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STUDIES ON ALGAL COMMUNITIES OF SÃO MIGUEL, AZORES

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To my students

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RESUMO

As comunidades litorais da zona das marés e da zona submersa adjacente (até à profundidade de 15m) de dois locais da ilha de São Miguel (São Roque, costa sul e São Vicente, costa norte) foram estudadas durante dois anos (Setembro 1993 a Setembro 1995). A metodologia de amostragem compreendeu a determinação dos padrões de zonação na zona das marés e recolhas qualitativas e quantitativas de amostras nas duas zonas estudadas. O trabalho laboratorial compreendeu triagem e preservação do material colectado, posterior determinação específica e elaboração de colecções de referência. As plantas foram observadas para avaliação do estado reprodutivo e de efeitos de herbivoria e determinaram-se os respectivos tamanho e biomassa. Os dados foram analisados recorrendo a vários métodos matemáticos, envolvendo comparações não-paramétricas, medidas de similaridade e dissimilaridade, análise multivariada e medidas de diversidade e riqueza específica.

Foram identificados 156 taxa, dos quais 9 não puderam ser completamente determinados. A flora algal dos Açores foi enriquecida em 29 novos registos, incluindo actualmente 336 species (52 Chlorophyta, 68 Phaeophyta e 216 Rhodophyta). Das espécies observadas merecem destaque *Codium fragile* e *Antithamnion diminuatum* (possíveis introduções recentes), *Endarachne binghamiae* (descrito originalmente para a Califórnia), *Ceramium circinatum* (novo registo para os Açores e nordeste Atlântico desta espécie mediterrânica), *Jania crassa* e *J. verrucosa* (cujo limite norte de distribuição foi alargado aos Açores) e *Coccotyus truncatus* e *Scagelia pylaisaei* (cujo limite sul se estende agora até aos Açores).

As algas estudadas apresentaram diferentes preferências ecológicas, algumas estando restritas à zona das marés, outras à zona submersa adjacente. Na zona das marés diagnosticaram-se vários nichos: a maioria das espécies foi encontrada nas rochas expostas, distribuindo-se verticalmente na costa de acordo com as respectivas preferências ecológicas; algumas foram encontradas exclusivamente em fendas e locais sombrios; outras ocorreram unicamente nas poças litorais.

Observaram-se variações sazonais na ocorrência, crescimento e/ou reprodução de um grande número de espécies. Algumas ocorreram todo o ano, e.g. *Enteromorpha muscoides*, enquanto outras foram observadas apenas numa ou duas estações do ano, e.g. *Taonia atomaria*. Em geral, no nível inferior da zona das marés e na zona submersa adjacente as maiores plantas e os valores mais elevados de biomassa ocorreram na Primavera e no Verão. A fenologia reprodutiva variou com as espécies: algumas apresentaram um longo período reprodutivo (e.g. *Plocamium cartilagineum*, fértil durante vários meses, e *Fucus spiralis*, fértil durante todo o ano); outras exibiram uma sazonalidade reprodutiva mais marcada (*Sargassum* em roseta tipo *hystrix* e *Jania verrucosa*, férteis no Verão, e *Chondracanthus acicularis*, fértil no Outono).

Em termos biogeográficos, a natureza mista da flora algal dos Açores foi comprovada por este estudo. Muitas espécies são euritérmicas, estando amplamente distribuídas no Atlântico Norte. Outras são estritamente temperadas, algumas delas encontrando nos Açores o seu limite sul, e.g. *Zanardinia prototypus*. Algumas são temperadas-quentes e/ou tropicais, tendo nos Açores o respectivo limite norte. De entre estas salientam-se as espécies macaronésicas *Codium elisabethae* e *Cystoseira abies-marina*. A primeira foi durante muito tempo considerada endémica para os Açores, mas foi recentemente encontrada no arquipélago da Madeira. A análise florística revelou grandes semelhanças com o nordeste Atlântico. A maior parte das espécies (92) é anfiatlântica (e.g. *Bryopsis hypnoides*), 35 só ocorrem no nordeste Atlântico e no Mediterrâneo (e.g. *Corallina elongata*), e 12 são exclusivas do nordeste Atlântico (e.g. *Rhodymenia holmesii*). Nenhuma das espécies é exclusiva do noroeste Atlântico. Dentro do arquipélago, não foram encontradas diferenças significativas quando se compararam as floras das ilhas de São Miguel, Faial e Flores.

Na zona das marés identificaram-se cinco níveis distintos, embora estivesse sempre presente um elevado grau de sobreposição entre eles. Os níveis superiores eram dominadas por litorinídeos e cracas, as populações algais formando os três níveis seguintes. A faixa algal superior era dominada pela associação *Fucus spiralis/Gelidium microdon*, seguindo-se as faixas dos povoamentos algais em forma de musgo e das algas frondosas. No nível superior da zona das marés o musgo era essencialmente monoespecífico e dominado por *Caulacanthus ustulatus*. No nível inferior o musgo era dominado por algas calcárias erectas, as comunidades de São Roque e de São Vicente diferindo entre si nas espécies acompanhantes. A maioria das espécies frondosas presentes no último nível (*Pterocladia*, *Asparagopsis*, etc.) encontrava-se também na zona submersa adjacente.

Na zona das marés estudaram-se as comunidades de *Caulacanthus* em São Roque, de *Fucus spiralis/Gelidium microdon* em São Vicente e de musgo multiespecífico em ambos os locais. Observou-se um padrão sazonal na evolução anual da biomassa nas quatro comunidades, as dos níveis superiores apresentando menores valores de biomassa no Verão, o oposto ocorrendo nas inferiores, cuja biomassa mais elevada foi observada no fim do Verão e princípio de Outono. Não foram detectadas diferenças significativas entre os dois anos, sugerindo comunidades relativamente estáveis, pelo menos a curto prazo.

Na zona submersa os povoamentos algais de ambos os locais apresentaram diferenças qualitativas e quantitativas em função do gradiente de profundidade. As análises efectuadas indicaram a ocorrência de duas comunidades em cada local (5 e 15m), separadas por uma larga zona de transição, a qual era mais distinta em São Roque. A comunidade dos 15m de São Roque foi a que apresentou maior número de espécies (58), a diversidade mínima ocorrendo na comunidade dos 5m do mesmo local (33 espécies). A evolução anual da biomassa não revelou sazonalidade nas comunidades de São Roque, mas em São Vicente os valores mais elevados de biomassa foram registados na Primavera e Verão. Embora se tenham observado variações nas comunidades entre os dois anos, não foram diagnosticadas diferenças significativas o que indica que, à semelhança da zona das marés, as comunidades são relativamente estáveis.

ABSTRACT

The Azores consists of an isolated group of islands in the North Atlantic, situated 1200 Km west of the Portuguese mainland coast. Their marine flora has not been intensively studied, although various preliminary surveys over the past 150 years have been made on different islands.

The benthic algal communities at two different sites, located on opposite coasts of São Miguel Island (São Roque in the south and São Vicente on the more exposed north coast), were studied over a two year period (September 1993-September 1995). At both sites, the littoral region was surveyed from the upper intertidal down to a depth of 15m in the adjoining sublittoral zone. Field methodology included the collection of samples from both intertidal and subtidal levels, and the determination of zonation patterns in the intertidal. Minimal areas for destructive sampling from both levels were assessed. Regular sampling was done by means of both qualitative and quantitative collections. Laboratory techniques included sorting and preservation of material for identification into species and the preparation of reference collections. The sizes of specimens were measured so as to give and indication of seasonality in growth and their reproductive status was noted. Biomass (standing crop) determinations were made from samples cleared from quadrats and then dried. The data were analysed using various mathematical methods, including non-parametric comparisons, measurements of similarity and dissimilarity, multivariate analyses, and measurements of species richness and diversity.

A total of 156 taxa was identified, including 9 which could not yet be fully determined. The present study added 29 new species records to the marine algal flora of the Azores, which totals now 336 species (52 Chlorophyta, 68 Phaeophyta and 216 Rhodophyta). Rare or noteworthy species included *Codium fragile* and *Antithamnion diminuatum* (possible introductions), *Endarachne binghamiae* (first described from California), *Ceramium circinatum* (new record for the Azores and the eastern N. Atlantic of this Mediterranean species), *Jania crassa* and *J. verrucosa* (northern limit of distribution) and *Coccotyus truncatus* and *Scagelia pylaisaei* (southern limit of distribution).

The algae studied showed different ecological preferences, some being restricted to the intertidal, while others were subtidal. In the intertidal, several niches were detected: most species occurred on open rocks, a few being restricted to the upper level; others were found only in shaded places, such as on crevices; some were strictly in tide pools.

Seasonal patterns were detected in the occurrence, growth, and reproduction of certain species. Some were present all year, e.g. *Enteromorpha muscoides*, while others were more seasonal in their appearance, e.g. *Taonia atomaria*. In general, the lower intertidal and sublittoral species were characterized by larger plants with higher biomass values in spring and summer. The reproductive phenology varied according to species. Some had an extensive fertile period, e.g. *Fucus*

spiralis which bore receptacles throughout the year. Other algae, such as *Plocamium cartilagineum*, had prolonged periods of fertility (up to several months), while a few were markedly seasonal in their reproduction (rosette *Sargassum* type *hystrix* and *Jania verrucosa* in summer; *Chondracanthus acicularis* in autumn).

The biogeographically mixed nature of the Azorean algal flora was confirmed by the present study. Most species seems to be eurythermal, having a wide distribution in the North Atlantic. Some of the species found show a more temperate distribution, with the Azores as their southern limit in distribution, e.g. *Zanardinia prototypus*. In contrast, a few algae can be regarded as warm temperate or tropical, with the Azores as their northern limit. Typical Macaronesian species are represented by *Codium elisabethae* and *Cystoseira abies-marina*. The former was formerly regarded as endemic to the Azores but has now been found in the Madeira archipelago. Floristic analyses reveal large similarities with the floras of the eastern Atlantic and Mediterranean. Most species (92) are amphi-Atlantic (e.g. *Bryopsis hypnoides*), 35 are only present in the eastern Atlantic and the Mediterranean (e.g. *Corallina elongata*), and 12 are exclusively from the eastern Atlantic (e.g. *Rhodymenia holmesii*). None of the species was exclusively from the western Atlantic. Within the archipelago, no significant differences were observed when comparing the seaweed flora recorded for the islands of São Miguel, Faial and Flores, which cover a longitudinal distance of approximately 520 Km.

The intertidal zonation survey revealed five distinct zones, although there was a variable degree of overlapping between them. The two upper zones were characterized by animals (littorinids and barnacles). Lower down, the algal populations formed three distinct belts: an upper *Fucus spiralis / Gelidium microdon* association; a more extensive turf zone; and a band featuring erect or frondose algae. In the upper eulittoral, the turf was mainly monospecific, being dominated by *Caulacanthus ustulatus*. The lower littoral turf was dominated by articulated coralline algae, the associated species differing between the two sites studied. Mainly erect algae (*Pterocladia, Asparagopsis*, etc.) occurred furthest down the shore and extended into the nearby shallow sublittoral.

Two intertidal communities were studied at each locality. The upper eulittoral turf (dominated by *Caulacanthus*) in São Roque and the *Fucus spiralis / Gelidium microdon* association at São Vicente, in addition to the lower littoral zone at both sites comprising the coralline turf, with its many associated species. These lower communities had a higher diversity. A general pattern was observed in the seasonal variation of biomass within the four intertidal communities sampled. In the upper ones the lowest standing crops occurred in summer whereas, for the lower zones, the greatest biomass values were measured in late summer/early autumn. No significant annual variations could be detected, indicating relatively stable communities, at least on a short-term basis.

In the subtidal, basic qualitative and quantitative differences were described at the two localities, revealing a depth-related gradient in species diversity and biomass. In general, red algae, such as corallines and *Pterocladia*, predominated in the shallow sublittoral (5m) while browns, e.g. *Zonaria* and *Stypocaulon*, were more abundant at 15m. Analyses indicated the existence at each study site of two communities (5 and 15m depths), separated by a large transition zone which was more distinct at São Roque. The 15m community at this site was the one with the largest number of species (58), the lowest diversity occurring within the 5m community at the same site (33 species). No clear pattern could be discerned in seasonal biomass changes for these communities, whereas at São Vicente, the highest biomass was recorded in spring/summer. Although variations were observed in the subtidal communities during the two years of sampling, no significant or major differences could be demonstrated, thus indicating, as with the intertidal communities, a relatively stable situation.

1. INTRODUCTION

1.1. Review of phycological studies in the Azores

In contrast to the marine fauna of the Azores, that has been studied since the 18th century (Adanson, 1757), the research in to the marine algae of the Azores began in the middle of the last century when Guthnick and the two Hochstetters, father and son, visited the Azores. They arrived in April 1838 and between that date and the beginning of August visited São Miguel, Terceira, Faial, Flores, Corvo and Pico. This expedition produced several publications on the vegetation of the Azores but the first mentioning marine algae was Mauricius Seubert's "Flora Azorica, Quan ex collectionibus schedisque Hochstetteri patris et filii", published in 1844, which included a list of 44 species of marine algae collected by the Hochstetters. This work constitutes a starting point for the marine flora of these islands, although no indication of the locality on the islands where the seaweeds were collected, or their abundance, was given.

Two years later, Carew Hunt, in his work "A description of the island of St. Michael (Azores)", mentioned Seubert's "Flora Azorica", and noted two species of marine algae, one of them already having been mentioned by Seubert.

In 1857 Henri Drouët visited the Azores. In his "Catalogue de la Flore des îles Açores precédé de l'itinéraire d'un voyage dan cet archipel", published in 1866, he listed 48 species of marine algae, but comparison with Seubert's list shows that they are the same, with the addition of four new records, for which he also did not give the locality.

Later, G. Agardh visited the island of Santa Maria as a member of the Corvette Josephine expedition. In his work "Om de under Korvetten Josephine's expedition, sistliden sommer, insamlede Algerne" published on 1870, he enumerated 46 species collected in Santa Maria; 23 of these were not listed by Seubert (1844).

In 1889, Antonio Piccone published "Alghe della Crociera del Corsaro alle Azzorre". He reported 27 species collected from 50 different localities by Captain Enrico D'Albertis. Among these, 15 were mentioned for the first time, while some were dredged from considerable depths (e.g. *Carpomitra cabrera*, 90 m depth, off Formigas islets). Recently, Prud'homme van Reine *et al.* (1994) have reinvestigated the Macaronesian seaweeds studied by Piccone. They made many nomenclatural changes and as a result seven taxa were newly recorded for Macaronesia and thirty have been deleted from the Catalogue of the Macaronesian marine algae.

A few years later, in 1896, William Trelease, the Director of the Botanical Garden of Missouri, USA, visited the Azores. His work "Botanical observations on the Azores", published in 1897, although making only a few additions to the known species, gave an indication for the known distribution of several species on the islands. He stated that the marine algal flora, though unquestionably small, would doubtless be increased considerably by collections carried out over the entire year.

In 1904, Alfredo Sampaio in his book "Memória sobre a Ilha Terceira", dedicated to his father, the physician Dr. José Nogueira Sampaio, presented a good review of the botanical work done on Terceira island incorporating a list of all plants recorded for the Azores, including marine algae, and indicating the authors responsible for each species. Some of these species had been identified by Dr. Nogueira Sampaio himself.

During the Campagnes of S.A.S. le Prince de Monaco, Louis Gain visited the Azores and on his work "Algues provenant des campagnes de l'Hirondelle II (1911-1912)" published in 1914, he listed the species of marine algae collected on those expeditions to the archipelagos of Azores and Madeira. The Azorean material was collected on the islands of Flores and São Miguel.

The German botanist Otto Christian Schmidt visited the islands of São Miguel, Terceira and Faial in 1928 and produced a comprehensive work on the littoral algal flora of each island. In his first works (Schmidt, 1929a, 1929b, 1929c), he listed a few algal species with the descriptions of their morphology and distinctive characteristics. In his final work (Schmidt, 1931), he presented a review of the earlier algal studies on the Azores, and compiled a list of species with their respective descriptions. He also analysed the algal associations which he had identified throughout the archipelago (2 supralittoral, 17 littoral and 5 sublittoral). This was, until recently, the most comprehensive study of the Azorean algae, on which Schmidt recorded 193 species (30 Chlorophyta, 32 Phaeophyta, 77 Rhodophyta) and described nine endemic species, five Chlorophyta (*Bryopsis penicillata*, *Cladophora michaelensis*, *Cladophora theotonii*, *Cladophora weizenbauri*, *Codium elisabethae*) and four Rhodophyta (*Lithophyllum azorum*, *Lithophyllum bipartitum*, *Polysiphonia azorica*, *Polysiphonia hochstetteriana*). Most of these have never been subsequently recorded. *C. elisabethae* has been referred in several publications, but is no longer considered endemic, because it was recently recorded for Porto Santo, Madeira archipelago (Audiffred & Prud'homme van Reine, 1985; Prud'homme van Reine, 1988).

The eminent French phycologist, Jean Feldmann (1946), based on Schmidt's list of species, assessed the biogeographical affinities of various North Atlantic islands. He stated that the marine algae of the Azores showed an overall affinity with the Mediterranean and Europe, but also contained a tropical component.

In 1955, Chapman published the paper "Aspects of the fauna and flora of the Azores. VI. The density of animal life in the coralline alga zone", where the ecological role of the coralline turf on the Azorean coasts was discussed for the first time. Later, with the aim of investigating plant-animal interactions, Marques (1984) studied the effects of the sea-urchin *Arbacia lixula* (L.) on algal communities of São Miguel and Graciosa.

Palminha (1957) has visited several islands of the archipelago and only added the occurrence of *Lithophyllum tortuosum* (Esper.) Foslie (= *Tenarea tortuosa* (Esper.) Lem.) to Schmidt's list (q.v.). He also gave information on the vertical distribution of the seaweeds on the intertidal of Madalena do Pico, but made no comments on Schmidt's species associations.

The Queen Mary College (London) organized a general marine biological survey in 1957 to several islands of the Azores. The results were never published in the scientific literature but only as a report which is not easily obtainable.

Two years later, Larkum visited Terceira island as a member of the "Azores Expedition 1959" of the Imperial College of Science and Technology, London. During this expedition, a comprehensive collection of marine algae was made, both from the intertidal and sublittoral. Zonation studies were carried out on the seaweeds. In the report published in 1960, Larkum listed 60 species of marine algae, including three of the endemic species given previously by Schmidt (1931), *Cladophora weizenbauri*, *Codium elisabethae* and *Polysiphonia hochstetteriana*, and seven new records for the Azores.

In 1965, the Chelsea College of Science and Technology, University of London, sent an expedition to the island of São Jorge. James Pryor was the student marine botanist of this expedition and in his report (1967b), he presented a list of species, including one new record for the Azores (*Cordylecladia erecta*), and observations on the intertidal seaweed zonation. Two years later, another expedition from the same College visited the island of Flores. In his preliminary report Pryor (1967a) made some general comments on the littoral zonation and the algal exploitation for the agar industry. No species were listed.

A few years later, the French phycologists Ardré, Boudouresque and Cabioch presented some zonation observations for the Azores in general (Ardré *et al.*, 1973). Their paper was the result of the mission "Biaçores", organized by the Natural History Museum of Paris. In this survey, held in 1971, the oceanographic ship "Jean Charcot" visited the islands of Santa Maria, São Miguel, Terceira, Graciosa, São Jorge, Faial, Flores, the islets of Formigas and the sea mounts of D. João de Castro and Princesa Alice.

With the development of the agar industry on the Azores (São Miguel and Terceira), several studies concentrated on the agarophyte red alga *Pterocladia capillacea* (S. G. Gmel.) Bornet et Thur. were undertaken. The first was carried out by Silva, Veiguinha and Martins (Silva *et al.*, 1969), who evaluated the algological possibilities of the Azores and Madeira archipelagos. Later, in the late 1970's, Richard Fralick from Plymouth State College, New Hampshire, USA, visited the archipelago several times, and spent one year on Terceira island. From his work several reports and papers were produced (Fralick, 1977, 1978, 1980; Fralick & Andrade, 1981; Fralick *et al.*, 1990a). Later, Santos and Duarte (1991) included the Azores on their article "Marine plant harvest in Portugal".

The taxonomic studies continued (Ardré *et al.*, 1974; Fralick *et al.*, 1985; Neto, 1989, 1991a, 1992b; Bullock *et al.*, 1990; Fralick & Hehre, 1990; Neto & Baldwin, 1990; Neto *et al.*, 1991; Fredericq *et al.*, 1992; Gil-Rodríguez & Haroun, 1992; Athanasiadis & Tittley, 1994) but ecological investigations, describing benthic marine algal communities structure and zonation, were also initiated. In São Miguel, Castro and Viegas (1987), Hawkins *et al.* (1990) and Neto (1991b, 1992a) studied the zonation patterns of littoral organisms at different locations around the island. Neto and Azevedo (1990) studied the intertidal zonation at two sites on the island of Flores. This work was continued more recently in collaboration with two English workers, Ian Tittley and William Farnham (Tittley *et al.*, in press).

Neto (1994), on her checklist of the Azorean benthic marine algae, brought together the existing published information and provided distributional records within the archipelago.

More recently, Tittley and Neto (1994, 1995), and Neto and Tittley (1995) studied the algal flora and the zonation of the Monte da Guia Nature Reserve in Faial.

I firstly became interested in the marine algae of the Azores when beginning to teach at Universidade dos Açores in 1987. From my initial work on the inventory of the seaweeds of several islands (Neto, 1989; Neto & Baldwin, 1990), followed by a preliminary work on the physiological ecology of *Pterocladia capillacea* (Fralick *et al.*, 1990), I developed an interest in the general seaweed assemblages on these islands and established that there were many ecological and taxonomic problems to be investigated. This thesis reports the results of the first detailed investigation into the Azorean marine algal communities, carried out over a continuous two year period, in contrast to the previous one-off expeditions discussed above.

1.2. Aims of the present study

The general objective of the present thesis is to produce a description and ecological survey of two littoral communities, from the upper littoral to the sublittoral down to 15m depth. This is the first study concerning the ecology and dynamics of algal communities over a continuous two year period.

The specific objectives are:

1. To produce the inventory of the marine algae of those communities.
2. To compare the studied algal flora with the flora of other locations elsewhere in the Atlantic.
3. To determine the habitats of the studied species.
4. To analyse the growth patterns in terms of biomass and size, and the reproductive phenology of the dominant species, comparing the results with other obtained elsewhere on the Atlantic.
5. To survey seasonal properties of the Azorean seaweed flora.
6. To study the intertidal zonation patterns, with comparisons between the two places.
7. To analyse the structure, organization and dynamics of the intertidal and subtidal communities, over the two year period, and to conclude about their stability.
8. To identify and summarize future research priorities on the Azorean littoral communities dominated by macroalgae.

2. OVERVIEW OF THE GEOGRAPHY AND OCEANOGRAPHY OF THE AZORES

The archipelago of the Azores is located roughly between the coordinates 37° to 40°N and 25° to 31°W (Fig. 1) and occupies an area of approximately 2344 km^2 along a tectonic zone running WNW-ESE. It includes nine volcanic islands and several small islets, which are organized into three separate groups (eastern or oriental, central and western or occidental).

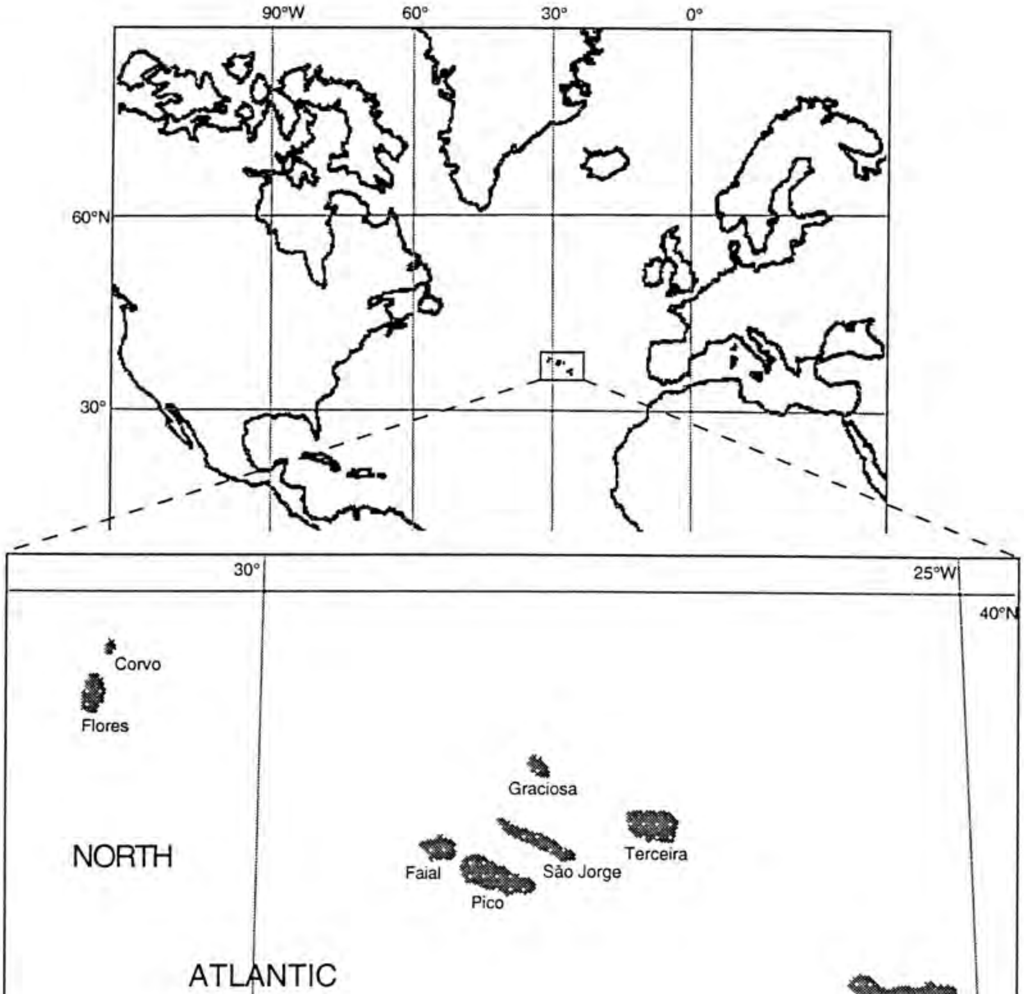


Fig. 1. The Azores and its location on the North Atlantic.

2.1. The islands

The islands we know today arose from the depth of the ocean at different times, essentially through volcanic activity due to tectonic movements. The archipelago lies over two tectonic plates in the Mid-Atlantic Rift. Flores and Corvo lie on the American plate. All the other islands are located on the Azorean microplate. This is a small, active tectonic and volcanic triangular enclave that lies at the triple junction of the Euro-Asian, African and American plates (Forjaz, 1986; Madeira & Ribeiro, 1990), at approximately 2000 m depth (Needhamn & Francheteau, 1974).

The archipelago lies on the middle of the northeastern Atlantic, within the warm temperate region, receiving the influence of masses of air with tropical, temperate cold and even polar characteristics. Due to its location away from any continent, its climate is highly influenced by the ocean, which is an important and permanent source of humidity (Brito, 1955; Rouch, 1966-67; Bettencourt, 1979; Instituto Hidrográfico, 1981). The Gulf Stream also influences the climate, mainly by acting as a barrier against the cold currents from the North (Fernandes, 1985).

All islands are characterized by high rainfall, the mean values of rain being higher than 900 mm at sea level, and decreasing from the western to the eastern group. Relative humidity is always high, usually varying between 70 to 80%, often reaching 90% (Fernandes, 1985).

Monthly mean values of air temperature show a regular annual variation with a maximum (22/23°C) in summer and a minimum (13/14°C) in February/March (Ricardo *et al.*, 1977; Instituto Hidrográfico, 1981).

The islands are exposed to strong winds which blow frequently from the east and from the west (Chapman, 1954; Instituto Hidrográfico, 1981), the strongest being the ones from the SW (Fernandes, 1985). According to Fernandes (1985), the winds from SW, W and NW are dominant in the eastern and central groups, while in the western group there is a greater influence of the winds from SE, E and NE.

All the islands are formed by volcanic rocks (mainly basalt) and surrounded by very deep water. The oldest rocks on the easternmost island of Santa Maria have been dated to the Miocene, c. 10 to 8 million years ago (Abdel-Monem *et al.*, 1975; Féraud *et al.*, 1980; see also Wilson, 1963). Since then, the islands have been in continuous formation as the result of the volcanic activity of the Mid-Atlantic Ridge. Thus each island is a mosaic of different ages. The youngest rocks are less than 40 years old (e.g. Capelinhos on the island of Faial) with most islands being between 3 and < 1 million years (Azevedo *et al.*, 1991). There are also various seamounts, including subsided islands (Ryall *et al.*, 1983; Lambeck, 1984).

Sedimentary rocks are only known in Santa Maria and the islets of Formigas. The view is held that such Miocene sediments extend at depth under all the island, and indeed Agostinho (1937) believed that at a greater depths such rocks were present in all the archipelago. In Santa Maria, these rocks are chiefly exposed along coastal sections and up valleys. Principal constituents are limestones, breccias, sandstones, conglomerates and tuffs (Mitchell-Thomé, 1976). The limestones have been classified by Berthois (1953), and among them is worth considering: the limestones having calcareous cement and rare organisms, but including *Lithothamnium*; the limestones exclusively organic having fragments of *Lithothamnium*; and the limestones with isotropic cementation, in which coccoliths and sporangia of Dasycladaceae occur. The presence of calcareous algae and Bryozoa in most samples indicates a littoral deposit in waters not exceeding 40 m in depth (Mitchell-Thomé, 1976).

