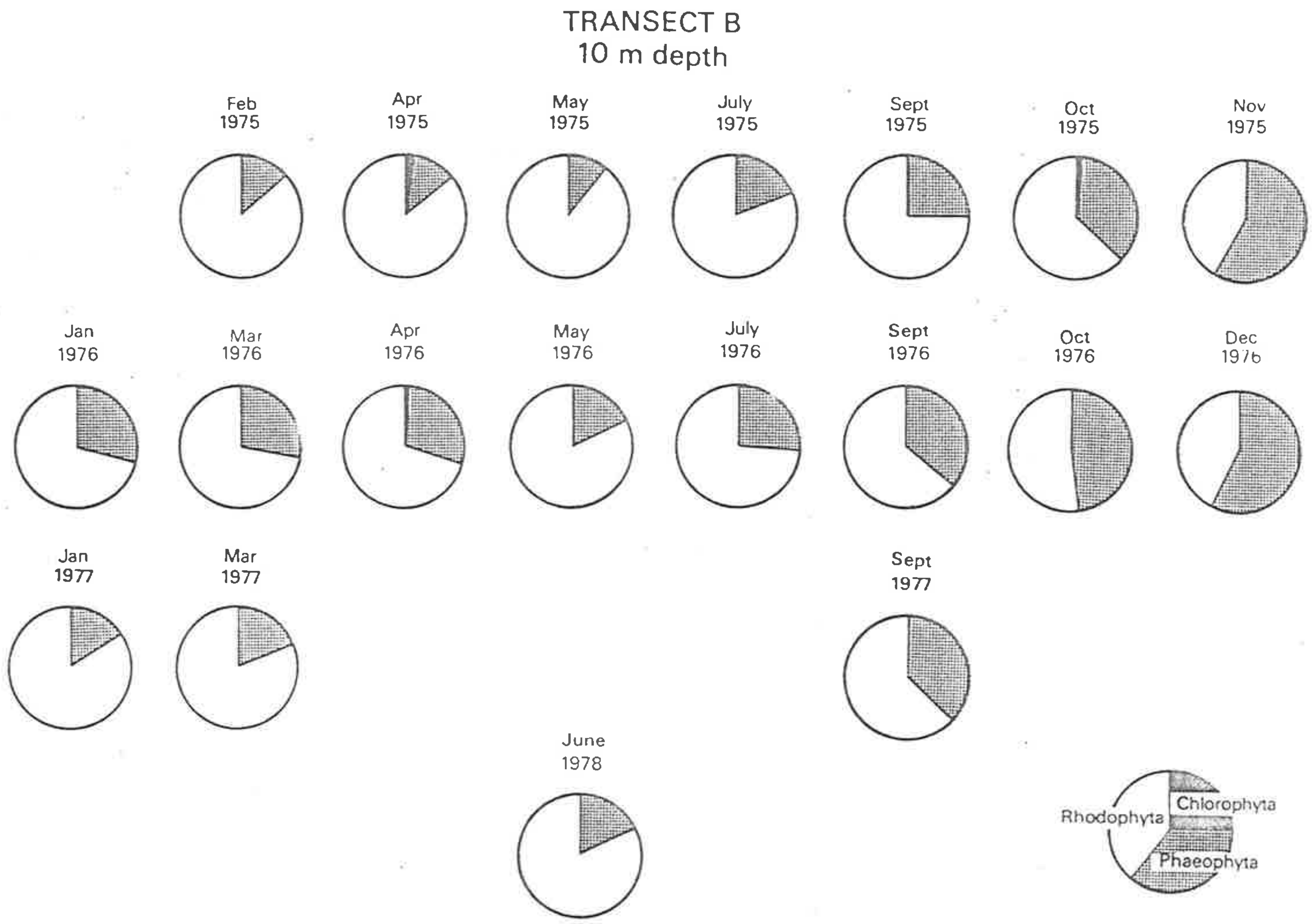

Fig. 95: Percentage abundance of Chlorophyta, Phaeophyta and Rhodophyta in the epiphytic community of *Posidonia sinuosa* at 10 m depth on Transect B.

TRANSECT C
2 m depth

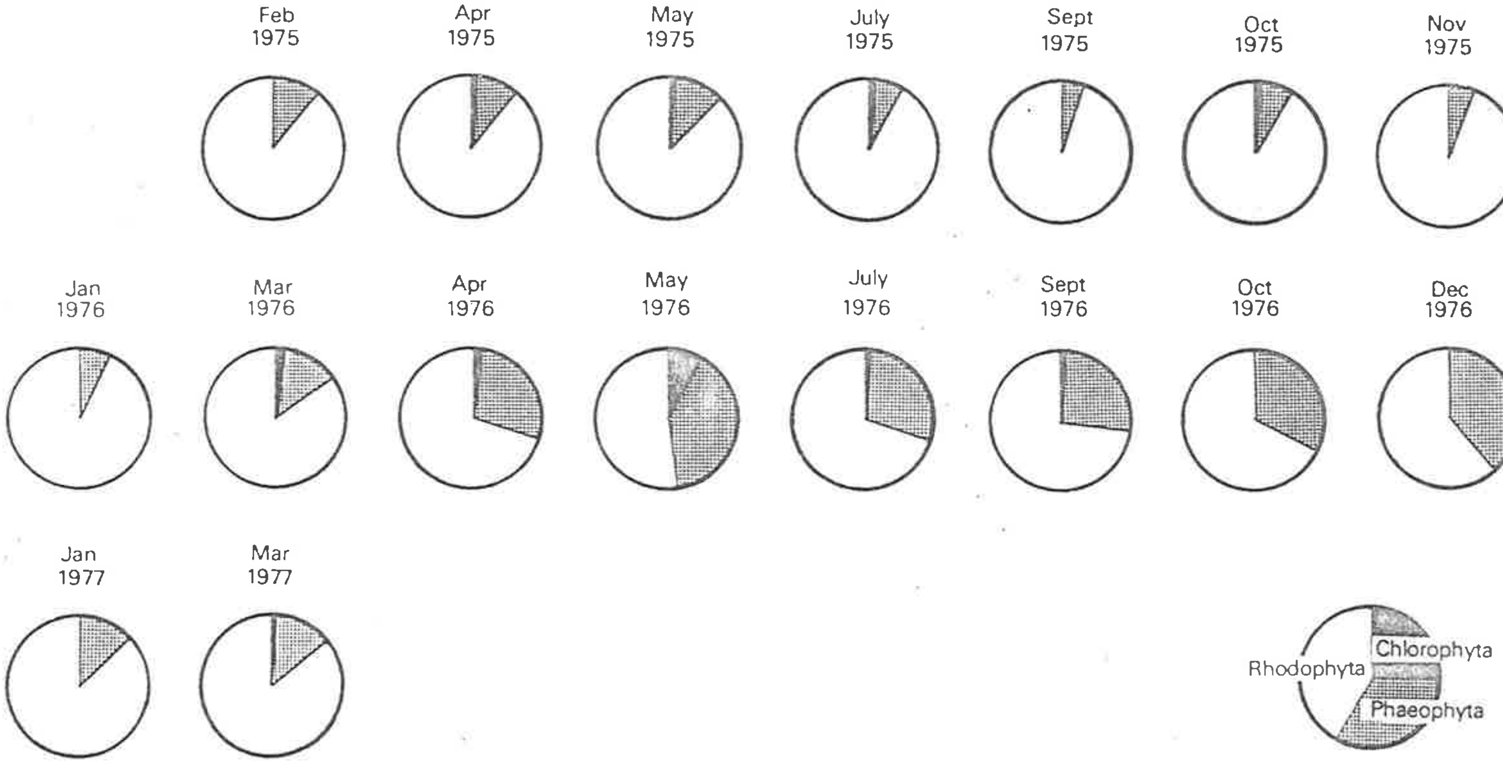

Fig. 96: Percentage abundance of Chlorophyta, Phaeophyta and Rhodophyta in the epiphytic community *Posidonia sinuosa* at 2 m depth on Transect C.

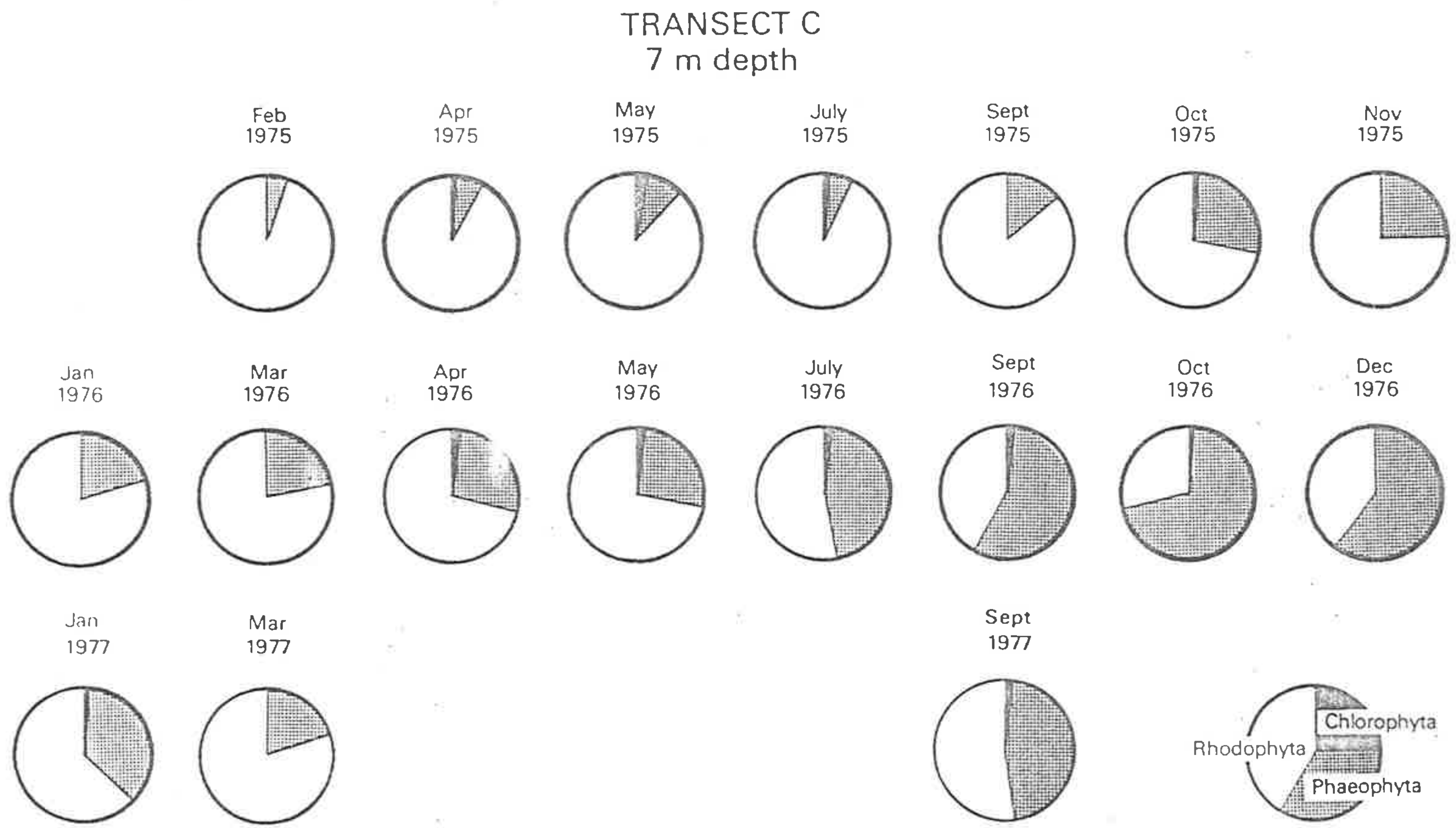

Fig. 97: Percentage abundance of Chlorophyta, Phaeophyta and Rhodophyta in the epiphytic community of *Posidonia sinuosa* at 7 m depth on Transect C.

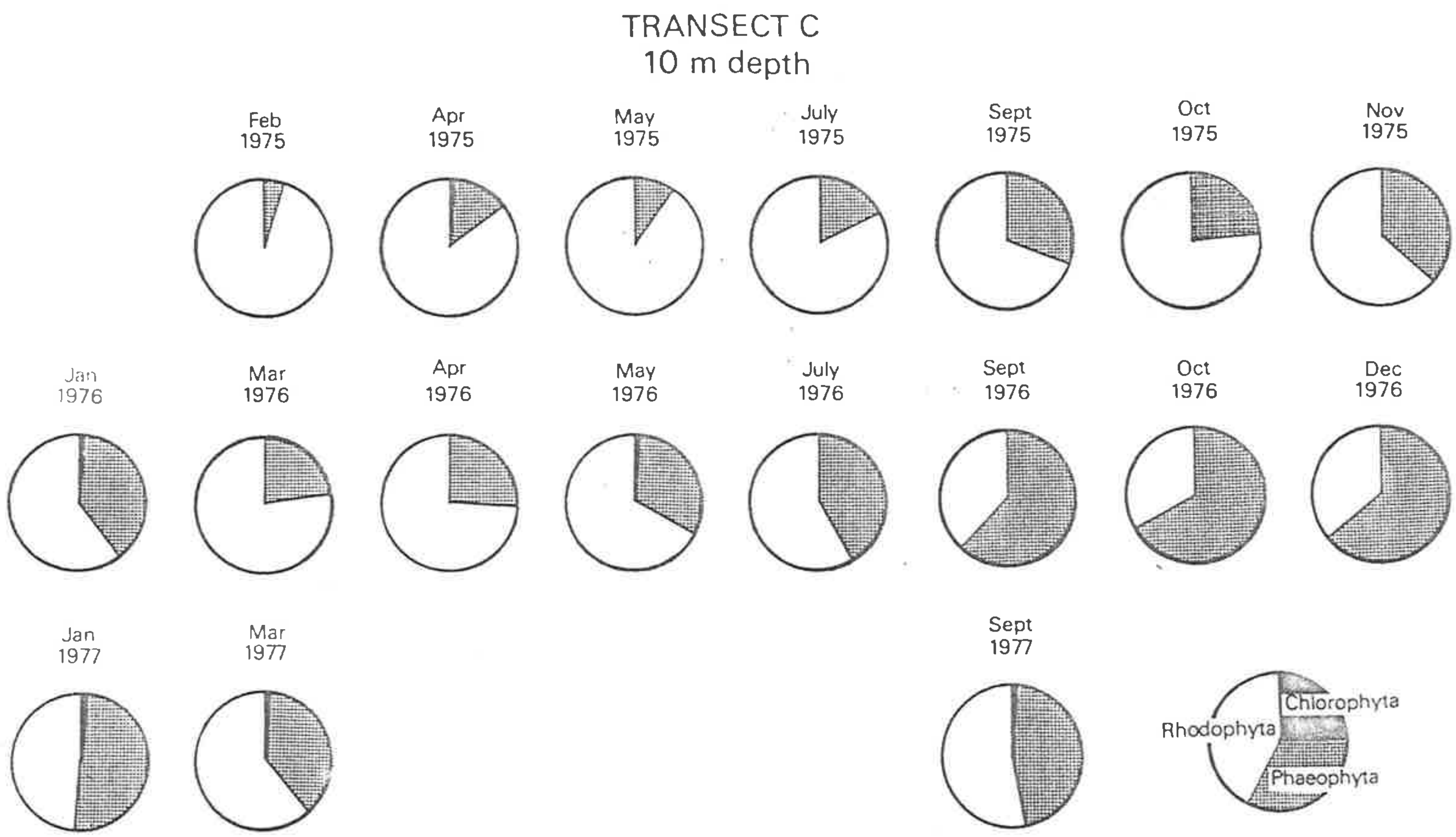

Fig. 98: Percentage abundance of Chlorophyta, Phaeophyta and Rhodophyta in the epiphytic community of *Posidonia sinuosa* at 10 m depth on Transect C.

Transect A

The *Rhodophyta* were more commonly collected at the 7 m deep site and generally constituted the greatest portion of the algal epiphyte community. During the spring and early summer months there was an increase in the percentage of species of *Phaeophyta* in the algal epiphytic community, but this trend was not evident at the 2 m deep site. The percentage abundance of species of *Phaeophyta* in the algal epiphytic community was greater at the 2 m deep site than at the 7 m deep site (Figs. 91, 92). Similarly the *Chlorophyta* were more common at the shallower site and attained their greatest percentage abundance during autumn (March-May).

Transect B

On the Transect B the *Rhodophyta* were the most common algae in the epiphytic community at 7 m and 10 m depths. At the 2 m depth the *Rhodophyta* were less abundant than the *Phaeophyta* although more of these species were recorded (Figs. 93, 94, 95). During 1975 and 1976 the *Phaeophyta* contribution at the 7 m and 10 m deep sites to the algal community was greatest during the spring and early summer (September-December). Samples collected at these sites on the Transect B during September 1977 similarly showed that the *Phaeophyta* contribution to the community was greater in the spring than in the late summer (March 1977) of that year. The percentage abundance of species of *Chlorophyta* at the collection sites was greatest during the autumn (April-May) and in the greatest abundance at the 2 m deep site.

Transect C

Species of *Rhodophyta* generally constituted the greatest portion of the epiphytic community at each of the collection sites on the Transect C. Unlike on the Transects A and B, the *Rhodophyta* were greater contributors to the structure of the epiphytic community at the 2 m deep site on the Transect C than at the 7 m and 10 m deep sites. During 1975, contribution of *Phaeophyta* to the algal epiphytic community of *P. sinuosa* at the 7 m and 10 m deep sites was greatest in spring and into early summer. Although the percentage abundance of *Phaeophyta* in collections was higher in the first half of 1976 than in 1975, their abundance again increased in spring 1976 and early summer 1977 (Figs. 96, 97, 98). Correspondingly the percentage abundance of *Phaeophyta* in September 1977 at the 7 m and 10 m depths was greater than in the late summer (March) of that year. The *Chlorophyta* were more common at the shallowest collection site and their greatest abundance in the epiphytic community occurred during the late summer and autumn months.