The coastline of all the islands is extremely rugged owing to the their recent volcanic formation. In many places the coast consists of high cliffs falling directly into the sea while in others the shoreline is composed of large irregular rock masses. The more vesicular rocks provide a large number of irregular crevices of different sizes which harbour a considerable fauna and which provide a good substratum for the attachment of algae. The less vesicular types are more dependent on the algal growth for the retention of its fauna (Santos *et al.*, 1994). Certain shores consist of a layer of rounded boulders between which coarse sand or gravel may be retained. Sandy shores are few in number. A depth of 1000 m may occur within a mile or two off shore, mainly in zones with a steep slope. Most shores are subject to swell and surge. Few shores are sheltered, except for some bays and harbours.

Tides are semi-diurnal and tidal range is less than 2 m, even at extreme neap tides. For São Miguel the maximum tidal difference recorded was 1.89 m, the mean values being 0.65 m in neap tides and 1.44 m in spring tides (Instituto Hidrográfico, 1981). Even during summer, long swells generated faraway frequently reach the islands and break upon the shore. Extremely heavy seas occur during winter.

The marine environment of the archipelago and of its surrounding Economic Exclusive Zone (EEZ), of more than 1 million square kilometres, is of considerable conservation and marine biological interest, in large part due to its isolated position in the middle of the northeastern Atlantic and to the recent age of the islands.

2.2. São Miguel Island

The island of São Miguel, with approximately 750 km2, is the largest of the archipelago. Its formation followed a series of volcanic events, different parts of the island having a different age. The oldest portion (4 M years old) is the eastern side, Nordeste, where the highest mountain of the island (Pico da Vara, 1103 m) is located. The island was then progressively formed to the west: Povoação (2 M years); Furnas (750.000 years); Serra de Água de Pau (250.000 years). An island, now forming the Sete Cidades complex, appeared 500.000 years ago, and only later (50.000 years ago) was connected to Serra de Água de Pau through the Serra Gorda and its succeeding line of peaks (Zbyszewski *et al.*, 1958; Zbyszewski & Ferreira, 1959; Martins, 1993).

The coastline, mainly of high, steep cliffs with a variety of stack, arch and gully formations, is about 155 Km in length and is mostly of difficult access by land. Although seashores are generally steeply slopping, there are places where depths of less than 30 m extend several hundred metres offshore.

The wave action is known to be stronger on north coast and responsible for the higher erosion that occurs there. The strong storms are always from west, the north coast being more influenced by waves coming from the northwest, the south by waves with a southwest provenance (Borges, 1995).

The maximum tidal difference recorded in São Miguel was 1.89 m, the mean values being

0.65 m during neap tides and 1.44 m for spring tides (Instituto Hidrográfico, 1981).

The temperature of the water surrounding the island varies between 13 and 25°C at surface, the minimum values occurring in March, the maximum in August/September (Instituto Hidrográfico, 1981). In the present study meteorological information was obtained for the years 1993-5 from Instituto Nacional de Metereologia e Geofísica (INMG). The mean monthly values of the seawater temperature were minimum (15/16°C) in February/ March and maximum (22/23°C) in August/September (Fig. 2).

The daily mean hours of bright sunshine are minimum in December and maximum in June/ July (Bettencourt, 1979). In the period from 1993 to 1995 the minimum values (2.9/3 h) occurred in winter (December to February) and the maximum (7.9/8 h) in summer (July/August, Fig. 3).

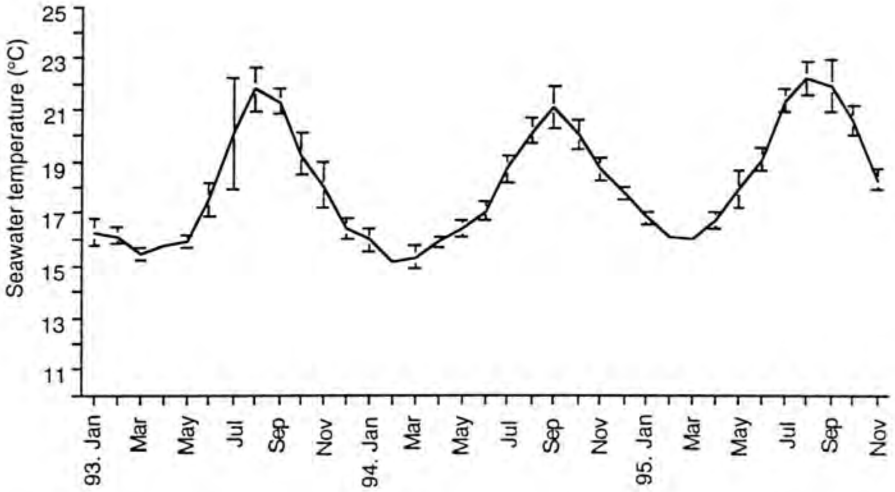


Fig. 2. Mean monthly values (± standard deviation) of the surface seawater temperature in São Miguel.

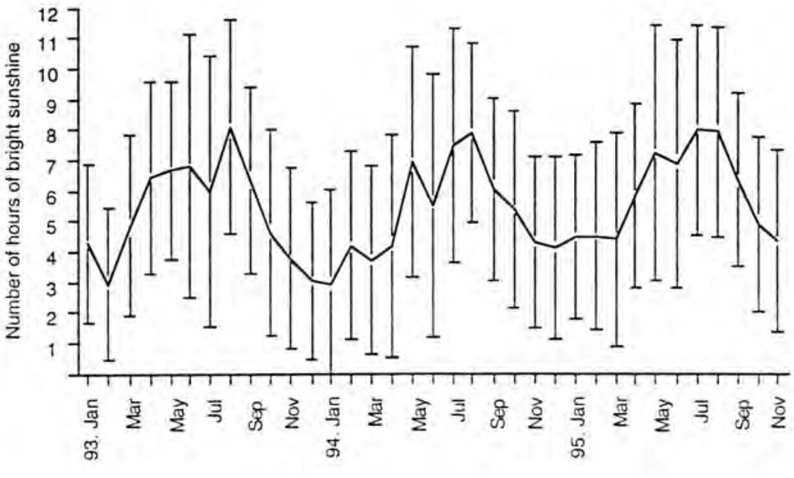


Fig. 3. Mean monthly number (± standard deviation) of hours of bright sunshine in São Miguel.

2.3. Ocean currents

The Azores are influenced by the oceanic circulation system predominating on the North Atlantic (Fig. 4), which includes a gyre that flows to the north, on the western side, with an intense thin jet (the Gulf Stream), and to the south, on the central/eastern side, with a multibranched current system. The Gulf Stream transports very efficiently warm water of equatorial and tropical origin into the colder northern waters (Kleine & Siedler, 1989). These currents pattern result in the high salinity, high temperature and low nutrient regime which typifies the Azores. During winter a deep mixed layer is present around 150m and in summer a seasonal thermocline develops around 40 to 100 m (Santos *et al.*, 1994).

The Gulf Stream is also the source of many instability processes, meanders and eddies. The situation becomes particularly complicated when this current leaves the North American coast, at about 40° to 45°N, towards the central zone of the North Atlantic where the Azores are located (Crease *et al.*, 1985; Gould, 1985; Kleine & Siedler, 1989).

Even when considering the means for the summer months during the past 42 years, the complexity of the current system that surrounds the Azores is remarkable (Santos *et al.*, 1994). The Gulf Stream splits into two branches, the North Atlantic Current (NAC) and the Azores Current (AC). This splitting of the Gulf Stream into two branches has long been recognized (Iselin, 1963). The origin of the Azores Current is found to be in the transition region between the Gulf Stream and the North Atlantic Current near the southeastern Newfoundland Rise (Kleine & Siedler, 1989). Each of those branches also divide into further branches, the NAC ones influencing more the northern part of the Azores, the AC ones having greater influence on the southern part. The AC influences also the Canaries and Madeira Currents (CC, MC). This general pattern changes over the year. The general regime is from the west to the east but there is a clear seasonal oscillation of the mean direction, with periods where NAC (coming from northwest) dominates and periods where AC (coming from the southwest) has a stronger influence (Santos *et al.*, 1994).

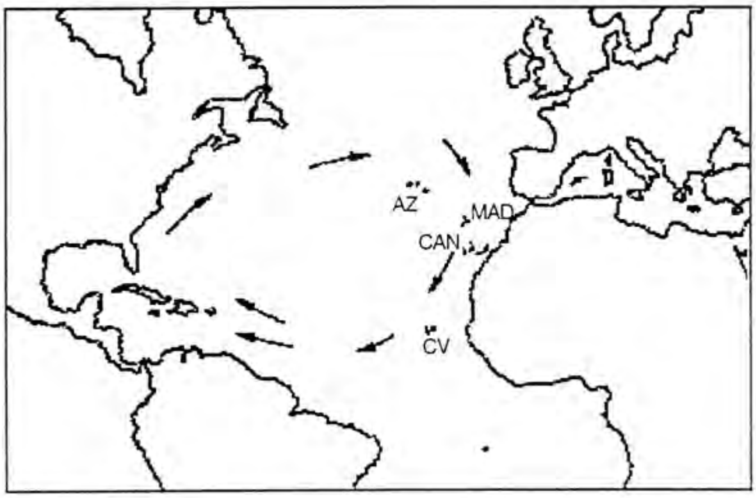


Fig. 4. Dominant currents of the North Atlantic gyre. AZ: Azores; CAN: Canaries; CV: Cape Verde; MAD: Madeira.

3. METHODS

3.1 Study sites

Most of the coast around the island of São Miguel is very steep (Brito, 1955), but in some places there are attractive bays with both cobblestones and bedrock. Two sites were selected on the open coast of São Miguel, one on the south coast (Rosto Cão, São Roque) and another one on the north coast (Poços, São Vicente), in places where the rocky shore showed a rather uniform aspect. Both sites were located within bays enclosing relatively shallow waters, permitting easy access for shore work and for diving, and are opposite to each other on the island (Fig. 5).

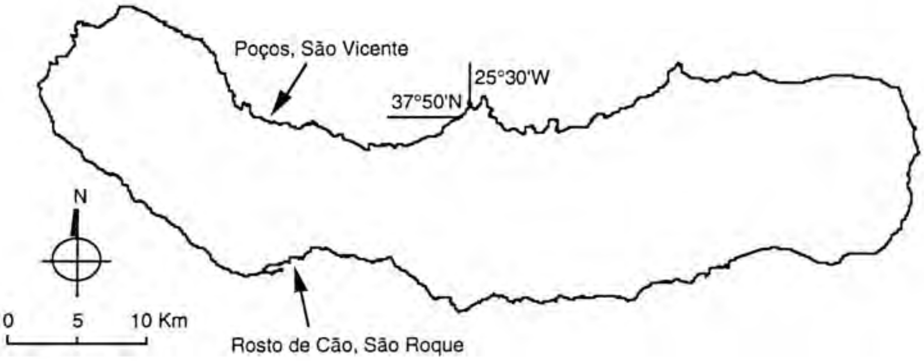


Fig. 5 Location of the study sites on the island of São Miguel

Rosto de Cão, São Roque

This is a small bay (Plate I.1) located on the South of the island, lying between the islet of the same name (to the east) and Baía de Belém (to the west). The intertidal zone is characterized by a compact bedrock of hard basaltic rock, steeply sloping, that continues subtidally. At this level, some patches of sand overlaid by large boulders and cobbles can be found.

Poços, São Vicente

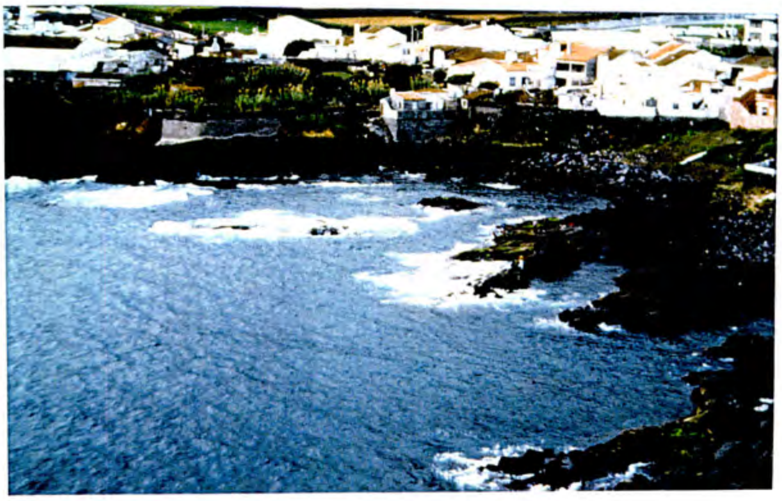
This site is a larger bay (Plate I.2) on the North of the island, which was very important in the old days (18th and 19th centuries) when hunting sperm whales was a common activity on the island. The slipway running down the intertidal zone was built so as to enable whales to be hauled up to the factory, which lies at the top of the harbour. Today this area is simply used as a small fishing harbour.

The intertidal zone to the east side of the slipway is steeply sloping and dominated by large cobbles and boulders. On the west side, there is gently sloping bedrock of hard basaltic rock, succeeded to the west by another large area of cobble rocks. The bedrock extends into the water, forming a reef that goes out until approximately 300 m off the shore. The very top of this reef stays emmersed during low tide periods, but can only be visited by boat on calm days, as it is divided by many channels of turbulent water.

Plate I 1. General view of the Bay of São Roque, south coast of São Miguel.

2. General view of the Bay of São Vicente, north coast of São Miguel.

3. Method used for the intertidal qualitative collections.



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Subtidally, large boulders are dominant but again there are some relatively extensive areas of bedrock, interspersed with many patches of sand.

3.2 Field methods

Work was undertaken in the period between September 1993 to September 1995. Both intertidal and subtidal levels were surveyed monthly.

The field methodology involved the assessment of the intertidal zonation patterns on both coasts, together with destructive collections at both levels, intertidal and subtidal. These were done by qualitative and quantitative means, the later involving the assessment of the minimal sampling area, in order to obtain representative collections with the minimum destructive impact on the communities being studied.

3.2.1 Intertidal level

3.2.1.1 Determination of the zonation patterns

For studies made in an area of changing vegetation, such as the intertidal zone, a line transect is usually the best choice (Dawes, 1981).

At each site a permanent transect, perpendicular to the coast, was laid down from a benchmark established above the highest point where living marine organisms (such as littorinids) occurred down to the lowest water level, in a continuous belt. Elevations along the transect were determined relative to a known intertidal benchmark of known elevation, following the spirit levelling method (Emery, 1961; Dawes, 1981; Hawkins & Jones, 1992). Two graduated poles of two meters in length, each one having an attached spirit level, were placed at the two places to be levelled, making a right angle. The horizontal distance between the two points was read on the horizontal pole; the elevation was read on the vertical pole (Fig. 6).

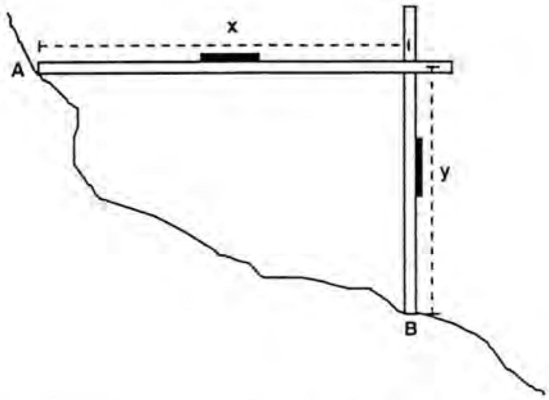


Fig. 6. Schematic representation of the spirit leveling method of Emery (1961): x and y are, respectively the horizontal and vertical distances between points A and B.

All elevations were related to Chart Datum, Azores (CD), by using the level of the sea at the time of predicted low water. Considering the presence of residual swell even on calm days and the simplicity of the method used, the elevations are only approximate (± 0.1 m). A detailed description of the profile was made and the dimensions assessed. Every zone distinguishable *in situ* was described, ranging from the lowest zone emerging during the deepest wave troughs up to the zone above which no macroscopic marine organisms were present.

The following standard levels were used within the transect: mean low tide level (MLTL), and mean high tide level (MHTL).

A profile of each station was drawn and the vertical distribution of the main organisms recorded along it.

Motile animals were counted individually and the areal cover-abundance of barnacles and each algal species was estimated along the transect in a continuous belt, using a 0.25 m2 quadrat marked with 36 dots, following the methods described by Hawkins and Jones (1992) and Meese and Tomich (1992). According to Thomas (1985), areal coverage of species is a good index of their importance, specially where communities are essentially unstratified, consisting of algal turfs, encrusting species and invertebrates, which are mostly small and sedentary or slow moving. The area of 0.25 m^2 was used, following previous ecological works on the Azorean shores with which I have been involved (see Hawkins *et al.*, 1990; Neto & Tittley, 1995 on Faial; Tittley *et al.*, in press on Flores). It was decided to make the quadrat readings in a continuous belt along the line, so as to be able to identify the extent of overlap between the different populations in adjacent zones.

3.2.1.2 Assessment of sampling area

The littoral region of the Azorean shores is, as a result of the small tidal range, very reduced in extent (with few exceptions e.g. Lajes do Pico Bay), and characterized by a large overlap between populations (see Neto, 1991b, 1992a). Despite the pronounced zonation, most algal zones are very narrow. Large quadrats therefore cannot be used.

Two zones were chosen, the upper and lower eulittoral, and for each one the minimal area to be scrapped was determined. Six scrapings of 100 cm^2 (10x10 cm quadrat) were made at each level and the data analysed. The upper level had low diversity and one quadrat covered all the species. For the lower eulittoral, the relationship between the number of species and the area was established, according to Margaleff (1974), Saldanha (1974), Goldsmith and Harrison (1976), Coppejans (1980), and Vallmitjana (1987). The species/area curve (Fig. 7) became more or less horizontal at a sample size of two quadrats of 100 cm^2.

Owing to the limited extension of the intertidal and considering the sites were going to be surveyed for a period of two years, it was decided to adopt as sampling area only one quadrat of 100 cm^2, as for the upper level. This area represents the minimal area for the intertidal quantitative collections that causes less negative impact on the communities. The same area was subsequently used by Tittley *et al.* (in press) for similar studies on Flores. Three replicates for each sample were taken to allow a representative sampling and statistical analyses.

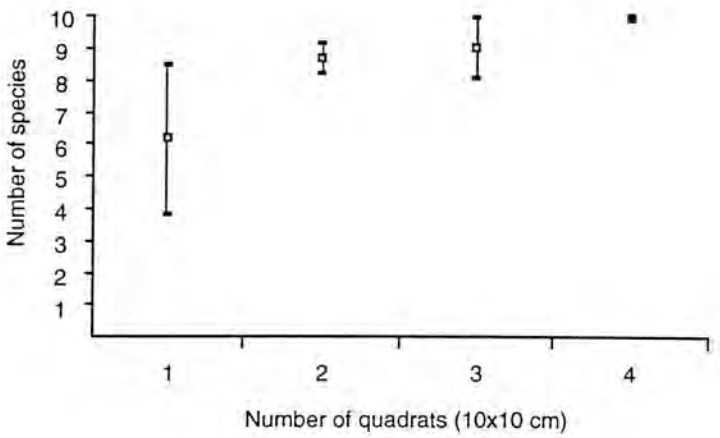


Fig. 7. Species/area relationship for the lower eulittoral communities.

3.2.1.3 Collection of samples

For the qualitative collections, specimens of each species were collected from the entire intertidal zone into labelled bags (Plate I.3). The position and habitat of the species on the shore (substratum, tide pool, open rock, crevice) were noted.

For the quantitative collections, samples of the predetermined area (100 cm2) were scraped using a chisel into labelled mesh bags. The collections were made from the two major algal zones and three replicates were taken within each zone. The location of each quadrat was determined by reading from a table of random numbers two series of numbers, one for the direction (E/W) and the other for the distance (up to 100 cm). All the replicates were made along an horizontal row, owing to the narrowness of the zones surveyed.

3.2.2 Subtidal level

3.2.2.1 Assessment of minimal area

Until this investigation, no quantitative study of the subtidal algal communities in the Azores had been made. Neto and Tittley (1995) carried out a preliminary survey of the subtidal populations of Monte da Guia nature reserve but their survey was based on the collections made for studying micro-invertebrate phytal communities. For the purpose of the present study and limited by the available equipment, it was decided not to go deeper than 15m. This was the deepest zone with rock substratum and conspicuous algal populations at the south coast site. On the north site algae grow deeper than 40 m.

The minimal area to be sampled by scraping was obtained by determining the relationships between (1) the number of species/area and (2) biomass/area. Twelve scrapings of 625 cm2 (25x25 cm quadrat) were made at the 15m depth level in São Vicente, and the data analysed.

(1) The species/area method of minimal area assessment followed Margaleff (1974), Saldanha

(1974), Goldsmith and Harrison (1976), Coppejans (1980), and Vallmitjana (1987). The species/area curve is shown in Figure 8. The number of species increases with total quadrat area but then levels off (as expected, see Braun-Blanquet,1932; Krebs, 1989). From Figure 8, it can be seen that the curve becames more or less horizontal at a sample size of four quadrats. This was taken as the minimal area for the studied communities.

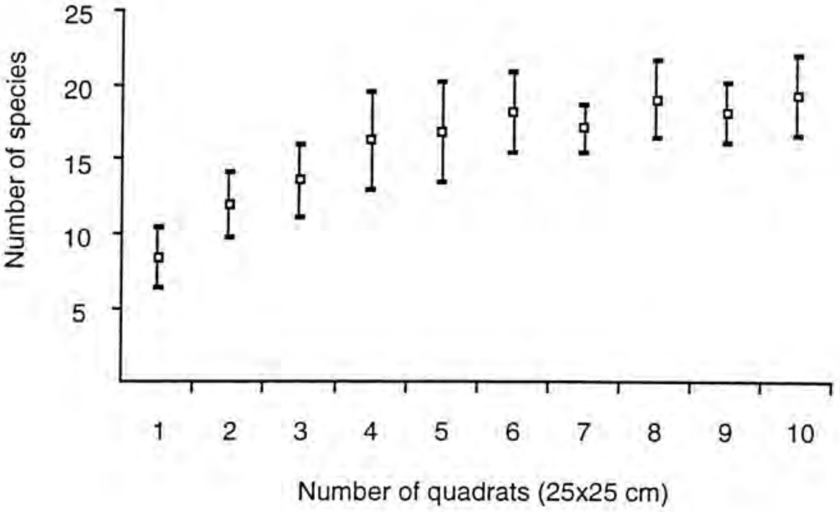


Fig. 8. Species/area relationship for the subtidal communities.

(2) To assess the minimal area based on the species biomass/area relationship, the method of Bellan-Santini (1969), and Sierra and Férnandez (1984), was followed. This method uses as a stabilization criterion the maintenance of the coefficient of variation close to 10%. This coefficient (CV) is simply the standard deviation expressed as a percentage of the mean (Sokal & Rohlf,1995):

$$CV = \frac{100sd}{\bar{x}},$$

where $\bar{x}$ is the mean biomass of the samples considered and *sd* the standard deviation of those samples.

The relation biomass/area followed a linear pattern but the coefficient of variation decreased rapidly and begun stabilizing around the 10% value for a total area provided by 3 to 5 scraped samples (Fig. 9).

It was decided to use as minimal area 2500 cm2 (4x625 cm2), as it was also the smallest surface where almost all the species of the community studied are present (cf. Fig. 8).

In other regions, the minimal area used in subtidal quantitative collections has often been only 625 cm2 (France: Bellan-Santini,1969; True,1970; Boudouresque, 1971; mainland Portugal: Saldanha, 1974; Santos & Melo, 1984; tropical West Africa: John *et al.*, 1977; South Africa, Anderson & Stegenga, 1989), but as seen above, that area can not be considered adequate to sample properly the studied Azorean communities.

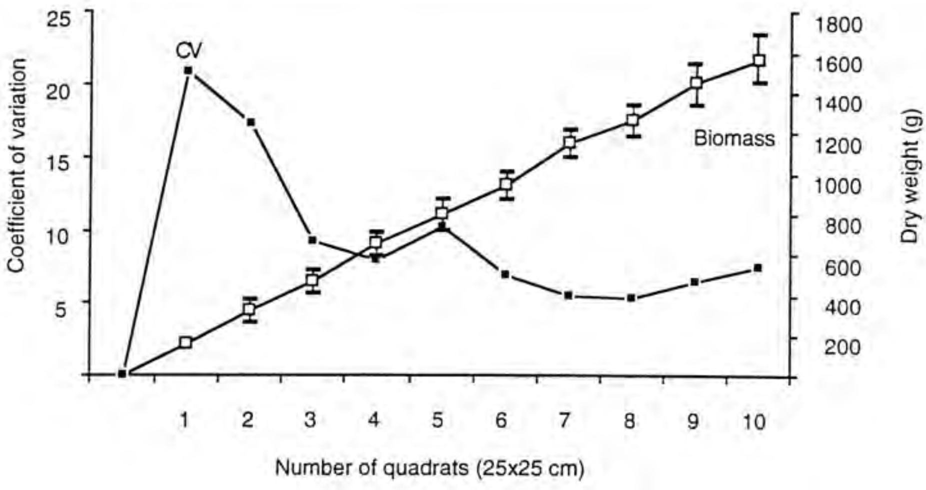


Fig. 9. Biomass/area relationship for the subtidal communities: mean dry weight ± standard deviation and coefficient of variation (CV).

3.2.2.2 Collection of samples

To investigate the possible effects of a depth gradient, it was decided to survey three depth levels: 5, 10 and 15 m. Both qualitative and quantitative destructive collections were made at each of these depths. Subtidal investigations were undertaken by SCUBA diving.

Qualitative collections were made by swimming around the area and collecting representative specimens of each species into previously labelled bags. As with the intertidal collections, habitat details for each species (depth, substratum, orientation and aspect of the rock, gully, crevice, cave, etc.) were noted on underwater writing boards.

On each sampling occasion, and for each level, three replicate samples of 2500 cm2 were collected at random, a sample consisting of the material obtained by carefully scrapping with a chisel all the attached algae inside the quadrat into a fine mesh net bag (Plate II.1). The location of each quadrat was determined by reading from a table of random numbers two series of values, one for the azimuth and the other for the distance up to 10 m. The azimuth was determined with a compass and the distance with a measuring tape.

3.3 Laboratory techniques

3.3.1 Sorting and preservation

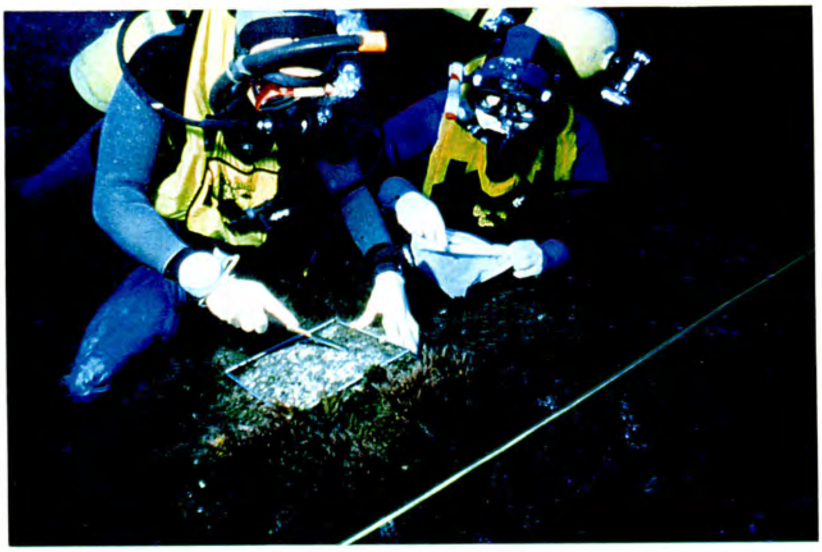
In the laboratory, the algae from both qualitative and quantitative collections were sorted into species. Whenever possible the material was observed on the same day, otherwise the samples were kept in the refrigerator overnight.

All plants were examined microscopically, using stereo and compound microscopes, to detect the occurrence of reproductive structures and effects of herbivory. Samples that could not be examined alive were preserved in 5% buffered formaldehyde-sea water solution (Nezelof *et al.*, 1972).

Plate II 1. Method used for the subtidal quantitative collections.

2. *Ulva rigida*: Microscopic denticles on the basal margin of the frond (x100).

3. *Ectocarpus siliculosus*: Portion of plant showing plurilocular sporangia (x40).



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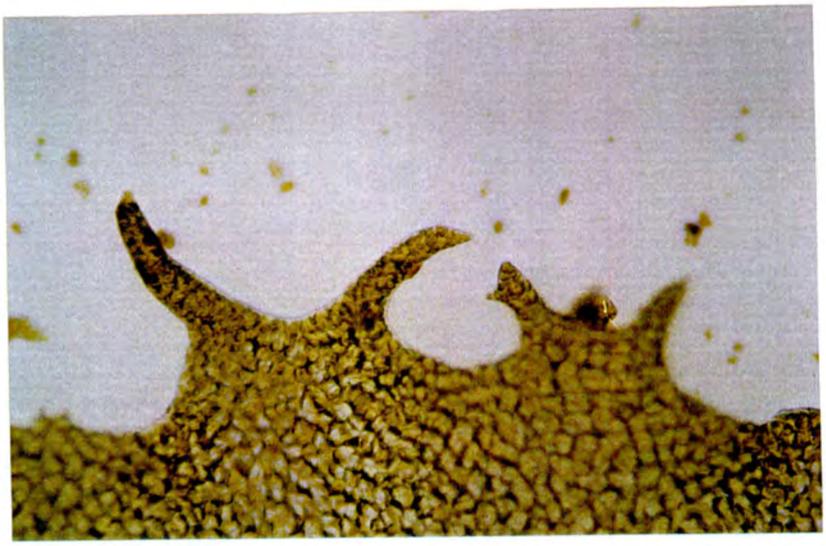

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3.2.2 Species determination

The identification of species was based on morphological and anatomical characters and reproductive structures. This is usually a difficult task, as many algal species are known to be polymorphic (plastic), exhibiting variable phenotypes according to their environmental conditions. Furthermore, many species have heteromorphic life histories. In most cases, determination requires the observation of reproductive structures (e.g. cystocarps in red algae), which are not always present. In the case of the larger, more complex algae, the anatomy of the thallus needs to be investigated, as well as the reproductive structures, which are often immersed within the thallus.