C. Changes in the Epiphytic Community

At the three study sites, Transects A, B and C, in upper Spencer Gulf the *Chlorophyta* on *Posidonia sinuosa* made up only a minor component of the algal epiphytic community and were most commonly collected at the shallowest collection sites. Van der Ben 1969, 1971; Ballantine & Humm 1975; Ducker et al. 1977; May et al. 1978 have all noted that species of *Chlorophyta* are generally inconspicuous compared to species of *Phaeophyta* and *Rhodophyta* within the algal epiphytic communities of many seagrass species. The largest number of species of *Chlorophyta* were recorded in late summer and autumn which is the same period that Brauner (1975) suggested was most conducive to growth of these species in his study on epiphytes of *Zostera marina* at Beaufort, North Carolina, U.S.A.

Near Redcliff Point the trend in depth distribution of the algal phyla conforms to the classical theory that the descending sequence of benthic algae into deeper water is *Chlorophyta*, *Phaeophyta* and *Rhodophyta*, respectively. The *Rhodophyta:Phaeophyta* species ratio in the "erect" epiphytic community of *Posidonia sinuosa*, 3.5:1, was higher than both the 2.7:1 noted by Van der Ben in 1969 and the ratio he reported in 1971 (2.3:1) for 94 algal species epiphytic on *P. oceanica* in the Mediterranean.

In spring and early summer there was a decrease in the percentage abundance of *Phaeophyta*. This was attributed to firstly a small increase in the abundance of *Rhodophyta* during this period. Ten summer-winter species were listed previously (Chapter Seven) and these species were characterized by their low frequencies and low density indices in spring. Nine of these ten species belong to the *Rhodophyta* and one, *Pachydictyon polycladum*, belongs to the *Phaeophyta*. The decline in *Rhodophyta* abundance in spring and early summer (September-November) also caused a decline in the Total Density Value of the algal epiphytic community during this period. The low in total density of algae was followed by a rapid increase in algal density in summer which peaked in late-summer or autumn. This increase coincided with the re-emergence of the summer-winter species as well as the appearance of the summer species, the summer-autumn species, and in late summer and autumn the appearance of the autumn-winter species, in the community.

The seasonal fluctuations in the Total Density Values, i.e. the overall seasonal changes in the epiphytic community, were more evident at the deeper sites. This should be expected because it was apparent that the seasonal changes in many of the individual species were more regular and more marked at these sites.

Ducker et al. (1977) suggested a spring bloom (October-November) occurred in the epiphytes of *Amphibolis* spp. in southern Australia and Shepherd (1973) when showing the availability of epiphytic algae of *Amphibolis* for food for abalone near Tipara Reef, Spencer Gulf, South Australia, indicated a spring maximum of epiphytic biomass. The peak in the total algal density in this study on *Posidonia* occurred in late summer and autumn (February-April). The difference in the season of maximum algal abundance of the epiphytes on *Amphibolis* and *Posidonia* may be explained by examination of their respective growth habits. In *Amphibolis* the young leaf surfaces, which are those available for colonization by epiphytic algae, are already located near the upper level of the leaf canopy of the *Amphibolis* seagrass bed, while the young leaf surfaces available on *Posidonia* are near the base of the plant. The epiphytes colonizing these leaves would not be conspicuous in the upper levels of the leaf canopy until the young leaf had lengthened. Only the longest WHOLE leaves were examined; thus settlement of the algae could have occurred sometime before collection. The time of appearance of the algal settlement would then depend on the *Posidonia* leaf growth rate, while in the case of the *Amphibolis* community it would primarily depend on the epiphytic algal growth rates.

It was suggested in Chapter Five that settlement of the algae on *Posidonia sinuosa* occurred approximately five months before collection of the sample. This would mean that a settlement of algal spores, on the young *Posidonia* leaf surfaces, from those species reaching the end of their life cycles, e.g. the summer-winter species and the autumn-winter species, in late winter and early spring coinciding with rising water temperatures, and probably occurring at a similar time as settlement for spring blooms reported for *Amphibolis* spp., would appear as a peak in total algal density on *P. sinuosa* in February to April.

Jones (1968) in his studies on *Thalassia* in Florida, U.S.A., found considerable seasonal variation in epiphyte productivity; peak rates occurred in February and March (late winter and spring), July and October, with very low rates of net production in the intervening period. The early peak was attributed to a spring bloom associated with the seasonal warming trend; in July and October there were blooms following hurricanes. Nelson (1979) studied an amphipod community of a *Zostera* bed near Beaufort, North Carolina, U.S.A. The temperature range of the seawater in the study area was from 5°C in winter to 30°C in summer and the salinity ranged from 26 to 36‰. (In upper Spencer Gulf: Temperature range, 11-26°C; Salinity range, 41.5-45.6‰). He found that in 1974 and 1975 the density of amphipods was greatest in late winter or early spring and this value decreased rapidly to its lowest in summer, and the values of density occurred in the same seasons as in the previous years, but the trends in the interim periods were not the same. Thus he concluded that the seasonal factors in generating the observed patterns in the amphipod community appeared to be minimal and that predation was important in regulating the amphipod assemblage.

In the Mediterranean studies it has not only been the physical factors but also the biology of the host plant, *P. oceanica*, that determined the annual changes in the epiphytic biomass. According to Van der Ben (1969, 1971) *P. oceanica's* leaves die-off in early autumn and are replaced by new leaves in mid-autumn, these leaves continue to grow until the following summer. The maximum covering of epiphytes occurs in summer before the leaves die-off.

In the algal epiphytic community of upper Spencer Gulf, grazing of the algae does occur. Long-rayed whiting, *Neodox radiatus*, bridled leatherjacket, *Acanthaluteres spilomelanurus*, velvet leatherjacket, *Navodon australis*, rough leatherjacket, *Scobinithys granulatus granulatus* and striped perch, *Helotes sexlineatus*, are fish species which have been recorded as having grazed upon *Posidonia* and its epiphytes in the study area (S.A. Department of Fisheries, unpublished data). Information on the grazing of the epiphytes by molluscs, polychaetes and crustaceans in the study area was not available but from observations during the study it would appear that overall the grazing of the epiphytes by marine organisms was minimal in regulating the seasonal pattern of the algae. Also there was not the annual shedding of leaves as in *P. oceanica*, so it was suggested that the seasonal patterns in the algal epiphytic community were determined by the physical factors.

Wind waves greater than 2 m are not generated near Redcliff Point because of the narrowness and small fetch of upper Spencer Gulf. Therefore the influence of winds and the resultant waves would have minimal effect on the seasonal patterns of the epiphytic algae. Furthermore there is no evidence that algal blooms occur as the result of storm activity, as suggested by Jones (1968) in Florida.

Light intensity reaching the algal community and the duration of daylight hours in upper Spencer Gulf were not recorded during the study.

The substrate *Posidonia sinuosa*, of the algal community, because it is also a living organism is influenced in turn by the environmental factors. On the Transects A and B there was an indication that seasonal environmental factors influenced the height of the standing crop of *P. sinuosa*. In spring there was an increase in the standing crop height followed by a decline the following summer. This same trend was not apparent on the Transect C. Flowering was annually regular in the study areas and perhaps occurring earlier at the 2 m deep sites than at the 10 m deep sites with buds developing from May through July, flowers occurring from August through October while fruits were seen annually, from late October through January, either floating on the surface of the waters or cast up at high tide level along the shores of upper Spencer Gulf. This suggested that daylength or photoperiod played a major role in the flowering proces of *P. sinuosa*, as indicated for *Thalassia testudinum* by Marmelstein et al. (1968), rather than other environmental factors.

Seawater temperatures near the study sites in upper Spencer Gulf were collected by the S.A. Department of Fisheries on a monthly basis. Temperatures increased during spring and declined during autumn with minimum temperatures being recorded in mid to late winter. The time of occurrence of maximum seawater temperatures in the study areas was more variable than the minima. The minimum Total Density Value occurred approximately 4 months after the minimum water temperature and the general shape of the Total Density Value graphs was similar to the temperature changes, therefore it was considered that water temperatures were important in regulating the seasonal changes in the algal epiphytic community.

Further investigation of structural changes in the algal epiphytic community was warranted and analyses to

(1) examine the dominance-diversity of the community

and

(2) the repetitiveness and predictability of the seasonal community changes,

were undertaken.

(1) Dominance-diversity of the Community

Diversity indices which summarize large amounts of information about the community have been developed and two definitions of diversity index have evolved. One kind of diversity index is determined by the numerical equality of the species; the more the constituent species are represented by equal numbers of individuals, biomass or productivity the higher the diversity index. Whittaker (1965) discusses dominance-diversity in this context. The other kind of diversity index, species diversity, is determined by the number of species in a sample in a given environment.

The number of species (species diversity) recorded in each collection at a particular site did not vary significantly throughout the study. Reduction of species diversity when passing from moderately to strongly polluted parts of an area is frequently used in pollution ecology to measure the stress to which the community is exposed (Jernelöv & Rosenberg 1976), therefore the number of algal epiphytic species in a *P. sinuosa* sample may be a useful monitoring parameter. However Sanders (1968) suggests that dominance and species diversities vary with time, predictability of the environment, changes in predation and competition and without knowledge of the influence of these factors then interpretation of changes in the diversity index cannot be made with confidence.

An examination of the community structure by plotting the logarithm of the density indices of each algal species against its rank, ordered from the most to the least dense (Fig. 99), illustrated the dominance relations between species at each of the collections, and characteristically they all showed a steep slope in the upper part, representing a few dominant species in the collection each appropriating a substantial fraction of niche space (Whittaker 1965). Samples from different sites showed strong dominance within the epiphytic community and according to Wilhm & Dorris (1968) natural biotic communities are characterized by the presence of a few species with many individuals and many species with a few individuals. When monitoring environmental change in an aquatic community, composition and diversity of that community can be extremely sensitive biological indicators (Gaufin 1973), therefore the dominance-diversity curves for samples collected in the first twelve months at the Transect B, 10 m depth were plotted in the same way as previously (Fig. 100) and strong dominance was evident in the community throughout the year. Whittaker (1965) suggested that in biotic communities, which are mixtures of unequally successful species, the dominants overshadow all others, but it is the number of the less conspicuous species which primarily determines the community's diversity.

The dominance-diversity curves were characteristically steeply

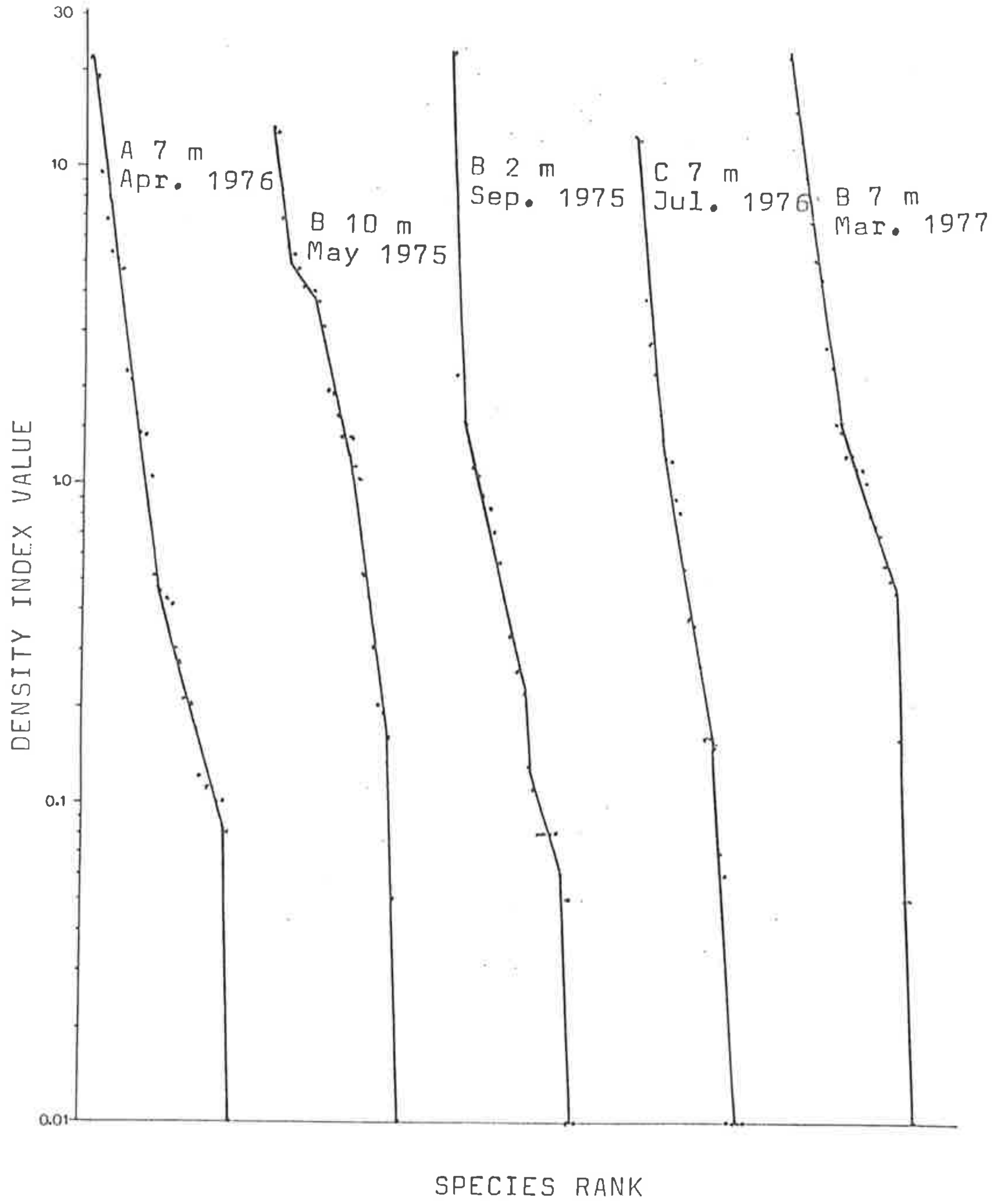

Fig. 99: Dominance - diversity curves for the algal epiphytic communities on five different sampling occasions.

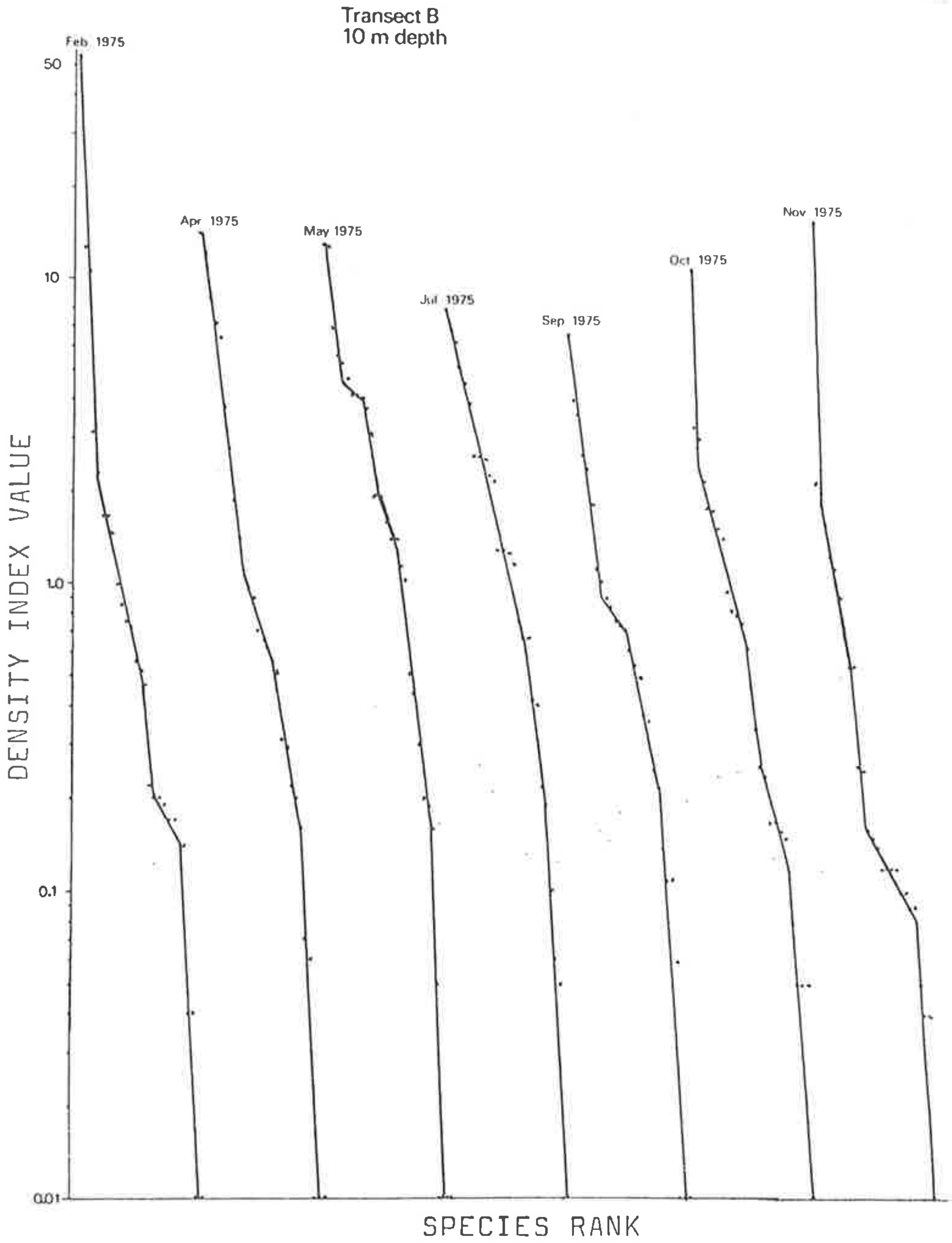

Fig. 100: Dominance - diversity curves for the algal epiphytic community at 10 m depth on the Transect B, during 1975.

sloping curves in the upper end indicating that a few dominant species were appropriating a substantial fraction of the samples. The graphs showed minor change in the middle area of the curves and this represents alteration in the sharing of niche space by the subordinate species, which in this case are mostly seasonal species. It is suggested that changes in the subordinate seasonal species groups; summer-autumn, autumn-winter, summer-winter and summer groups, cause the minor alterations in the structure of the middle order of the dominance-diversity curves in February, May, September and November (Fig. 100).