It is worth noting here that the Azorean algae are poorly known and have a mixed component of several geographical regions, which causes many problems in their identification. Various floras and keys from elsewhere were accordingly found to be helpful for the specific identification of the algae collected. These included Børgesen (1925, 1926, 1927, 1929, 1930), Schmidt (1931), Feldmann-Mazoyer (1940), Gayral (1958, 1966), Taylor (1967, 1978), Ardré (1970), Levring (1974), Dixon and Irvine (1977), Fritsch (1977a, b), South and Adams (1979), Lawson and John (1982), Irvine (1983), Gayral and Cosson (1986), Yoneshigue *et al.* (1986), Fletcher (1987), Afonso-Carrillo and Sansón (1989), Hiscock (1979, 1984), Jónsson *et al.* (1989), Littler *et al.* (1989), Burrows (1991), Boudouresque *et al.* (1992), Cabioc'h *et al.* (1992), Maggs and Hommersand (1993), and Irvine and Chamberlain (1994).

For more critical and taxonomically difficult taxa, appropriate authorities were consulted. In some cases specimens were taken to the Natural History Museum (London) for comparison with collections there. In other cases, the plants were sent to appropriate specialists.

The systematic organization and nomenclatural synopsis of the species presented in this study generally follows that adopted by South and Tittley (1986) with modifications suggested since then. These are cited in Chapter 4.

No general descriptions of higher algal taxa are provided in this work, as there are many comprehensive accounts in the literature, e.g. Fritsch (1977a, b), Dawes (1981), Lobban and Wynne (1981), Sze (1986), Bold and Wynne (1987), Bold *et al.* (1987), South and Whittick (1987), van den Hoek *et al.* (1995), and many specialized papers on different aspects, e.g. Grubb (1925), Dixon (1963, 1970, 1982), L'Hardy-Halos (1971), Furnari and Scammacca (1970), Gabrielson and Garbary (1986), Price *et al.* (1988), Cole and Sheath (1990), and Brawley and Johnson (1992).

3.3.3 Histology

The entire thallus, portions or sections of it were observed microscopically. Cells and other structures were measured, using a calibrated micrometer eye piece. For the identification of some species, histological work was necessary, as most anatomical descriptions are based on transverse sections. Details of any reproductive structures encountered were also obtained, such as the pattern of cleavage in tetrasporangia of red algae.

Transverse sections were made using a freezing microtome. Small portions of the specimens selected for microscopic study were frozen on the stage of a thermoelectric freezing microtome in Hamilton's solution (30% sucrose, 1% gum arabic in distilled water plus thymol crystal; see Farnham, 1978) and sectioned. Sections were cut at 5 to 30 μm, the thickness depending on the nature of the material and the species involved. Sections were then placed on glass slides, using an artist's fine brush.

For green and brown algae no permanent slides were made and in most cases no staining was used. When the material was fresh, the sections were mounted in seawater and observed. With preserved material, the plants were washed and the sections were mounted in distilled or tap water. For some Chlorophyta Lugol's iodine reagent was used to reveal the pyrenoids by staining their starch content. The number of pyrenoids per cell can be a taxonomic character.

For most red algae, permanent slides were made from the entire plant (as in the filamentous forms), or from transverse sections or small portions of the thallus (3-5 mm^2) in other morphological types. In most cases, the algal material, after being immersed in 1% sodium hydroxide, was stained on the slide with 1% aqueous solution of aniline blue, washed with distilled water and then acidified with a drop of 1% hydrochloric acid, as a fixative. Staining was followed under the dissecting microscope, and as soon as enough stain had been absorbed, the acid was pipetted off. The length of time necessary for proper staining varied according to the alga and its state of preservation, but usually one to five minutes in the stain was sufficient. The preparations were then made permanent by mounting them in a solution of 50% "Karo" corn syrup, preserved with phenol (see Johansen, 1940). Anatomical details could sometimes be observed more clearly by gently squashing the specimens or sections mounted this way. This staining method, with slight alterations, has been used by several authors (e.g. Sparling, 1957; Hommersand, 1963; Searles, 1968; Gordon, 1971; Edelstein *et al.*, 1974; Farnham, 1978; Parsons, 1980).

For specimens with a thick and tough thallus, it was necessary to soften it with 10% sodium hydroxide (as recommended by Norris, 1957), so that it could be easily squashed. In some cases, mainly filamentous red algae, the material was stained using the glycerin method (Chemin, 1929, *fide* Tsuda & Abbott, 1985). The algal material was fixed in 5% buffered formaldehyde-sea water solution for 5 to 10 minutes and left overnight in a 33% glycerol-water solution. The next day, the glycerol was drawn off, a few drops of molten glycerin jelly incorporating gentian violet stain, were added and a cover slip applied.

Aniline blue stain is commonly used and was preferred, because it is known as a useful general stain (Sparling, 1957; Tsuda & Abbott, 1985) and is simple to use, so that good preparations can be readily made with it (Norris, 1957). Its disadvantage is that it does not stain nuclei clearly, although in some cases it proved to be quite effective in showing nuclei (Sparling, 1957), especially for some members of the Ceramiaceae.

A representative collection of colour slides was made using a microphotography system OLYMPUS PM10-35AD-1. Some of them were made into photographs and are used to illustrate this work.

3.3.4 Biomass determination

The plants from quantitative collections were weighed on an electronic top-pan balance. For each species the excess of water was removed by shacking the plants vigorously and the fresh weight was determined. The plants were then dried in an oven at 70°C, until constant weight was attained (see Bellan-Santini, 1964). The dry weight of each species was then determined. The mean monthly values of biomass (dry weight) for each species were then calculated.

3.3.5 Size measurement

Up to four plants from qualitative collections were measured, so as to give an indication of seasonal changes in their growth. The overall length of each erect specimen, exclusive of its holdfast, was recorded. For specimens with a different morphology e.g. *Codium elisabethae*, *Colpomenia*, *Hydroclathrus*, etc., the maximum diameter was recorded. The mean monthly values were calculated. Filamentous algae shorter than one centimetre were not measured.

3.3.6 Reference collections

Many algae, mainly the Rhodophyta, are difficult to identify from dried specimens. On the other hand, many marine algae will fade if kept in preservative (Tsuda & Abbott, 1985). A compromise between these two situations was achieved by keeping part of the specimens in vials with preservative while drying the remainder of the collection as herbarium specimens. Two types of reference collections were therefore established, one in liquid, the other on paper.

According to Nezelof *et al.* (1972), there is no such thing as an ideal fixative. Formalin and alcohol are among the more commonly used ones, the former being recommended when a freezing microtome will be used. In the liquid collection, specimens were preserved in 5% buffered formaldehyde-sea water solution. In the herbarium collection, the specimens were mounted on herbarium sheets, following the method described by Gayral and Cosson (1986). Both collections are deposited at the University of the Azores.

3.4 Mathematical analyses

3.4.1 Comparisons

The non-parametric Wilcoxon signed rank test was used for comparisons, following the method of Snedcor and Cochram (1967) and Kent and Coker (1996). The usual level of significance of 5% was adopted.

This non-parametric test is appropriate to situations where the parametric assumptions of the paired t-test cannot be met, particularly the assumption of normality of the background populations of the two samples and the requirement of equal variance.

The Wilcoxon test is based on differences between the pairs of data from two samples when they are ranked or put on the ordinal scale.

Firstly the null hypothesis must be stated (H_0)- that there is no difference between the two samples. Secondly a directional alternative hypothesis (H_1) is put forward that the samples are different. Then a significance level is selected.

Next the absolute differences (ignoring signs) between the matched pairs of observations are found. Any pairs which are equal in value and where this difference is zero are removed from analyses. The differences are then ranked, with the smallest value given the rank of 1. The signs are then restored, the ranks are sorted in two columns, according to their sign, and their values in each column summed. The smaller (absolute) value is called T. This T value can then be looked up in appropriate statistical tables, which give critical values of T for samples of differing sizes from n=6 to n=33, n being the number of pairs. The test cannot be applied to samples of less than 6. For samples larger than 33, T must be converted into a Z score:

$$Z = \frac{T - 1/4n(n+1)}{\sqrt{\{n(n+1)(2n+1)\}/24}}$$

This Z value can then be looked up in the normal distribution tables.

3.4.2 Measurements of similarity and dissimilarity

Floristic comparisons between the different sampling sites and levels were made by calculating their similarity.

Similarity indices measure the degree to which the species composition of quadrats or sample matches is alike. Dissimilarity coefficients assess the degree to which two quadrats or samples differ in composition. It follows that dissimilarity is the complement of similarity (Kent & Coker, 1996).

In the present study the Sørensen coefficient of similarity (S_S, also known as Dice index), the Jaccard coefficient of similarity (S_J), and the dissimilarity coefficient of squared Euclidean distance (D_{ij}), are used.

The Sørensen and Jaccard coefficients are very simple indices, applied both to qualitative and quantitative data, although more commonly used for presence/absence data. Their formulae are respectively:

$$S_S = \frac{2a}{2a+b+c} \quad \text{and} \quad S_J = \frac{a}{a+b+c},$$

where *a* is the number of species in common to both samples, *b* is the number of species in sample 1 but not on sample 2, and *c* is the number of species present only in sample 2 (Kent & Coker, 1996).

The Sørensen coefficient is generally preferred because it gives weight to the species that are common to the quadrats or samples rather than to those that only occur in either sample.

The coefficient of squared Euclidean distance is based on the Euclidean properties of a right-angle triangle and the fact that the square on the hypotenuse is equal to the sum of the squares on the opposite two sides. If two species X and Y occur in two quadrats 1 and 2, the similarity or "distance" between them in geometric space is defined as (Kent & Coker, 1996):

$$S_E = \sqrt{(X_1 - X_2) + (Y_1 - Y_2)}$$

For more than two species, the generalized formula becomes:

$$D_{ij} = \sqrt{\sum_{k=1}^{m} (X_{ik} - X_{jk})^2} \ ,$$

where D_{ij} is the squared Euclidean distance between quadrats *i* and *j*, m is the number of species, X_{ij} the abundance of the k^{th} species in quadrat *i*, and X_{jk} the abundance of the k^{th} species in quadrat *j*.

The lower the value of the square Euclidean distance coefficient between two quadrats, the more similar they are in terms of species composition (Kent & Coker, 1996).

3.4.3 Multivariate analyses

The outputs of those similarity analyses were subjected, in most cases, to numerical multivariate analyses, as these are considered the best means of comparing samples in order to assess similarities and differences. Kent and Coker (1996) reviewed the use of such methods, and their recommendations are followed here. The weighted-pairs method for cluster analyses with computer-assisted methods (NTSYS package; Rohlf, 1994) was used, following Santelices and Abbott (1987), Ballesteros and Romero (1988), and Smith (1992). The different communities were classified using the two way indicator species analyses (TWINSPAN), following Anderson and Stegenga (1989), and Kooistra *et al.* (1989).

The cluster analyses is a method of grouping variables according to the magnitude and interrelationship among their correlations (Sokal & Rohlf, 1995). This analyses is concerned with the identification of groups of similar objects: given a sample of *n* objects, each of which with a score on *p* variables, the method will devise a scheme for grouping the objects into classes so that similar ones are in the same class. The method will produce a dendrogram where the objects are separated by groups, the ones closest together being merged, the ones spread out being split (Manly, 1994).

The TWINSPAN, a polythethic divisive clustering technique (Hill, 1979; Gauch & Whittaker, 1981) produces a classification of species and plots by progressive splitting of ordinations, and at each split, indicator species are chosen to define the two groups of plots. Quantitative data of the species' biomass and presence/absence data, were used and compared. A key concept of TWINSPAN and phytosociology is that for each division of a set of quadrats, a dichotomy can be made with a group of quadrats on one side characterized by one set of differential species and a second group on the other side characterized by a second set of differential species. Ideally species will belong to one side of the dichotomy or the other (Kent & Coker, 1996). A general idea of the composition of the communities studied can be obtained this way.

3.4.4 Diversity and species richness

Of the various indices of diversity, the most frequently used is the simple totalling of species numbers to give species richness (Magurran, 1988). Of the indices that combine species richness with relative abundance, probably the most widely used is the Shannon diversity index (Margaleff, 1957; Niell, 1974; Kent & Coker, 1996), also called the Shannon-Wiener index or often mistakenly referred to as the Shannon-Weaver index (Kent & Coker, 1996). This index makes the assumption that individuals are randomly sampled from an "infinitely large" population and also assumes that all the species from a community are included in the sample.

The Shannon diversity index, (H), is calculated from the formula:

$$H = -\sum_{i=1}^{s} Pi.\ ln\ Pi$$

where s represents the number of species, Pi the proportion of individuals or the abundance of the ith species expressed as a proportion of total cover, and ln is the natural logaritm.

3.4.5 Dominance-diversity curves (Rank abundance diagrams)

By the application of single-figure diversity indices to characterize complex community structures, much of the original species information can be lost. In consequence, various workers, notably Whittaker (1965), have plotted the graph of the proportional abundance of species in a sample or quadrat on a log scale against their rank from most to least abundant. The form of the resulting line or curve can be used to describe the evenness of species distribution and relative species dominance within a community (Kent & Coker, 1996).

3.5 Abbreviations used in figures

In the figures, **I** is used for the intertidal level and **S** for the subtidal; São Roque is abbreviated as **S** (for South coast), and São Vicente as **N** (for North coast); **H** (high) and **L** (low) are used respectively for the upper and lower intertidal; the three depth levels are indicated as **5m**, **10m** and **15m**. The following notation is therefore used:

IS - Intertidal level of São Roque
ISH - Upper eulittoral of São Roque
ISL - Lower eulittoral of São Roque

IN - Intertidal level of São Vicente
INH - Upper eulittoral of São Vicente
INL - Lower eulittoral of São Vicente

SS - Subtidal level of São Roque
5m S - Subtidal level of São Roque, 5m depth
10m S - Subtidal level of São Roque, 10m depth
15m S - Subtidal level of São Roque, 15m depth

SN - Subtidal level of São Vicente
5m N - Subtidal level of São Vicente, 5m depth
10m N - Subtidal level of São Vicente, 10m depth
15m N - Subtidal level of São Vicente, 15m depth

4. SYSTEMATICS AND OBSERVATIONS ON THE SPECIES BIOLOGY, ECOLOGY AND DISTRIBUTION

In the present study 156 taxa were identified: 18 Chlorophyta, 27 Phaeophyta and 111 Rhodophyta. For nine of these (2 Phaeophyta and 7 Rhodophyta), a "working" name has been given for convenience, as it was not possible to identify them to generic or species levels. In Table I all taxa are listed alphabetically under each division. At the bottom the 9 taxa mentioned above are listed. The distribution of each taxon in the North Atlantic is also given, based on the available literature. The phytogeographic seaweed regions of van den Hoek (1984) have been used, with the following adaptations: Madeira, Canaries and the Mediterranean are presented separately, and the British Isles are included in the Cold Temperate Northeast Atlantic Region.

The systematic organization and nomenclatural synopsis of the species presented in this chapter generally follows that adopted by South and Tittley (1986) with later modifications, mainly by Maggs and Pueschel (1989). Spelling and abbreviations of algal authorities follow Brummit and Powell (1992). Some further synonyms have been given by Schnetter *et al.* (1987), Guiry and Garbary (1990), Silva and Decew (1992), Wynne and Heine (1992), Hommersand *et al.* (1993), Nam *et al.* (1994) and Prud'homme van Reine *et al.* (1994). For each division, genera are listed alphabetically under each family, and species are listed alphabetically under each genus.

Observations on the occurrence and biology of the species listed in Table I are given based on my studies and the relevant literature. The following information is presented for each species:

i) other synonyms used in previous works on the Azorean algal flora (see checklist in Neto, 1994);
ii) distinguishing features, including the characteristics of each species which prevent confusion with similar Azorean species;
iii) the habitat(s) occupied at the study sites;
iv) occurrence and abundance. For most species the maximum length/maximum diameter of plants and the mean biomass are presented graphically on a monthly basis for each sample;
v) observations on the reproductive condition;
vi) comments on seasonality and reproduction in other locations elsewhere in the Atlantic Ocean, based on the available literature.

Most of the information given for each taxon is based on personal observations. Detailed systematic descriptions and illustrations of most species occurring in the Azores can be found in several floras (Gayral, 1958, 1966; Bliding, 1963, 1968; Taylor, 1967; Dixon & Irvine, 1977; Gayral & Cosson, 1986; Lawson & John, 1982; van den Hoek, 1982a; Irvine, 1983; Fletcher, 1987; Littler *et al.*, 1989; Burrows, 1991; Boudouresque *et al.*, 1992; Cabioc'h *et al.*, 1992; Maggs & Hommersand, 1993; Irvine & Chamberlain, 1994). Whenever appropriate distinctive features are illustrated.

For the identification of some genera and species, specialized papers and revisions of fami-

Table I. List of the species collected on the present study. The phytogeographic seaweed regions of Van den Hoek (1984) are used with the following adaptations: Madeira, Canaries and the Mediterranean are presented separately and the British Isles are included in the cold temperate northeast Atlantic region. AR - Arctic; CNWA - Cold Temperate NW Atlantic; CNEA - Cold Temperate NE Atlantic; WNWA - Warm Temperate NW Atlantic; WNEA - Warm Temperate NE Atlantic (excluding the Azores); TWA - Tropical NW Atlantic; TEA - Tropical NE Atlantic; MAD - Madeira; CAN - Canaries; MED - Mediterranean. The symbols before the taxa mean a new record for the Azores (*) or for the island of São Miguel (#). Each taxon was classified according to its presence in the Arctic (A), Cold Temperate Region (C), Warm Temperate Region (W) or the Tropics (T); OUT means the taxa is not known in the North Atlantic. References are listed at the bottom of the table.

CHLOROPHYTA	Abbrev.		AR	CNWA	CNEA	WNWA	WNEA	TWA	TEA	MAD	CAN	MED	Observations	References
#Anadyomene stellata	anaste	CWT		1		1		1	1		1	1		7 14 18 131 137
#Bryopsis hypnoides	bryhyp	ACWT	1	1	1	1	1	1	1	1	1	1		6 21 52 54 82 131 132 137
Chaetomorpha linum	chalin	ACWT	1	1	1	1	1	1	1	1	1	1		6 7 18 21 22 54 77 78 86 108 126 131 132 137
**Chaetomorpha mediterranea*	chamed	CW			1		1						AZ-South. limit	21 108
Cladophora coelothrix	clacoe	CWT		1	1	1	1	1	1	1	1	1		6 21 72 82 136 137
**Cladophora hutchinsiae*	clahut	CWT		1	1	1	1	1	1	1	1	1		9 14 72 86 126 131 132 135 136
#Cladophora laetevirens	clalae	CWT		1	1	1	1	1	1	1	1	1		6 7 18 21 54 72 82 132 136 137
**Cladophora lehmanniana*	claleh	CWT			1		1		1		1	1		21 72 136
Cladophora prolifera	clapro	CWT		1	1	1	1	1	1	1	1	1		14 18 48 53 64 72 82 86 126 131 135 136 137
Codium adhaerens	codadh	CWT		1	1	1	1	1	1	1	1	1		6 21 32 52 53 54 126
#Codium decorticatum	coddec	CWT		1	1	1	1	1	1	1	1	1		6 18 30 82 131 137
Codium elisabethae	codeli	W								1				8 111
#Codium fragile	codfra	ACW	1	1	1	1	1		1?					13 18 21 77 100
**Codium vermilara*	codver	CW			1		1					1	AZ-South. limit	6 18 21 30 54 127
Enteromorpha intestinalis	entint	ACWT	1	1	1	1	1	1	1	1	1	1		12 18 21 27 52 53 54 70 82 86 110 126 132 133 137 139
Enteromorpha muscoides	entmus	ACWT	1	1	1	1	1	1	1	1	1	1		6 14 21 52 53 54 86 126 133 137
Ulva rigida	ulvrig	ACWT	1	1	1	1	1	1	1	1	1	1		4 18 21 22 52 53 54 70 82 133 137
Valonia utricularis	valutr	CWT		1		1	1	1	1	1	1	1		6 14 18 53 126 131 137

PHAEOPHYTA	Abbrev.		AR	CNWA	CNEA	WNWA	WNEA	TWA	TEA	MAD	CAN	MED	Observations	
#Carpomitra costata	carcos	ACWT	1	1	1		1		1		1	1		9 18 48
Cladostephus spongiosus	claspo	ACWT	1	1	1		1		1	1	1	1		6 7 18 22 52 70 82 103 126 132
Colpomenia sinuosa	colsin	ACWT	1	1		1	1	1	1		1	1		6 7 15 18 38 53 82 103 126 137
Cystoseira abies-marina	cysabi	WT							1	1	1		Spp macaronesian	15 86 103
Cystoseira foeniculaceus	cysfoe	CWT			1		1		1	1	1	1		22 52 54 82 103 114
#Cystoseira humilis	cyshum	CWT			1		1		1	1	1	1		6 22 103
Dictyopteris membranacea	dicmem	CWT		1	1	1	1	1	1	1	1	1		4 6 7 18 22 52 53 54 103 126 137
Dictyota dichotoma	dicdic	CWT		1	1	1	1	1	1	1	1	1		4 6 7 18 22 38 52 53 54 67 82 86 103 125 126 131 133 137
#Ectocarpus siliculosus	ectsil	ACWT	1	1	1	1	1	1	1	1	1	1		6 38 52 54 70 103 131 132 133 137
#Endarachne binghamiae	endbin	OUT											Introduction	
Fucus spiralis	fucspi	ACW	1	1	1		1		1		1			6 22 52 53 54 70 92 68 97 103 115 126 132
Halopteris filicina	halfil	CWT			1		1		1	1	1	1		6 18 22 53 54 103 126
#Hincksia mitchelliae	hinmit	CWT			1	1	1	1	1		1			6 24 38 57 86 129 132
#Hydroclathrus clathratus	hydcla	CWT		1		1	1	1	1	1	1	1		6 15 18 82 86 103 131 137
Padina pavonica	padpav	CWT		1	1	1	1	1	1	1	1	1		6 7 18 22 52 53 54 82 86 103 104 126 131 137
#Sargassum cymosum	sarcym	CWT		1		1		1	1					82 103 131 137
**Sargassum filipendula*	sarfil	CWT		1		1		1	1		1			38 82 103 131 132 137
Sargassum vulgare	sarvul	CWT		1	1	1	1	1	1	1	1	1		7 53 82 86 103 126 131 137
Scytosiphon lomentaria	scylom	ACWT	1	1	1	1	1	1	1	1	1	1		6 7 15 18 22 48 52 54 70 79 86 88 103 112 126 131 132 133 137
Sphaerotrichia divaricata	sphdiv	AC	1	1	1							1	AZ-South. limit	74 101 112 124 128 138
Stypocaulon scoparia	stysco	ACWT	1	1	1	1	1		1	1	1	1		4 6 7 15 18 22 53 54 82 86 103 126 132
**Stypopodium zonale*	styzon	CWT		1		1		1	1		1			38 57 82 87 103 131 137
Taonia atomaria	taoato	CWT			1		1		1	1	1	1		6 18 22 52 53 54 82 86 103 126
Zanardinia prototypus	zanpro	CW			1		1					1	AZ-South. limit	6 18 38 48
Zonaria tournefortii	zontou	CWT		1		1	1	1	1	1	1	1		15 18 53 82 86 103 126 131 137

Table I (cont.)

RHODOPHYTA	Abbrev.		AR	CNWA	CNEA	WNWA	WNEA	TWA	TEA	MAD	CAN	MED	Observations	References
Acrosorium venulosum	acrven	ACWT	1	1	1	1	1	1	1	1	1	1		6 7 17 18 53 86 89 105 126 131 137
#Aglaothamnion bipinnatum	aglbip	CW			1		1						AZ-South. limit	89 120
#Aglaothamnion byssoides	aglbys	CWT		1	1	1	1	1	1	1	1	1		17 34 46 82 86 89 105 120 131 132 137
**Aglaothamnion gallicum*	aglgal	CWT			1		1		1		1	1		6 89 105
Aglaothamnion hookeri	aglhoo	CWT			1		1		1	1	1	1		6 82 89 105
**Aglaothamnion pseudobyssoides*	aglpse	CW			1		1						AZ-South. limit	6 89
#Amphiroa beauvoisii	ampbea	CWT		1		1	1	1	1	1	1	1		6 39 53 82 86 98 105 131 137
**Anotrichium barbatum*	anobar	CWT		1	1	1	1	1	1	1	1	1		7 89 105 137
**Anotrichium furcellatum*	anofur	CWT			1		1		1		1	1		89 105 130
#Antithamnion diminuatum	antdim	OUT											Introduction	6 46 53 54 89 126
#Apoglossum ruscifolium	aporus	CWT		1	1	1	1	1	1	1	1	1		6 7 9 18 22 52 53 54 89 105 126 137
Asparagopsis armata	asparm	CWT			1		1		1	1	1	1		5 6 7 18 22 31 33 35 42 44 50 51 52 53 54 55 56 59 63 86 93 105 126
#Bornetia secundiflora	borsec	CWT		1	1		1		1		1	1		6 18 22 36 46 52 53 54 82 89 105 126
Botryocladia botryoides	botbot	WT					1		1	1	1	1		7 52 82 105 126
**Brongniartella byssoides*	brobys	ACW	1		1		1					1	AZ-South. limit	6 54 89
Callithamnion corymbosum	calcor	ACWT	1	1	1	1	1	1	1	1	1	1		6 7 34 46 89 105 131 132 137
#Callithamnion granulatum	calgra	CWT			1		1	1	1		1	1		6 46 52 53 54 82 89 105 109
Callithamnion tetragonum	caltet	ACW	1	1	1	1	1		1	1	1	1		6 34 46 86 89 105 113 126 132
Caulacanthus ustulatus	cauust	CWT		1			1		1	1	1	1		6 7 43 53 82 85 86 105 126
Centroceras clavulatum	cencla	CWT		1		1	1	1	1	1	1	1		6 46 46 53 82 86 105 126 131 137
**Ceramium botryocarpum*	cerbot	CW			1		1						AZ-South. limit	89
Ceramium ciliatum	cercil	ACW	1		1		1		1	1	1	1		6 7 17 18 22 46 52 53 54 86 89 105 126
#Ceramium cimbricum	cercim	ACWT	1	1	1	1	1	1				1		82 89 105 131 132
**Ceramium circinatum*	cercir	ACWT	1	1	1	1	1	1				1		7 46 105 132
#Ceramium deslongchampii	cerdes	ACWT	1	1	1	1	1	1	1	1	1	1		89 131 132
#Ceramium diaphanum	cerdia	ACWT	1	1	1	1	1	1	1	1	1	1		4 6 7 17 46 46 52 53 54 105 131 132 137
Ceramium echionotum	cerech	CWT			1		1		1	1	1	1		4 6 17 46 52 53 54 86 89 105 126
**Ceramium flaccidum*	cerfla	CWT			1		1		1	1	1	1		7 89 105 126 137
Ceramium nodulosum	cernod	ACWT	1	1	1	1	1	1	1	1	1	1		6 46 52 53 54 89 105 126 131 132 137
**Ceramium pallidum*	cerpal	C			1								AZ-South. limit	89
**Ceramium secundatum*	cersec	C			1								AZ-South. limit	89
#Ceramium strictum sensu Harv.	cerstr	CWT		1	1	1	1	1		1				86 89 119 123 137
Champia parvula	chapar	ACWT	1	1	1	1	1	1	1	1	1	1		6 7 18 22 53 54 70 82 86 105 126 131 132 137
Chondracanthus acicularis	choaci	CWT		1	1	1	1	1	1	1	1	1		4 6 7 18 22 33 47 52 53 54 58 61 82 106 126 131 137
Chondracanthus teedii	chotee	CWT		1	1	1	1	1	1			1		6 18 19 22 33 53 54 106 126 131 137
**Chondria coerulescens*	chocoe	CWT			1		1		1	1	1	1		6 7 52 53 54 89 105 126
Chondria dasyphylla	chodas	CWT		1	1	1	1	1	1	1	1	1		6 7 17 22 52 53 54 89 105 131 132 137
Coccotyus truncatus	coctru	AC	1	1	1								AZ-South. limit	33 93
**Compsothamnion decompositum*	comdec	CW			1		1						AZ-South. limit	89
Corallina elongata	corelo	ACW	1		1		1		1	1	1	1		2 4 6 7 18 22 39 52 53 67 77 82 105
Cryptopleura ramosa	cryram	CWT		1	1	1	1	1	1	1	1	1		6 18 22 52 54 54 73 86 89 105 116 126 137
#Dasya corymbifera	dascor	CWT		1	1	1	1	1	1	1	1	1		7 18 22 86 89 105 131 137
**Dasya hutchinsiae*	dashut	CWT			1		1		1	1	1	1		6 7 86 89 105
Dasya ocellata	dasoce	CWT		1	1	1	1	1	1	1	1	1		6 7 17 86 89 105 126 131 137
Dilsea carnosa	dilcar	ACW	1		1		1						AZ-South. limit	6 22 52 54 70
**Drachiella heterocarpa*	drahet	CW			1		1						AZ-South. limit	89
Dudresnaya verticillata	dudver	CWT			1		1		1	1	1	1		7 18 70 86 105
Erythrodermis traillii	erytra	ACW	1	1	1	1	1						AZ-South. limit	33 90 132
#Gastroclonium ovatum	gasova	CWT		1	1	1	1	1	1		1	1		4 6 22 52 54 70 106 131 137
**Gastroclonium reflexum*	gasref	CWT			1		1	1	1		1	1		6 70 106

Table I (cont.)

RHODOPHYTA (cont.)	Abbrev.		AR	CNWA	CNEA	WNWA	WNEA	TWA	TEA	MAD	CAN	MED	Observations	References
Gelidium latifolium	gellat	ACWT	1	1	1	1	1	1	1			1		4 6 7 18 22 33 47 52 53 54 106 117 118 126
Gelidium microdon	gelmic	CWT			1		1		1	1	1	1		6 53 54 106 126
Gelidium pusillum	gelpus	CWT		1	1	1	1	1	1	1	1	1		4 6 7 33 52 53 54 82 106 118 126 131 137
Grateloupia dichotoma	gradic	CWT		1	1	1	1	1	1		1	1		6 7 16 70 82 106 131 137
#Griffithsia corallinoides	gricor	CWT			1		1		1		1	1		22 52 89 106
Gymnogongrus crenulatus	gymcre	ACWT	1	1	1	1	1	1	1		1	1		4 6 18 22 25 33 52 53 106 126 137
Gymnogongrus griffithsiae	gymgri	CWT		1	1	1	1	1	1	1	1	1		6 7 18 22 29 33 53 54 82 106 126 131 132 137
Haliptilon virgatum	halvir	CWT			1		1		1	1	1	1		107
**Haraldiophyllum bonnemaisonii*	harbon	CWT			1		1		1					89 107
Hypnea musciformis	hypmus	CWT		1		1	1	1	1	1	1	1		4 6 7 11 16 18 28 53 82 84 86 107 126 131 132 137
Hypoglossum hypoglossoides	hyphyp	CWT		1	1	1	1	1	1	1	1	1		6 7 17 18 22 52 53 82 86 89 97 107 126 137
Jania adhaerens	janadh	CWT		1		1	1	1	1	1	1	1		39 82 107 131 137
**Jania capillacea*	jancap	CWT		1		1	1	1	1					82 107 131
Jania crassa	jancra	T							1				AZ-North. limit	82 107
Jania longifurca	janlon	WT					1		1	1		1		6 22 53 54 107
Jania rubens	janrub	CWT		1	1	1	1	1	1	1	1	1		6 7 22 39 52 53 54 82 86 107 131 137
**Jania verrucosa*	janver	T							1				AZ-North. limit	82 107
Kallymenia reniformis	kalren	CWT		1	1		1		1	1	1	1		18 22 69 70 86 107 132
Laurencia hybrida	lauhyb	CWT			1		1		1	1	1			6 22 71 71 89 126
Laurencia obtusa	lauobt	CWT		1	1	1	1	1	1	1	1	1		6 7 17 18 22 52 53 54 71 71 82 86 89 126 131 137
#Liagora distenta	liadis	CWT			1		1		1	1	1	1		18 71 86 126
Liagora viscida	liavis	CWT			1		1	1	1	1	1	1		6 18 71 71
Lomentaria articulata	lomart	ACWT	1		1		1	1	1	1	1	1		6 16 22 52 53 54 70 71 71 82 126
#Lophosiphonia reptabunda	loprep	CWT		1	1	1	1	1	1	1	1	1		6 7 71 126 137
Mastocarpus stellatus	masste	ACWT	1	1	1	1	1	1	1		1	1		6 20 22 26 33 40 52 54 60 71 91 132 137
Nemalion helminthoides	nemhel	ACWT	1	1	1	1	1	1	1		1	1		6 7 18 22 33 52 53 71 71 126 131 137
Nitophyllum punctatum	nitpun	CWT		1	1	1	1	1	1	1	1	1		6 7 18 22 52 53 54 71 71 89 126 131 137
Osmundia pinnatifida	osmpin	CWT		1	1	1	1	1	1	1	1	1		4 6 18 22 52 53 54 66 71 71 82 126 137
#Peyssonnelia squamaria	peysqu	WT					1		1		1	1		6 7 83
Phyllophora crispa	phycri	ACW	1		1		1					1		6 7 22 33 52
Plocamium cartilagineum	plocar	ACW	1		1		1		1	1	1	1		6 7 18 22 33 52 53 54 73 82 83 126
Polysiphonia atlantica	polatl	CWT		1	1	1	1	1	1	1	1	1		6 17 53 54 75 76 83 86 89 131 137
#Polysiphonia brodiaei	polbro	ACWT	1	1	1	1	1	1	1	1	1	1		6 10 81 83 86 89
#Polysiphonia denudata	polden	ACWT	1	1	1	1	1	1	1	1	1	1		6 41 65 75 76 81 82 83 86 89 102 131 132 137
Polysiphonia elongata	polelo	ACW	1	1	1		1		1	1	1	1		6 7 10 18 22 52 83 86 89 97 132
**Polysiphonia foetidissima*	polfoe	CWT		1	1	1	1	1		1		1		6 10 83 89 131 137
Polysiphonia fucoides	polfuc	ACWT	1	1	1	1	1	1	1	1	1	1		6 10 52 54 76 83 86 89 131 132
**Polysiphonia furcellata*	polfur	CWT			1		1		1	1	1	1		6 7 44 81 83 89
Pterocladia capillacea	ptecap	CWT		1	1	1	1	1	1	1	1	1		1 4 6 18 22 23 33 36 37 53 54 82 83 86 126 131 134 137
#Pterothamnion crispum	ptecri	CWT			1		1		1		1	1		7 83 89
#Pterothamnion plumula	pteplu	ACWT	1	1	1	1	1	1	1		1	1		52 54 83 89 126 137
**Radicilingua thysanorhizans*	radthy	CW			1		1					1	AZ-South. limit	6 89
Rhodymenia holmesii	rhohol	CWT			1		1		1					62 70
Rhodymenia pseudopalmata	rhopse	CWT		1	1	1	1	1	1	1	1	1		4 6 22 52 70 82 131
**Scagelia pylaisaei*	scapyl	AC	1	1	1								AZ-South. limit	89
#Scageliopsis patens	scapat	OUT											Introduction	
#Schimmelmannia schousboei	schsch	CW			1		1			1		1		93 128 140
Schizymenia dubyi	schdub	ACW	1		1		1			1		1		3 6 18 22 33 53 54 86
#Spermothamnion repens	sperep	ACWT	1	1	1	1	1	1	1		1	1		6 7 17 46 89 122 137
#Sphaerococcus coronopifolius	sphcor	CWT			1		1		1	1	1	1		6 7 18 22 33 52 53 54 86 126

Table 1 (cont.)

RHODOPHYTA (cont.)	Abbrev.		AR	CNWA	CNEA	WNWA	WNEA	TWA	TEA	MAD	CAN	MED	Observations	References
#Sphondylothamnion multifidum	sphmul	CWT			1		1		1		1	1		6 7 17 46 53 54 89
Symphyocladia marchantioides	symmar	OUT											Introduction	
#Taenioma nanum	taenan	CWT		1		1	1	1	1	1				82 137
**Wrangelia penicillata*	wrapen	ACWT	1	1		1	1	1	1	1	1	1		7 18 46 82 86 131 137
PROBLEMATIC TAXA														
Rosette Sargassum type acinarium	rossaa													
Rosette Sargassum type hystrix	rossah													
?Callophyllis sp.	?callo													
?Chondrymenia	?chond													
"Menia" nd (1)	menia1													
"Menia" nd (2)	menia2													
?Predaea/Nemastoma	?prene													
?Predaea/Platoma/Nemastoma	?prpln													
Sebdenia prox.	sebde?													

REFERENCES

(1) Abdel-Fattah et al., 1973; (2) Algarra & Niell, 1990; (3) Alongi & Cormaci, 1993; (4) Anadón & Fernández, 1986; (5) Aranda et al., 1984; (6) Ardré, 1970; (7) Athanasiadis, 1987; (8) Audiffred & Prud'homme van Reine, 1985; (9) Ballesteros et al., 1992; (10) Batten, 1922; (11) Benz et al., 1979; (12) Blackler, 1956; (13) Borden & Stein, 1969; (14) Børgesen, 1925; (15) Børgesen, 1926; (16) Børgesen, 1929; (17) Børgesen, 1930; (18) Boudouresque et al., 1992; (19) Braga, 1990; (20) Burns & Mathieson, 1972b; (21) Burrows, 1991; (22) Cabioc'h et al., 1992; (23) Calabrese, 1971; (24) Cardinal, 1964; (25) Chemin, 1929; (26) Chen et al., 1974; (27) Christie & Evans, 1962; (28) Conover, 1958; (29) Cordeiro-Marino & Poza, 1981; (30) Dangeard, 1958; (31) Dangeard, 1961; (32) Dellow, 1952; (33) Dixon & Irvine, 1977; (34) Dixon & Price, 1981; (35) Dixon, 1964; (36) Dixon, 1965; (37) Dixon, 1973; (36) Dixon,1965; (38) Earle, 1969; (39) Economou-Amilli et al., 1990; (40) Edelstein et al., 1974; (41) Edwards & Kapraun, 1973; (42) Feldmann & Feldmann, 1942; (43) Feldmann, 1938; (44) Feldmann, 1954; (46) Feldmann-Mazoyer, 1940; (47) Fernández et al., 1987; (48) Fletcher, 1987; (50) Furnari & Scammacca, 1970; (51) Gallardo et al., 1985; Gayral & Cosson,1986; (53) Gayral, 1958; (54) Gayral, 1966; (55) Giaccone et al., 1985; (56) Giaccone, 1978; (57) Gil-Rodriguez & Afonso-Carillo, 1980; (58) Guiry & Cunningham, 1984; (59) Guiry & Dawes, 1992; (60) Guiry & West, 1983; (61) Guiry, 1984a; (62) Guiry, 1977; (63) Güven & Öztig, 1971; (64) Hamel, 1924; (65) Hehre & Mathieson, 1970; (66) Hernández-Gonzalez & Gil-Rodrigues, 1994; (67) Hörnig et al., 1992; (68) Irvine & Chamberlain, 1994; (69) Irvine et al., 1975; (70) Irvine, 1982; (70) Irvine, 1983; (71) John et l., 1994b; (72) Jónsson et al., 1989; (73) Kain, 1982; (74) Kang, 1966; (75) Kapraun et al., 1983; (76) Kapraun, 1977b; (77) Knight & Parke, 1931; (78) Kornmann, 1972; (79) Kristiansen et al., 1991; (80) L'Hardy-Halos & Maggs, 1991; (81) Lauret, 1970; (82) Lawson & John, 1982; (83) Lawson et al., 1995; (84) Lawson, 1957; (85) Lebonché, 1957; (86) Levring, 1974; (87) Littler et al., 1989; (88) Lund, 1966; (89) Maggs & Hommersand, 1993; (90) Maggs, 1989; (91) Marshall et al., 1949; (92) Mathieson & Guo, 1992; (93) Mazza, 1903; (94) Meñez & Mathieson, 1981; (95) Newroth, 1971; (96) Niell et al., 1987; (97) Niemeck & Mathieson, 1976; (98) Norris & Johansen, 1981; (99) Palminha, 1958; (100) Parker, 1975; (101) Peters et al., 1993; (102) Phillips, 1960; (103) Price et al., 1978; (104) Price et al., 1979; (105) Price et al., 1986; (106) Price et al., 1988; (107) Price et al., 1992; (108) Price, 1967; (109) Price, 1978; (110) Pringle, 1986; (111) Prud'homme van Reine, 1988; (112) Rhodes & Connel, 1973; (113) Riouall, 1985; (114) Roberts, 1968; (115) Robertson, 1987; (116) Rodrigues, 1957; (117) Rueness & Fredriksen, 1989; (118) Rueness & Fredriksen, 1990; (119) Rueness & Kornfeldt, 1992; (120) Rueness & Rueness, 1980; (121) Rueness & Rueness, 1985; (122) Rueness, 1971; (123) Rueness, 1973; (124) Scagel, et al., 1989; (125) Schnetter, 1987; (126) Seoane-Camba, 1965; (127) Silva, 1955; (128) South & Tittley, 1986; (129) Steentoft, 1967; (130) Stegenga & Mol, 1983; (131) Taylor, 1967; (132) Taylor, 1978; (133) Tittley et al.,1984; (134) Tolomio et al., 1986; (135) Van den Hoek, 1963; (136) Van Den Hoek, 1982a; (137) Wynne, 1985; (138) Yoshide et al., 1990; (139) Zaneveld & Barnes, 1965; Gorostiaga (pers. comm.)

lies and orders have been used, besides the general floras and keys already mentioned. These are indicated in each case under the designation: "Additional references".

The quantitative and qualitative raw data are presented in the Appendices A1-A14.

4.1 CHLOROPHYTA

CLASS CHLOROPHYCEAE

ULVALES

Additional references: Bliding (1963, 1968).

ULVACEAE

Enteromorpha intestinalis (L.) Link

Ulva intestinalis C. Agardh
Enteromorpha compressa (L.) Grev.
Ulva compressa L.

Additional references: Koeman and van den Hoek (1982); Pringle (1986).

Distinguishing features: Tubular plants, unbranched, the cells in a regular to irregular arrangement and one to two pyrenoids per cell.

Enteromorpha compressa (L.) Grev. was until very recently considered a distinct species, separated from *E. intestinalis* by its branched filaments. The distinction between the two species was not always easy (Bliding, 1963), and Silva and Burrows (1973) suggested two subspecies of *E. intestinalis* (*E. intestinalis* (L.) Link subsp. *intestinalis; E. intestinalis* (L.) Link subsp. *compressa*). South and Hooper (1980) accordingly brought *E. compressa* in to synonymy with *E. intestinalis*. Distinguishing the subspecies presented the same problems of distinguishing the original species, as there was the practical problem of deciding whether or not a plant is branched when the expression of branching is slight. On the other hand, Koeman and van den Hoek (1982) considered that this overlap in the branching pattern is comparable to that encountered in other algal groups, as in the genus *Cladophora* (van den Hoek, 1963, 1964, 1982a), and kept the two species separate. Later, Burrows (1991) proposed the aggregate species *E. intestinalis* (L.) Link as the most useful to apply until more work has been carried out on this complex from a genetical point of view.

The material from the present study was all unbranched, although on other occasions branched plants have been found in the Azores.

Habitat: Epilithic in the littoral zone at the north site, both in the spray zone and in tide pools but never forming extensive belts.

Seasonality: This species was only occasionally present in the material collected by scraping, its biomass varying from 3 to 15 g/m2 (Fig. 10) and its maximum length from 3 to 7.3 cm (Fig. 11).

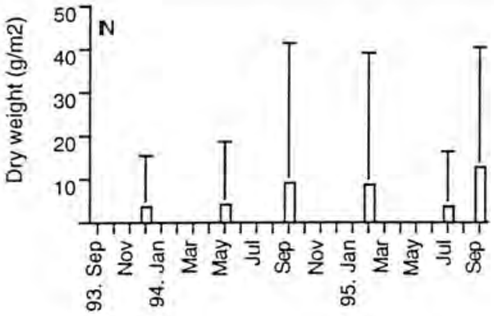


Fig. 10 Monthly biomass (mean + standard deviation) of *E. intestinalis*. For abreviations see section 3.5.

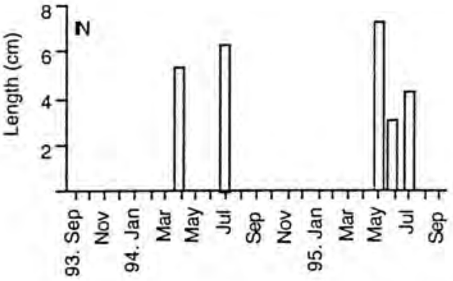


Fig. 11 Monthly maximum length of *E. intestinalis* For abreviations see section 3.5.

Reproduction: Fertile plants (with reproductive cells on the apical regions of the blade) were only found from May to July 1995.

Remarks: Common for most of the year, all round the coasts of the British Isles (Burrows, 1991) and on the northeastern coast of North America (Taylor, 1978), where plants can be found in a reproductive condition at all times of the year. Towards the northern limit of its distribution maximum development and reproduction occur during the summer months (Burrows, 1991), although Blackler (1956) noted that reproduction occurred all year round in Scotland. Zaneveld and Barnes (1965) observed reproduction between June and October in the western Atlantic, although fronds were present year round. Christie and Evans (1962) showed that swarmer production decreased between September and mid December in northern Wales. Pringle (1986), working with plants from Nova Scotia, supported the conclusion of Christie and Evans (1962) that the discharge of swarmers in *E. intestinalis* is periodic, showing a maximum around spring tides, and that certain environmental factors such as temperature may influence the phase length of the cycle. Further south, this species was found all the year in Madeira (Levring, 1974), and between November and July in Spain, the largest plants being present in February and March (Seoane-Camba, 1965).

In this study, although never frequent, this species was collected in all seasons, with reproductive plants occurring in late spring and summer. It is not possible to comment on the influence of spring tides on the release of swarmers, as the collections did not follow the tide cycle.

Enteromorpha muscoides (Clem.) Cremades, in Cremades et Perez-Cirera

Enteromorpha ramulosa (Sm.) Hook.
Ulva ramulosa Sm.

Distinguishing features: Plant repeatedly branched with alternating long branches and short spine-like branchlets; cells rounded to quadrangular with usually more than five pyrenoids. This species has been recorded in the Azores as *E. ramulosa*, even in recent works (see Neto, 1994), although it was named as *E. crinita* by Blinding (1963) and Burrows (1991). More recently, Prud'homme van Reine *et al.* (1994) changed its name to the designation used in this study.

Habitat: The same as for *E. intestinalis*.

Seasonality: Plants were collected throughout the sampling period. No seasonal pattern was observed in their biomass, which ranged from 10 to 140 g/m2 (Fig. 12). The lengths of collected plants varied between 1.5 and 5.5 cm (Fig. 13).

Reproduction: Reproductive plants were only found in May 1994, and in January and February 1995.

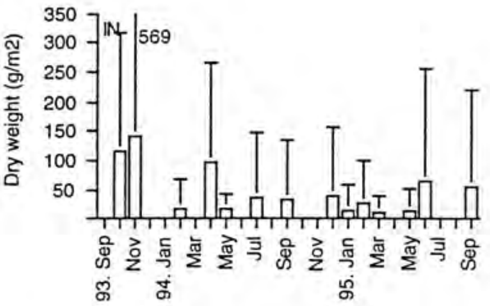


Fig. 12 Monthly biomass (mean + standard deviation) of *E. muscoides*. For abreviations see section 3.5.

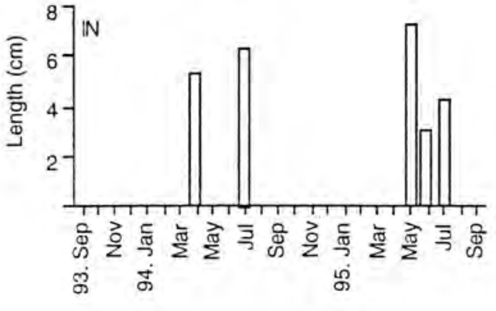


Fig. 13 Monthly maximum length of *E. muscoides*. For abreviations see section 3.5.

Remarks: Generally distributed in the British Isles, where it can be found throughout the year, although more common during the late summer and winter months through to April; reproductive plants present in summer (Burrows, 1991). Present from January to April in Spain (Seoane-Camba, 1965), in spring and summer in mainland Portugal (Ardré, 1970), this species was collected a few times during the summer in Madeira (Levring, 1974) and throughout the year in the Canaries (Børgesen, 1925) and Morocco (Gayral, 1958).

Ulva rigida C. Agardh

Ulva rigida var. *rigida* J. Agardh

Additional reference: Koeman and van den Hoek (1980).

Distinguishing features: The plants studied were light green, often deeply divided and many times crispy in texture. Transverse sections revealed elongate cells, 2-3 times as long as broad. The majority of cells in the middle and apical regions of the blade contained two to four pyrenoids. These features fit under the description of *Ulva rigida* given by Bliding (1968), Koeman and van den Hoek (1980), and Burrows (1991). In addition, Burrows (1991) uses as a diagnostic feature the larger size of rhizoidal cells in the upper basal region, in comparison to the vegetative cells. I could only observe this feature in a few plants. In most of the plants examined, these two type of cells were approximately the same size, as in other species (*U. lactuca* and *U. olivescens*). The microscopic denticles on the basal margin of the frond (Plate II.2), referred to by Burrows (1991) and only observed in a few plants during this study, were found to be common in July 1996, in plants from São Vicente.

Besides the overlapping characters mentioned above, pyrenoids are not always apparent, even after staining with Iodine (KI), and the columnar cells are not reliable as a diagnostic feature. These observations reveal that some problems persist in the identification of *Ulva* species from the Azores.

Habitat: Tolerant to sand cover, *U. rigida* was common in the intertidal and subtidal levels at both sites, although more abundant intertidally.

Seasonality: No seasonal pattern was detected in the biomass of this species throughout the year at any level (Fig. 14). However, a seasonal growing pattern can be seen in all the levels sampled, with larger plants present in summer and smaller ones in autumn/winter on both coasts (Fig. 15).

Reproduction: Reproductive plants were found throughout the year in the intertidal, while in the subtidal level they were found only in May and October at São Roque, and in May, June and August at São Vicente. Fertile plants were recognized by different means: some plants showed white margins, and the examination of the empty cells indicated a recent release of swarmers;

other plants had reproductive cells around the margins of the blade (as result of direct conversion of vegetative cells).

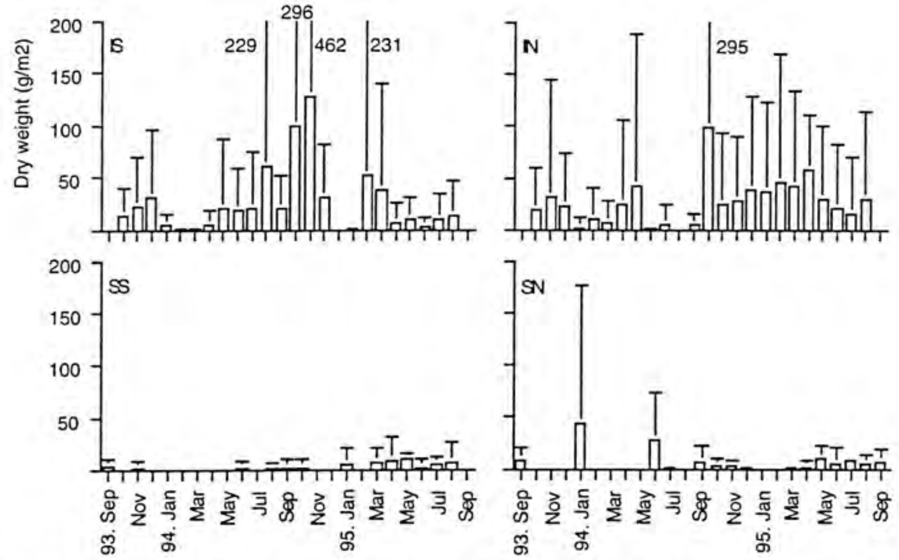


Fig. 14 Monthly biomass (mean + standard deviation) of *U. rigida*. For abreviations see section 3.5.

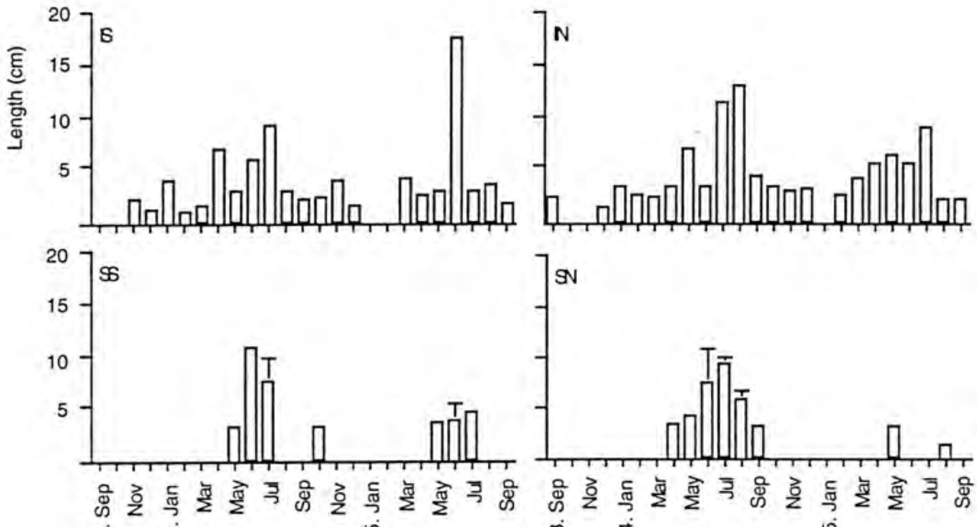


Fig. 15 Monthly maximum length of *U. rigida* (error bars indicate the standard deviation). For abreviations see section 3.5.

Remarks: Recently reported in the Netherlands (Koeman & van den Hoek, 1980), this species is distributed generally in the North Atlantic Ocean, probably more commonly than indicated by the records (Gayral, 1966; Irvine, 1982; Tittley *et al.*, 1985a, b; Wynne, 1985; Anadón & Fernández, 1986; Gayral & Cosson, 1986; Boudoresque *et al.*, 1992; Cabioc'h *et al.*, 1992). In the British Isles, plants are common during the summer months and may be present all year round. Reproductive plants have been found in the summer but the seasonal behaviour in relation to reproduction is not known (Burrows, 1991). Further south, this species has also been recorded throughout the year in Morocco (Gayral, 1958), Madeira (Levring, 1974), the Canaries and in Africa (Lawson & John, 1982).

CLADOPHORALES

CLADOPHORACEAE

Additional references: *Cladophora* (van den Hoek, 1963, 1982a; Jónsson *et al.*, 1989).

Chaetomorpha linum (O. F. Müller) Kützing

Conferva linum O. F. Müller
Chaetomorpha aerea (Dillwyn) Kützing
Chaetomorpha aerea (Dillwyn) Kützing f. *fibrosa* Kuetz.
Chaetomorpha aerea (Dillwyn) Kützing f. *crassa* Kützing

Distinguishing features: For this determination I have followed Burrows (1991) who included *C. aerea* under this designation. All plants collected by me were attached; cell width was 120-170µm at the base and 250-300µm along the filament.

Habitat: Attached to rocks, shells and coralline algae in the intertidal level on both sites.

Seasonality: Never abundant, equally common at both sites, (Wilcoxon test 85, 23 pairs, $p=0.11$), this species was present throughout the sampling period, being more frequent in the first year in São Roque (São Roque: Wilcoxon test 11, 12 pairs, $p<0.05$; São Vicente: Wilcoxon test 33, 12 pairs, $p>0.05$). No pattern was detected on its biomass over the year, with values varying from 2 to 130 g/m2 (Fig 16). The length of the plants sampled ranged from 2.5 to 10 cm (Fig. 17).

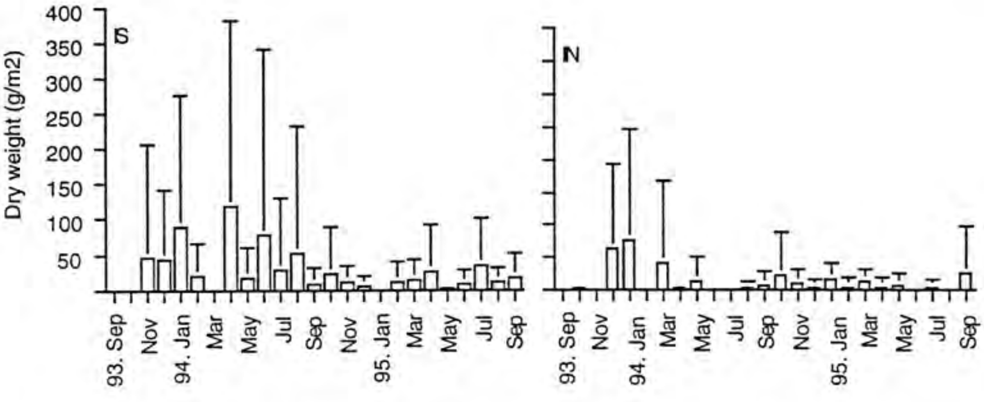


Fig. 16 Monthly biomass (mean + standard deviation) of *C. linum*. For abreviations see section 3.5.

Reproduction: Fertile plants were only found from June to September 1995 at São Roque, indicating that reproduction takes place in summer.

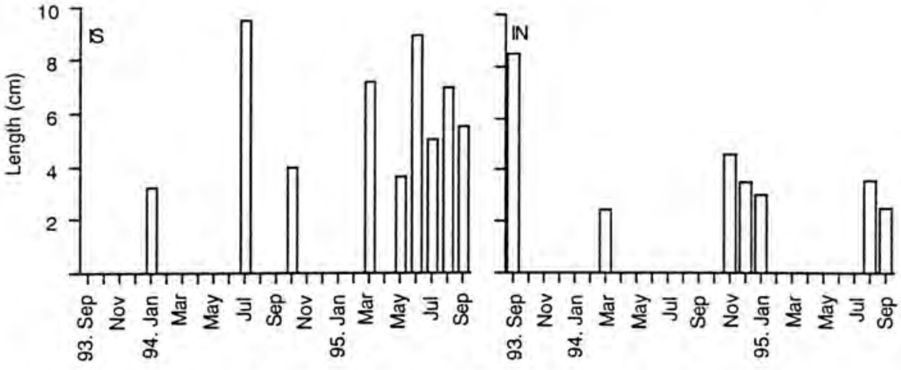


Fig. 17 Monthly maximum length of *C. linum*. For abreviations see section 3.5.