Overall the uniformity of the graphs suggested that a community of similar structural type and at a similar stage of succession was collected and examined on each occasion.

(2) Repetitiveness and Predictability of the Community Changes

One of the aims of this study was to provide information that could be used as part of a marine monitoring programme, and knowledge of the predictability or likelihood of repetition of these changes would be important in designing a marine monitoring programme based on examination of the algal epiphytic community. It has already been suggested that the constituent species of the algal epiphytic community fall into two main categories; seasonal and non-seasonal species. The changes within these species populations influence the community structure at each collection.

The Spearman Rank Correlation Coefficient, r_s, was used to evaluate the association between the epiphytic algal communities of seagrass samples collected at a particular study site but first it was necessary to establish a benchmark association value above which one might discuss the repetitiveness of the algal community. Duplicate samples of seagrasses were collected at different times and study sites during the survey and examined. These samples were collected at;

(i) Transect B, 10 m depth on 29-V-1975,

(ii) Transect B, 2 m depth on 10-IX-1975,

(iii) Transect A, 7 m depth on 6-IV-1976,

(iv) Transect C, 7 m depth on 13-VII-1976, and

(v) Transect B, 7 m depth on 8-III-1977.

Table 50 lists the algal species collected in the samples and their respective frequencies of each of the algal species. The algal species were ranked in descending order of frequency and the association value of the duplicate samples was determined by the Spearman Rank Correlation Coefficient, r_s, corrected for tied scores (Siegel 1956).

Association Coefficient: $$r_s = \frac{\sum_{i=1}^{N} x_i^2 + \sum_{i=1}^{N} y_i^2 - \sum_{i=1}^{N} d_i^2}{2\sqrt{\sum_{i=1}^{N} x_i^2 \sum_{i=1}^{N} y_i^2}}$$

where $$\sum_{i=1}^{N} x_i^2 = \frac{N^3 - N}{12} - \sum T_x,$$

and N = number of species listed in sample x, and $T = \frac{t^3 - t}{12}$,

t = the number of observations tied at a given rank and thus $\sum T_x$ indicates that the various values for all the various groups of tied observations are summed.

Similarly $$\sum_{i=1}^{N} Yi^2 = \frac{N^3 - N}{12} - \sum Ty,$$

and d_i = the difference between the two ranks for species i. The results are shown in Table 50. The mean association value,

$$\bar{r}_s = \frac{\sum_{i=1}^{5} r_s}{5}$$

and its standard deviation were also calculated.

The lower 99% confidence limit (0.799) for the association value was determined to establish a benchmark level for accepting that two samples were the same. It was decided that if the frequency association value between any two samples was greater than 0.779 then the two samples could have been collected on the same occasion from the same site.

Examination of the repetitiveness of the seasonal changes in the epiphytic algal communities involved calculation of the association values between communities recorded for each of the collections at a particular site and clustering of these values by the unweighted arithmetic average linkage according to Sokal & Sneath (1963). Firstly, the association values between only the seasonal species in the community were calculated (Tables 51-58). Secondly, the association values for the occurrence of only the fourteen most common species (Table 43) in the samples collected during the study were calculated for each particular site (Tables 59-66), and finally the association values for a complete list of 38 algal species or species groups were calculated between samples at each study site (Tables 67-74).

Species	Frequency of species in Duplicate Samples									
	Site and Date of Collection									
	B-10 m May 1975		B-2 m Sept 1975		A-7 m April 1976		C-7 m July 1976		B-7 m March 1977	
	sample		sample		sample		sample		sample	
	1	2	1	2	1	2	1	2	1	2
Bryopsis plumosa	1	2	–	–	3	–	–	–	–	–
Cladophora fascicularis	10	12	5	8	2	13	19	15	13	8
Asperococcus bullosus	16	12	11	10	–	–	7	10	–	–
Castagnea epiphytica	–	–	19	8	1	2	8	12	–	2
Giffordia mitchelliae	6	12	6	3	8	12	27	29	–	2
Giraudya robusta	–	–	7	4	–	–	11	14	–	1
Pachydictyon polycladum	12	8	7	6	25	13	23	20	27	28
Sphacelaria spp.	28	30	30	30	30	30	30	30	30	30
Anotrichium tenue	1	2	–	–	1	–	1	1	–	–
Antithamnion divergens	25	28	–	1	21	20	2	–	11	15
Audouinella sp.	6	4	1	–	20	13	2	12	12	4
Centroceras clavulatum	13	4	4	4	19	24	–	–	20	10
Ceramium puberulum	17	14	25	20	8	–	16	16	17	8
Ceramium shepherdii	27	30	2	3	20	25	–	–	30	25
Other *Ceramium* spp.	23	10	2	–	1	2	1	–	18	0
Champia zostericola	8	6	22	18	15	14	3	–	17	24
Chondria dasyphylla	–	–	–	–	–	–	–	–	–	–
Corallina sp.	–	–	2	–	–	–	–	–	–	–
Crouania sp.	–	–	–	–	6	7	–	–	2	–
Dasya spp.	27	22	9	9	14	13	15	9	24	20
Gloiosaccion brownii	21	16	10	4	2	–	–	–	14	11
Griffithsia monilis	26	20	3	1	2	11	2	3	18	15
Herposiphonia sp. 1	30	25	14	14	7	27	29	28	24	18
Hypnea musciformis	19	21	3	2	6	25	5	2	15	12
Jania micrarthrodia	28	25	25	28	30	29	23	20	26	27
Jeannerettia pedicellata	–	2	–	–	7	11	1	1	3	5
Laurencia forsteri	27	23	21	18	29	29	7	9	30	26
Lomentaria sp.	17	7	8	5	1	4	–	–	24	15
Metagoniolithon chara	2	–	9	4	5	3	–	–	–	–
Platysiphonia miniata	22	15	–	–	28	6	19	23	19	26
Polysiphonia spp.	30	30	3	3	30	30	29	30	29	30
Polysiphonia decipiens	21	20	6	3	28	20	21	24	27	24
Protokützingia australasica	–	1	–	–	2	13	–	–	2	5
Ptilocladia australis	24	15	2	1	8	9	–	–	4	6
Spyridia tasmanica	28	26	12	10	29	30	19	20	28	26
Association Value; r_s	0.943		0.949		0.802		0.947		0.926	

Mean Association Value; $\bar{r}_s = 0.913$ S.D. $= 0.0629$

99% Confidence Interval 0.913 ± 0.1341

Table 50: Frequency of occurrence of 35 algal epiphytic species or species groups in duplicate samples of thirty leaves of *Posidonia sinuosa*, and the Association Value for each pair of duplicate samples.

TRANSECT A 2 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77
FEB75	1.000																	
APR75	0.426	1.000																
MAY75	0.285	0.652	1.000															
JUL75	0.089	0.476	0.863	1.000														
SEP75	0.291	0.574	0.836	0.866	1.000													
OCT75	0.328	0.622	0.849	0.766	0.887	1.000												
NOV75	0.380	0.745	0.808	0.743	0.835	0.804	1.000											
JAN76	0.599	0.709	0.615	0.590	0.658	0.584	0.846	1.000										
MAR76	0.402	0.869	0.642	0.625	0.610	0.620	0.775	0.798	1.000									
APR76	0.409	0.830	0.729	0.600	0.673	0.653	0.770	0.802	0.757	1.000								
MAY76	0.643	0.720	0.672	0.556	0.635	0.663	0.679	0.655	0.746	0.725	1.000							
JUL76	−0.037	0.422	0.831	0.863	0.794	0.661	0.604	0.463	0.445	0.652	0.418	1.000						
SEP76	0.114	0.354	0.680	0.711	0.730	0.629	0.633	0.375	0.354	0.392	0.489	0.726	1.000					
OCT76	0.122	0.603	0.765	0.823	0.847	0.658	0.744	0.636	0.706	0.610	0.518	0.773	0.594	1.000				
DEC76	0.383	0.706	0.605	0.672	0.751	0.710	0.866	0.811	0.784	0.734	0.726	0.503	0.576	0.602	1.000			
JAN77	0.669	0.657	0.614	0.501	0.535	0.479	0.681	0.793	0.730	0.673	0.814	0.408	0.426	0.532	0.736	1.000		
MAR77	0.567	0.748	0.618	0.479	0.538	0.602	0.584	0.538	0.789	0.641	0.875	0.386	0.505	0.495	0.610	0.693	1.000	
SEP77	0.263	0.532	0.887	0.894	0.903	0.766	0.809	0.729	0.624	0.707	0.569	0.859	0.604	0.871	0.660	0.625	0.431	1.000

Table 51: Association Values for samples, constituted by the Seasonal Species, collected at Transect A, 2 m depth between Feb. 1975 and Sep. 1977.

TRANSECT A 7 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77
FEB75	1.000																	
APR75	0.700	1.000																
MAY75	0.622	0.841	1.000															
JUL75	0.368	0.695	0.857	1.000														
SEP75	0.514	0.654	0.804	0.767	1.000													
OCT75	0.639	0.751	0.898	0.804	0.776	1.000												
NOV75	0.592	0.635	0.624	0.572	0.681	0.727	1.000											
JAN76	0.870	0.634	0.530	0.255	0.430	0.516	0.558	1.000										
MAR76	0.889	0.799	0.660	0.454	0.627	0.594	0.714	0.898	1.000									
APR76	0.666	0.835	0.734	0.539	0.534	0.685	0.632	0.759	0.821	1.000								
MAY76	0.499	0.766	0.893	0.820	0.774	0.755	0.576	0.538	0.649	0.790	1.000							
JUL76	0.521	0.660	0.851	0.810	0.758	0.677	0.489	0.502	0.617	0.611	0.931	1.000						
SEP76	0.515	0.633	0.725	0.531	0.475	0.527	0.397	0.520	0.547	0.464	0.653	0.774	1.000					
OCT76	0.416	0.437	0.599	0.448	0.439	0.444	0.231	0.497	0.437	0.401	0.666	0.800	0.872	1.000				
DEC76	0.771	0.587	0.603	0.386	0.480	0.594	0.435	0.848	0.733	0.617	0.563	0.604	0.680	0.736	1.000			
JAN77	0.788	0.543	0.459	0.212	0.356	0.468	0.539	0.900	0.767	0.644	0.481	0.454	0.529	0.561	0.884	1.000		
MAR77	0.821	0.816	0.681	0.395	0.476	0.626	0.617	0.903	0.876	0.830	0.629	0.551	0.672	0.550	0.847	0.869	1.000	
SEP77	0.495	0.618	0.821	0.826	0.790	0.728	0.602	0.451	0.616	0.573	0.851	0.920	0.688	0.700	0.583	0.393	0.512	1.000

Table 52: Association Values for samples, constituted by the Seasonal Species, collected at Transect A, 7 m depth between Feb. 1975 and Sep. 1977.

TRANSECT B 2 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77	JUN78
FEB75	1.000																		
APR75	0.657	1.000																	
MAY75	0.577	0.735	1.000																
JUL75	0.469	0.590	0.938	1.000															
SEP75	0.357	0.659	0.840	0.890	1.000														
OCT75	0.461	0.772	0.858	0.859	0.841	1.000													
NOV75	0.556	0.629	0.298	0.200	0.271	0.408	1.000												
JAN76	0.634	0.785	0.678	0.494	0.469	0.678	0.712	1.000											
MAR76	0.684	0.953	0.765	0.595	0.609	0.726	0.565	0.803	1.000										
APR76	0.431	0.930	0.637	0.514	0.652	0.720	0.626	0.732	0.859	1.000									
MAY76	0.307	0.727	0.656	0.616	0.723	0.791	0.372	0.637	0.674	0.754	1.000								
JUL76	0.326	0.696	0.773	0.799	0.865	0.835	0.363	0.602	0.622	0.724	0.889	1.000							
SEP76	0.339	0.722	0.738	0.761	0.810	0.778	0.433	0.521	0.623	0.731	0.767	0.901	1.000						
OCT76	0.325	0.731	0.562	0.578	0.679	0.793	0.510	0.597	0.652	0.753	0.914	0.842	0.810	1.000					
DEC76	0.357	0.781	0.535	0.480	0.530	0.711	0.616	0.692	0.725	0.788	0.782	0.692	0.762	0.884	1.000				
JAN77	0.555	0.784	0.572	0.463	0.422	0.608	0.612	0.811	0.770	0.805	0.714	0.664	0.574	0.686	0.767	1.000			
MAR77	0.518	0.861	0.640	0.562	0.610	0.739	0.606	0.710	0.873	0.851	0.670	0.656	0.596	0.671	0.740	0.820	1.000		
SEP77	0.424	0.632	0.652	0.664	0.638	0.873	0.337	0.612	0.603	0.565	0.843	0.782	0.645	0.821	0.706	0.639	0.683	1.000	
JUN78	0.572	0.851	0.765	0.695	0.740	0.848	0.450	0.652	0.813	0.770	0.698	0.700	0.748	0.717	0.735	0.608	0.759	0.737	1.000

Table 53: Association Values for samples, constituted by the Seasonal Species, collected at Transect B, 2 m depth between Feb. 1975 and June 1978.

TRANSECT B 7 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77	JUN78
FEB75	1.000																		
APR75	0.727	1.000																	
MAY75	0.606	0.645	1.000																
JUL75	0.522	0.616	0.888	1.000															
SEP75	0.490	0.631	0.818	0.843	1.000														
OCT75	0.329	0.362	0.591	0.714	0.752	1.000													
NOV75	0.590	0.768	0.539	0.653	0.586	0.706	1.000												
JAN76	0.779	0.615	0.526	0.518	0.371	0.308	0.682	1.000											
MAR76	0.873	0.789	0.673	0.592	0.479	0.304	0.652	0.817	1.000										
APR76	0.756	0.881	0.693	0.678	0.584	0.428	0.831	0.764	0.826	1.000									
MAY76	0.734	0.753	0.785	0.766	0.743	0.641	0.778	0.628	0.793	0.844	1.000								
JUL76	0.673	0.619	0.884	0.885	0.800	0.680	0.612	0.548	0.693	0.735	0.891	1.000							
SEP76	0.629	0.592	0.751	0.823	0.754	0.795	0.718	0.585	0.610	0.720	0.804	0.909	1.000						
OCT76	0.436	0.450	0.623	0.785	0.633	0.780	0.716	0.465	0.445	0.621	0.707	0.819	0.866	1.000					
DEC76	0.726	0.774	0.588	0.531	0.402	0.297	0.715	0.713	0.838	0.892	0.746	0.667	0.634	0.631	1.000				
JAN77	0.812	0.695	0.511	0.422	0.320	0.235	0.616	0.783	0.819	0.820	0.714	0.657	0.662	0.515	0.834	1.000			
MAR77	0.847	0.843	0.676	0.539	0.462	0.312	0.671	0.719	0.879	0.897	0.775	0.706	0.665	0.503	0.910	0.890	1.000		
SEP77	0.804	0.690	0.868	0.804	0.804	0.617	0.574	0.561	0.743	0.731	0.836	0.906	0.847	0.669	0.665	0.619	0.743	1.000	
JUN78	0.835	0.817	0.807	0.698	0.691	0.520	0.676	0.629	0.841	0.853	0.830	0.828	0.772	0.642	0.858	0.755	0.920	0.892	1.000

Table 54: Association Values for samples, constituted by the Seasonal Species, collected at Transect B, 7 m depth between Feb. 1975 and June 1978.

TRANSECT B 10 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77	JUN78
FEB75	1.000																		
APR75	0.684	1.000																	
MAY75	0.428	0.804	1.000																
JUL75	0.309	0.643	0.930	1.000															
SEP75	0.257	0.600	0.833	0.862	1.000														
OCT75	0.316	0.583	0.704	0.727	0.870	1.000													
NOV75	0.573	0.659	0.532	0.444	0.606	0.695	1.000												
JAN76	0.830	0.668	0.461	0.350	0.313	0.310	0.526	1.000											
MAR76	0.735	0.882	0.752	0.580	0.576	0.534	0.649	0.818	1.000										
APR76	0.635	0.926	0.817	0.684	0.601	0.526	0.692	0.697	0.909	1.000									
MAY76	0.507	0.800	0.922	0.867	0.811	0.716	0.668	0.532	0.803	0.878	1.000								
JUL76	0.383	0.727	0.925	0.889	0.885	0.755	0.539	0.412	0.715	0.757	0.923	1.000							
SEP76	0.309	0.634	0.845	0.850	0.918	0.774	0.509	0.364	0.621	0.623	0.778	0.933	1.000						
OCT76	0.464	0.781	0.820	0.749	0.830	0.865	0.628	0.479	0.752	0.704	0.777	0.860	0.877	1.00					
DEC76	0.685	0.884	0.704	0.562	0.424	0.441	0.539	0.551	0.783	0.806	0.642	0.616	0.549	0.707	1.000				
JAN77	0.864	0.767	0.614	0.477	0.414	0.403	0.626	0.904	0.887	0.832	0.686	0.563	0.491	0.576	0.689	1.00			
MAR77	0.759	0.897	0.709	0.561	0.455	0.369	0.569	0.694	0.870	0.913	0.746	0.638	0.534	0.595	0.840	0.874	1.000		
SEP77	0.354	0.702	0.847	0.848	0.898	0.759	0.516	0.431	0.692	0.710	0.846	0.941	0.951	0.871	0.573	0.544	0.600	1.000	
JUN78	0.495	0.756	0.907	0.824	0.701	0.679	0.512	0.489	0.703	0.726	0.821	0.811	0.706	0.737	0.705	0.610	0.640	0.692	1.000

Table 55: Association Values for samples, constituted by the Seasonal Species, collected at Transect B, 10 m depth between Feb. 1975 and June 1978.

TRANSECT C 2 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77
FEB75	1.000																	
APR75	0.713	1.000																
MAY75	0.487	0.821	1.000															
JUL75	0.255	0.478	0.778	1.000														
SEP75	0.159	0.211	0.336	0.629	1.000													
OCT75	0.625	0.798	0.655	0.525	0.500	1.000												
NOV75	0.096	0.312	0.429	0.578	0.700	0.549	1.000											
JAN76	0.541	0.673	0.466	0.385	0.409	0.774	0.503	1.000										
MAR76	0.272	0.494	0.353	0.504	0.640	0.636	0.603	0.714	1.000									
APR76	0.304	0.605	0.536	0.608	0.642	0.742	0.771	0.732	0.808	1.000								
MAY76	−0.142	0.252	0.420	0.687	0.640	0.385	0.599	0.410	0.642	0.643	1.000							
JUL76	−0.015	0.281	0.389	0.697	0.694	0.395	0.718	0.473	0.754	0.823	0.794	1.000						
SEP76	−0.009	0.178	0.188	0.449	0.549	0.315	0.624	0.503	0.702	0.659	0.622	0.831	1.000					
OCT76	0.278	0.408	0.306	0.437	0.570	0.541	0.655	0.812	0.845	0.811	0.531	0.707	0.764	1.000				
DEC76	0.475	0.353	0.266	0.362	0.402	0.397	0.491	0.582	0.543	0.713	0.243	0.618	0.661	0.734	1.000			
JAN77	0.463	0.499	0.380	0.396	0.408	0.430	0.516	0.605	0.558	0.758	0.321	0.663	0.496	0.609	0.841	1.000		
MAR77	0.376	0.667	0.513	0.408	0.444	0.676	0.559	0.680	0.534	0.788	0.298	0.536	0.358	0.587	0.538	0.689	1.000	
SEP77	0.054	0.042	0.231	0.667	0.872	0.303	0.613	0.285	0.568	0.564	0.686	0.819	0.713	0.523	0.503	0.432	0.277	1.000

Table 56: Association Values for samples, constituted by the Seasonal Species, collected at Transect C, 2 m depth between Feb. 1975 and Sep. 1977.

TRANSECT C 7 m depth

FEB75	1.000																	
APR75	0.569	1.000																
MAY75	0.469	0.791	1.000															
JUL75	0.362	0.742	0.923	1.000														
SEP75	0.376	0.668	0.853	0.816	1.000													
OCT75	0.296	0.777	0.792	0.754	0.761	1.000												
NOV75	0.458	0.675	0.614	0.639	0.756	0.545	1.000											
JAN76	0.888	0.697	0.487	0.376	0.416	0.399	0.597	1.000										
MAR76	0.670	0.880	0.732	0.651	0.677	0.678	0.743	0.816	1.000									
APR76	0.646	0.913	0.839	0.832	0.735	0.777	0.715	0.752	0.902	1.000								
MAY76	0.184	0.782	0.671	0.723	0.652	0.838	0.627	0.422	0.659	0.796	1.000							
JUL76	0.133	0.717	0.692	0.691	0.663	0.872	0.550	0.371	0.641	0.733	0.933	1.000						
SEP76	0.124	0.663	0.676	0.669	0.702	0.874	0.597	0.354	0.614	0.678	0.878	0.960	1.000					
OCT76	0.201	0.775	0.709	0.741	0.755	0.859	0.733	0.443	0.734	0.781	0.927	0.914	0.945	1.000				
DEC76	0.226	0.780	0.754	0.738	0.615	0.730	0.688	0.447	0.684	0.707	0.792	0.778	0.753	0.819	1.000			
JAN77	0.655	0.826	0.746	0.725	0.685	0.699	0.716	0.795	0.841	0.897	0.774	0.728	0.642	0.724	0.758	1.000		
MAR77	0.463	0.862	0.819	0.867	0.732	0.746	0.765	0.577	0.781	0.887	0.820	0.758	0.705	0.818	0.851	0.878	1.000	
SEP77	0.181	0.681	0.674	0.745	0.745	0.857	0.688	0.344	0.627	0.727	0.874	0.863	0.922	0.957	0.734	0.639	1.778	1.000
	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN75	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77

Table 57: Association Values for samples, constituted by the Seasonal Species, collected at Transect C, 7 m depth between Feb. 1975 and Sep. 1977.

TRANSECT C 10 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77
FEB75	1.000																	
APR75	0.661	1.000																
MAY75	0.541	0.769	1.000															
JUL75	0.330	0.656	0.791	1.000														
SEP75	0.370	0.581	0.809	0.801	1.000													
OCT75	0.587	0.613	0.738	0.783	0.713	1.000												
NOV75	0.411	0.668	0.606	0.716	0.565	0.852	1.000											
JAN76	0.649	0.812	0.652	0.539	0.495	0.616	0.703	1.000										
MAR76	0.769	0.873	0.725	0.599	0.543	0.700	0.696	0.870	1.000									
APR76	0.760	0.843	0.727	0.680	0.614	0.713	0.722	0.802	0.907	1.000								
MAY76	0.500	0.702	0.772	0.869	0.846	0.831	0.746	0.579	0.707	0.740	1.000							
JUL76	0.281	0.524	0.624	0.828	0.789	0.640	0.573	0.384	0.515	0.576	0.826	1.000						
SEP76	0.195	0.441	0.609	0.838	0.856	0.706	0.621	0.377	0.461	0.512	0.858	0.952	1.000					
OCT76	0.091	0.459	0.652	0.723	0.651	0.564	0.571	0.348	0.408	0.523	0.680	0.688	0.705	1.000				
DEC76	0.381	0.659	0.663	0.586	0.542	0.554	0.755	0.691	0.606	0.734	0.626	0.487	0.470	0.675	1.000			
JAN77	0.438	0.725	0.632	0.620	0.500	0.583	0.776	0.749	0.742	0.790	0.641	0.537	0.481	0.548	0.831	1.000		
MAR77	0.637	0.915	0.767	0.674	0.613	0.647	0.743	0.824	0.900	0.926	0.739	0.549	0.491	0.553	0.787	0.888	1.000	
SEP77	0.300	0.564	0.697	0.889	0.819	0.738	0.706	0.474	0.509	0.657	0.875	0.785	0.810	0.754	0.672	0.676	0.663	1.000

Table 58: Association Values for samples, constituted by the Seasonal Species, collected at Transect C, 10 m depth between Feb. 1975 and Sep. 1977.

TRANSECT A 2 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77
FEB75	1.000																	
APR75	0.764	1.000																
MAY75	0.637	0.912	1.000															
JUL75	0.407	0.742	0.881	1.000														
SEP75	0.673	0.888	0.897	0.881	1.000													
OCT75	0.722	0.903	0.948	0.843	0.947	1.000												
NOV75	0.611	0.912	0.915	0.834	0.915	0.958	1.000											
JAN76	0.654	0.836	0.849	0.767	0.857	0.898	0.917	1.000										
MAR76	0.481	0.830	0.846	0.746	0.801	0.820	0.847	0.872	1.000									
APR76	0.407	0.779	0.788	0.678	0.735	0.736	0.774	0.793	0.936	1.000								
MAY76	0.489	0.618	0.638	0.659	0.695	0.631	0.640	0.792	0.746	0.754	1.000							
JUL76	0.348	0.619	0.809	0.972	0.821	0.774	0.739	0.686	0.654	0.610	0.666	1.000						
SEP76	0.482	0.723	0.806	0.940	0.851	0.760	0.733	0.664	0.656	0.548	0.648	0.920	1.000					
OCT76	0.604	0.852	0.843	0.900	0.947	0.856	0.850	0.826	0.782	0.673	0.733	0.825	0.924	1.000				
DEC76	0.473	0.799	0.874	0.951	0.896	0.869	0.861	0.783	0.784	0.702	0.699	0.894	0.899	0.922	1.000			
JAN77	0.549	0.824	0.877	0.940	0.937	0.895	0.896	0.872	0.840	0.718	0.713	0.876	0.913	0.955	0.921	1.000		
MAR77	0.522	0.743	0.758	0.805	0.772	0.712	0.738	0.840	0.845	0.758	0.869	0.757	0.825	0.860	0.785	0.887	1.000	
SEP77	0.488	0.774	0.865	0.924	0.950	0.887	0.872	0.832	0.751	0.700	0.666	0.878	0.852	0.916	0.880	0.934	0.753	1.000

Table 59: Association Values for samples, constituted by the 14 most common algal epiphytic species, collected at Transect A, 2 m depth between Feb. 1975 and Sep. 1977.

TRANSECT A 7 m depth

FEB75	1.000																	
APR75	0.778	1.000																
MAY75	0.583	0.733	1.000															
JUL75	0.313	0.529	0.712	1.000														
SEP75	0.595	0.530	0.635	0.773	1.000													
OCT75	0.494	0.375	0.486	0.556	0.868	1.000												
NOV75	0.493	0.407	0.433	0.555	0.880	0.860	1.000											
JAN76	0.830	0.534	0.496	0.167	0.602	0.616	0.600	1.000										
MAR76	0.760	0.665	0.628	0.417	0.688	0.568	0.722	0.880	1.000									
APR76	0.350	0.359	0.564	0.308	0.430	0.310	0.368	0.571	0.720	1.000								
MAY76	0.456	0.434	0.706	0.367	0.390	0.277	0.260	0.641	0.727	0.904	1.000							
JUL76	0.452	0.364	0.694	0.603	0.688	0.525	0.564	0.645	0.788	0.822	0.858	1.000						
SEP76	0.403	0.355	0.632	0.664	0.717	0.483	0.584	0.554	0.755	0.819	0.807	0.958	1.000					
OCT76	0.372	0.317	0.601	0.492	0.604	0.530	0.515	0.537	0.657	0.796	0.774	0.843	0.867	1.000				
DEC76	0.393	0.254	0.501	0.198	0.369	0.342	0.354	0.623	0.666	0.733	0.789	0.729	0.720	0.889	1.000			
JAN77	0.527	0.437	0.586	0.323	0.539	0.470	0.461	0.628	0.704	0.760	0.714	0.772	0.738	0.911	0.850	1.000		
MAR77	0.307	0.250	0.422	0.185	0.285	0.122	0.266	0.502	0.677	0.894	0.830	0.804	0.793	0.803	0.781	0.827	1.000	
SEP77	0.599	0.411	0.540	0.448	0.681	0.662	0.685	0.784	0.839	0.657	0.707	0.834	0.813	0.870	0.824	0.818	0.699	1.000
	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77

Table 60: Association Values for samples, constituted by the 14 most common algal epiphytic species, collected at Transect A, 7 m depth between Feb. 1975 and Sep. 1977.

TRANSECT B 2 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77	JUN78
FEB75	1.000																		
APR75	0.775	1.000																	
MAY75	0.392	0.491	1.000																
JUL75	0.542	0.565	0.813	1.000															
SEP75	0.691	0.823	0.645	0.829	1.000														
OCT75	0.749	0.762	0.653	0.907	0.852	1.000													
NOV75	0.689	0.780	0.517	0.721	0.744	0.892	1.000												
JAN76	0.509	0.764	0.819	0.724	0.713	0.733	0.740	1.000											
MAR76	0.323	0.717	0.647	0.596	0.711	0.624	0.716	0.845	1.000										
APR76	0.226	0.710	0.486	0.481	0.697	0.526	0.632	0.767	0.899	1.000									
MAY76	0.363	0.617	0.729	0.772	0.839	0.651	0.588	0.749	0.761	0.715	1.000								
JUL76	0.692	0.841	0.638	0.785	0.876	0.863	0.759	0.798	0.696	0.664	0.816	1.000							
SEP76	0.692	0.875	0.669	0.824	0.856	0.927	0.881	0.867	0.783	0.696	0.764	0.948	1.000						
OCT76	0.629	0.799	0.594	0.831	0.882	0.928	0.899	0.773	0.799	0.712	0.772	0.876	0.934	1.000					
DEC76	0.444	0.635	0.478	0.736	0.703	0.810	0.891	0.707	0.747	0.652	0.709	0.745	0.842	0.908	1.000				
JAN77	0.390	0.533	0.514	0.677	0.564	0.733	0.771	0.793	0.711	0.589	0.583	0.682	0.796	0.798	0.874	1.000			
MAR77	0.185	0.616	0.538	0.573	0.650	0.561	0.668	0.806	0.937	0.902	0.736	0.628	0.725	0.749	0.796	0.787	1.000		
SEP77	0.717	0.803	0.686	0.871	0.875	0.943	0.812	0.809	0.701	0.616	0.741	0.929	0.936	0.935	0.807	0.763	0.648	1.000	
JUN78	0.632	0.889	0.623	0.766	0.898	0.860	0.883	0.839	0.881	0.821	0.823	0.891	0.941	0.956	0.870	0.736	0.824	0.900	1.000

Table 61: Association Values for samples, constituted by the 14 most common algal epiphytic species, collected at Transect B, 2 m depth between Feb. 1975 and June 1978.

TRANSECT B 7 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77	JUN78
FEB75	1.000																		
APR75	0.650	1.000																	
MAY75	0.781	0.843	1.000																
JUL75	0.565	0.758	0.732	1.000															
SEP75	0.515	0.709	0.695	0.891	1.000														
OCT75	0.381	0.459	0.460	0.754	0.898	1.000													
NOV75	0.480	0.612	0.571	0.873	0.929	0.889	1.000												
JAN76	0.734	0.649	0.738	0.702	0.754	0.734	0.716	1.000											
MAR76	0.560	0.813	0.730	0.745	0.599	0.451	0.501	0.625	1.000										
APR76	0.474	0.692	0.739	0.533	0.330	0.121	0.204	0.379	0.741	1.000									
MAY76	0.373	0.815	0.662	0.640	0.442	0.174	0.381	0.311	0.652	0.798	1.000								
JUL76	0.535	0.816	0.789	0.883	0.745	0.485	0.687	0.540	0.820	0.679	0.755	1.000							
SEP76	0.487	0.579	0.627	0.850	0.857	0.756	0.829	0.544	0.667	0.387	0.426	0.821	1.000						
OCT76	0.382	0.627	0.553	0.756	0.805	0.760	0.853	0.536	0.642	0.382	0.458	0.748	0.894	1.000					
DEC76	0.370	0.742	0.689	0.552	0.650	0.468	0.598	0.509	0.666	0.577	0.583	0.709	0.660	0.824	1.000				
JAN77	0.457	0.635	0.774	0.585	0.623	0.496	0.600	0.635	0.640	0.621	0.532	0.669	0.638	0.730	0.887	1.000			
MAR77	0.469	0.797	0.706	0.540	0.367	0.149	0.306	0.516	0.787	0.859	0.819	0.703	0.323	0.425	0.676	0.699	1.000		
SEP77	0.606	0.679	0.787	0.809	0.871	0.762	0.732	0.848	0.688	0.452	0.418	0.714	0.724	0.597	0.571	0.693	0.528	1.000	
JUN78	0.587	0.902	0.746	0.770	0.717	0.457	0.588	0.591	0.781	0.647	0.789	0.870	0.662	0.635	0.678	0.517	0.708	0.661	1.000

Table 62: Association Values for samples, constituted by the 14 most common algal epiphytic species, collected at Transect B, 7 m depth between Feb. 1975 and June 1978

TRANSECT B 10 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77	JUN78
FEB75	1.000																		
APR75	0.783	1.000																	
MAY75	0.603	0.886	1.000																
JUL75	0.467	0.654	0.764	1.000															
SEP75	0.279	0.271	0.441	0.745	1.000														
OCT75	0.455	0.546	0.691	0.826	0.881	1.000													
NOV75	0.323	0.341	0.504	0.657	0.818	0.735	1.000												
JAN76	0.585	0.706	0.624	0.751	0.569	0.631	0.416	1.000											
MAR76	0.570	0.801	0.638	0.363	0.172	0.469	0.127	0.680	1.000										
APR76	0.516	0.861	0.769	0.455	0.030	0.349	0.104	0.523	0.772	1.000									
MAY76	0.567	0.856	0.708	0.582	0.167	0.385	0.174	0.507	0.652	0.762	1.000								
JUL76	0.417	0.770	0.705	0.544	0.420	0.518	0.337	0.745	0.807	0.721	0.734	1.000							
SEP76	0.303	0.485	0.605	0.480	0.675	0.655	0.546	0.484	0.470	0.475	0.363	0.724	1.000						
OCT76	0.464	0.655	0.766	0.426	0.477	0.633	0.577	0.401	0.644	0.610	0.508	0.717	0.780	1.000					
DEC76	0.210	0.419	0.589	0.339	0.515	0.549	0.593	0.456	0.529	0.401	0.192	0.660	0.756	0.878	1.000				
JAN77	0.779	0.805	0.667	0.474	0.361	0.487	0.316	0.674	0.697	0.732	0.581	0.689	0.707	0.603	0.442	1.000			
MAR77	0.592	0.846	0.622	0.427	0.192	0.479	0.134	0.586	0.892	0.803	0.808	0.774	0.466	0.548	0.298	0.734	1.000		
SEP77	0.323	0.440	0.448	0.738	0.819	0.707	0.557	0.755	0.333	0.237	0.355	0.596	0.680	0.309	0.358	0.586	0.430	1.000	
JUN78	0.530	0.694	0.765	0.753	0.626	0.668	0.822	0.718	0.462	0.432	0.460	0.624	0.501	0.646	0.667	0.508	0.393	0.567	1.000

Table 63: Association Values for samples, constituted by the 14 most common algal epiphytic species, collected at Transect B, 10 m depth between Feb. 1975 and June 1978.