Remarks: Attached and unattached plants are abundant in spring and summer, but may be found at any time of the year in the British Isles (Burrows, 1991) and along the northeastern coast of North America (Taylor, 1978). Gametes have been recorded in attached plants, mainly from April to August, and zoospores mainly from August until November (Price, 1967), but fertile plants can be found all the year round (Knight & Parke, 1931). The unattached form has not been found in a fertile condition in the field but Kornmann (1972) obtained both zoospores and gametes in culture from material collected from the type locality in October. Common in spring in the Aegean Sea (Athanasiadis, 1987). Collected from November to July in Spain (Seoane-Camba, 1965) and between autumn and spring in mainland Portugal (Ardré, 1970). Plants of this species were collected in Madeira all year round (Levring, 1974).

Chaetomorpha mediterranea (Kützing) Kützing

New record for the Azores. Common in the northeast Atlantic, from the British Isles down to mainland Portugal, and in the Mediterranean (Price, 1967; Burrows, 1991).

Distinguishing features: Entangled filaments forming an unattached spongy mass of firm and crisp texture.

Habitat: Filaments of this species were found over other algae in the intertidal at São Roque.

Seasonality: Filaments were collected only in February 1995.

Reproduction: No data.

Remarks: Generally common in the British Isles, where it can be found all year round, although more abundant in summer. According to Price (1967), vegetative reproduction is dominant, although swarmers have been found in July and young plants in September.

Cladophora coelothrix **Kützing**

Conferva repens J. Agardh

Distinguishing features: Plants growing in a cushion-like turf, often entangled with other species. Dark green, blackish when dried, the fronds are densely but irregularly branched with lateral insertion of branches. Apical cells 55-200µm in diameter, 4-9 times as long as broad.

Habitat: Present in the lower intertidal at both sites.

Seasonality: More common at São Vicente, where it was present through the year. Here its biomass varied over the sampling period, with mean values ranging from 5 to 80 g/m2 (Fig. 18). The length of plants varied between 1 and 2.5 cm (Fig. 19). At São Roque, only one plant was collected, in August 1994.

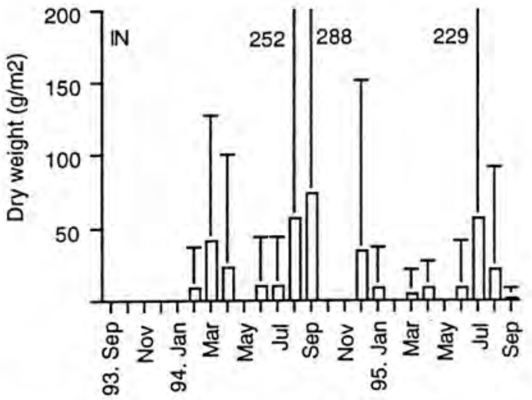


Fig. 18 Monthly biomass (mean + standard deviation) of *C. coelothrix*. For abreviations see section 3.5.

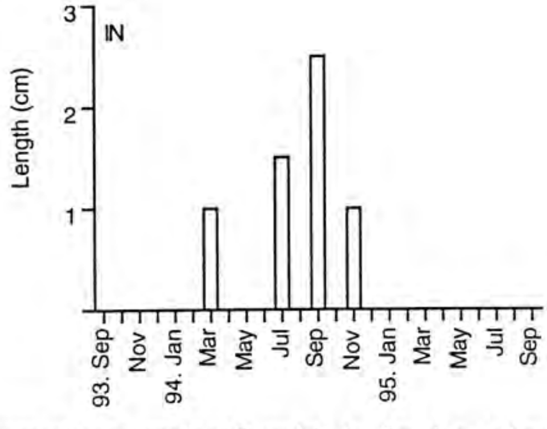


Fig. 19 Monthly maximum length of *C. coelothrix*. For abreviations see section 3.5.

Reproduction: Empty cells (as a result of discharged swarmers) were found in the plants collected between July and September 1994, indicating that reproduction takes place in summer.

Remarks: Plants of this species can be found at all times of the year in the British Isles and mainland Portugal but they have never been recorded in a reproductive condition (Burrows, 1991;

Ardré, 1970).

Cladophora hutchinsiae (Dillwyn) Kützing

New record for the Azores. Common in the Mediterranean, generally distributed in the eastern and western Atlantic Ocean (Børgesen, 1925; van den Hoek, 1963, 1982a; Seoane-Camba, 1965; Levring, 1974; Taylor, 1967, 1978; Jónsson *et al.*, 1989; Ballesteros *et al.*, 1992).

Distinguishing features: Fronds light green. Intercalary growth dominant, and apical cells 140 to 160μm in diameter and 1 to 4 times as long as broad. Easily recognized by the apical branching pattern and the broad cells with low length/width ratios.

Habitat: This species was found in a tide pool at São Vicente.

Seasonality: Plants were collected in March and November 1994; the length of filaments was 1.0 and 1.2 cm respectively.

Reproduction: Both plants were vegetative.

Remarks: In the British Isles plants are conspicuous during late spring and summer but can still be found as small plants during the winter (Burrows, 1991). Further south this species was found throughout the year in mainland Portugal (Ardré, 1970) and Madeira (Levring, 1974). The reproductive period has not been established in the British Isles. The release of biflagellate swarmers has been observed on only a few occasions (by Archer, 1963 *fide* van den Hoek, 1963); fertile plants were seen by Burrows (1991) in September. In mainland Portugal, reproductive structures were only observed in February and June (Ardré, 1970).

Cladophora laetevirens (Dillwyn) Kützing

New record for São Miguel. Previously recorded from Flores, Faial, Graciosa, Terceira and Santa Maria (see Neto, 1994).

Distinguishing features: Fronds light green with dominant apical growth. Apical cells 35 to 75μm in diameter and 2 to 4 times as long as broad.

Habitat: Occasionally present in midlittoral rock pools at both sites.

Seasonality: This species was never abundant (mean biomass not exceeding 70 g/m2). Plants were collected in June 1994 at São Roque and in May and October 1995 at São Vicente, varying in length between 2 and 3.7 cm.

Reproduction: All plants contained empty cells, indicating a previous liberation of reproductive cells.

Remarks: This species is probably present all the year in the British Isles but is most conspicuous during the spring and summer months when plants reproduce (Burrows, 1991). Common in the Aegean Sea, where specimens with empty cells were collected in July (Athanasiadis, 1987). Ardré (1970) found it in all seasons in mainland Portugal, with gametophyte plants present in October.

Cladophora lehmanniana (Lindenberg) Kützing

New record for the Azores. Common in the Mediterranean, and also present in the eastern Atlantic Ocean and the Canaries (Børgesen, 1925; van den Hoek, 1963, 1982a; Jónsson *et al.*, 1989).

Distinguishing features: Distinguished from *C. laetevirens* by the narrower but longer apical cells (22 to 40µm diameter and 5-20 times as long as broad).

Habitat: Present at São Vicente (lower intertidal pools) and in São Roque (subtidal), although never frequent.

Seasonality: Only three plants were collected, one in São Vicente (September 1994) and two at São Roque (July 1994 and 1995), lengths respectively 4.3, 2.3 and 1.0 cm.

Reproduction: Both plants collected in 1994 were reproductive.

Remarks: Common in the warmer waters of the Mediterranean, this species reaches the south coast of England and the west coast of Ireland (Burrows, 1991). Plants are known to be present during the summer in the British Isles but there is no information on seasonal pattern of growth or reproductive period. Van den Hoek (1963) found plants from Spain producing quadriflagellate zoospores on one occasion.

Cladophora prolifera (Roth) Kützing

Conferva prolifera Roth
Conferva prolifera Roth var. *fastigiata* (H)
Cladophora catenata (Agardh) Ardiss.
Conferva catenata L. (Roth)

Distinguishing features: Thallus rather rigid, dark green and composed of interwoven tufts. Numerous rhizoids winding around lower axial cells and growing down over the substratum. Growth is by apical cells, which are 120 to 200µm in diameter and 2-8 times as long as broad.

Habitat: Frequent in tide pools and open rocks in the lower intertidal at São Vicente, this species was also present in the subtidal level of both sites.

Seasonality: It was never present in the subtidal qualitative collections and was not abundant in the scraped material, the mean biomass never exceeding 8 g/m2. In the intertidal it was a common species, being present throughout the sampling period, although no seasonal pattern was detected either on its biomass or growth (Figs. 20 and 21). Mean biomass varied between 5 and 50 g/m2 and the length of the observed plants was between 1.5 and 6 cm.

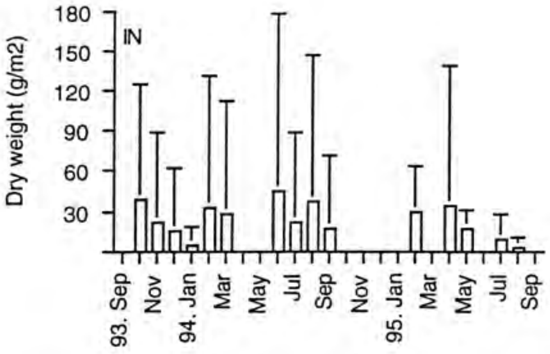


Fig. 20 Monthly biomass (mean + standard deviation) of *C. prolifera*. For abreviations see section 3.5.

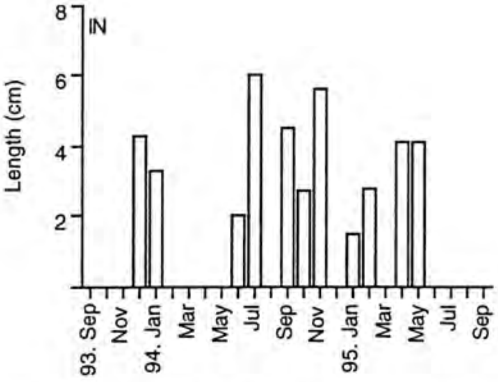


Fig. 21 Monthly maximum length of *C. prolifera*. For abreviations see section 3.5.

Reproduction: Reproductive plants were not frequent: they were found in July and October 1994, and between February and April 1995, indicating that reproduction takes place throughout the year.

Remarks: This species is probably present throughout the year in the British Isles but most of the records refer to the summer months (Burrows, 1991). Also more abundant in the summer in the Gulf of Gascogne (Hamel, 1924), it was collected in March and from July to December in Spain (Seoane-Camba, 1965) and throughout the year in mainland Portugal (Ardré, 1970), Madeira (Levring, 1974) and Canaries (Børgesen, 1925). Production of swarmers has not been reported for the British Isles (Burrows, 1991). Van den Hoek (1963) found biflagellate swarmers on a few occasions in plants from France and Spain, and he reported that they germinate directly to form new plants. Funk (1955) found young plants in August and September at Naples.

ANADYOMENACEAE

Anadyomene stellata (Wulfen) C. Agardh

New record for São Miguel. Previously recorded from Faial, Pico (see Neto, 1994). Recently found in Flores (Tittley *et al.*, in press).

Distinguishing features: Plant foliaceous and inconspicuously stalked. Blades rounded and crisp, formed by a polychotomously branching, flabellate series of cells forming fan-like ribs. These are barely visible to the unaided eye (0.25 to 0.33 mm diameter).

Habitat: Epilithic in the subtidal at São Vicente (15m depth).

Seasonality: Only collected twice, in April and July 1995.

Reproduction: Only vegetative material found.

Remarks: Frequent on the eastern tropical and subtropical coasts of America (Taylor, 1967), this species was present in all seasons in the Aegean Sea but was more common in late summer and autumn (Athanasiadis, 1987). Also collected over the year in the Canaries (Børgesen, 1925).

SIPHONOCLADALES
VALONIACEAE

Valonia utricularis (Roth) C. Agardh

Distinguishing features: Plants coenocytic, composed of short branching filaments of large cylindrical and clavate cells.

Habitat: Subtidally, growing under other algae, more common on the south site.

Seasonality: At São Roque this species was present for much of the sampling period, its mean biomass fluctuating between 0.1 and 7.5 g/m2 (Fig. 22), the lengths of the measured plants varying between 1.5 cm (June) and 3 cm (August). At São Vicente plants were collected in November 1994 (5m depth) and in February and August 1995 (15m).

Reproduction: No reproductive plants were found.

Remarks: Plants of this species have also been collected all year round in Spain (Seoane-Camba, 1965), mainland Portugal (Ardré, 1970), Madeira (Levring, 1974) and the Canaries (Børgesen, 1925).

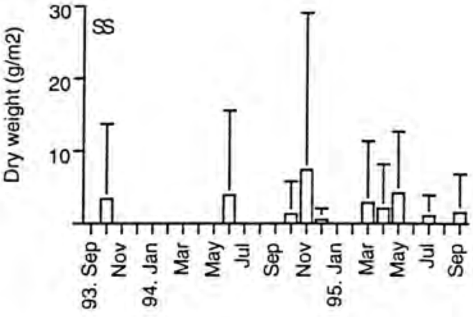


Fig. 22 Monthly biomass (mean + standard deviation) of *V. utricularis*. For abreviations see section 3.5.

BRYOPSIDALES

BRYOPSIDACEAE

Bryopsis hypnoides J. V. Lamour.

New record for São Miguel. Previously recorded from Flores and Faial (see Neto, 1994).

Distinguishing features: Thallus dark green. Main branches of indeterminate growth arranged spirally or irregularly, all around the main axis.

Habitat: Epilithic in lower littoral pools and in the shallow sublittoral, this species was present at all sampled levels down to 15m.

Seasonality: Clearly most abundant at the southern intertidal site, where plants were present for much of the sampling period, no seasonal pattern could be discerned in its biomass, which was greatest in November 1994 and February 1995 (Fig. 23). Plants length varied between 3 and 7.5 cm, the larger plants being collected in spring (Fig. 24). Elsewhere, only a few, smaller plants were collected, which resulted in lower values for biomass and size (Figs. 23 and 24).

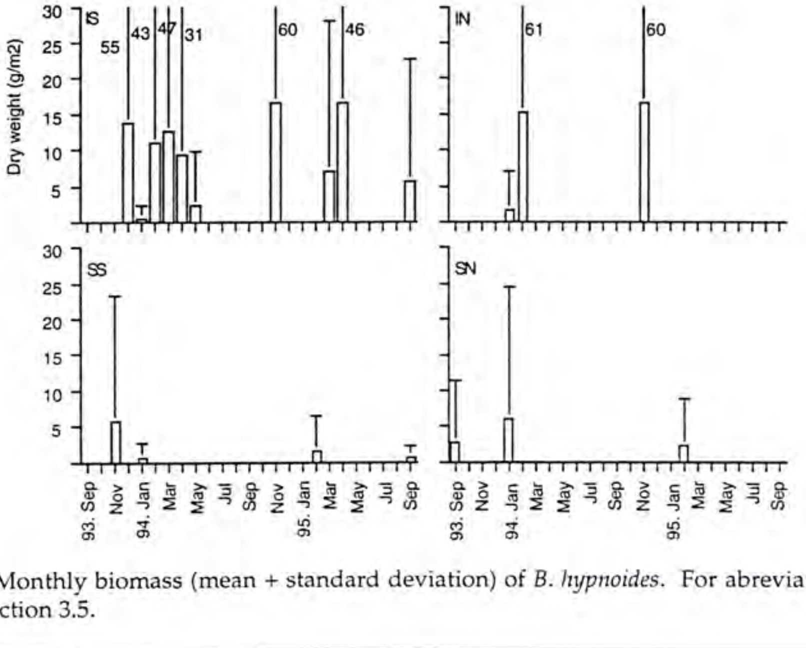


Fig. 23 Monthly biomass (mean + standard deviation) of *B. hypnoides*. For abreviations see section 3.5.

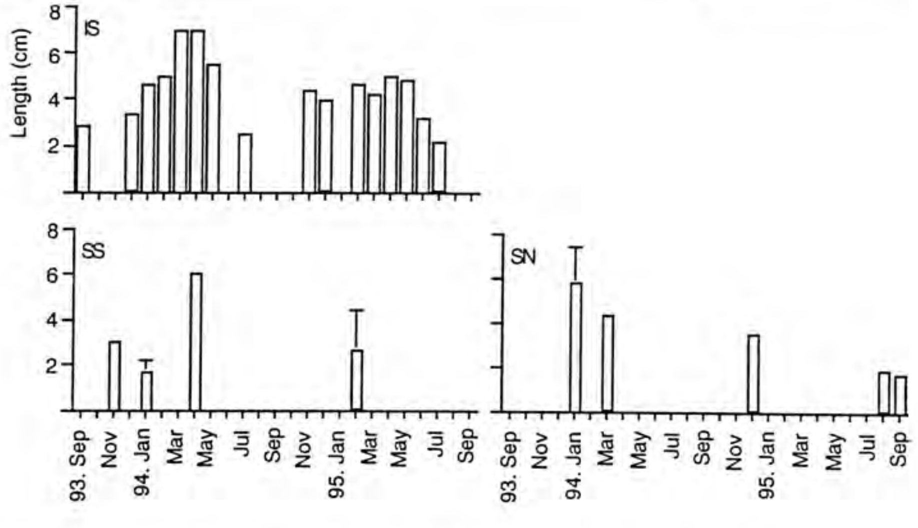


Fig. 24 Monthly maximum length of *B. hypnoides* (error bars indicate the standard deviation). For abreviations see section 3.5.

Reproduction: At São Roque fertile plants were found during the year in the intertidal, and in April and February in the subtidal; at São Vicente only one fertile plant was seen in January 1995 from the intertidal level.

Remarks: Present most of the year in the British Isles, but most conspicuous in the spring, sexual plants were observed between May and September (Burrows, 1991). Also noted as common along the northeastern coasts of North America (Taylor, 1978), this species was collected between April and June in mainland Portugal (Ardré, 1970).

CODIACEAE

Additional references: *Codium* (Silva, 1951, 1955, 1957, 1959, 1960; Chapman, 1956; Silva & Womersley, 1956; Delépine, 1959; Ardré, 1961; Dangeard, 1958, 1965; Womersley, 1984).

Codium adhaerens C. Agardh

Distinguishing features: Thallus a dark green felt, irregular in shape, closely adherent to the rock surface. Texture rather gelatinous but firm. Utricles cylindrical with rounded ends.

Habitat: Covering rock surfaces in the lower intertidal and shallow sublittoral, this species was present on both coasts.

Seasonality: Although never abundant, this species was collected at both localities between June 1994 and October 1995. At São Vicente it was strictly intertidal but at São Roque it was present also subtidally.

Reproduction: Reproductive plants were found at both stations in late summer/autumn.

Remarks: Plants appear to be present all the year round in the British Isles but apparently die-back after flourishing and then reappear the following year (Dellow, 1952); also collected throughout the year in Spain (Seoane-Camba, 1965) and in mainland Portugal (Ardré, 1970). Fertile plants were present in summer, but especially towards October, in the British Isles (Burrows, 1991), and were also restricted to summer in Morocco (Gayral, 1958).

Codium decorticatum (Woodw.) Howe

New record for São Miguel. Previously recorded from Faial, Pico and Terceira (see Neto, 1994).

Distinguishing features: Thallus dark green and terete, except at the dichotomies which are wider and flattened. Utricles large, more or less cylindrical (115-850μm diameter, 800-2000μm long) and with very rounded or truncated ends, thus easily distinguishable from those of *C. fragile*.

Habitat: This species was only present subtidally, being collected at 10m depth at both sites.

Seasonality: Only three plants were collected during the sampling period, two at São Roque (July 1994 and September 1995) and one at São Vicente (November 1993). These specimens were 2.3 to 21.9 cm long.

Reproduction: Only the plant collected in September was gametangial.

Remarks: Ardré (1970) found this species at all seasons in mainland Portugal, mature gametophytes being present in June and October. Dangeard (1958) reported the occurrence of reproductive plants in France in autumn.

Codium elisabethae O. C. Schmidt

Considered as endemic in the Azores by Schmidt (1931) but has recently been found at Porto Santo, Madeira archipelago (Audiffred & Prud'homme van Reine, 1985; Prud'homme van Reine, 1988).

Distinguishing features: Thallus a flattened spongy sphere with a velvety surface, attached by interwoven filaments to rocky and other substrata. Utricles slightly constricted below with mucronate apices, this feature allowing separation from *C. bursa*, a similar species whose record for the island of Santa Maria (Agardh, 1870) requires confirmation.

Habitat: Tolerant to sand cover, growing attached to rock surfaces in the sublittoral down to 15m and often in clusters, this species was present at both localities.

Seasonality: It was collected throughout the sampling period at both stations. Its biomass fluctuated over the year with generally higher values at São Roque, particularly in summer, whereas at São Vicente the standing crop showed a peak in December 1993 (Fig. 25). At both study sites, plants were similar in size, up to 8 cm in diameter (Fig. 26) but not showing any obvious seasonal growth.

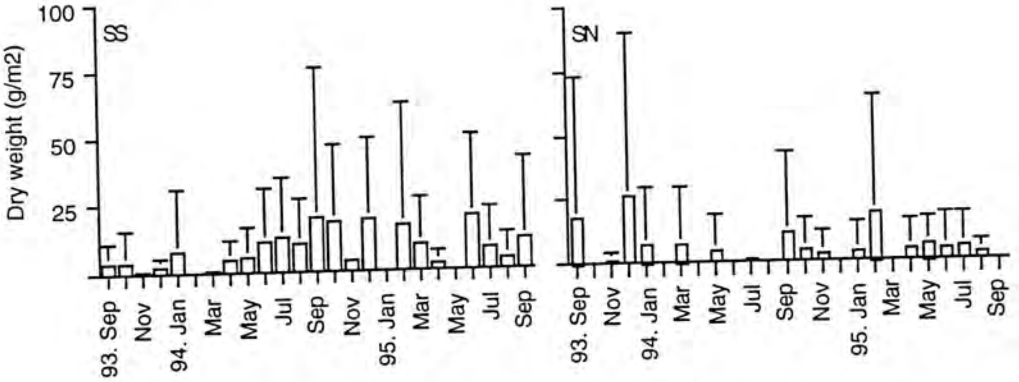


Fig. 25 Monthly biomass (mean + standard deviation) of *Codium elisabethae*. For abreviations see section 3.5.

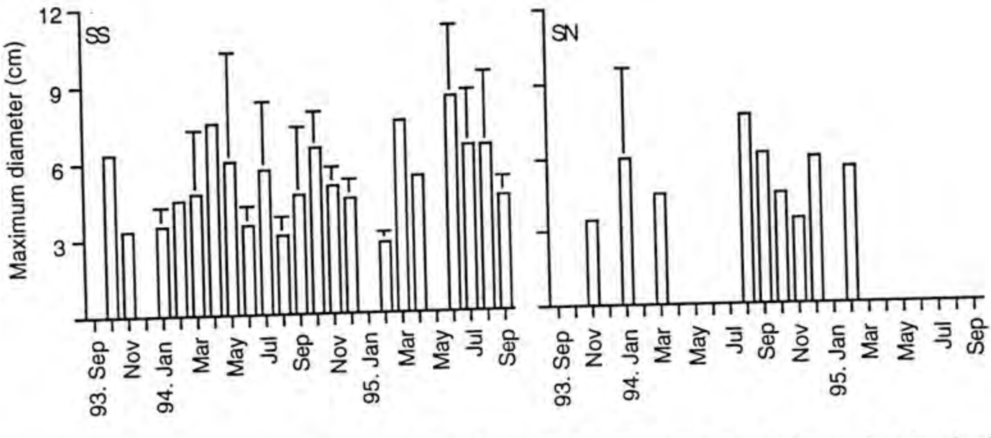


Fig. 26 Monthly maximum diameter of *Codium elisabethae* (error bars indicate the standard deviation). For abreviations see section 3.5.

Reproduction: Fertile plants were found in October, December and February, indicating that reproduction of this species takes place in autumn/winter.

Codium fragile (Suringar) Hariot

New record for São Miguel. Found recently in Flores (Tittley *et al.*, in press). Widely distributed in the North Atlantic (Knight & Parke, 1931; Borden & Stein, 1969; Silva, 1955, 1957; Parkes, 1975; Burrows, 1991).

Distinguishing features: Thallus dark green and terete, never flattened at the dichotomies (unlike *C. decorticatum*), attached by a stout base. Utricles large, more or less cylindrical and with short, and most times blunt, mucrons (up to 15 µm long). The umbonate utricles easily differentiate *C. fragile* from the other dichotomous species of *Codium* in the Azores.

Habitat: Epilithic in the subtidal zone (15m) at São Roque.

Seasonality: Only one plant was collected, in August 1994.

Reproduction: The plant was not reproductive.

Remarks: *Codium fragile* is considered to have a worldwide distribution, occurring in all continents and it has been regarded as a recent introduction in many places on both sides of the Atlantic (Silva, 1955; Feldmann, 1956; Dangeard, 1958; Delépine, 1959; Ramus, 1971; Fralick & Mathieson, 1973; Parkes, 1975; Hillson, 1976; Hanisak, 1980; Searles *et al.*, 1984; Burrows, 1991). This is mainly due to the vigour and adaptability of plants, allowing their rapid spread (Dangeard & Parriaud, 1956). Dangeard (1958) commented that, although only introduced on to the Basque coast after 1940, it soon became the most common dichotomous *Codium* species on those shores. Feldmann (1956) demonstrated the occurrence of parthenogenesis in *C. fragile* on Banyuls-sur-Mer, where this species was also at that time a recent introduction. This involved the production of macrogametes which once liberated developed directly on the shore. According to Dangeard and Parriaud (1956) and Delépine (1959), the efficiency of this mode of reproduction would account for the rapid spread of this species in recent times. Its presence in the Azores reported now for the first time (the specimen from São Miguel collected in 1994 and one from Flores in 1995), suggests its recent introduction into these islands.

There are four subspecies on the Atlantic, mainly distinguishable by the dimensions of their utricles (Table II).

Table II. Utricle dimensions (in µm) of the four atlantic subspecies of *C. fragile*.

Subspecies	Diameter	Length	Mucron length	References
atlanticum	(130) 170-330	780-1200	10-14	Silva (1955, 1957)
tomentosoides	(105) 165-325 (400)	550-1050	to 68	Silva (1955, 1957)
capense	(80) 130-270 (350)	730-1100	to 60	Silva (1959)
scandinavicum	190-420 (670)	480-850 (1200)	to 20	Silva (1957)

The plant collected from São Roque had utricles 50-290µm in diameter and 620-740µm in length, with mucrons 10µm long. Hair scars were not seen. These measurements overlap most of those for the above subspecies, although only subsp. *atlanticum* has such small mucrons. This subspecies is known from the northeast Atlantic down to England (Silva, 1957; Parkes, 1975; Knight & Parke, 1931; Burrows, 1991). Subspecies *tomentosoides* extends further south down to France and the Netherlands (Silva, 1957), and subspecies *scandinavicum* is known from Scandinavia, England, France and Spain (Silva, 1957). Subspecies *capense* is known from southwest Africa around the Cape of Good Hope to Robberg Cape Province (Silva, 1959). According to Silva (1955), different subspecies may show overlap or intermediate characters, mainly at their centers of distribution. With only one single plant, it would be premature to conclude about its subspecific status, as it might even be a new subspecies. More plants are needed before drawing any firm conclusions.

Codium vermilara (Olivi) Chiaje

New record for the Azores. Present in the Mediterranean, and on the temperate region of the northeast Atlantic (Silva, 1955; Dangeard, 1958; Gayral, 1966; Ardré, 1970; Burrows, 1991; Boudouresque *et al.*, 1992).

Distinguishing features: Thallus irregularly branched, terete with short terminal segments. Utricles obovate to cylindrical, with rounded apices, 400-700μm long, 100-250μm in diameter.

Habitat: Epilithic in the subtidal at São Roque.

Seasonality: One plant was collected in October 1994.

Reproduction: The plant possessed mature gametangia.

Remarks: Like *C. fragile*, this is likely another recent introduction to the Azores, as it is very distinctive and was not found in previous collections. In the Atlantic it extends from Norway to Morocco (Silva, 1955). According to Burrows (1991), the main occurrence of this species in the sublittoral region make records probably incomplete. Therefore not much is known about its seasonal growth pattern or its reproductive period in the British Isles, although there are records of gametangia for August and September. Dangeard (1958) found this species fertile in France from August to November, and several authors report its presence in Spain (Polo & Seoane, 1979; Gili & Ros, 1982; Romero, 1981; Ballesteros, 1982). Common in the Mediterranean (Silva, 1955), where Ballesteros 1988) describes a community on the Costa Brava growing between 8 and 20m depth. This community has its highest biomass in summer/autumn. Ardré (1970) collected it at all seasons in mainland Portugal.

4.2 PHAEOPHYTA

CLASS PHAEOPHYCEAE

Additional references: Hamel (1939); Wynne 1969).

ECTOCARPALES

Additional reference: Clayton (1974).

ECTOCARPACEAE

Additional references: Cardinal (1964); *Ectocarpus* and *Giffordia* (Clayton, 1972).

Ectocarpus siliculosus (Dillwyn) Lyngbye

New record for São Miguel. Previously recorded for the Azores by South and Tittley (1986), without specifying the island.

Distinguishing features: Plants epiphytic, attached by rhizoids. No typical main axis and obvious fascicles of branches. Narrow plurilocular sporangia (Plate II.3).

Habitat: Epiphytic on rosette *Sargassum* (q.v.) in lower tide pools at São Vicente.

Seasonality: One plant was collected in May 1994.

Reproduction: The plant had pedicellate plurilocular sporangia.

Remarks: Collected in winter and spring in the Gulf of Mexico (Earle, 1969) and in mainland Portugal (Ardré, 1970). Gametophyte plants were observed in the summer in North America (Taylor, 1978).