TRANSECT C 2 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77
FEB75	1.000																	
APR75	0.889	1.000																
MAY75	0.746	0.865	1.000															
JUL75	0.738	0.751	0.866	1.000														
SEP75	0.740	0.836	0.858	0.803	1.000													
OCT75	0.849	0.719	0.734	0.817	0.726	1.000												
NOV75	0.696	0.623	0.756	0.869	0.822	0.822	1.000											
JAN76	0.832	0.735	0.706	0.794	0.711	0.896	0.833	1.000										
MAR76	0.773	0.734	0.675	0.830	0.770	0.861	0.860	0.928	1.000									
APR76	0.560	0.585	0.587	0.702	0.610	0.619	0.689	0.783	0.883	1.000								
MAY76	0.421	0.355	0.378	0.588	0.465	0.472	0.613	0.574	0.741	0.877	1.000							
JUL76	0.405	0.367	0.471	0.688	0.472	0.533	0.733	0.667	0.794	0.896	0.919	1.000						
SEP76	0.576	0.455	0.506	0.699	0.517	0.644	0.806	0.803	0.839	0.854	0.825	0.922	1.000					
OCT76	0.670	0.598	0.476	0.628	0.633	0.691	0.738	0.873	0.904	0.836	0.754	0.758	0.867	1.000				
DEC76	0.693	0.642	0.546	0.666	0.653	0.693	0.768	0.906	0.915	0.866	0.698	0.771	0.897	0.962	1.000			
JAN77	0.665	0.558	0.535	0.676	0.562	0.654	0.775	0.865	0.860	0.870	0.814	0.855	0.944	0.931	0.929	1.000		
MAR77	0.555	0.591	0.715	0.795	0.670	0.620	0.867	0.790	0.822	0.824	0.673	0.843	0.836	0.722	0.802	0.843	1.000	
SEP77	0.598	0.496	0.608	0.780	0.626	0.698	0.840	0.774	0.853	0.893	0.915	0.936	0.935	0.806	0.807	0.894	0.829	1.000

Table 64: Association Values for samples, constituted by the 14 most common algal apiphytic species, collected at Transect C, 2 m depth between Feb. 1975 and Sep. 1977.

TRANSECT C 7 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77
FEB75	1.000																	
APR75	0.675	1.000																
MAY75	0.663	0.815	1.000															
JUL75	0.434	0.168	0.386	1.000														
SEP75	0.829	0.642	0.661	0.690	1.000													
OCT75	0.697	0.567	0.576	0.612	0.899	1.000												
NOV75	0.710	0.731	0.472	0.252	0.765	0.800	1.000											
JAN76	0.855	0.628	0.509	0.266	0.756	0.669	0.845	1.000										
MAR76	0.612	0.597	0.411	0.127	0.613	0.646	0.905	0.853	1.000									
APR76	0.542	0.414	0.501	0.112	0.506	0.478	0.599	0.770	0.821	1.000								
MAY76	0.262	0.396	0.320	0.084	0.444	0.590	0.695	0.634	0.815	0.765	1.000							
JUL76	0.361	0.399	0.372	0.174	0.490	0.609	0.667	0.698	0.776	0.780	0.956	1.000						
SEP76	0.493	0.384	0.406	0.300	0.607	0.719	0.727	0.754	0.838	0.841	0.909	0.959	1.000					
OCT76	0.582	0.545	0.479	0.371	0.719	0.731	0.829	0.826	0.894	0.778	0.859	0.899	0.932	1.000				
DEC76	0.321	0.398	0.116	0.081	0.357	0.309	0.660	0.720	0.730	0.586	0.709	0.692	0.614	0.695	1.000			
JAN77	0.258	0.214	0.049	0.007	0.174	0.202	0.482	0.603	0.605	0.634	0.640	0.716	0.671	0.591	0.812	1.000		
MAR77	0.167	0.151	-0.014	-0.005	0.130	0.120	0.468	0.529	0.651	0.640	0.639	0.621	0.598	0.564	0.824	0.907	1.000	
SEP77	0.542	0.496	0.498	0.497	0.811	0.828	0.796	0.678	0.773	0.633	0.725	0.738	0.825	0.910	0.453	0.309	0.302	1.000

Table 65: Association Values for samples, constituted by the 14 most common algal epiphytic species, collected at Transect C, 7 m depth between Feb. 1975 and Sep. 1977.

TRANSECT C 10 m depth

FEB75	1.000																	
APR75	0.734	1.000																
MAY75	0.825	0.842	1.000															
JUL75	0.759	0.623	0.751	1.000														
SEP75	0.702	0.524	0.611	0.848	1.000													
OCT75	0.770	0.664	0.761	0.977	0.872	1.000												
NOV75	0.759	0.831	0.842	0.824	0.756	0.880	1.000											
JAN76	0.757	0.749	0.835	0.865	0.761	0.905	0.871	1.000										
MAR76	0.558	0.857	0.753	0.617	0.573	0.675	0.734	0.754	1.000									
APR76	0.557	0.760	0.816	0.663	0.520	0.735	0.774	0.845	0.872	1.000								
MAY76	0.353	0.553	0.618	0.537	0.474	0.584	0.498	0.679	0.816	0.851	1.000							
JUL76	0.370	0.423	0.494	0.652	0.594	0.639	0.417	0.534	0.692	0.613	0.851	1.000						
SEP76	0.530	0.521	0.630	0.730	0.693	0.726	0.564	0.601	0.763	0.671	0.773	0.933	1.000					
OCT76	0.406	0.542	0.570	0.585	0.449	0.622	0.596	0.436	0.695	0.674	0.578	0.691	0.823	1.000				
DEC76	0.521	0.575	0.725	0.684	0.545	0.747	0.720	0.695	0.776	0.876	0.743	0.676	0.806	0.883	1.000			
JAN77	0.554	0.531	0.746	0.777	0.628	0.796	0.703	0.829	0.672	0.876	0.803	0.706	0.754	0.632	0.836	1.000		
MAR77	0.371	0.604	0.702	0.447	0.199	0.439	0.484	0.625	0.721	0.807	0.759	0.549	0.588	0.531	0.681	0.775	1.000	
SEP77	0.674	0.563	0.656	0.935	0.790	0.910	0.743	0.886	0.613	0.668	0.589	0.648	0.693	0.458	0.613	0.828	0.547	1.000
	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV76	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC77	JAN77	MAR77	SEP77

Table 66: Association Values for samples, constituted by the 14 most common algal epiphytic species, collected at Transect C, 10 m depth between Feb. 1975 and Sep. 1977.

TRANSECT A 2 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77
FEB75	1.000																	
APR75	0.644	1.000																
MAY75	0.609	0.795	1.000															
JUL75	0.463	0.652	0.856	1.000														
SEP75	0.507	0.683	0.857	0.852	1.000													
OCT75	0.567	0.671	0.821	0.719	0.862	1.000												
NOV75	0.684	0.798	0.829	0.737	0.827	0.839	1.000											
JAN76	0.562	0.695	0.703	0.715	0.758	0.688	0.750	1.000										
MAR76	0.650	0.888	0.776	0.721	0.712	0.684	0.842	0.725	1.000									
APR76	0.574	0.833	0.747	0.688	0.641	0.643	0.743	0.701	0.829	1.000								
MAY76	0.566	0.730	0.658	0.660	0.642	0.593	0.694	0.651	0.790	0.765	1.000							
JUL76	0.334	0.585	0.749	0.867	0.739	0.617	0.670	0.593	0.622	0.723	0.674	1.000						
SEP76	0.456	0.592	0.727	0.757	0.772	0.757	0.740	0.603	0.583	0.590	0.674	0.803	1.000					
OCT76	0.518	0.700	0.784	0.838	0.815	0.779	0.776	0.759	0.731	0.704	0.657	0.813	0.843	1.000				
DEC76	0.561	0.681	0.682	0.809	0.774	0.738	0.754	0.854	0.731	0.719	0.706	0.675	0.742	0.803	1.000			
JAN77	0.724	0.746	0.713	0.670	0.641	0.623	0.753	0.747	0.788	0.761	0.716	0.580	0.615	0.718	0.791	1.000		
MAR77	0.578	0.762	0.684	0.666	0.657	0.660	0.648	0.710	0.786	0.727	0.828	0.602	0.678	0.721	0.763	0.782	1.000	
SEP77	0.431	0.619	0.775	0.846	0.796	0.705	0.732	0.754	0.674	0.751	0.689	0.886	0.776	0.880	0.739	0.686	0.627	1.000

Table 67: Association Values for samples, constituted by 38 species/species groups of algal epiphtes, collected at Transect A, 2 m depth between Feb. 1975.

TRANSECT A 7 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77
FEB75	1.000																	
APR75	0.841	1.000																
MAY75	0.768	0.887	1.000															
JUL75	0.646	0.776	0.899	1.000														
SEP75	0.734	0.753	0.822	0.819	1.000													
OCT75	0.714	0.705	0.775	0.780	0.837	1.000												
NOV75	0.734	0.727	0.702	0.683	0.782	0.819	1.000											
JAN76	0.828	0.696	0.644	0.542	0.606	0.612	0.694	1.000										
MAR76	0.868	0.831	0.759	0.664	0.715	0.684	0.802	0.890	1.000									
APR76	0.650	0.735	0.745	0.639	0.592	0.586	0.615	0.748	0.806	1.000								
MAY76	0.586	0.716	0.840	0.761	0.725	0.560	0.567	0.569	0.659	0.785	1.000							
JUL76	0.635	0.709	0.825	0.831	0.795	0.681	0.609	0.648	0.697	0.696	0.860	1.000						
SEP76	0.575	0.647	0.697	0.585	0.633	0.503	0.451	0.541	0.568	0.545	0.720	0.777	1.000					
OCT76	0.487	0.496	0.607	0.538	0.610	0.500	0.361	0.515	0.487	0.479	0.662	0.768	0.911	1.000				
DEC76	0.708	0.593	0.630	0.547	0.658	0.627	0.597	0.820	0.738	0.651	0.589	0.641	0.672	0.717	1.000			
JAN77	0.760	0.703	0.633	0.516	0.604	0.585	0.694	0.879	0.828	0.721	0.579	0.656	0.639	0.635	0.831	1.000		
MAR77	0.769	0.806	0.743	0.599	0.593	0.605	0.633	0.844	0.857	0.839	0.693	0.698	0.685	0.581	0.736	0.861	1.000	
SEP77	0.591	0.603	0.715	0.724	0.765	0.653	0.537	0.567	0.615	0.601	0.781	0.876	0.772	0.801	0.617	0.542	0.585	1.000

Table 68: Association Values for samples, constituted by 38 species/species groups of algal epiphytes, collected at Transect A, 7 m depth between Feb. 1975 and Sep. 1977.

TRANSECT B 2 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77	JUN78
FEB75	1.000																		
APR75	0.741	1.000																	
MAY75	0.617	0.729	1.000																
JUL75	0.638	0.678	0.921	1.000															
SEP75	0.501	0.681	0.807	0.886	1.000														
OCT75	0.598	0.735	0.726	0.809	0.829	1.000													
NOV75	0.674	0.672	0.507	0.574	0.618	0.815	1.000												
JAN76	0.695	0.803	0.766	0.710	0.672	0.770	0.770	1.000											
MAR76	0.681	0.849	0.779	0.695	0.665	0.630	0.587	0.821	1.000										
APR76	0.542	0.845	0.692	0.633	0.662	0.558	0.512	0.764	0.895	1.000									
MAY76	0.576	0.767	0.732	0.734	0.687	0.629	0.482	0.748	0.790	0.810	1.000								
JUL76	0.598	0.736	0.769	0.815	0.803	0.712	0.558	0.724	0.747	0.798	0.865	1.000							
SEP76	0.646	0.756	0.762	0.823	0.783	0.704	0.613	0.699	0.775	0.815	0.837	0.952	1.000						
OCT76	0.586	0.731	0.670	0.741	0.792	0.782	0.706	0.709	0.726	0.737	0.754	0.854	0.856	1.000					
DEC76	0.583	0.776	0.681	0.705	0.704	0.798	0.776	0.785	0.771	0.732	0.717	0.771	0.802	0.913	1.000				
JAN77	0.736	0.792	0.654	0.676	0.609	0.776	0.807	0.868	0.758	0.716	0.727	0.741	0.737	0.761	0.839	1.000			
MAR77	0.629	0.853	0.697	0.689	0.666	0.753	0.674	0.814	0.852	0.826	0.752	0.712	0.707	0.690	0.762	0.848	1.000		
SEP77	0.641	0.742	0.763	0.827	0.789	0.823	0.644	0.772	0.726	0.704	0.815	0.861	0.829	0.899	0.835	0.765	0.756	1.000	
JUN78	0.658	0.850	0.810	0.803	0.822	0.774	0.646	0.772	0.844	0.817	0.778	0.846	0.849	0.838	0.828	0.711	0.790	0.868	1.000

TABLE 69: Association Values for samples, constituted by 38 species/species groups of algal epiphytes, collected at Transect B, 2 m depth between Feb. 1975 and June 1978.

TRANSECT B 7 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77	JUN78
FEB75	1.000																		
APR75	0.822	1.000																	
MAY75	0.737	0.778	1.000																
JUL75	0.702	0.734	0.918	1.000															
SEP75	0.645	0.725	0.833	0.825	1.000														
OCT75	0.587	0.594	0.689	0.732	0.869	1.000													
NOV75	0.654	0.707	0.682	0.751	0.788	0.831	1.000												
JAN76	0.817	0.722	0.709	0.740	0.607	0.578	0.763	1.000											
MAR76	0.819	0.792	0.753	0.744	0.619	0.535	0.698	0.835	1.000										
APR76	0.726	0.805	0.744	0.732	0.599	0.494	0.696	0.722	0.854	1.000									
MAY76	0.744	0.757	0.838	0.829	0.768	0.677	0.735	0.699	0.817	0.853	1.000								
JUL76	0.733	0.681	0.866	0.885	0.810	0.740	0.722	0.676	0.774	0.783	0.884	1.000							
SEP76	0.693	0.664	0.777	0.845	0.815	0.826	0.799	0.679	0.696	0.707	0.778	0.924	1.000						
OCT76	0.580	0.588	0.678	0.745	0.799	0.864	0.794	0.558	0.557	0.597	0.696	0.817	0.897	1.000					
DEC76	0.831	0.860	0.741	0.721	0.606	0.569	0.708	0.793	0.858	0.832	0.752	0.735	0.705	0.652	1.000				
JAN77	0.845	0.794	0.713	0.710	0.591	0.541	0.728	0.891	0.872	0.809	0.760	0.740	0.728	0.610	0.882	1.000			
MAR77	0.830	0.815	0.776	0.745	0.611	0.528	0.691	0.812	0.909	0.885	0.845	0.782	0.706	0.583	0.887	0.920	1.000		
SEP77	0.803	0.734	0.853	0.844	0.865	0.785	0.743	0.702	0.787	0.732	0.855	0.913	0.864	0.785	0.761	0.741	0.807	1.000	
JUN78	0.806	0.772	0.831	0.816	0.769	0.668	0.755	0.731	0.842	0.824	0.857	0.891	0.824	0.713	0.846	0.789	0.888	0.905	1.000

Table 70: Association Values for samples, constituted by 38 species/species groups of algal epiphytes, collected at Transect B, 7 m depth between Feb. 1975 and June 1978.

TRANSECT B 10 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77	JUN78
FEB75	1.000																		
APR75	0.854	1.000																	
MAY75	0.656	0.873	1.000																
JUL75	0.529	0.746	0.910	1.000															
SEP75	0.439	0.662	0.802	0.838	1.000														
OCT75	0.473	0.678	0.753	0.763	0.873	1.000													
NOV75	0.576	0.721	0.678	0.659	0.811	0.840	1.000												
JAN76	0.792	0.769	0.665	0.628	0.537	0.581	0.667	1.000											
MAR76	0.693	0.819	0.767	0.693	0.598	0.642	0.650	0.823	1.000										
APR76	0.709	0.871	0.821	0.738	0.602	0.582	0.646	0.752	0.918	1.000									
MAY76	0.602	0.801	0.882	0.887	0.740	0.680	0.668	0.663	0.807	0.885	1.000								
JUL76	0.539	0.782	0.911	0.874	0.852	0.804	0.700	0.612	0.784	0.798	0.898	1.000							
SEP76	0.448	0.675	0.780	0.771	0.854	0.846	0.703	0.553	0.689	0.657	0.728	0.908	1.000						
OCT76	0.504	0.734	0.788	0.737	0.812	0.878	0.764	0.595	0.752	0.698	0.727	0.834	0.898	1.000					
DEC76	0.735	0.845	0.768	0.659	0.636	0.694	0.702	0.706	0.774	0.740	0.621	0.712	0.703	0.776	1.000				
JAN77	0.860	0.851	0.736	0.659	0.537	0.589	0.669	0.885	0.872	0.833	0.727	0.671	0.616	0.662	0.758	1.000			
MAR77	0.801	0.908	0.810	0.721	0.607	0.605	0.673	0.770	0.908	0.925	0.825	0.783	0.678	0.712	0.811	0.901	1.000		
SEP77	0.467	0.696	0.800	0.853	0.911	0.814	0.712	0.587	0.698	0.681	0.794	0.901	0.901	0.817	0.663	0.621	0.687	1.000	
JUN78	0.600	0.771	0.870	0.869	0.722	0.755	0.676	0.674	0.801	0.764	0.836	0.851	0.710	0.713	0.743	0.726	0.754	0.781	1.000

Table 71: Association Values for samples, constituted by 38 species/species groups of algal epiphytes, collected at Transect B, 10 m depth between Feb. 1975 and June 1978.

TRANSECT C 2 m depth

FEB75	1.000																	
APR75	0.814	1.000																
MAY75	0.668	0.801	1.000															
JUL75	0.557	0.621	0.836	1.000														
SEP75	0.513	0.622	0.647	0.700	1.000													
OCT75	0.641	0.671	0.714	0.683	0.663	1.000												
NOV75	0.574	0.626	0.690	0.734	0.786	0.735	1.000											
JAN76	0.635	0.697	0.674	0.596	0.630	0.792	0.728	1.000										
MAR76	0.523	0.582	0.569	0.598	0.569	0.581	0.656	0.736	1.000									
APR76	0.505	0.611	0.622	0.637	0.523	0.579	0.686	0.736	0.853	1.000								
MAY76	0.353	0.472	0.559	0.589	0.455	0.362	0.567	0.525	0.719	0.773	1.000							
JUL76	0.421	0.473	0.569	0.638	0.530	0.405	0.645	0.522	0.737	0.783	0.884	1.000						
SEP76	0.440	0.433	0.469	0.562	0.553	0.480	0.683	0.532	0.637	0.631	0.737	0.852	1.000					
OCT76	0.523	0.543	0.535	0.573	0.654	0.620	0.737	0.717	0.702	0.689	0.613	0.730	0.853	1.000				
DEC76	0.591	0.523	0.553	0.577	0.599	0.574	0.721	0.748	0.686	0.753	0.545	0.693	0.750	0.817	1.000			
JAN77	0.521	0.549	0.555	0.537	0.559	0.552	0.681	0.727	0.627	0.745	0.571	0.694	0.684	0.744	0.898	1.000		
MAR77	0.534	0.712	0.604	0.564	0.553	0.604	0.646	0.781	0.597	0.732	0.408	0.426	0.355	0.495	0.626	0.690	1.000	
SEP77	0.456	0.422	0.523	0.676	0.721	0.522	0.722	0.495	0.580	0.585	0.712	0.817	0.902	0.783	0.708	0.690	0.374	1.000
	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV76	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC77	JAN77	MAR77	SEP77

Table 72: Association Values for samples, constituted by 38 species/species groups of algal epiphytes, collected at Transect C, 2 m depth between Feb. 1975 and Sep. 1977.

TRANSECT C 7 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77
FEB75	1.000																	
APR75	0.796	1.000																
MAY75	0.752	0.906	1.000															
JUL75	0.670	0.822	0.892	1.000														
SEP75	0.652	0.745	0.841	0.823	1.000													
OCT75	0.668	0.842	0.859	0.823	0.859	1.000												
NOV75	0.706	0.816	0.776	0.798	0.844	0.818	1.000											
JAN76	0.846	0.782	0.708	0.653	0.656	0.734	0.801	1.000										
MAR76	0.767	0.848	0.821	0.790	0.803	0.834	0.852	0.870	1.000									
APR76	0.738	0.847	0.831	0.835	0.783	0.815	0.813	0.821	0.927	1.000								
MAY76	0.484	0.731	0.685	0.704	0.766	0.782	0.726	0.603	0.776	0.838	1.000							
JUL76	0.442	0.649	0.677	0.671	0.784	0.774	0.653	0.548	0.751	0.784	0.947	1.000						
SEP76	0.453	0.611	0.660	0.649	0.812	0.776	0.678	0.543	0.736	0.744	0.912	0.973	1.000					
OCT76	0.529	0.711	0.725	0.718	0.847	0.817	0.775	0.610	0.773	0.750	0.903	0.914	0.938	1.000				
DEC76	0.541	0.759	0.775	0.764	0.780	0.787	0.783	0.652	0.778	0.762	0.841	0.829	0.825	0.900	1.000			
JAN77	0.702	0.773	0.766	0.780	0.773	0.753	0.765	0.790	0.862	0.896	0.830	0.803	0.744	0.775	0.830	1.000		
MAR77	0.604	0.775	0.778	0.844	0.814	0.782	0.798	0.685	0.845	0.912	0.885	0.850	0.804	0.828	0.862	0.906	1.000	
SEP77	0.531	0.711	0.733	0.768	0.868	0.859	0.803	0.588	0.761	0.767	0.863	0.859	0.890	0.927	0.816	0.730	0.821	1.000

Table 73: Association Values for samples, constituted by 38 species/species groups of algal epiphytes, collected at Transect C, 7 m depth between Feb. 1975 and Sep. 1977.

TRANSECT C 10 m depth

	FEB75	APR75	MAY75	JUL75	SEP75	OCT75	NOV75	JAN76	MAR76	APR76	MAY76	JUL76	SEP76	OCT76	DEC76	JAN77	MAR77	SEP77
FEB75	1.000																	
APR75	0.837	1.000																
MAY75	0.771	0.892	1.000															
JUL75	0.681	0.812	0.896	1.000														
SEP75	0.716	0.784	0.878	0.879	1.000													
OCT75	0.769	0.767	0.815	0.859	0.864	1.000												
NOV75	0.687	0.811	0.793	0.836	0.780	0.886	1.000											
JAN76	0.786	0.885	0.802	0.777	0.769	0.809	0.818	1.000										
MAR76	0.797	0.866	0.804	0.778	0.768	0.798	0.757	0.896	1.000									
APR76	0.762	0.805	0.790	0.800	0.775	0.791	0.791	0.837	0.882	1.000								
MAY76	0.559	0.655	0.731	0.784	0.759	0.732	0.741	0.648	0.695	0.801	1.000							
JUL76	0.492	0.586	0.668	0.777	0.716	0.662	0.673	0.555	0.612	0.703	0.875	1.000						
SEP76	0.493	0.571	0.700	0.810	0.783	0.724	0.715	0.555	0.606	0.635	0.850	0.931	1.000					
OCT76	0.467	0.589	0.725	0.760	0.712	0.660	0.707	0.545	0.593	0.644	0.754	0.798	0.859	1.000				
DEC76	0.567	0.688	0.741	0.722	0.691	0.669	0.795	0.718	0.672	0.740	0.695	0.640	0.684	0.800	1.000			
JAN77	0.673	0.826	0.742	0.746	0.716	0.756	0.834	0.869	0.822	0.794	0.692	0.651	0.627	0.647	0.786	1.000		
MAR77	0.683	0.851	0.777	0.734	0.678	0.710	0.752	0.820	0.837	0.783	0.679	0.659	0.642	0.667	0.766	0.872	1.000	
SEP77	0.576	0.651	0.755	0.853	0.839	0.808	0.812	0.679	0.648	0.769	0.874	0.824	0.852	0.812	0.788	0.746	0.674	1.000

Table 74: Association Values for samples, constituted by 38 species/species groups of algal epiphytes, collected at Transect C, 10 m depth between Feb. 1975 and Sep. 1977.

Transect A

The analyses of the association values for the seasonal species at the 2 m depth (Fig. 101) showed a clustering of samples collected in late autumn through to spring 1975, winter and spring 1976 and spring 1977. Smaller clusters were also evident, firstly autumn 1975 with autumn 1976, and secondly late spring 1975 with early summer 1976. The same analyses for the 7 m deep site provided two major clusterings (Fig. 101). One included samples from late autumn 1975 to spring 1975 with samples also from winter 1976 and spring 1977. The other included the summer collections from 1975, 1976 and 1977.

The analyses at the 2 m deep site of the 14 most common algal epiphyte species showed a large clustering of thirteen collections and only five collections were not included within the large clustering (Fig. 102). At the 7 m deep site four clusterings occurred; spring 1975, spring 1976 and 1977 with early summer 1977, summer 1976 with summer 1975, and autumn to early spring 1976 (Fig. 103). Repetition of seasonal features in the 14 most common algal epiphyte species was not recorded on the Transect A.

Analyses of all the "erect" algal species in the epiphytic community delineated four small clusterings at the 2 m deep site (Fig. 103). These clusterings did not exhibit a regular repetitiveness in the structure of the algal epiphytic community but rather demonstrated that the arrangement of species in a collection influenced the structure of the algal epiphytic community examined in the following collection. At 7 m depth not only was the similarity of collections from one sample period to the next evident, but also there was similarity or association of

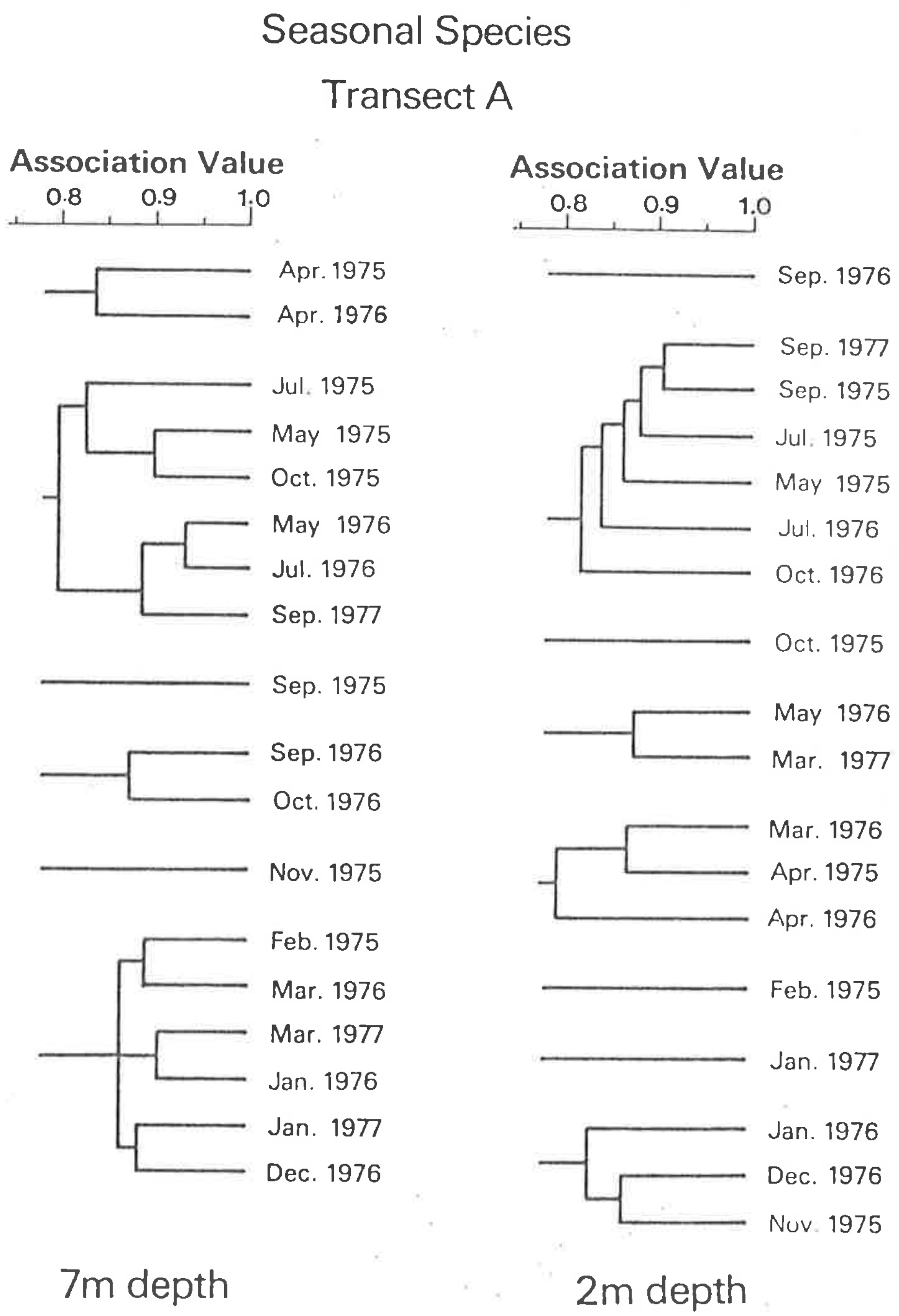

Fig. 101: Dendogram of cluster analysis of the association values for the seasonal "erect" algal species of the epiphytic community for samples collected at 2 m and 7 m depths on Transect A.

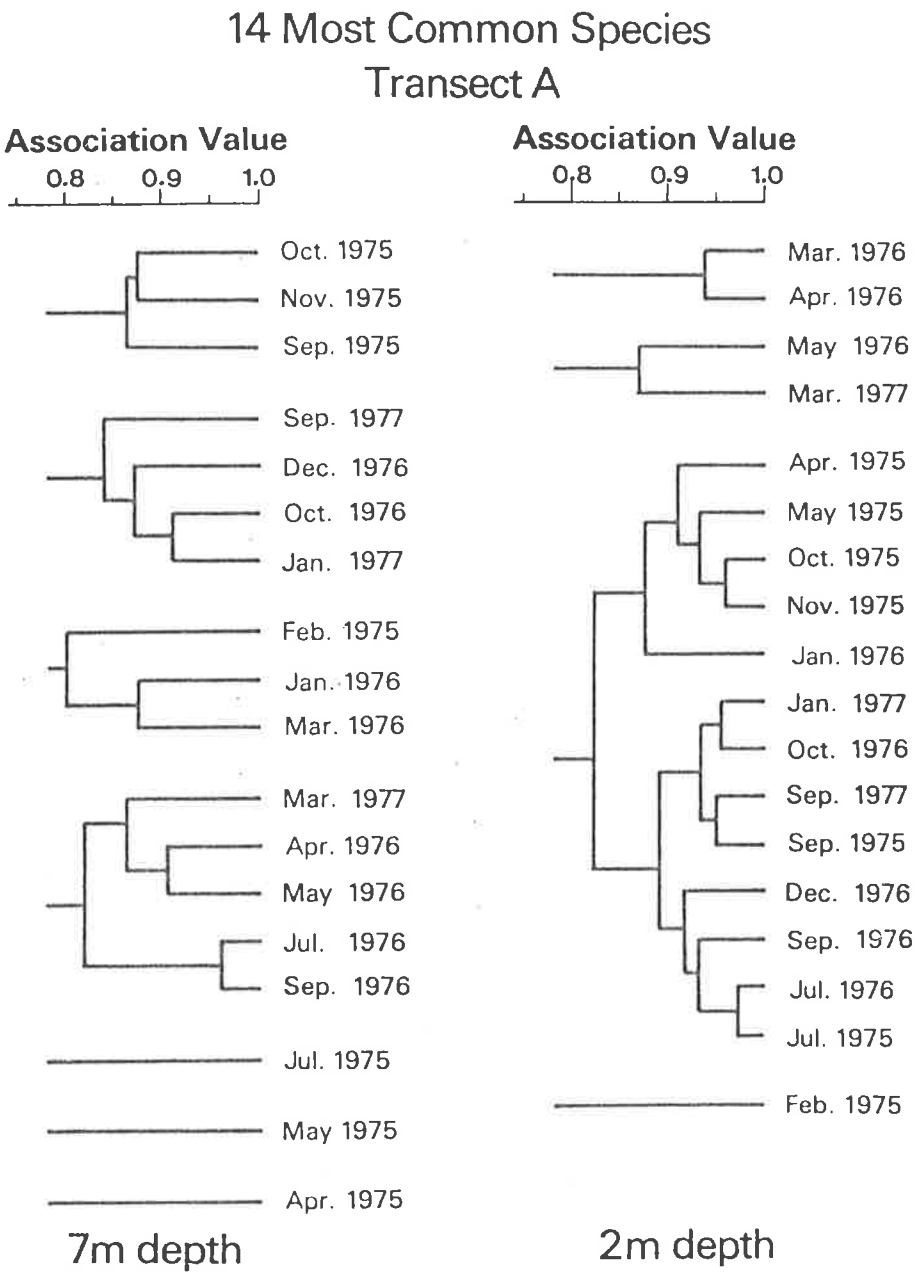

Fig. 102: Dendogram of cluster analysis of the association values for the 14 most common "erect" algal species of the epiphytic community for samples collected at 2 m and 7 m depths on Transect A.