Hincksia mitchelliae (Harv.) Silva in Silva, Menez and Moe

Ectocarpus virescens (Thur.) Sauv.

New record for São Miguel. Previously recorded in Terceira (see Neto, 1994).

Additional reference: Cabrera (1970).

Distinguishing features: Plants in diffuse mats, attached by rhizoids and the longer filaments sometimes stranded together. Branching abundant. Plurilocular sporangia with large locules (Plate III.1).

Habitat: The same as for *Ectocarpus siliculosus*.

Seasonality: Two plants were collected in August and September 1995.

Reproduction: Both plants were reproductive with non-pedicellate plurilocular sporangia.

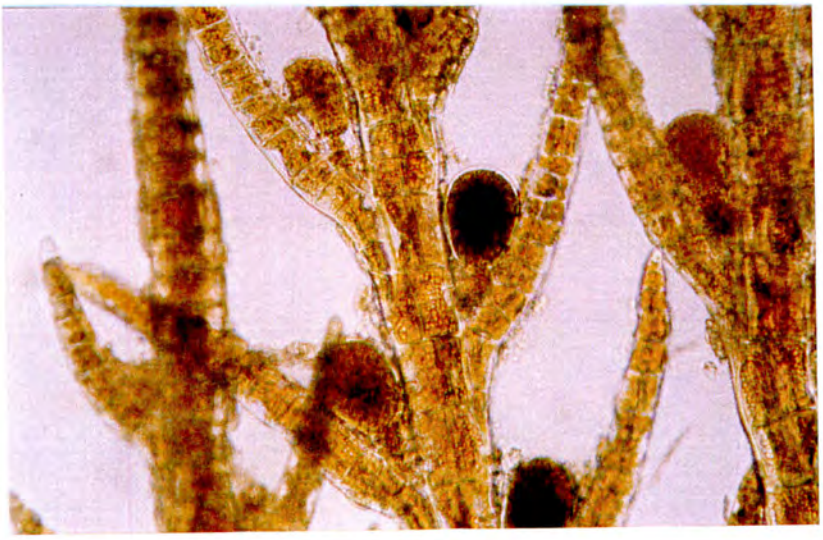
Plate III

1. *Hincksia mitchelliae*: Portion of plant showing plurilocular sporangia (x400).

2. *Halopteris filicina*: Portion of plant showing unilocular sporangia (x200).

3. *Dictyota dichotoma*: Transverse section through fertile blade region showing isolated unilocular sporangia (x400).

1



2

3

Remarks: In North America this species is found in summer and autumn, reproductive structures being recorded in autumn (Taylor, 1978). In the Gulf of Mexico it is present throughout the year, although more abundant in the summer (Earle, 1969). Never abundant in Roscoff (Brittany), female gametophytes were collected in July and sporophyte plants between July and December (Cardinal, 1964). In mainland Portugal plants were collected only in June and August, both plants bearing sporangia (Ardré, 1970). In Madeira this species was also present in summer (Levring, 1974).

CHORDARIALES

CHORDARIACEAE

Sphaerotrichia divaricata (C. Agardh) Kylin

Chordaria divaricata C. Agardh

Additional reference: Ajisaka and Umezaki (1978).

Distinguishing features: The sporophyte has a cartilaginous thallus with a compact structure. Its transverse-section shows a wide, loose medulla and a narrow cortex. Cell-division is confined to the intercalary meristem.

Habitat: Epilithic in the lower intertidal pools at both sites.

Seasonality: At São Roque, only one plant, measuring 15.5 cm, was collected in June 1994. At São Vicente, slightly smaller plants (11 to 13.5 cm) were collected in February 1994, and from March to May 1995.

Reproduction: All plants had unilocular sporangia, and were presumably sporophytes.

Remarks: This summer annual species (Novaczek & McLachlan, 1987) occurs on cold-temperate coasts in the northern hemisphere, on both sides of the Atlantic and Pacific Oceans (Kang, 1966; South & Tittley, 1986; Scagel *et al.*, 1989; Yoshida *et al.*, 1990). Apparently this species had not been recorded in Europe south of the Channel Islands (Peters *et al.*, 1993), except for São Miguel, Azores (Neto, 1991a, b, 1994) and a recent discovery in the Mediterranean (Riouall, 1985). The sporophyte is seasonal, appearing in April and May in colder regions (Perestenko, 1980; Novaczek & Mclachlan, 1987), and later in the Mediterranean, where it was seen from May to July (Riouall, 1985). During the rest of the year the species survives in the form of microscopic gametophytes (Hygen, 1934; Ajisaka & Umizaki, 1978). According to Peters *et al.* (1987), gametes, zygotes, and thus new sporophytes are formed only in long days at temperatures below 15 °C.

The crossing studies of Peters *et al.* (1993) support the assumption of Riouall (1985) that *S. divaricata* was introduced into the Mediterranean from Japan. It is likely that the population on

São Miguel was also introduced recently.

CUTLERIALES

CUTLERIACEAE

Zanardinia prototypus (Nardo) Nardo

Zanardinia collaris (Montagne) P. Crouan et H. Crouan

Distinguishing features: Thallus flattened and horizontally expanded, circular or fan-like, sometimes irregular in shape, loosely attached on the under-surface by rhizoids. Coriaceous in texture, the thallus has a ruffled margin, with a distinct hair-like fringe, denoting its distinctive, trichothallic meristem.

Habitat: Epilithic in a lower littoral pool at São Vicente.

Seasonality: Only one plant was collected, in May 1994.

Reproduction: The plant was sterile.

Remarks: Perennial plant in the British Isles, where reproductive structures have never been found (Fletcher, 1987). In the Gulf of Mexico and North Carolina this species is present throughout the year, although more abundant in summer and autumn (Earle, 1969). Collected only in spring in mainland Portugal, gametophyte plants being present in March and April (Ardré, 1970).

SPHACELARIALES

STYPOCAULACEAE

Halopteris filicina (Grat.) Kützing

Sphacelaria filicina C. Agardh

Distinguishing features: Plants usually forming tufts, attached by a fibrous disc. Fronds regularly branched, with unilocular sporangia, ovoid in shape.

Habitat: Both epilithic and epiphytic at both places but only in the subtidal level.

Seasonality: Although very common in the qualitative collections (Fig. 27), this species was never abundant in the biomass samples, never exceeding 17 g/m2. The length of plants did not vary much in São Roque (4 to 7.5 cm). In São Vicente, plants were generally larger (5 to 11.5 cm).

Reproduction: Most plants were sporophytes, with unilocular sporangia (Plate III.2).

Remarks: Collected in all seasons in mainland Portugal (Ardré, 1970), while in Spain only one sterile plant was collected in January (Seoane-Camba, 1965).

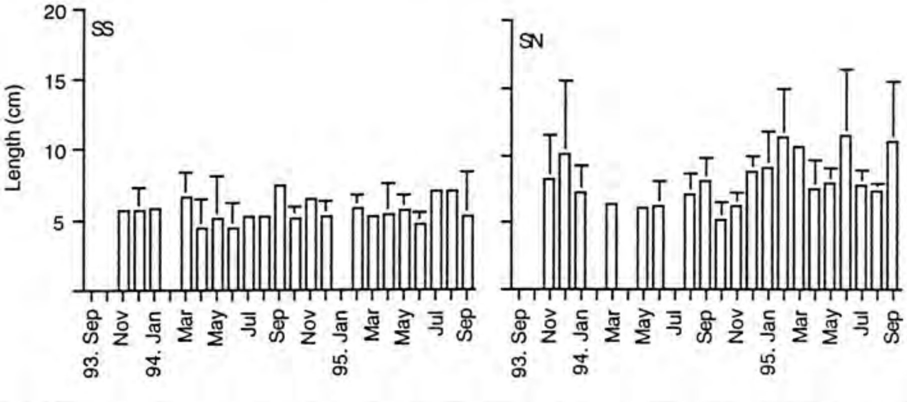


Fig. 27 Monthly maximum length of *H. filicina* (error bars indicate the standard deviation). For abreviations see section 3.5.

Stypocaulon scoparia (L.) Kützing

Halopteris scoparia (L.) Sauv.
Sphacelaria scoparia Agardh
Sphacelaria scoparia Lyngbye var. *pennata* Agardh
Stypocaulon scoparium Kützing
Ceramium scoparium DC.

Distinguishing features: Plants usually forming erect tufts, attached to the substratum by a fibrous disc; branching irregularly alternate and distichous; sporangia, ovoid in shape, arising on 1-2 celled stalks.

Habitat: Epilithic, this species formed corymbose tufts in the lower intertidal and subtidal levels of both coasts.

Seasonality: Although present at both levels, this species was much more abundant in the subtidal (Fig. 28), where it was one of the dominant species in the 15m depth communities of both coasts. At this level, this species was collected throughout the sampling period, its mean biomass showing a seasonal pattern on both coasts, with the higher values in the summer months (Fig. 28). As with *Halopteris*, the length of collected plants was greater and more variable at São Vicente (Fig. 29). In the intertidal it was much less abundant in São Roque, its mean biomass never exceeding 26 g/m2, as a result of the smaller plants (usually less than 5 cm in length). In São Vicente, *Stypocaulon* was more abundant and frequent both in qualitative and quantitative collections (Figs. 28 and 29). The highest biomass was in summer and the length of plants ranged between 2.7 and 11.0 cm.

Reproduction: Intertidal plants with unilocular sporangia, were collected between April and December at São Roque, and from December to February at São Vicente. In the subtidal, unilocular sporangia were seen from January to August at São Roque, and in October at São Vicente.

Remarks: Present all year round in the Aegean Sea (Athanasiadis, 1987), Spain (Seoane-Camba, 1965; Anadón & Fernández, 1986), mainland Portugal (Ardré, 1970), Madeira (Levring, 1974) and Canaries (Børgesen, 1926). Reproductive plants with unilocular sporangia were found in November in the Aegean Sea (Athanasiadis, 1987), in February in mainland Portugal (Ardré, 1970) and in January in the Canaries (Børgesen, 1926).

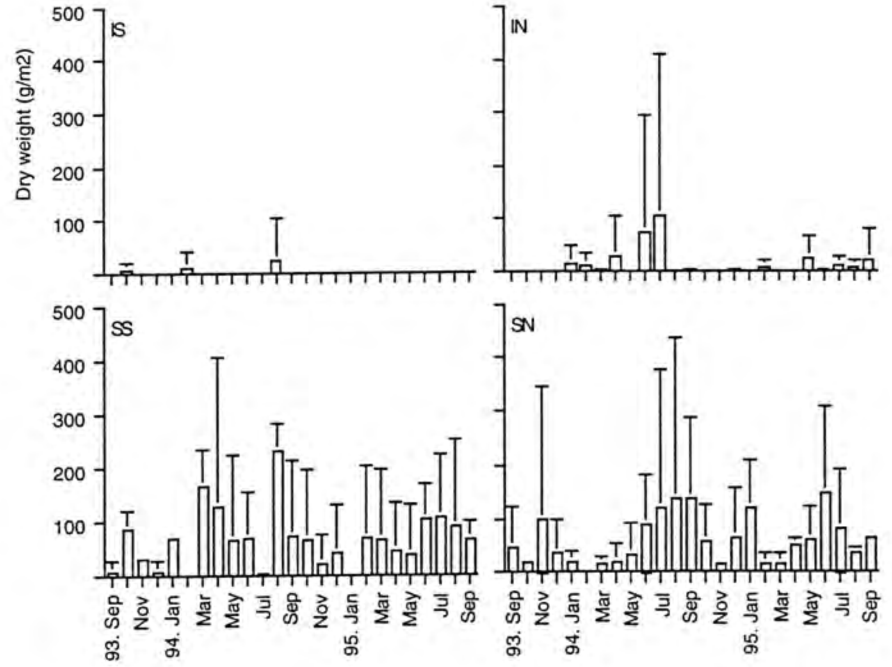


Fig. 28 Monthly biomass (mean + standard deviation) of *S. scoparia*. For abreviations see section 3.5.

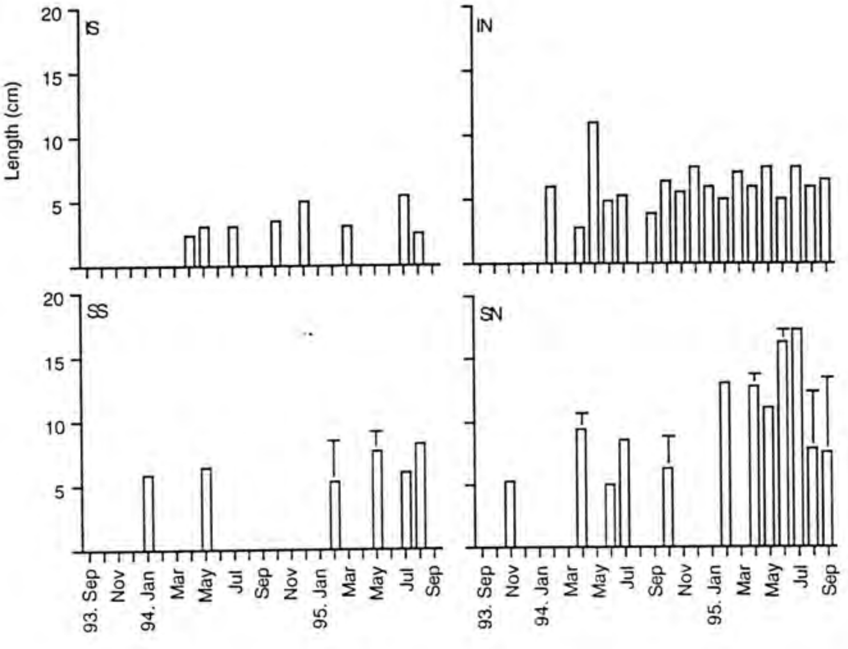


Fig. 29 Monthly maximum length of *S. scoparia* (error bars indicate the standard deviation). For abreviations see section 3.5.

The seasonality in reproduction of this species that seems to occur elsewhere, does not occur in São Miguel, where reproductive plants were seen all year round. On the other hand, a seasonal pattern was detected in its biomass in São Miguel, with higher values occurring in summer, as already noted.

CLADOSTEPHACEAE

Cladostephus spongiosus (Huds.) C. Agardh

Cladostephus verticillatus (Lightf.) C. Agardh

Distinguishing features: Thallus dark brown, with axes totally covered by short, radial ramuli densely disposed, resembling a brush.

Habitat: Restricted to the subtidal level, this species was present at both localities.

Seasonality: It was collected in October 1993 at São Vicente and from September to November 1993 at São Roque.

Reproduction: No data.

Remarks: Collected throughout the year in the Aegean Sea (Athanasiadis, 1987), Spain (Seoane-Camba, 1965) and mainland Portugal (Ardré, 1970). Reproductive plants with unilocular sporangia were seen in winter in North America (Taylor, 1978), in April in Spain (Seoane-Camba, 1965) and in June and February in mainland Portugal (Ardré, 1970).

DICTYOTALES

Additional reference: Gaillard (1972).

DICTYOTACEAE

Additional references: *Dictyota* (Schnetter *et al.*, 1987; Hörnig & Schnetter, 1988; Hörnig *et al.*, 1992a, b; Hörnig *et al.*, 1993).

Dictyopteris membranacea (Stackh.) Batters

Dictyopteris polypodioides (Desf.) J. V. Lamour.
Halyseris polypodioides (Desf.) C. Agardh

Additional reference: Katsaros and Galatis (1988).

Distinguishing features: Ribbon-like thallus, characterized by a prominent midrib and irregularly dichotomous branches. No veinlets on the leaves.

Habitat: Tolerant to occasional sand cover, this species was found growing on rocks below 10m depth on both coasts.

Seasonality: It was never frequent. At São Vicente, plants were collected from May to July 1994 and in March and July 1995, their lengths varying between 2.6 and 17 cm. At São Roque only one plant was found in April 1995.

Reproduction: Only one sporophyte plant with scattered unilocular sporangia, was observed in July 1994.

Remarks: Collected at all seasons in the Aegean Sea (Athanasiadis, 1987), *Dictyopteris* was only found between April and November in Spain (Anadón & Fernández, 1986) and between March and October in mainland Portugal (Ardré, 1970). Sporophyte plants were present in late autumn in the Aegean Sea (Athanasiadis, 1987), in May and September in Spain (Seoane-Camba, 1965) and in March, April, June and October in mainland Portugal (Ardré, 1970). Present in the British Isles, where it probably regenerates from a perennial base (Farnham, pers. comm.).

Dictyota dichotoma (Huds.) J. V. Lamour.

Dictyota dichotoma (Huds.) J. V. Lamour. f. *attenuata* (Kützing) De Toni
Dictyota dichotoma (Huds.) J. V. Lamour. f. *intricata* (Kützing) C. Agardh
Zonaria dichotoma (Huds.) C. Agardh
Zonaria dichotoma (Huds.) C. Agardh var. *intricata* C. Agardh

Additional references: Gaillard and L'Hardy-Halos (1979, 1980, 1984, 1986, 1990); Katsaros and Galatis (1985); Hörnig and Schnetter (1988).

Distinguishing features: Plants erect and bushy, branching regularly dichotomous, sometimes spirally twisted, with the tips blunt to somewhat tapering. Internodal segments 5-10 breadths long. Often iridescent underwater.

Habitat: Epilithic in the lower intertidal, especially within tide pools, and even more frequent and abundant in the shallow subtidal, this species was present on both sites.

Seasonality: In intertidal level, this species was more common at São Vicente, where plants were collected for most of the year (Fig. 30). The largest plants, nearly 8 cm in length, occurred in late spring and summer. Although common, it was never abundant, its mean biomass not exceeding 14 g/m2. Surprisingly at São Roque, only three plants were collected from the intertidal, which were much smaller (3.2 to 4.6 cm). In the subtidal *Dictyota* was collected throughout the sampling period on both coasts, being larger and more abundant in late spring to early summer (Figs. 30 and 31).

Reproduction: Only sporophyte plants, bearing isolated unilocular sporangia, (Plate III.3), were collected at São Roque in the intertidal (March and June 1995), whereas at São Vicente both generations were present. Here diploid plants were collected between December and July. Female gametophytes, with sori of oogonia (Plate IV.1), occurred in March and one male plant, with antheridial sori (Plate IV.2), was collected in November 1994. Both generations were collected subtidally at the two sites. In São Roque, sporophytes were found for much of the year (October to July). Female gametophytes were found in November, February, March and August, while only one male plant was collected, in June 1995. At São Vicente sporophyte plants were also found, from October to July. Female thalli were present in August and December but no male plants were found at all.

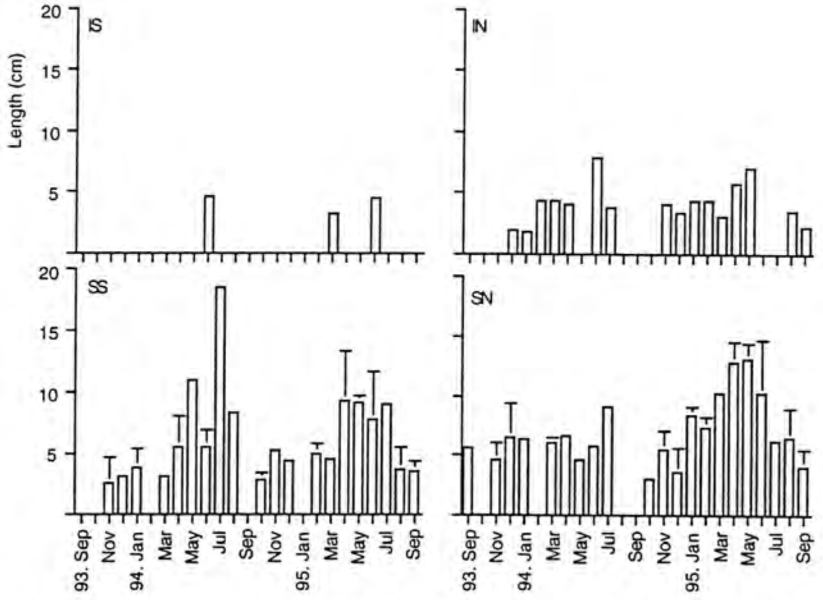


Fig. 30 Monthly maximum length of *D. dichotoma* (error bars indicate the standard deviation). For abreviations see section 3.5.

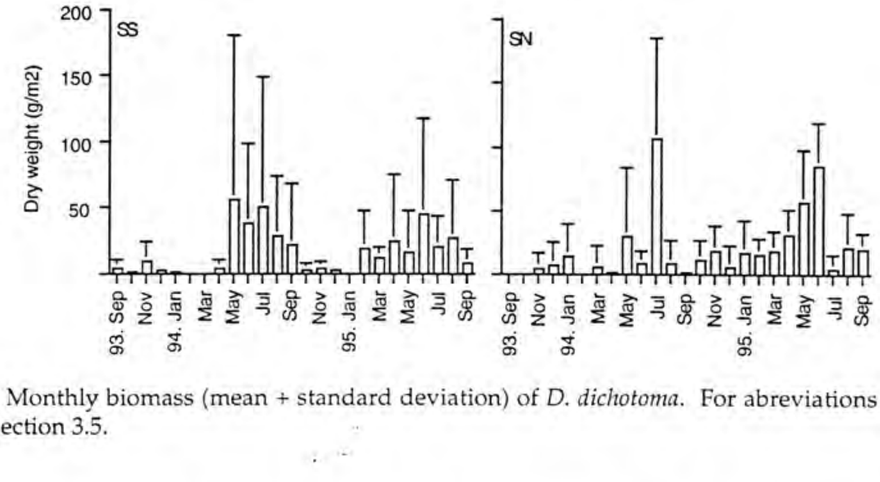


Fig. 31 Monthly biomass (mean + standard deviation) of *D. dichotoma*. For abreviations see section 3.5.

In summary, although presenting a seasonal pattern on its growth and biomass, with the higher values occurring in late spring and summer, no seasonality was apparent in the reproduction of *D. dichotoma* in São Miguel. Male plants were surprisingly rare in view of the genotypic sex

Plate IV 1-2. *Dictyota dichotoma*: 1. Transverse section through fertile blade region of a female gametophyte showing sori of oogonia (x200); 2. Transverse section through fertile blade region of a male gametophyte showing antheridial sori (x400).

3. *Padina pavonica*: Transverse section through fertile blade region showing unilocular sporangia (x200).

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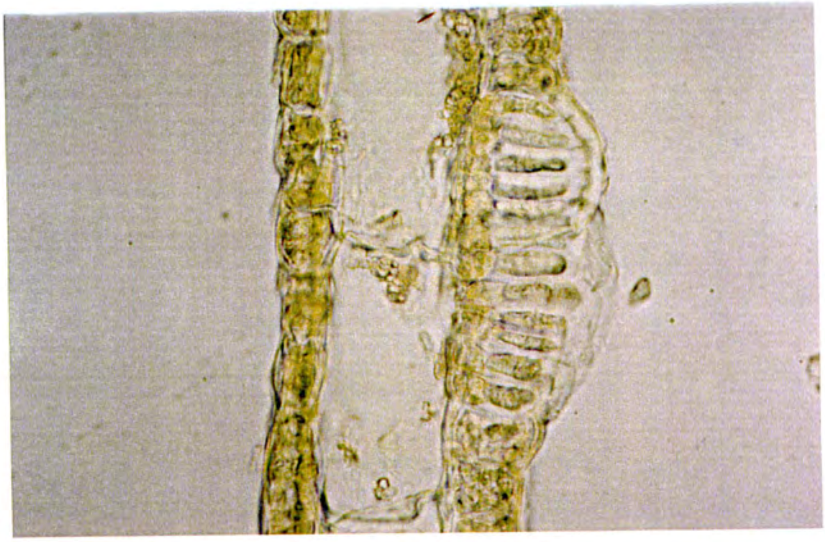

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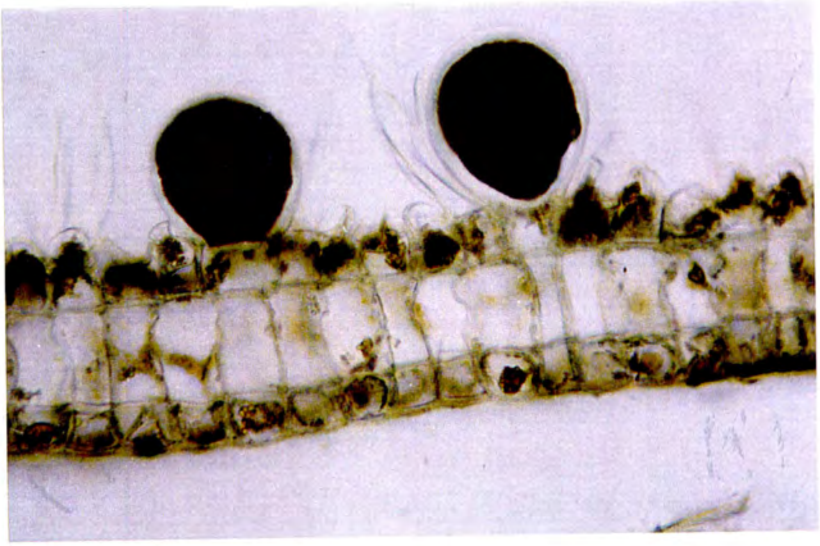

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differentiation indicated for this species which should result in equal numbers of male and female plants (Fritsch, 1977b).

Remarks: A common species in Florida (Earle, 1969), British Isles (Fritsch, 1977b), Aegean Sea (Athanasiadis, 1987), Spain (Anadón & Fernández, 1986), mainland Portugal (Ardré, 1970) and Madeira (Levring, 1974), where it can be seen all year, although more abundant in summer.

Sporophyte plants have been recorded throughout the year in Wales (Williams, 1898), in April and July in Spain (Seoane-Camba, 1965) and from March to October in mainland Portugal (Ardré, 1970). Price and Tittley (1978) recorded sporophyte plants in August and September, and sexual plants in June, in the Island of Mull.

Sexual plants are known to show a remarkable periodicity, different populations varying in their periodicity of gamete release. In British waters *D. dichotoma* shows a regular fortnightly production of sexual sori from July onwards, corresponding to the interval between two spring tides. The sori are initiated during a period of neap tides, and liberation of the sexual cells takes place at a variable number of tides after the highest spring tide (Williams, 1898, 1904, 1905; Fritsch, 1977b). A similar, though less marked, fortnightly production of sexual sori takes place at Naples, where *D. dichotoma* occurs at some depth and the tidal differences are slight (Lewis, 1910). On the other hand, in Jamaica, where the tides are irregular, periodicity is scarcely evident. On the shores of North Carolina the successive crops of sexual sori are produced at monthly intervals (spring tides of full moon) (Hoyt, 1907, 1927; Fritsch, 1977b).

A correlation appear to exist between the fruiting period of *Dictyota* and the tidal conditions to which it is exposed. Nevertheless, plants removed to the laboratory produced gametangia at the same time as those growing in the field (Hoyt, 1927). This suggests therefore that periodicity in the release of gametes in this species is endogenous and probably related to more than one factor, although tides play a major role.

It is not possible to comment on the influence of tides on this species sexual reproduction in São Miguel, as the observations did not follow the tide cycle.

Padina pavonica (L.) J. V. Lamour.
Zonaria pavonia Agardh

Additional references: Ramón and Friedmann (1965); Price *et al.* (1979).

Distinguishing features: Blades fan-like, usually curved into the shape of a trumpet, often substantially calcified on the upper surface and more lightly below. Iridescent in water.

Habitat: Only frequent in the lower intertidal at São Vicente, this species was also present in the subtidal level (5 to 15m depth) at both stations.

Seasonality: In the intertidal, plants were collected throughout the sampling season, except for the period from October 1993 to February 1994 (Fig. 32). Small plants were present in late winter, their size increasing in spring and summer. Although frequent, this species was never abundant, its mean biomass less than 12 g/m2. Subtidal specimens of *Padina* were restricted to summer (June-October) at both sites (Fig. 32). The largest plants were about 6-7 cm in length from all locations but the biomass was lower in the sublittoral (maximum values 5.5 g/m2 at São Roque and 8.0 g/m2 at São Vicente).

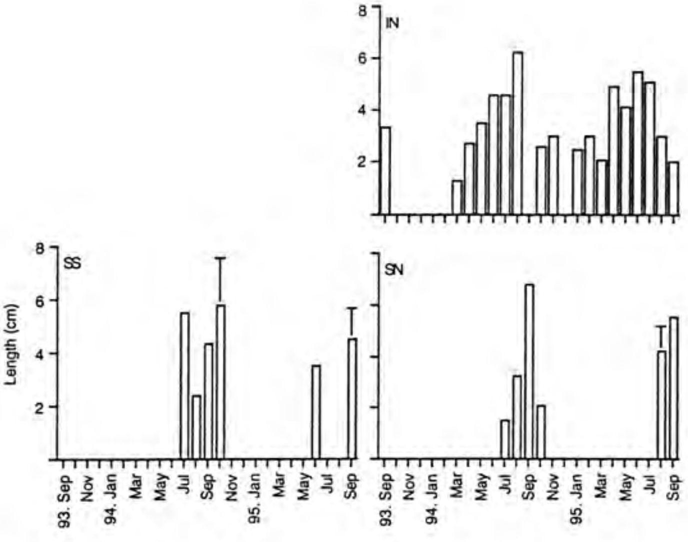


Fig. 32 Monthly maximum length of *P. pavonica* (error bars indicate the standard deviation). For abreviations see section 3.5.

Reproduction: Only sporophytic plants, with unilocular sporangia (Plate IV.3), were found. In the intertidal reproductive plants were present throughout the year, while subtidally they were only seen in summer/earlier autumn (July-October).