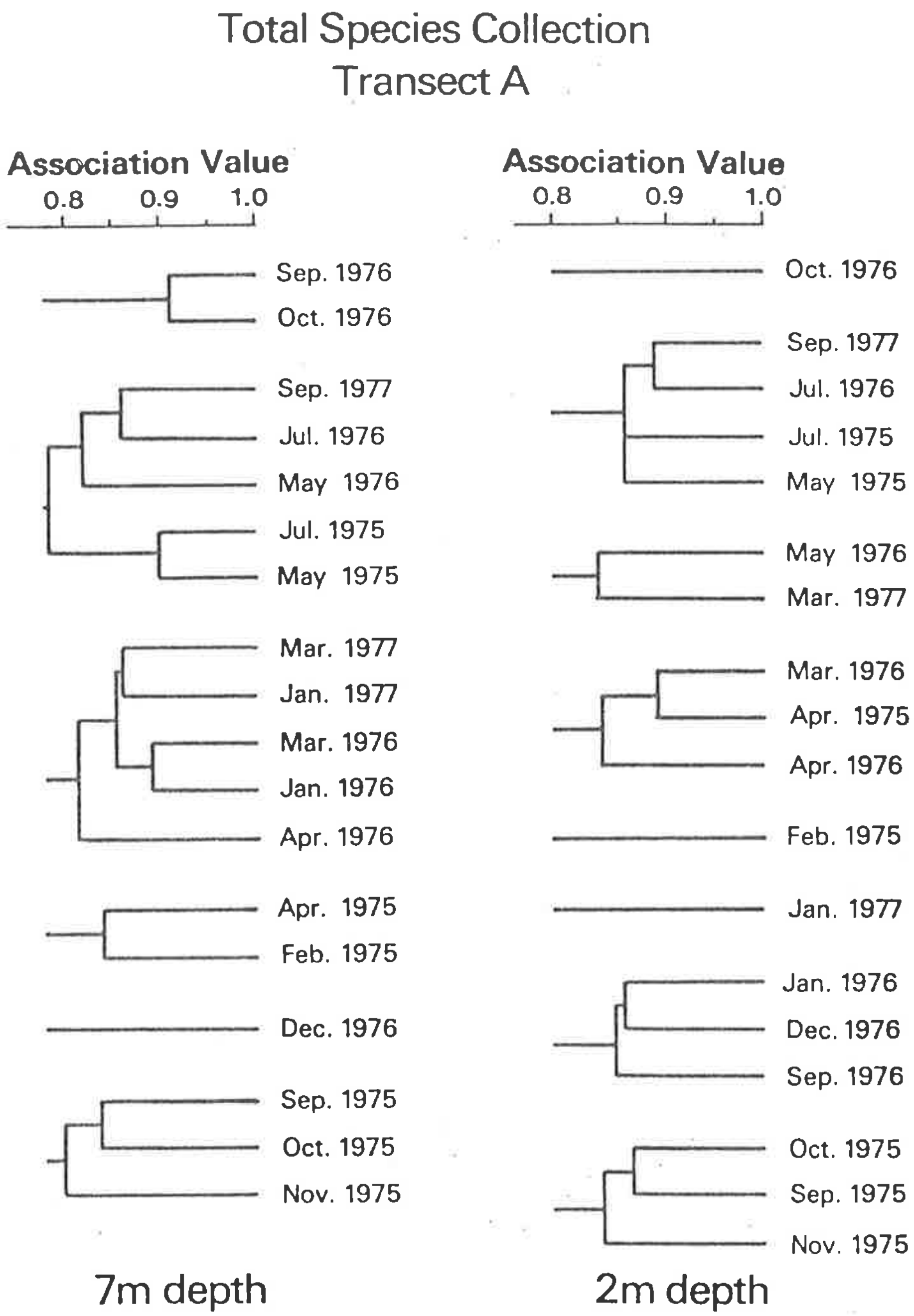

Fig. 103: Dendogram of cluster analysis of the association values for the "erect" algal species of the epiphytic community for samples collected at 2 m and 7 m depths on Transect A.

samples from the same seasons in different years. A winter group (May-July (Sep.)) and a summer-autumn group (Jan.-Apr.) could be recognized.

Transect B

Analyses of the association values of the algal epiphytic community made up by only the seasonal species showed two main clusterings at 2 m depth (Fig. 104). A late summer and autumn group, including samples from 1975, 1976, 1977 and June 1978, which suggested that there was seasonal repetition, and a late autumn through to early summer group (May-Dec.), including samples collected in 1976 only, which suggested that similarities between consecutive collections were greater than those between collections in the same season but in different years. However the 7 m depth results (Fig. 104) suggested that changes in the populations of the seasonal species and the resultant changes in the community structure were seasonally regular and two clusterings, a late autumn to early spring group (May-Sep.) and a summer to autumn group (Dec.-Apr.) were recognized. Similar results were obtained at 10 m depth (Fig. 104) where association values between samples in corresponding seasons but in different years were clustered. These results indicated that the overall changes in the seasonal species of the algal epiphytic community were more marked and more regular at the 7 m, 10 m deep sites than at the 2 m deep site.

Analyses of the association values for the 14 most common algal epiphytic species gave different results (Fig. 105) to those analyses for the seasonal species. The resultant clusters of collections indicated that population changes in the common algal epiphytes at the 2 m deep site would be more readily attributed to seasonal effects than the population changes that occurred at the 7 m and 10 m deep sites. At 2 m depth all

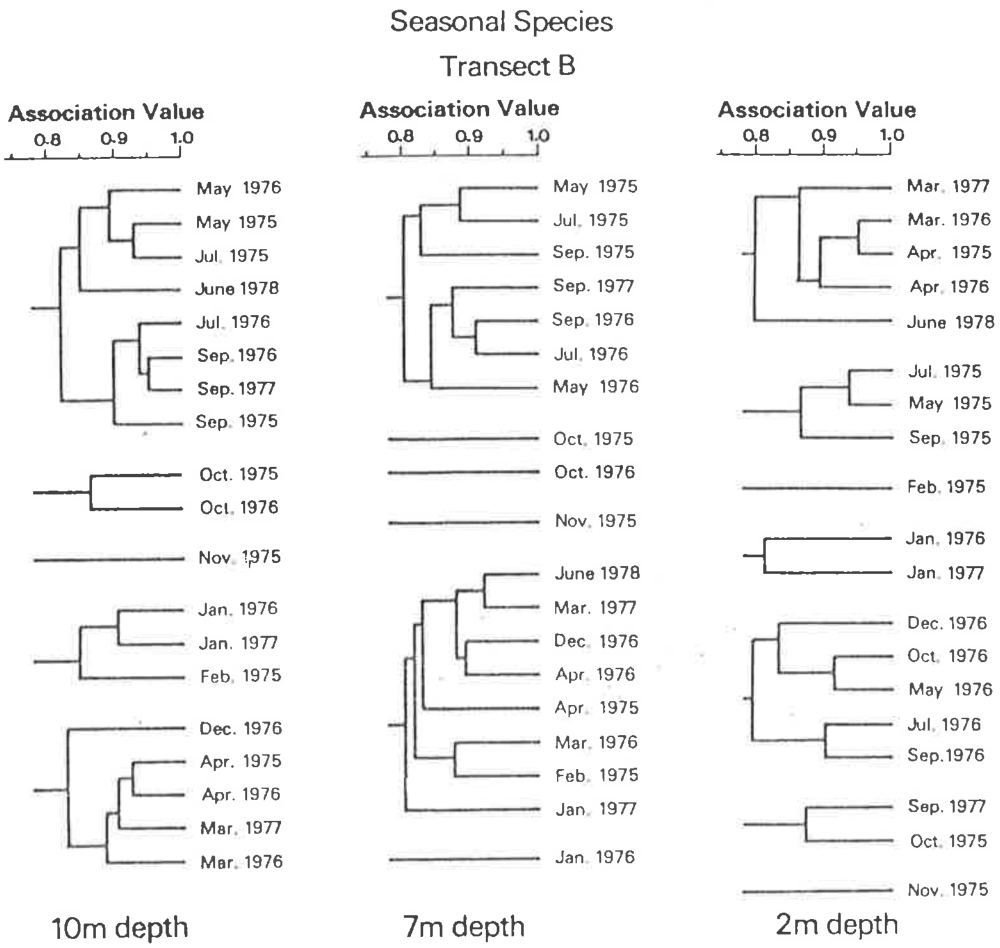

Fig. 104: Dendogram of cluster analysis of the association values for the seasonal "erect" algal species of the epiphytic community for samples collected at 2 m, 7 m and 10 m depths on Transect B.

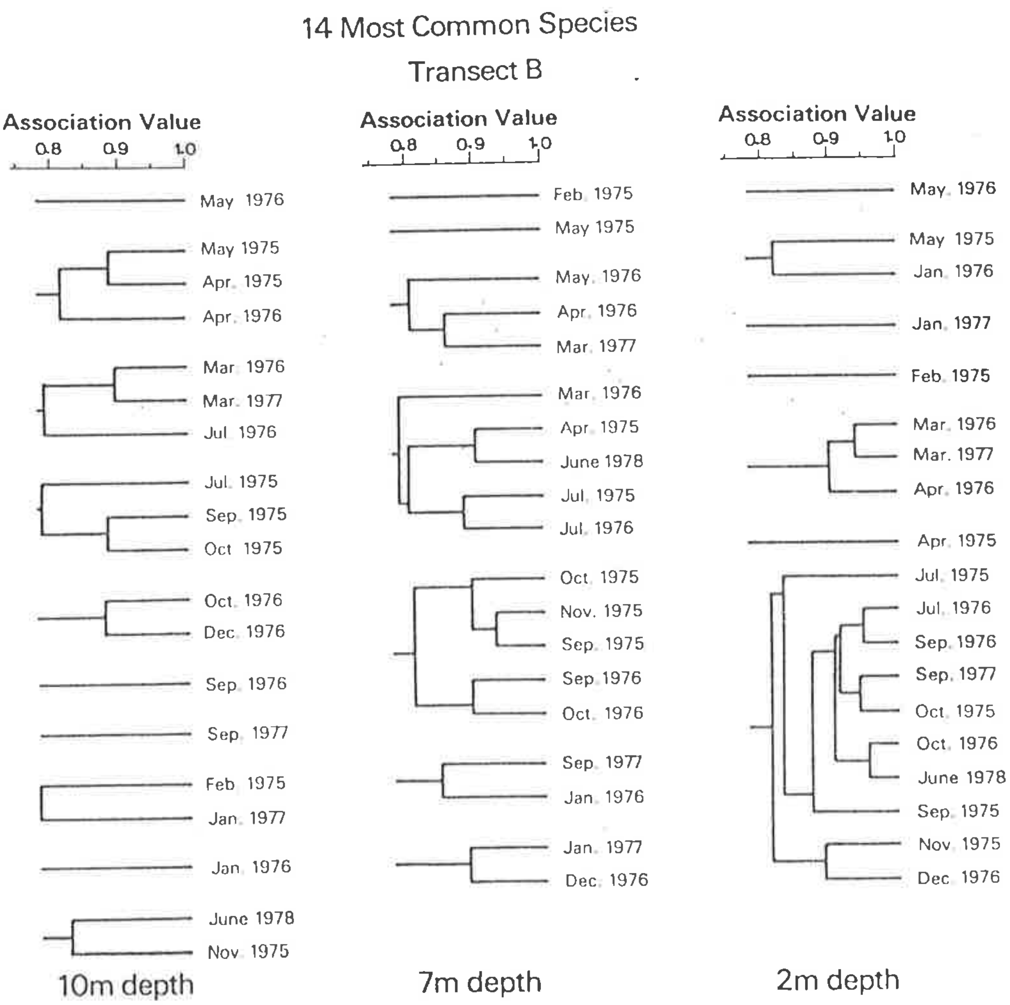

Fig. 105: Dendogram of cluster analysis of the association values for the 14 most common "erect" algal species of the epiphytic community for samples collected at 2 m, 7 m and 10 m depths on Transect B.

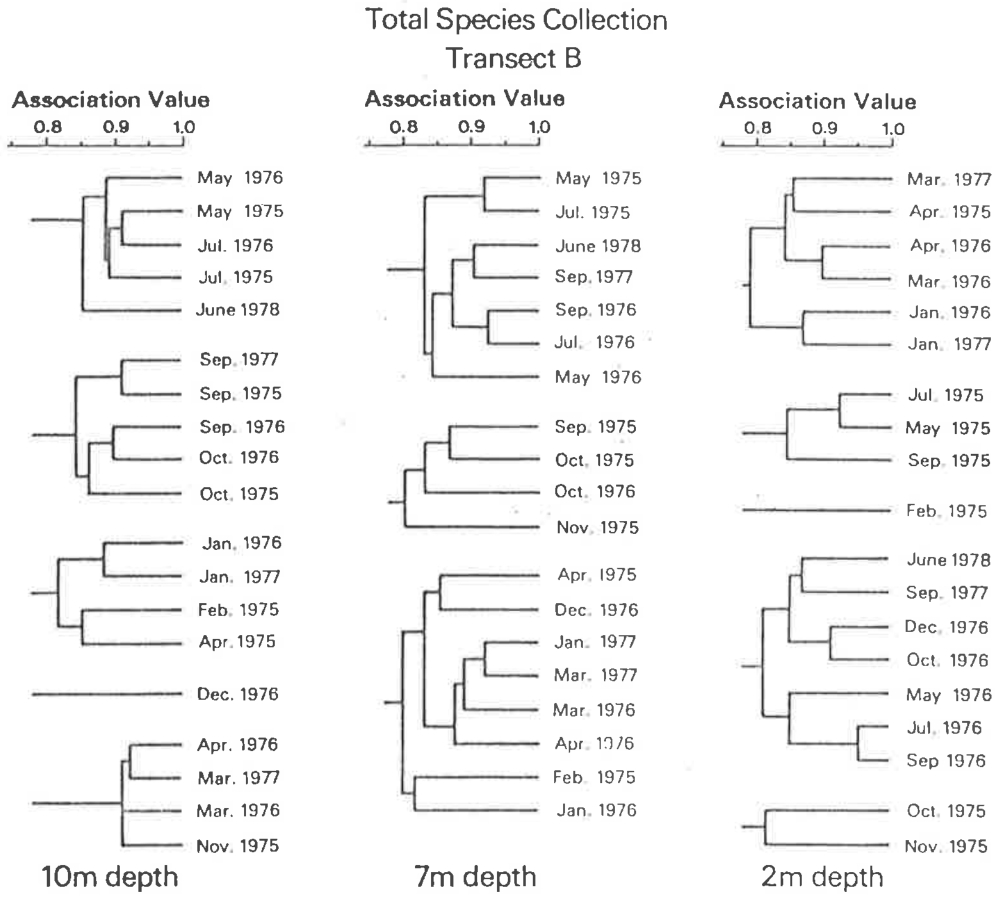

Fig. 106: Dendogram of cluster analysis of the association values for the "erect" algal species of the epiphytic community for samples collected at 2 m, 7 m and 10 m depths on Transect B.

samples collected in winter through to late spring or early summer (June-Dec.) irrespective of the year in which they were collected could be placed in the same cluster. At 7 m depth a cluster of winter samples and another of spring samples were recognized. No large clusterings could be drawn from the association values at 10 m depth.

Analyses of the association values for 38 "erect" algal epiphyte species at the 2 m deep site resulted in three main clusterings (Fig. 106). Except for a summer-autumn cluster involving samples from 1975, 1976 and 1977 there was not a clustering of seasonal samples from different years. The other clusters were labelled as firstly a 1975 winter group and secondly a 1976 winter and spring group with similar algal epiphytic communities recorded in September 1977 and June 1978. Two main clusters were evident at the 7 m deep site (Fig. 106); samples collected from summer through to mid-autumn (Dec.-Apr.) for 1975, 1976 and 1977 were placed in one group, the other group included samples collected in late autumn to early spring (May-Sep.) in 1975, 1976, 1977 and 1978, although the samples collected in spring 1975 (Sep., Oct. and Nov.) were not able to be incorporated within this group. The samples from the 10 m deep site were separated into 4 seasonal clusters; a late autumn to winter group (May-July), a spring group (Sep.-Oct.), a summer group (Jan.-Feb. (Apr.)) and a late summer to autumn group (Mar.-Apr.). Seasonal changes in the epiphytic algal populations were most marked at this site and consequently enabled the establishment of these seasonal clusters.

<u>Transect C</u>

Analyses of the association values of the seasonal species in samples collected at 2 m depth did not delineate seasonal clusters (Fig. 107). At 7 m depth two main clusters were formed; a late summer-autumn group and a late autumn through to spring group, although the samples of May,

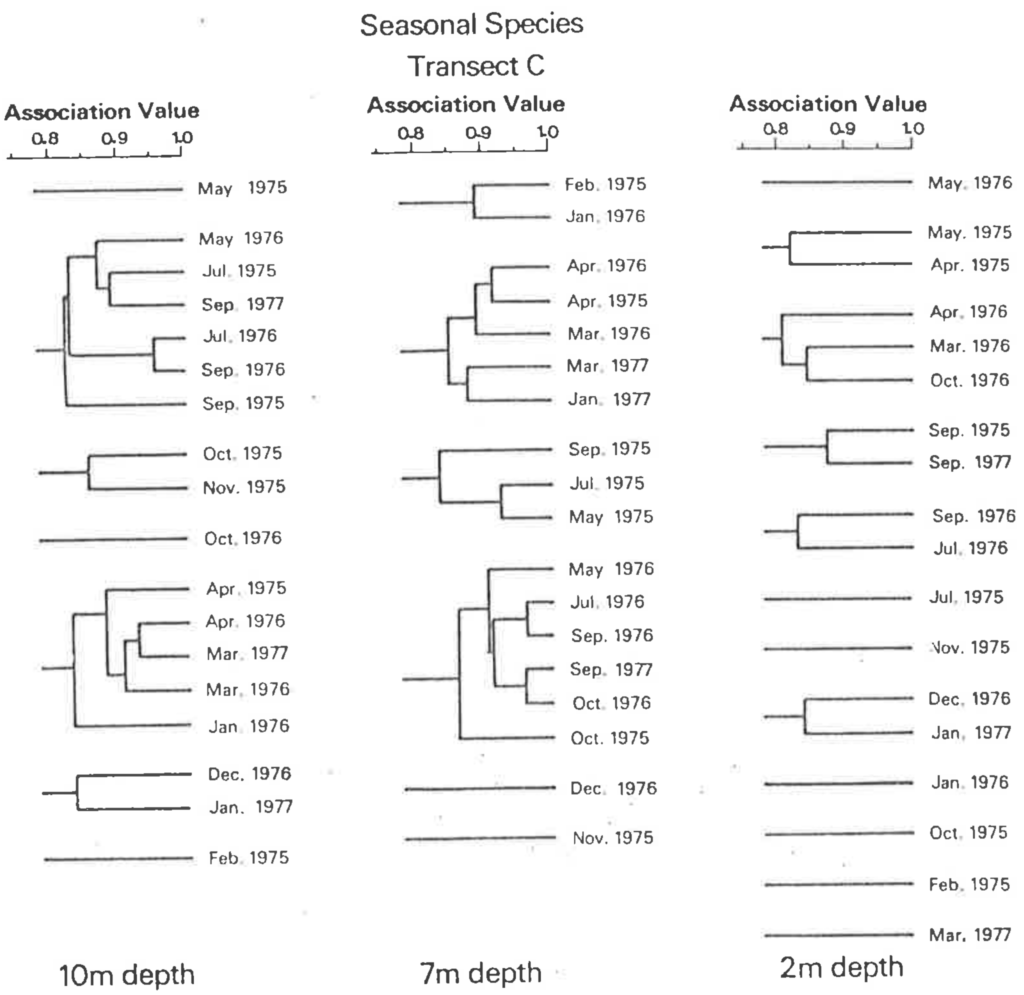

Fig. 107: Dendogram of cluster analysis of the association values for the seasonal "erect" algal species of the epiphytic community for samples collected at 2 m, 7 m and 10 m depths on Transect C.