Remarks: The genus *Padina*, although spread in all Atlantic Ocean (Seoane-Camba, 1965; Gayral, 1966; Ardré, 1970; Levring, 1974), is particularly abundant on the Mediterranean (Carter, 1927; Gayral, 1966; Athanasiadis, 1987). Sporophyte plants were collected in spring in the Aegean Sea (Athanasiadis, 1987), in summer and autumn in mainland Portugal (Ardré, 1970) and all year round in Madeira (Levring, 1974). In southern England, *Padina* regenerates from a perennial rhizoidal system over summer and no gametophytes have been recorded (Carter, 1927).

The genus *Padina* is known for being dioecious with the exception of *P. pavonica*, which is monoecious (Taylor, 1976; Newton, 1962; Gaillard, 1972; Fritsch, 1977b). Studies on gametangia of this species have been done on the Mediterranean (see review in Price *et al.*, 1979). The investigations of Ramón and Friedmann (1965) and Ramon (1969) on the reproductive phenology of *P. pavonica* on the Mediterranean revealed the occurrence of a threshold temperature above which gametophytes appear. From those studies a correlation was established between the type of gametophyte and increasing temperature. Ramón (1969) observed that up to certain temperature the gametophytes were monoecious, but with further increase on the seawater temperature, they would become predominantly dioecious. The male gametophyte appeared first; the female gametophyte was only detected in the relatively high summer temperature (27-30°C) of the Israeli coastal waters.

In the present study all plants were sporophytic, which may indicate that the seawater temperature never reached the threshold necessary for the production of the gametophytes. Laboratory studies on reproduction in Azorean populations would allow a better understanding of this species reproductive phenology.

Stypopodium zonale (Lamour) Papenf.

New record for the Azores. Common on western and eastern Atlantic, south to Brazil and South Africa (Papenfuss, 1940; Taylor, 1967; Price *et al.*, 1978; Gil-Rodríguez & Afonso-Carrillo, 1980; Littler *et al.*, 1989; Lawson & John 1982; Wynne, 1985).

Distinguishing features: Plants attached by a large holdfast of compacted rhizoids. The blades, transversely zonate at irregular intervals, are at first broadly fan-shaped, with an irregularly growing margin and an attenuate base, and sometimes variously cleft into cuneate or even strap-shaped segments.

Habitat: Epilithic in the subtidal at São Roque (10m depth).

Seasonality: Only one plant was collected in May 1995.

Reproduction: No reproductive structures were seen.

Remarks: Known to occur elsewhere from the lower intertidal zone to depths of 55 m, although more common between 1-10m attached to rocks, coral and shells (Taylor, 1967), this species is particularly abundant in Gulf of Mexico (Earle, 1969).

Taonia atomaria (Woodw.) J. Agardh

Distinguishing features: Plants attached by rhizoids. Branching irregularly dichotomous and blades presenting concentric lines.

Habitat: Epilithic in tide pools and subtidally on both coasts.

Seasonality: In the intertidal, only two plants were found, one in May 1994 at São Roque, the other in June 1995 at São Vicente. At the former site in the subtidal this species, although collected from June to November 1994 and from April to June 1995, was never found in the cleared quadrats. Both subtidal populations were similar in their summer seasonal occurrence and maximum lengths (16.0-17.0 cm), as can be seen from Figure 33. At São Vicente plants of *Taonia* survived over winter, the highest biomass values being recorded in January 1994 and June 1995 (Fig. 34).

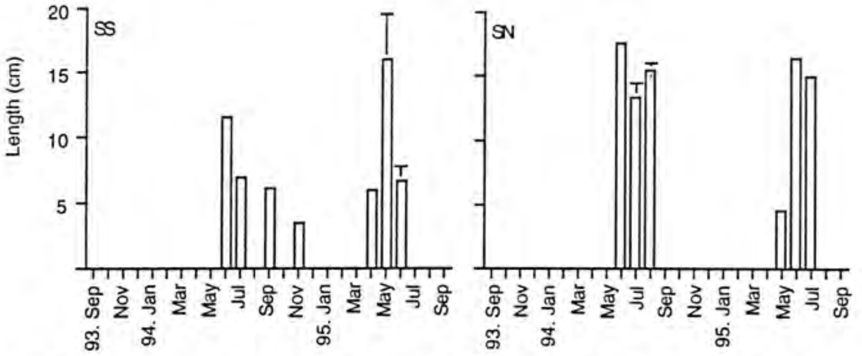


Fig. 33 Monthly maximum length of *T. atomaria* (error bars indicate the standard deviation). For abreviations see section 3.5.

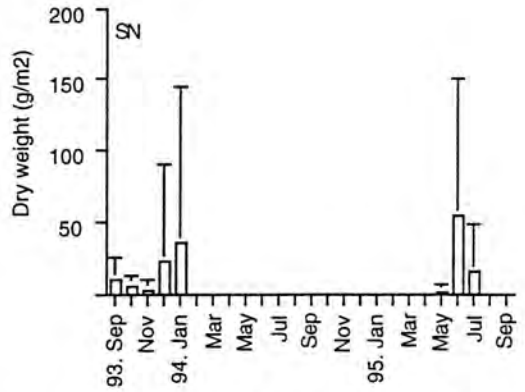


Fig. 34 Monthly biomass (mean + standard deviation) of *T. atomaria*. For abreviations see section 3.5.

Reproduction: The intertidal plants were sterile. Sporophytic plants with unilocular sporangia were found in the sublittoral collections. At São Roque all the material was fertile while at São Vicente sporophyte plants were only collected from May to August.

Remarks: In summary, a seasonal pattern has been found in reproduction and growth of this species, with both reproductive and larger plants occurring in late spring and summer. This reproductive seasonality has also been observed further north in the Atlantic. In Spain, plants with unilocular sporangia were collected between April and August (Seoane-Camba, 1965) and in mainland Portugal, sporophyte plants were observed only from June to August (Ardré, 1970), despite plants being collected until October. Further south, there is less information. Only one fertile plant was collected in April in Madeira (Levring, 1974), but in Morocco, sporophyte plants were collected from spring to December (Gayral, 1958), extending the reproductive period into autumn.

Zonaria tournefortii (J. V. Lamour.) Mont.

Zonaria flava (Clem) C. Agardh

Distinguishing features: Fronds erect with elongate stipes, attached by a cushion-like holdfast. Branches develop into cuneate, flattened blades, which are marked by vague lines radiating from their base and by distant, rather indistinct, concentric zonations parallel to the apical margin. Stipes briefly continued as midribs onto the flattened segments of the lamina.

Habitat: Epilithic in the lower intertidal and subtidal levels, down to 15m.

Seasonality: In the intertidal level only three plants were collected at Poços (December 1993, November 1994 and July 1995). In the subtidal, although present in both coasts throughout the sampling period, this species was much more abundant in the north (Fig. 35), where it was one of the dominant species. The plants were also larger at São Vicente, usually over 10 cm in length, while at São Roque the thalli were always shorter (Fig. 36).

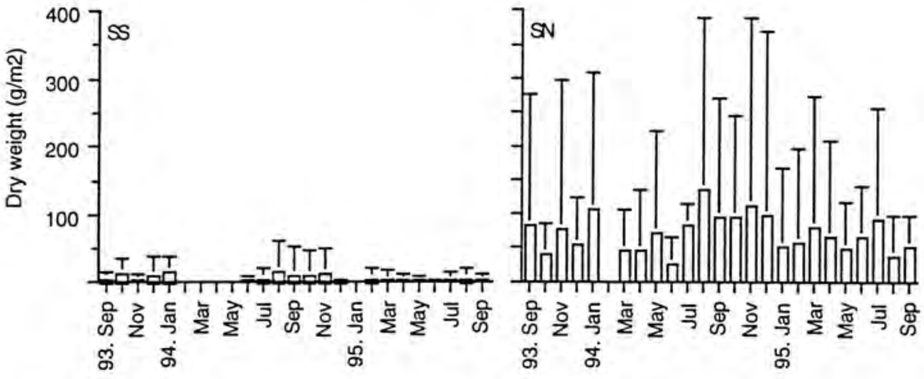


Fig. 35 Monthly biomass (mean + standard deviation) of *Z. tournefortii*. For abreviations see section 3.5.

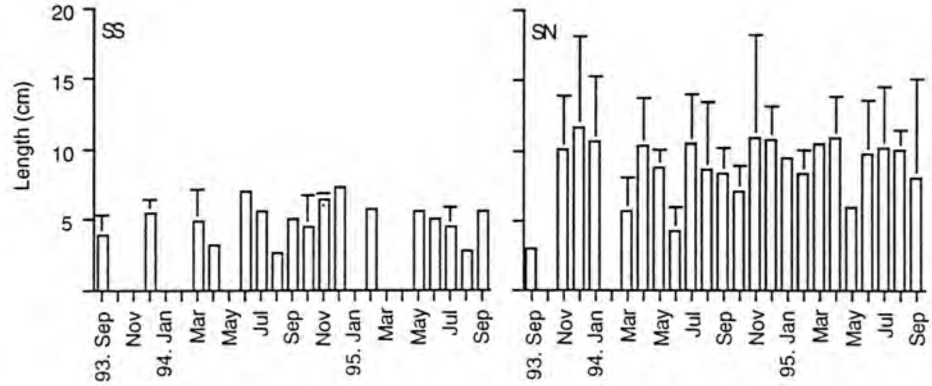


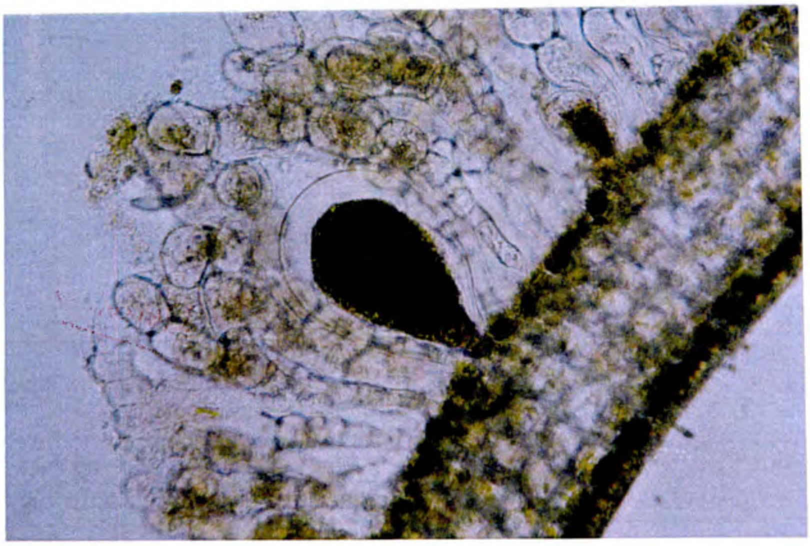
Fig. 36 Monthly maximum length of *Z. tournefortii* (error bars indicate the standard deviation). For abreviations see section 3.5.

Reproduction: The intertidal plant collected in November 1994 displayed sori of unilocular sporangia with paraphyses (Plate V.1), representing the sporophyte generation. Most of the subtidal

Plate V

1-2. *Zonaria tournefortii*: 1. Transverse section through fertile blade region showing unilocular sporangia with paraphyses (x200); 2. Transverse section through fertile blade region of a female gametophyte showing sori of oogonia interspersed with paraphyses (x200).

3. *Endarachne binghamiae*: Transverse section through sterile blade region showing a filamentous medulla surounded by an inner cortex of large cells and an outer cortex of much smaller cells (x200).



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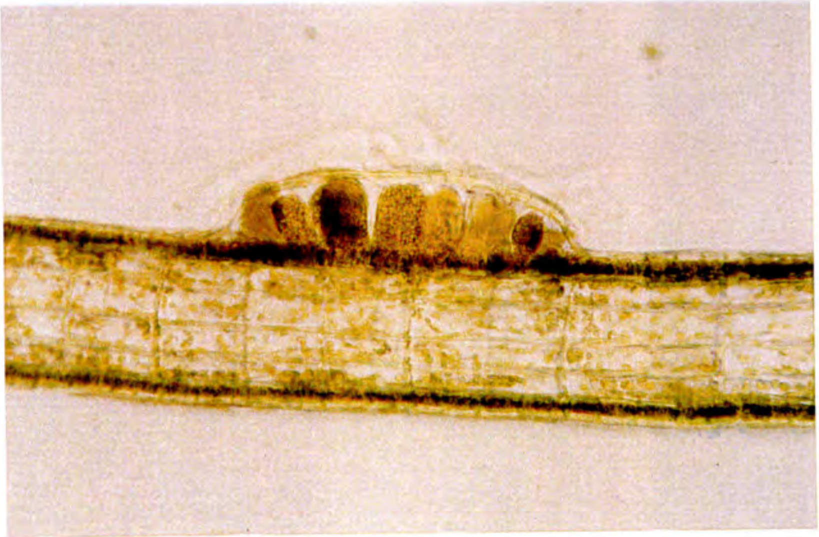

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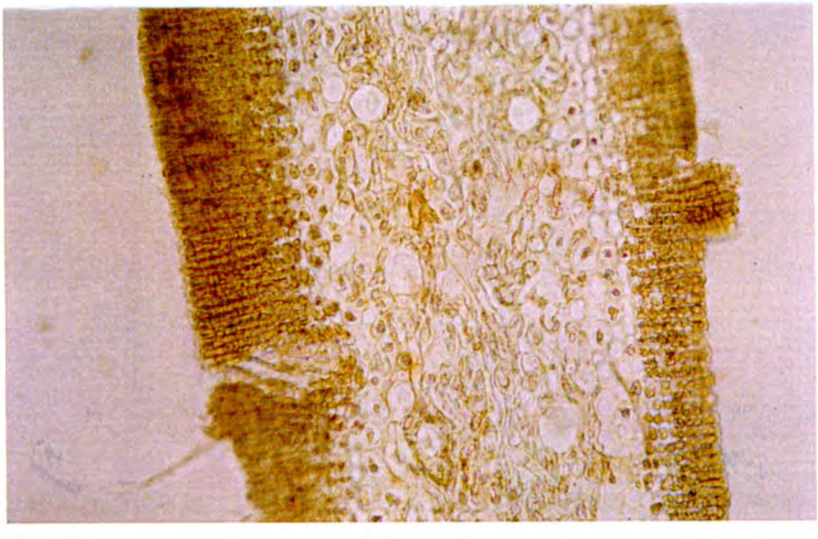

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collections were also similar fertile. At the subtidal, sporophyte plants were present most of the year at both coasts. Gametophyte plants, all female, recognized by their sori of oogonia interspersed with paraphyses (Plate V.2), were only found at São Vicente in December, February, April, May and August.

Remarks: Collected in Madeira throughout the year (Levring, 1974), while in the Canaries plants of this species were only found in January (Børgesen, 1926).

SPOROCHNALES

SPOROCHNACEAE

Carpomitra costata (Stackh.) Batters

Carpomitra cabrerae (Clemente) Kützing

New record for São Miguel. Previously found in Faial, Terceira and Formigas (see Neto, 1994). Recently recorded in Flores (Tittley *et al., in press*).

Additional reference: Santos and Melo (1984).

Distinguishing features: The sporophyte is a macroscopic plant, much branched, dorsoventrally flattened, arising from a small and terete stipe and fibrous holdfast; erect blades with distinct midrib and pseudodichotomous branching. Apex obtuse or truncate, often with young projecting, cylindrical and terete terminal branches, with or without a basal collar and/or terminal tuft of hair-like filaments, which denote the presence of a trichothallic meristem.

Habitat: Epilithic in the subtidal at São Roque at a depth of 15m.

Seasonality: Only one plant was collected in August 1995.

Reproduction: The plant was not reproductive.

Remarks: In the British Isles the macroscopic sporophyte was recorded between June and September (Fletcher, 1987). Collected in Lanzarote, Canaries in June (Ballesteros *et al.*, 1992).

DICTYOSIPHONALES

PUNCTARIACEAE

Endarachne binghamiae J. Agardh

New record for São Miguel. Previously found in Faial, Pico and Terceira (see Neto, 1994).

Additional references: Setchell and Gardner (1925); Abbott and Hollenberg (1976); Yoneshigue

(1985).

Distinguishing features: Linear-lanceolate, gregarious thalli, arising from a disc, with slender stalks. Dark brown thallus with a leathery texture. Medulla filamentous, surrounded by an inner cortex of large cells and an outer cortex of much smaller cells (Plate V.3). There are no hairs in between the plurilocular sporangia, whereas they occur in *Petalonia fascia*, a very similar plant in general morphology.

Habitat: Epilithic in lower intertidal at both sites.

Seasonality: In all, five plants were collected during the sampling period, two at São Roque in July 1994 and March 1995 and the remainder at São Vicente (September 1993, November 1994, and January 1995). Their lengths ranged from 2 to 15 cm.

Reproduction: All the plants were fertile, bearing uniseriate, plurilocular sporangia, which occur in extensive sori and lack paraphyses. The development of plurilocular sporangia is similar to those of *Scytosiphon*. Unilocular sporangia unknown (Newton, 1962). This species has probably a heteromorphic life history, as in *Scytosiphon*.

Remarks: Originally described from California, where it is a common species (Setchell & Gardner, 1925; Abbott & Hollenberg, 1976), *Endarachne binghamiae* has subsequently been found in China, Japan, Australia and South Africa (Nizamuddin & Farooqi, 1968), Brazil (Yoneshigue, 1985) and St. Helena (Lawson *et al.*, 1993). It was first collected on the Azores from Terceira in 1980 by Richard A. Fralick (material kept at the Lisbon Herbarium). This was only recently reported by Tittley and Neto (1994), together with their collection from Faial and Pico.

SCYTOSIPHONACEAE

Additional references: *Colpomenia* (Sauvageau, 1926, 1927; Blackler, 1964).

Colpomenia sinuosa (Roth) Derbès et Solier
Asperococcus sinuosus J. Agardh

Additional references: Sauvageau (1926, 1927).

Distinguishing features: Thallus globose but becoming somewhat flattened, folded, wrinkled and lobed, yellowish-brown. Sori punctate and covered with a cuticule, this feature allowing separation between *C. sinuosa* and *C. peregrina* (Lawson & John, 1982). This later species was recorded with a query for the Azores by South and Tittley (1986), but never subsequently found.

Habitat: Epilithic or epiphytic in the algal turf, the gametophyte was present in the intertidal and shallow sublittoral at both localities.

Seasonality: *Colpomenia* was generally common in both the qualitative and quantitative intertidal collections, being collected from April to October at São Roque and throughout the year at São Vicente (Fig. 37). On both coasts the larger plants were found in spring and summer (Fig. 38). This alga was much less common in the sublittoral, especially at São Vicente. It was never an abundant species (Fig. 37). The largest plants were found in summer, nearly 7 cm broad (Fig. 38).

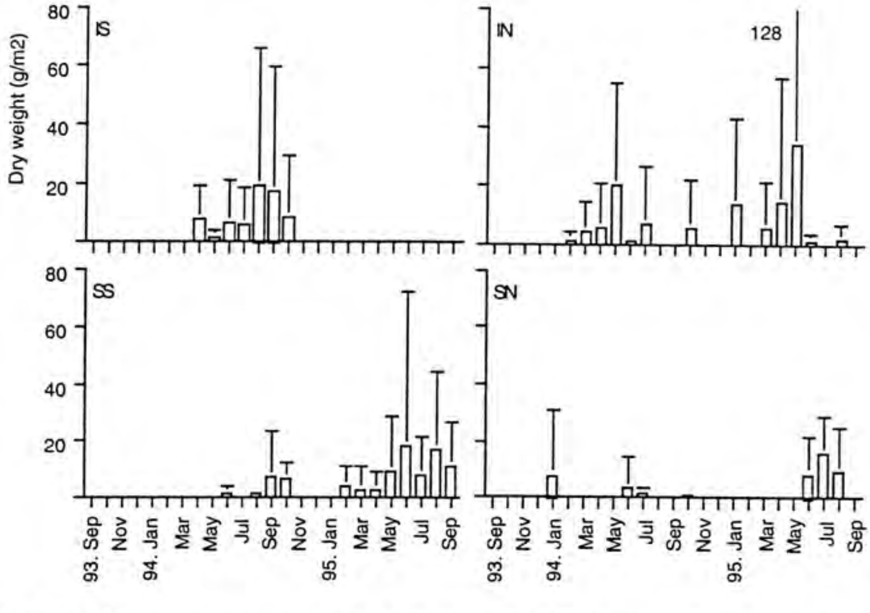


Fig. 37 Monthly biomass (mean + standard deviation) of *C. sinuosa*. For abreviations see section 3.5.

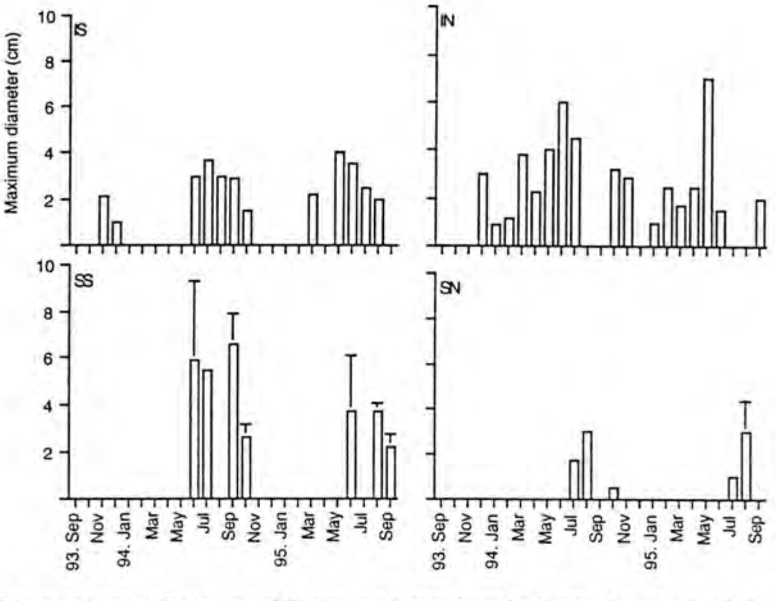


Fig. 38 Monthly maximum diameter of *C. sinuosa* (error bars indicate the standard deviation). For abreviations see section 3.5.

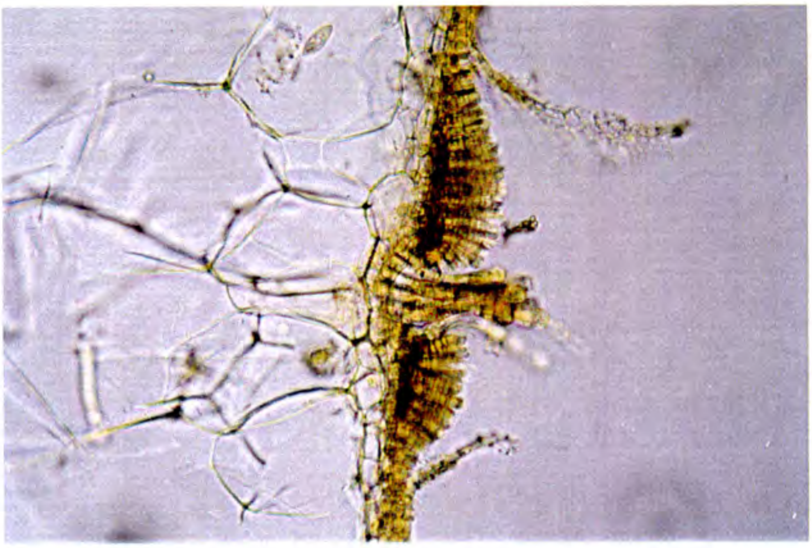
Reproduction: Most of the material collected was reproductive, forming sori of biseriate plurilocular sporangia, intermingled with unicellular paraphyses (Plate VI.1). No reproductive seasonality was detected for *C. sinuosa* in São Miguel.

Plate VI

1. *Colpomenia sinuosa*: Transverse section through fertile region showing sori of biseriate plurilocular sporangia intermingled with unicelular paraphyses (x200).

2. *Fucus spiralis*: Plants growing in patches in association with *Gelidium microdon*.

3. *Dilsea carnosa*: Cross section of blade showing the compact medula enclosed within a broad cortex of rounded inner cells, surronded by radial rows of small cells (x100).



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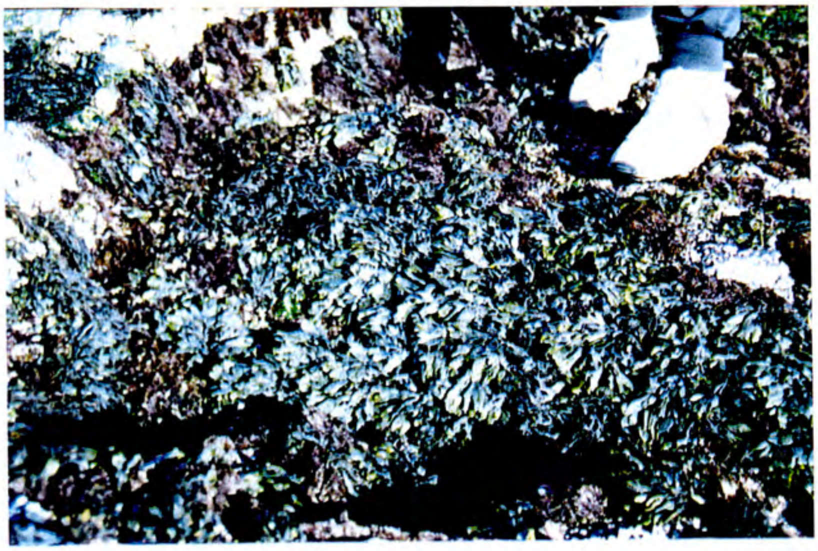

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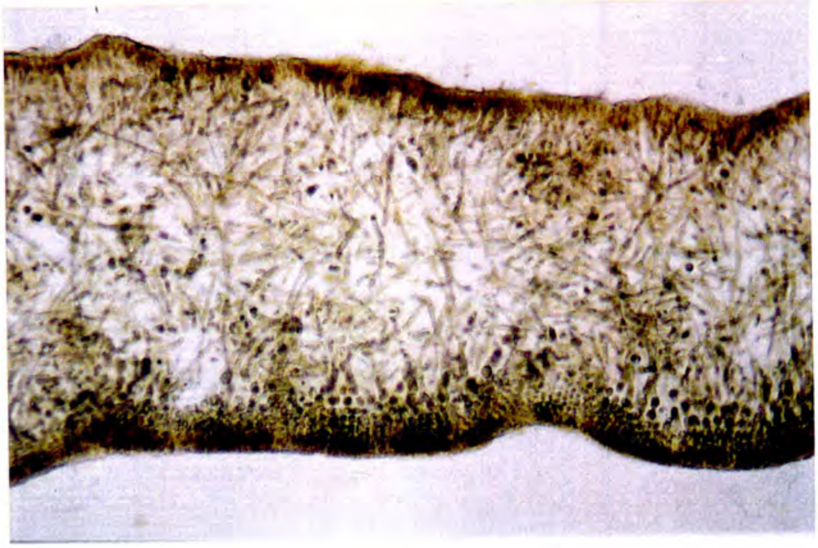

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Remarks: Widely distributed in warmer seas (Fritsch, 1977b). Collected only in spring and summer in the Gulf of Mexico (Earle, 1969), this species was collected throughout the year in the Aegean Sea (Athanasiadis, 1987), Spain (Seoane-Camba, 1965), mainland Portugal (Ardré, 1970) and Morocco (Gayral, 1958). In all these places, the larger plants and the correspondingly higher values of biomass were found in spring and summer, as was noticed at the two study sites. Reproductive plants have only been recorded for Spain and Canaries, where gametophyte plants were collected respectively between June and August in Spain (Seoane-Camba, 1965), and in December and January in the Canaries (Børgesen, 1926).

Hydroclathrus clathratus (Bory) Howe

New record for São Miguel. Previously recorded in Faial and Santa Maria (see Neto, 1994).

Additional reference: Oates and Cole (1987).

Distinguishing features: Thallus sub-spherical, more usually forming irregular masses, having numerous perforations, circular at first but often becoming elongated, up to a few centimeters in length.

Habitat: Although never abundant, this epilithic species was collected at both sites, being more frequent in the lower intertidal at São Vicente.

Seasonality: Thalli were found at various times throughout the year in the intertidal at São Vicente (Fig. 39), its biomass never exceeding 25 g/m2. The largest plants were present in late spring. Only one plant was collected from the intertidal at São Roque in March 1995. Likewise, in the subtidal, one plant was found at each site, in June 1994 at São Roque and in July 1994 at São Vicente.

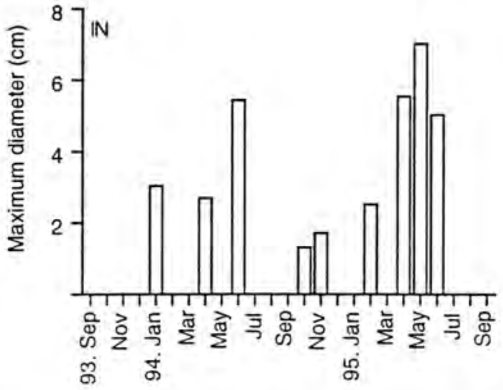


Fig. 39 Monthly maximum diameter of *H. clathratus*. For abreviations see section 3.5.

Reproduction: Only three reproductive plants, with sori of plurilocular sporangia were found, all from São Vicente, in June and October 1994, and May 1995.

Remarks: Collected in August in mainland Portugal (Ardré, 1970), between May and September in Madeira (Levring, 1969) and in March in the Canaries (Børgesen, 1926).

Scytosiphon lomentaria (Lyngbye) Link

Scytosiphon lomentarius (Lyngbye) J. Agardh

Additional references: Lund (1966); Clayton (1976); Kristiansen *et al.* (1991).