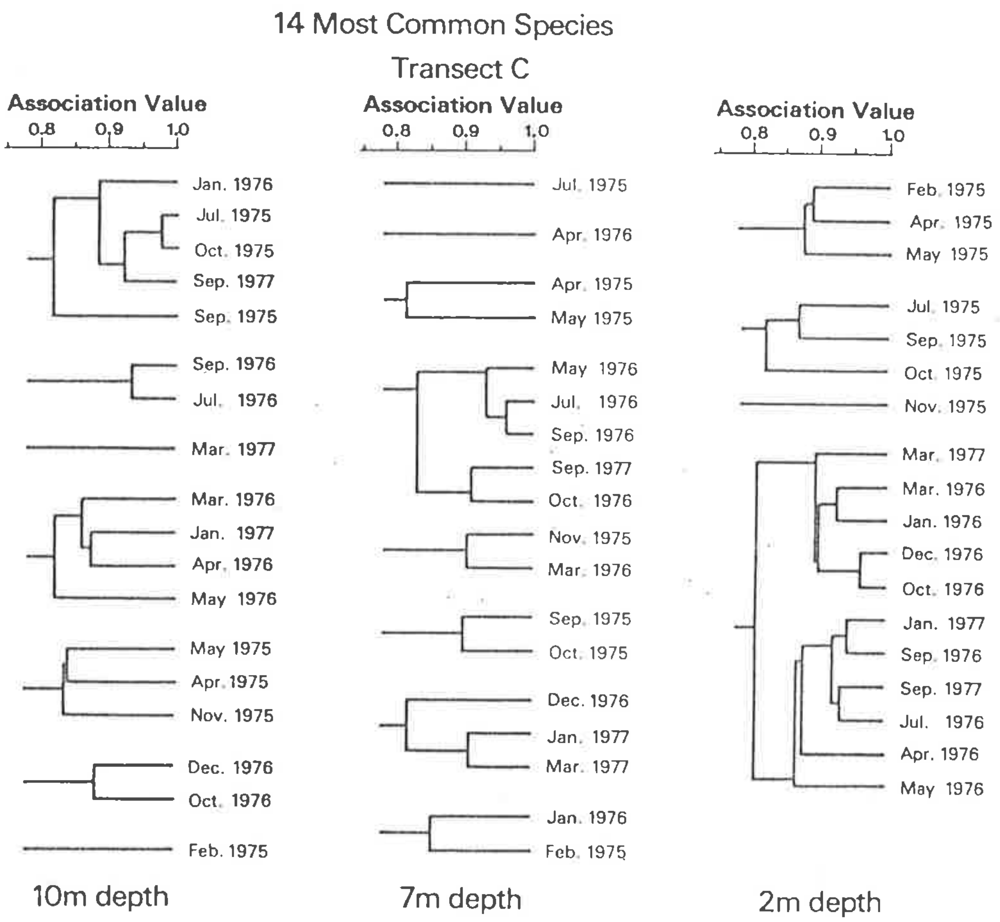

Fig. 108: Dendogram of cluster analysis of the association values for the 14 most common "erect" algal species of the epiphytic community for samples collected at 2 m, 7 m and 10 m depths on Transect C.

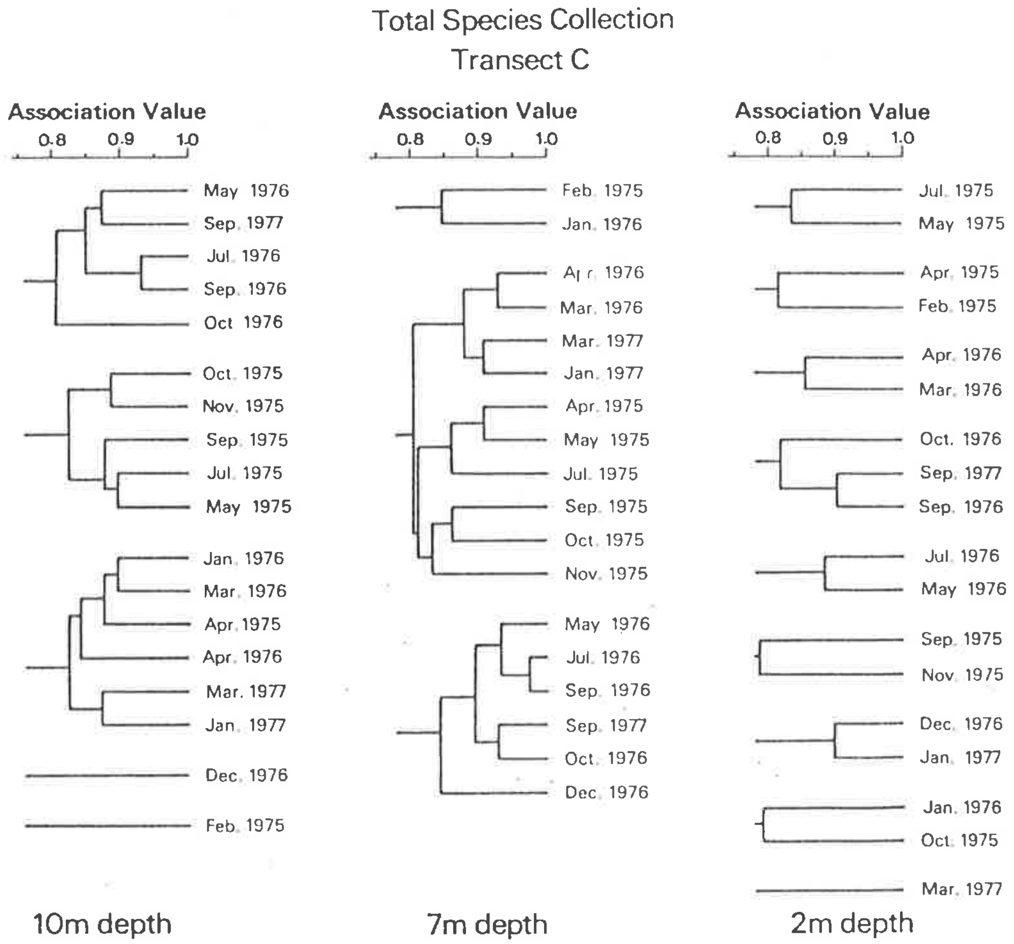

Fig. 109: Dendogram of cluster analysis of the association values for the "erect" algal species of the epiphytic community for samples collected at 2 m, 7 m and 10 m depths on Transect C.

July and September, 1975 were not included in the latter group. These same clusters were evident at the 10 m deep site (Fig. 107). These results showed that samples collected from the deeper sites in the same season but in different years were more likely to be similar than corresponding samples collected from the 2 m deep site.

The analyses of the association values of the community constituted by the 14 most common "erect" algal epiphyte species showed that at 2 m depth on the Transect C three clusterings occurred; a summer to autumn 1975 group, a winter through spring 1975 group and a grouping of all samples collected between January 1976 and September 1977. These results indicated that seasonal changes in the populations of the 14 most common species were not large enough to provide seasonal clusters. There was not a clustering of seasonal groups at 7 m depth (Fig. 108). At 10 m depth the three main clusters drawn were not within seasonal categories (Fig. 108).

The analyses of the association values of the algal epiphytic community constituted by 38 "erect" algal species or species groups did not provide evidence of seasonal clustering on the Transect C (Fig. 109).

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Thus the association values for the communities at 2 m depth, examined on the three transects A, B and C did not show any seasonal clusterings, although at the five remaining collection sites on these transects seasonal clusterings could be recognized within the analyses of the seasonal species in the epiphytic community. This suggested that at 2 m depth, seasonal changes in the environment were not indicated by corresponding regular changes in the seasonal species and therefore this feature would have to be taken into account in any future monitoring studies of the algal epiphytic community of *Posidonia sinuosa*, while at the deeper sites one may follow environmental changes by studying the changes in the seasonal epiphytic species.

The analyses of the association values for the occurrence of the 14 most common species in the samples and the analyses of the association values for a complete list of 38 algal species were carried out to provide an indication of the strength of the seasonal repetition in the structural changes of the algal epiphytic community. If repetition could be identified in these two analyses then the community would be a valuable tool by which to monitor environmental changes with a considerable decrease in the number of sampling occasions per year than undertaken in this study. Furthermore, if seasonal repetition of the changes was evident in both the most common species and the total community analyses, then there was a possibility that not all the "erect" algal epiphytic species changes would need to be recorded in a monitoring study. Consequently the time that would be required to record the parameters of this lesser number species in a monitoring study would also be decreased.

The analyses of the structural changes of the communities constituted by the 14 most common species showed seasonal clustering on the Transect B, 7 m deep site only. At the remaining collection sites the response of the six seasonal species within this common species group was masked by the irregular changes in frequency of the eight non-seasonal species within this group, and these results implied that a monitoring study would need to examine the total "erect" epiphytic community. The analyses of the 38 algal species or species groups of the "erect" epiphytic community did suggest that samples in a future monitoring study might not need to be collected as frequently as they were in this baseline study; this may be especially so on the Transects A and B at the 7 m and 10 m deep sites, because the masking effect of the non-seasonal species over the seasonal species was least at these sites.

CHAPTER NINE: CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY

Most of the "erect" algal epiphytes recorded on *Posidonia sinuosa* showed common morphological characters with species listed in studies on different seagrass species in Australia and in the northern hemisphere and many of the genera recorded in this study were in common with those recorded in other surveys of the algal epiphytes of seagrasses. These small, often filamentous and rapid growing algae are better adapted to carry out their life histories in or on the seagrass meadows than some other morphological types, e.g. kelps, large folious reds. The encrusting coralline and brown mat species were not examined in this study; however a study of these species would be likely to increase the number of algal epiphytic genera in common with other published surveys of seagrass epiphytes.

53 "erect" algal epiphytes of *P. sinuosa* were listed in this study and most of these species could be found on other plant hosts and/or on non-living substrata in the study areas. The presence of *P. sinuosa* presumably increased the surface on which they could grow and consequently increased their abundance in the study areas.

Species of Chlorophyta were only a minor component of the epiphytic community compared to species of the Phaeophyta and Rhodophyta.

Nearly any alga can be epiphytic for at least part of its life history as indicated by the presence of *Caulocystis uvifera* in its early stages of development on the leaf blades. The plants of this species observed on *P. sinuosa* were up to 1.5 cm high while plants growing on more solid substrate in the study areas were up to 60 cm high.

It is probable that some algal species exist as dwarf forms on *P. sinuosa*. Individuals of *Gloiosaccion brownii* on *P. sinuosa* were rarely greater than 1 cm high. These small plants were often fertile. Larger plants (up to 9 cm high) of this species were collected on non-living substrate in the study areas but most often were not fertile.

There was good correlation between presence and absence data (frequency) and density index values for most of the algal species. Frequency failed to indicate "algal blooms" and was limited in showing density changes in the populations of the most common species. However the morphology and growth of these small algae made the estimation of algal density very difficult. In terms of units of information gained per unit of effort spent, frequency was more precise and more valuable in this study. In future studies a more precise estimate of algal abundance, density and cover on the seagrass leaves could be obtained by using the point quadrat method, otherwise biomass (wet or dry weight) changes of the species may be a better indicator of population changes than the parameters used in this study.

Three major categories of algal epiphytes on *P. sinuosa* were identified in upper Spencer Gulf; the irregular transient or chance species, the non-seasonal species and the seasonal species. Two non-seasonal groups were present; firstly those species that formed a year round component of the epiphytic flora and secondly the species that were not a year round component and were irregular in their occurrence on the leaves. Four seasonal groups were differentiated during the study;

the summer,
the summer-autumn,
the autumn-winter, and
the summer-winter groups.

In some instances, e.g. *Centroceras clavulatum, Spyridia tasmanica, Laurencia forsteri, Ceramium shepherdii* and *Antithamnion divergens,* seasonal trends in species density or frequency were dependent on the locality and/or the depth of the sampling site. This study has emphasized the need to establish a series of permanent sampling sites to which one can return and collect samples on a regular basis.

Although there were differences in particular algal species densities and frequencies in the three study areas as well as differences in the seasonal trends of some species between study sites, overall there was adequate resemblance of species trends between sites A, B and C to suggest that these sites would provide a suitable network of stations for monitoring changes in the algal epiphytic community. 62% (21) of the 34 species/species groups showed the same seasonal cycles and depth distributions at study sites A, B and C, and with the baseline data collected in this study, site C could provide a valuable control site for monitoring changes in the algal epiphytes on *P. sinuosa* near Redcliff Point should an industrial complex be established in that area. A study of the effect of light intensity on algal spore settlement and development and also the water circulation patterns in upper Spencer Gulf would give a better understanding of the differences observed between the study sites.

This study also indicated that seasonal changes in the epiphytic community were more predictable at the 7 m and 10 m deep sites than at the 2 m deep sites. However a future biological monitoring programme would not only need to take this feature of the epiphytic community into consideration but also the situation of any industrial outfall.

Five algal epiphytes, *Sphacelaria* spp.,
Jania micrarthrodia
Herposiphonia sp. 1,
Polysiphonia decipiens and
Ceramium puberulum,

which were common all year round at the three study sites were nominated as possible indicator species. However some of the seasonal species may prove useful indicators during their season of occurrence or in some instances may indicate a man-made shift in seasonal occurrence. For example thermal effluent may cause an extended summer species season and a limited autumn-winter species season and if this did occur then species such as *Jeannerettia pedicellata, Protokützingia australasica, Giffordia mitchelliae, Asperococcus bullosus*, etc. would be valuable indicator species. Data on the presence of reproductive plants (collected in this study) of particular species may prove a useful tool for the indication of pollution in the Redcliff Point - Yatala Harbour area. Nevertheless co-ordinated laboratory and field programmes are required to examine which environmental factors control these species life cycles and to determine their susceptability to a range of liquid effluents and toxic materials to assess the species' values as indicator species in a marine monitoring programme.

The average height of the standing crop of *P. sinuosa* was estimated from the length of the 50 longest leaves at each study site. During the study the changes in the heights of the standing crop at the study sites did not appear to be significant although there were indications on Transects A and B that the average leaf blade length increased during spring and decreased during the following summer and autumn. A study of the leaf elongation rates of *P. sinuosa* during the different seasons with leaves of different ages should be undertaken.

During the study because of the sampling procedure and the examination of the community on only the distal one-third of the *Posidonia* leaf, it would be expected that there would be a delay between the time that spore settlement on new leaf areas occurred and the appearance of young plants being monitored in the collections. It was estimated that this delay could be four to five months. Investigations on both the *Posidonia* leaf elongation rate and the colonization and succession patterns of the algae on the *Posidonia* leaf blades would enable accurate assessment of this delay and a better understanding of the seasonal patterns in the algal species.

The "erect" algal epiphytic community at each collection site was characterized throughout the year by a few dominant species, each of which appropriated a substantial fraction of niche space, and several middle order subordinate species, which during the study showed seasonal alteration in the sharing of niche space.

The number of "erect" algal epiphyte species recorded in each collection at a particular site did not vary significantly throughout the study and this could be a valuable tool in future monitoring studies.

Many of the species were seasonal and analyses of these species indicated that these cycles were repetitive. However, analyses of the epiphytic community at each of the collection sites demonstrated that predictable seasonal repetition was masked by the irregular changes of the common non-seasonal species. These irregular changes in species e.g. *Jania micrarthrodia, Sphacelaria* spp. *Ceramium puberulum, Antithamnion divergens* etc. must be taken into account when designing a monitoring programme. The less common species, although individually not contributing significantly to the total abundance of the epiphytic community, were important in determining the community species composition in the different seasons.

This study showed that a monitoring study would be best based on examining the total "erect" epiphytic community rather than following the changes in the 14 most common epiphytic species, and a minimum of four collections per seasonal cycle would not enable the observer to determine if the differences in the communities are the result of a pollution source or a natural fluctuation. Therefore it is recommended that if a marine biological monitoring programme based on the algal epiphytic community of *Posidonia sinuosa* were established, several permanent sites in the appropriate areas and depths should be selected and sampled on at least a bimonthly basis.

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