Distinguishing features: Tubular thalli terete and unbranched, tapered basally and arising from a short-stalk, characteristically constricted at intervals when mature.

Habitat: Epilithic in upper littoral rock-pools at São Vicente.

Seasonality: Collected only in March and April 1995, when the plants were respectively 8.5 and 19.5 cm long.

Reproduction: The plant collected in April was a gametophyte, containing plurilocular sporangia.

Remarks: Culture studies by various workers have indicated that a heteromorphic life history occurs in *Scytosiphon*. The tubular fronds are usually regarded as gametophytes, which give rise to a crustose, sporophytic stage, usually resembling the genus *Ralfsia*. Nakamura (1965) had observed that the *Ralfsia*-like sporophyte thalli in Japanese material of *Scytosiphon* bore unilocular sporangia. Later, Tatewaki (1966), in culture experiments, obtained crustose thalli from zooides derived from *Scytosiphon* plants. See the revision by Wynne and Loiseaux (1976) for further detail.

Lüning (1980) discussed the effects of environmental factors, such as daylength, light quality and temperature, in determining the expression of life history in *S. lomentaria*.

Lund (1966) reported the crustose microthallus for March and November in Denmark, and Kristiansen *et al.* (1991) found the sexual macrothalli in February/March. The macrothallus is common and generally distributed around the British Isles, where it is recorded throughout the year but most commonly in spring/early summer (Fletcher, 1987). *Scytosiphon* is also present all year round in North America, larger plants present in summer and reproductive structures developing in winter and spring (Taylor, 1978). In Virginia, USA, this species passes the summer as a microthalli, which resembles *Ralfsia clavata* (Rhodes & Connel, 1973). These crusts then give rise directly to the macrothalli. A spring occurrence of *Scytosiphon* was observed in France (Gayral, 1966), the Aegean Sea (Athanasiadis, 1987), Madeira (Levring, 1974) and the Canaries (Børgesen, 1926). Elsewhere, the seasonality is different. In Spain, this species was only found in January (Seoane-Camba, 1965), while in mainland Portugal Ardré (1970) collected plants with plurilocular sporangia in June and October.

FUCALES

Additional reference: Nizamuddin (1970).

FUCACEAE

Fucus spiralis L.

Fucus spiralis L. var. *platycarpus* (Thur.) Batters
Fucus platycarpus Thur. var. *spiralis* L.

This species is found elsewhere in the Azores (Neto, 1994), and is the only fucoid present on the islands.

Additional references: Niell *et al.* (1987); Robertson (1987).

Distinguishing features: Plants bushy, branching rather regularly and widely dichotomous, branches usually plane, occasionally a little twisted, cryptostomata evident. Receptacles spherical and hermaphrodite, with a sterile rim occurring apically on the frond.

Habitat: This is one of the highest species of macroalgae on the Azorean shores and is the uppermost fucalean alga. Plants of this species can either form a distinct belt on the shore or grow in patches in association with *Gelidium microdon* (q. v.). The first situation was found at São Roque, while the second type of growth was dominant at São Vicente (Plate VI.2).

Seasonality: *Fucus spiralis* was more abundant at the north site, where it was collected throughout the year. Biomass values were much higher in the first year (Fig. 40), varying from 10 to 220.3 g/m2, whereas in the second year the standing crop estimates were much lower - less than 50 g/m2. Surprisingly, the lengths of plants were not lower during the second year, although there were always large monthly fluctuations (Fig. 41).

At São Roque *Fucus* was rather less common and was collected between March 1994 and October 1995. There was a comparable range in biomass estimates (21-210 g/m2, Fig. 40). Likewise, the largest plants at both sites were similar in length, c. 9 cm (Fig. 41).

Reproduction: All the plants examined possessed hermaphrodite conceptacles.

Remarks: Collected in all seasons in Spain (Seoane-Camba, 1965), mainland Portugal (Ardré, 1970) and Morocco (Gayral, 1958). Present in many other places in the North Atlantic but no information has been found on its seasonality. Conceptacles were observed in summer in Canada (Robertson, 1987) and northeastern coasts of America (Niemeck & Mathieson, 1976; Mathieson & Guo, 1992), between March and November on the Isle of Man (Knight & Parke, 1931), in spring in France (Gayral, 1966), from spring to early autumn in mainland Portugal (Ardré, 1970) and in winter in Morocco (Gayral, 1958). São Miguel seems to be the only place where conceptacles have been seen throughout the year.

Worth noting that European plants are bigger than those from this study, e.g. up to 30 cm in Norway (Rueness, 1977) and to 40-50 cm in Helgoland (Kornmann & Sahling, 1977).

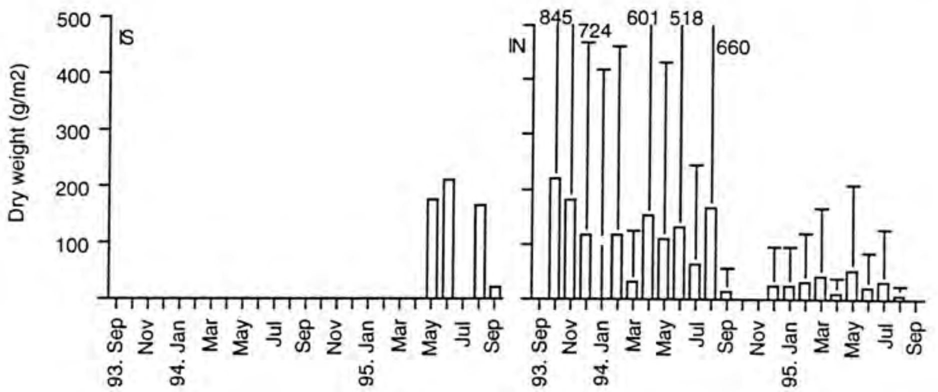


Fig. 40 Monthly biomass (mean + standard deviation) of *F. spiralis*. For abreviations see section 3.5.

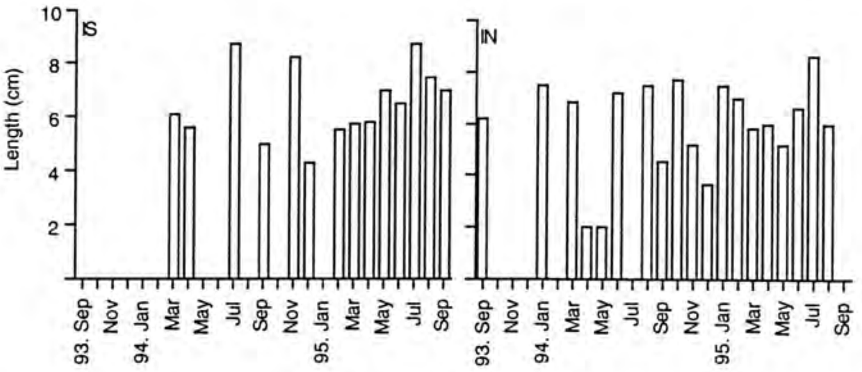


Fig. 41 Monthly maximum length of *F. spiralis*. For abreviations see section 3.5.

SARGASSACEAE

Sargassum cymosum C. Agardh

New record for São Miguel. Previously recorded from Faial and Pico (see Neto, 1994). Recently found in Flores (Tittley *et al.*, in press).

Distinguishing features: Foliar appendages elliptical to lanceolate or linear, with an entire or only slightly crenulate margin; cryptostomata small and scattered over the surface of the foliar appendages; vesicles usually few in number, spherical or occasionally apiculate; receptacles filiform and dichotomously divided.

Habitat: Epilithic in a lower tide pool at São Vicente.

Seasonality: Only one plant was collected in January 1995.

Reproduction: The plant was not reproductive.

Remarks: This tropical and subtropical species (Paula, 1994) is present all the year in Brazil, where it provides a common substratum for *H. musciformis* (Schenkman, 1989), and with maximum biomass values in late spring (November and December) and minimum values in winter (July).

Sargassum filipendula C. Agardh

New record for the Azores. Largely distributed on the western Atlantic, also recorded in the Canaries (Earle, 1969; Taylor, 1967, 1978; Price *et al.*, 1978; Lawson & John, 1982; Wynne, 1985). Recently found in Madeira (pers. obs.).

Distinguishing features: Foliar appendages linear to lanceolate with margin distinctly serrate; cryptostomata conspicuous and scattered or in rows along the midrib. Vesicles and receptacles axillary on the branches; vesicles stalked, spherical, 3-5 mm in diameter; receptacles simple or forked and sparsely racemosely branching.

Habitat: This species was only present in rock pools at São Vicente.

Seasonality: It was collected in June, July and October 1994 and between May and July 1995. Larger plants (up to 6 cm in length) were found in June 1994 and July 1995 (Fig. 42).

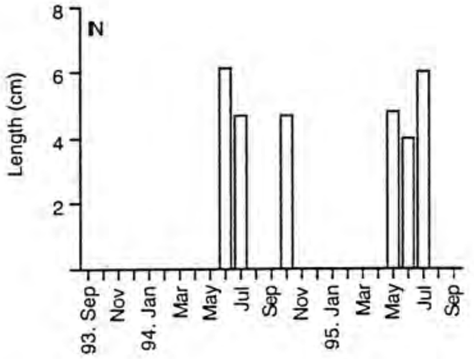


Fig. 42 Monthly maximum length of *S. filipendula*. For abreviations see section 3.5.

Reproduction: All the plants, except the one collected in May 1995, were reproductive, with conceptacles.

Remarks: Earle (1969) collected *S. filipendula* in winter and spring in the Gulf of Mexico, where fertile plants were present between December and March. This species was also present further north in America where reproductive plants were found in late summer and autumn (Taylor, 1978).

Rosette *Sargassum* species

This designation includes plants clearly belonging to the genus *Sargassum* because of their morphology. *Sargassum* is a large genus, morphologically variable, with more than 150 species described occurring in tropical, subtropical, and temperate zones of both hemispheres (Nizamuddin, 1970). It is the most conspicuous brown algae in tropical and subtropical waters, ranging from midlittoral to sublittoral zones (Bold & Wynne, 1987). The plants from the present study are distinct, not growing erect, however, but occurring in a rosette form over the substratum. This type of growth was also found in Faial in 1989 by Tittley and Neto (1994) and in Flores by Tittley *et al.* (in press). Two different types have been recognized as possibly separate species, which do not seem to have been described in the literature.

Rosette *Sargassum* type *acinarium*

Distinguishing features: Plants very branched. Foliar appendages with crenulate margins and cryptostomata in a single row on each side of the midrib.

Habitat: Growing over the rocks at 10m depth at São Roque.

Seasonality: Two plants were collected, in July and August 1994.

Reproduction: No receptacles were observed.

Rosette *Sargassum* type *hystrix*

Distinguishing features: Foliar appendages often forked, with entire margins and cryptostomata in series on each side of the midrib.

Habitat: Plants of this type were found both intertidally and subtidally growing directly over the rocks or over other algae. The intertidal plants were only found in tide pools at São Vicente.

Seasonality: This "morpho-species" was more frequent in the intertidal, where plants were collected between December 1993 and October 1995. Throughout the sampling period, its mean biomass showed large variations, 0.3-46 g/m2 (Fig. 43). Biomass was highest in June 1994 and May 1995 and this entity was generally more abundant in the second year. The longest plants were found in February for both years (Fig. 44).

In the subtidal, this species was more frequent at São Vicente, where plants were collected for much of the sampling period (Fig. 43). Here biomass was also variable but only about half of the maximal values for the intertidal, whereas plant sizes were similar. At São Roque, biomass was low, always less than 5 g/m2. Plants were collected only in summer for both years. Length were similar to the other samples c. 5 cm.

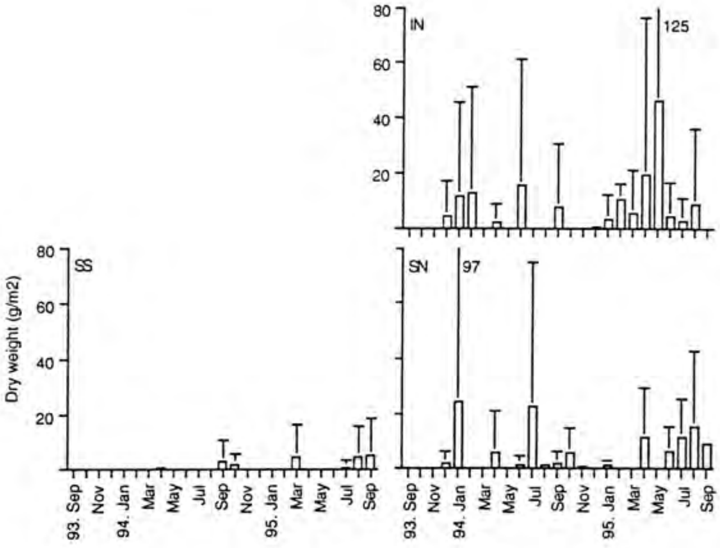


Fig. 43 Monthly biomass (mean + standard deviation) of Rosette *Sargassum* type *hystrix*. For abreviations see section 3.5.

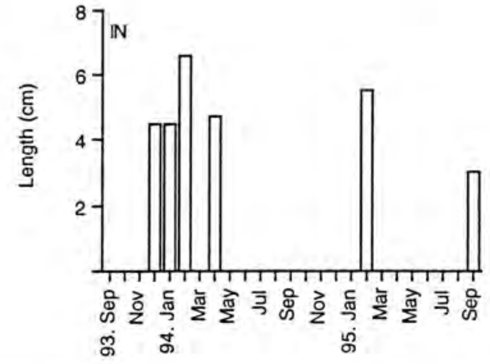


Fig. 44 Monthly maximum length of Rosette *Sargassum* type *hystrix*. For abreviations see section 3.5.

Reproduction: No reproductive plants were ever found in the intertidal. Reproductive plants, with mature conceptacles, were collected subtidally in July and August at both sites.

Sargassum vulgare C. Agardh

Sargassum vulgare C. Agardh var. *diversifolium* J. Agardh
Sargassum vulgare C. Agardh var. *furcata*
Sargassum vulgare C. Agardh var. *lanceolata*
Sargassum vulgare C. Agardh var. *tenuifolium*
Sargassum endivioefolium Bory
Sargassum fissifolium Mont.
Sargassum stenophyllum G. Martens

Distinguishing features: Plants bushy, with alternate, divided branches bearing at short intervals spirally disposed foliar appendages, with a serrate or undulate margin. Cryptostomata conspicuous (0.6 to 0.9 mm in diameter) in rows along the midrib. Receptacles not palmate or flattened.

Habitat: Epilithic in rock pools at São Vicente, also present in the subtidal at São Roque.

Seasonality: Intertidal plants were collected in October 1994, from March to May and then in August 1995. Lengths ranged from 3 to 7 cm (Fig. 45). Subtidally, this species was only occasionally present in the cleared quadrats and never abundant (0.09 to 7.3 g/m2, Fig. 46).

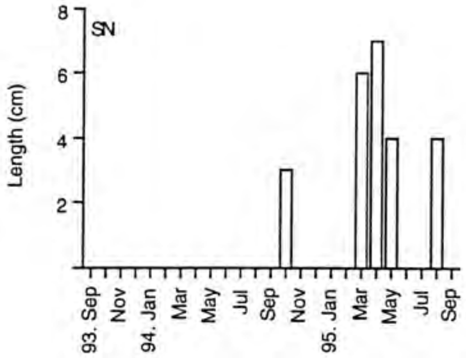


Fig. 45 Monthly maximum length of *S. vulgare*. For abreviations see section 3.5.

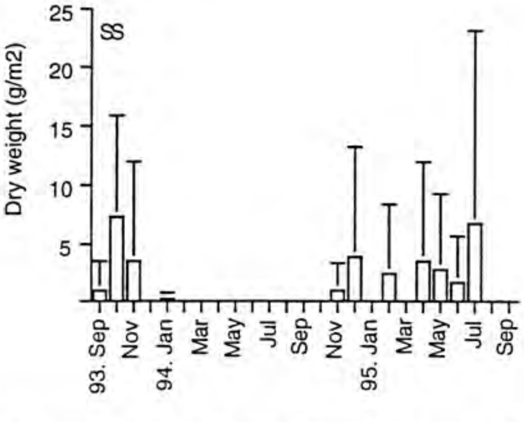


Fig. 46 Monthly biomass (mean + standard deviation) of *S. vulgare*. For abreviations see section 3.5.

Reproduction: Receptacular plants, containing hermaphrodite conceptacles were only present in the intertidal, being observed in October, March and August.

Remarks: Collected throughout the year in the Aegean Sea (Athanasiadis, 1987), Spain (Seoane-Camba, 1965) and Madeira (Levring, 1974). Fertile plants observed in summer in Morocco (Gayral, 1958).

CYSTOSEIRACEAE

Additional references: *Cystoseira* (Roberts, 1967; Gil-Rodríguez, 1980).

Cystoseira abies-marina (S. G. Gmel.) C. Agardh

Distinguishing features: Creeping thallus with spines, iridescent when immersed.

Habitat: Epilithic in the lower intertidal and shallow subtidal levels at both sites.

Seasonality: A frequent alga at São Vicente, but only in tide pools, being collected over most of the sampling period. The length of plants varied between 3.5 and 39.5 cm (Fig. 47) and its biomass was likewise variable, ranging from 1.3 to 141.1 g/m2 (Fig. 48). Subtidal populations were always more abundant in the summer and autumn (Figs. 47 and 48), but their biomass values were much lower (Fig. 48), especially at São Vicente, although frond length was only slightly smaller (2.5-30 cm) than that of the intertidal samples.

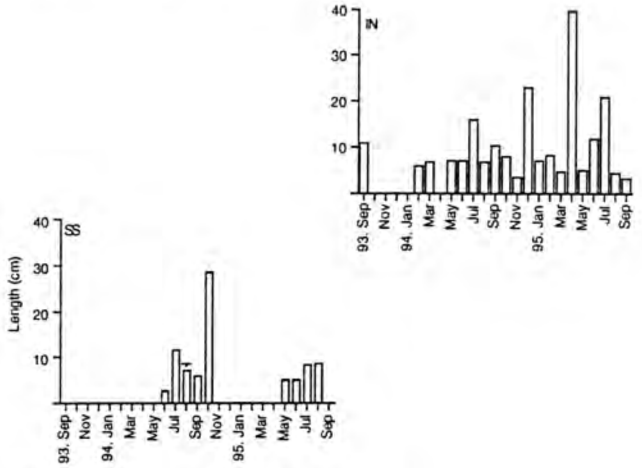


Fig. 47 Monthly maximum length of *C. abies-marina* (error bars indicate the standard deviation). For abreviations see section 3.5.

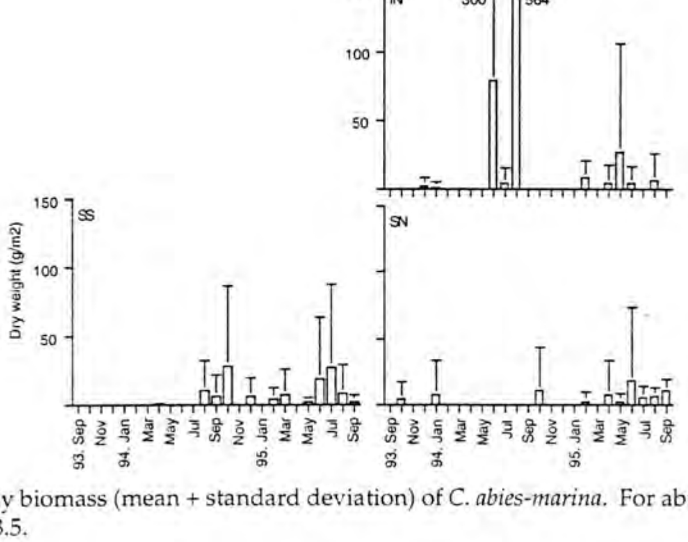


Fig. 48 Monthly biomass (mean + standard deviation) of *C. abies-marina*. For abreviations see section 3.5.

Reproduction: Hermaphrodite conceptacles were found on summer subtidal plants and on one intertidal plant collected in December 1994.

These results indicate a seasonality on the biomass and reproduction of this species, which is generally reproductive and more abundant in late summer/autumn.

Remarks: Collected at all seasons in Madeira (Levring, 1974) and in the Canaries, where it is fertile in winter (Børgesen, 1926). The Azores are the northern limit in distribution of this Macaronesian species.

Cystoseira foeniculaceus (L.) Grev.

Cystoseira abrotanifolia C. Agardh

Recorded with doubt from the Azores by South and Tittley (1986) but actually widespread in the archipelago (see Neto, 1994).

Additional reference: Roberts (1968).

Distinguishing features: Plant with stout axis, smooth or covered with small tubercles, and bearing alternate laterals in a bilateral fashion. Receptacles formed from the tips of the ultimate branchlets, lacking appendages, bearing hermaphrodites conceptacles.

Habitat: Epilithic in lower littoral rock pools at both sites and in shallow subtidal at São Roque.

Seasonality: This species was infrequent. Intertidal plants were much larger at São Roque, over 20 cm in length, but only up to 8 cm at São Vicente (Fig. 49). Subtidally, plants were only collected in July (10m depth), August and September 1995 (15m).

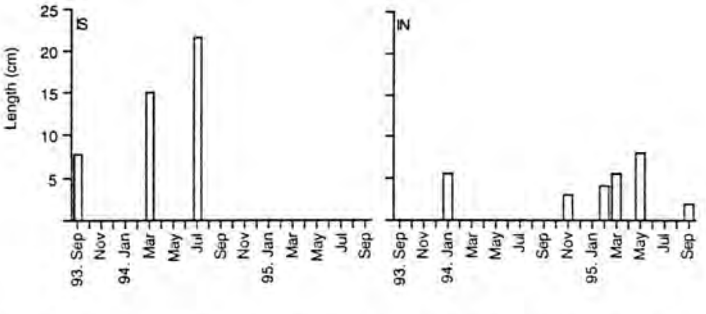


Fig. 49 Monthly maximum length of *C. foeniculaceus*. For abreviations see section 3.5.

Reproduction: Hermaphrodite conceptacles were only found in the intertidal plants collected in March, May, July and September, indicating the absence of any marked seasonality on the reproduction of this species or of an extended fertile period.

Remarks: In the British Isles this species is present throughout the year, fertile plants being present in spring and summer (Roberts, 1968) as in the Azores.

Cystoseira humilis Kützing

New record for São Miguel. Reported previously from Flores, Pico and Santa Maria (see Neto, 1994).

Distinguishing features: Thallus bearing spirally arranged laterals. Receptacles simple or forked, relatively short, bearing monoecious conceptacles.

Habitat: Epilithic in a tide pool at São Vicente.

Seasonality: Only one plant was collected, in June 1994.

Reproduction: The plant was fertile.

Remarks: Collected between March and October in mainland Portugal (Ardré, 1970).

4.3 RHODOPHYTA

Additional references: Kylin (1956); Dixon (1963, 1970); Scagel *et al*. (1982).

CLASS FLORIDEOPHYCEAE

Additional references: Guiry (1978a)

NEMALIALES

Additional references: Dixon (1982); *Liagora* (Hamel, 1930; Abbott, 1945, 1984).

HELMINTHOCLADIACEAE

Liagora distenta (Mert.) C. Agardh

New record for São Miguel. Although only tentatively listed by South and Tittley (1986) for the Azores, this species was later recorded from Pico (Tittley & Neto, 1994).

Distinguishing features: Thallus terete, moderately calcified, branching mainly dichotomous but with numerous small lateral branchlets.

Habitat: This species was only found at São Vicente, where it was epilithic on subtidal rocks, which are occasionally covered by sand.

Seasonality: Three plants were collected (June to August 1994), which were 8 to 13 cm in length.

Reproduction: No reproductive structures were seen.

Remarks: Collected in Spain likewise from June to August (Seoane-Camba, 1965) and in Madeira from April to July, with all these specimens being fertile (Levring, 1974).

Liagora viscida (Forssk.) C. Agardh

Distinguishing features: Thallus smooth, dichotomously branched, like *L. distenta*, but not producing lateral proliferations.

Habitat: This species was present in the shallow subtidal at both sites, especially in areas covered, at times, by sand. In the north it was usually associated with *L. distenta*.

Seasonality: Plants were collected in August and September 1994, and in June 1995 at São Roque (3-4 cm in length). Rather larger plants (2.7-9 cm) were collected a little earlier in the year (May to July 1994) at São Vicente.

Reproduction: The plant collected in June 1995 was a female gametophyte, with mature cystocarps.

Remarks: Ardré (1970) found this species in June and July in mainland Portugal, all plants being reproductive.

NEMALIACEAE

Nemalion helminthoides (Velley *in* With.) Batters
Nemalion lubricum Duby

Additional references: Magne (1961); Ramm-Anderson and Weterbee (1982).

Distinguishing features: Rubbery, erratically (simply to highly) branched plants composed of filaments embedded in a gelatinous matrix, constituting a multiaxial medullary system. Most authors, e.g. Hollenberg and Abbott (1965), recognize a single, polymorphic species of variable branching, rather than treat highly branched specimens as a separate species, *N. multifidum*. The morphological variability of Azorean material supports the former view.

Habitat: Epilithic/epizoic on rocks near low water experiencing wave-surge and usually associated with barnacles at São Roque, but never frequent. More recently found at São Vicente in the same situation (July 1996).

Seasonality: The gametangial phase of this species was only found from May to July 1994. The longest thalli were just over 20 cm long.

Reproduction: No reproductive structures have been found.

Remarks: Elsewhere, carpospores of *Nemalion* have been shown to germinate into a microscopic, filamentous stage, which overwinters and produces tetrasporangia (Fries, 1969). Closer examination of the barnacles is likely to detect this alternate phase.

Gametangial plants arise in March/April and persist until October in southern England (Dixon & Irvine, 1977). Further south, this species was collected in Spain in May (Seoane-Camba, 1965) and between April and June in mainland Portugal (Ardré, 1970). Fertile plants with spermatangia and carpogonia were seen by early May in England, and then carposporophytes liberating carpospores by early August (Dixon & Irvine, 1977). Along the northeastern coasts of North America, reproductive plants were present in midsummer (Taylor, 1978) and, in the Aegean Sea, Athanasiadis (1987) found carpogonial plants with carposporophytes in June.

BONNEMAISONIACEAE

Asparagopsis armata Harv.

Asparagopsis delilei Mont.
Falkenbergia rufolanosa (Harv.) F. Schmitz
Falkenbergia hillebrandii (Bornet) Falkenb.

Additional references: Feldmann (1939, 1965); Dixon 1964); Dangeard (1965).

Distinguishing features: Gametangial phase (*Asparagopsis*) is an erect plant. Thallus with prominent major axes, naked in the lower parts, but densely tufted in the upper; spirally-arranged branches arising in pairs and certain axes converted into short spiny axes. Tetrasporangial thallus (*Falkenbergia*) rose-pink in colour, formed of irregularly and branched polysiphonous axes, usually aggregated into spherical masses; each axial cell associated with three pericentral cells oriented spirally.

Habitat: The gametangial phase, epilithic or attached to other algae by the barbed axes, was present in lower intertidal and shallow subtidal on both coasts. Tetrasporangial phase usually sublittoral, epiphytic, rarely epilithic, more often free-floating.

Seasonality: The gametophyte was present for most of the sampling period. In the intertidal zone, mean values of biomass varied from 10 to 170 g/m2 (Fig. 50), being higher in the first year at both sites. However this difference was not significant (south coast: Wilcoxon test 15, 10 pairs, p=0.22; north coast: Wilcoxon test 13, 9 pairs, p=0.28). Larger plants were present in spring and early summer on both coasts (Fig. 51), being larger in São Vicente during all the sampling period

(Wilcoxon test 56, 22 pairs, p=0.02). In the subtidal, *A. armata* was also more abundant in the north site, where it was present for a longer period. At both stations, a seasonal pattern was detected, biomass being higher in spring (Fig. 50) and larger plants occurring in spring and summer (Fig. 51).

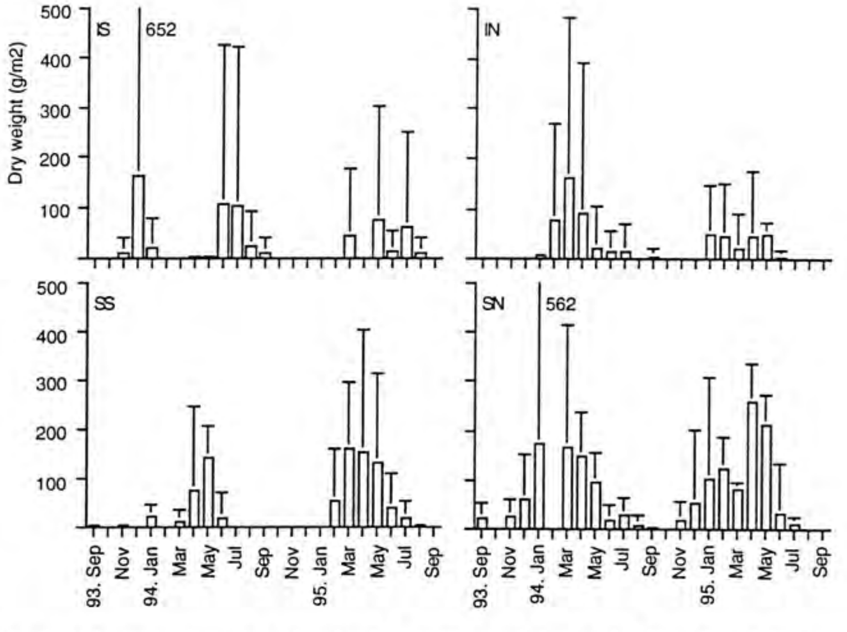


Fig. 50 Monthly biomass (mean + standard deviation) of *A. armata*. For abreviations see section 3.5.

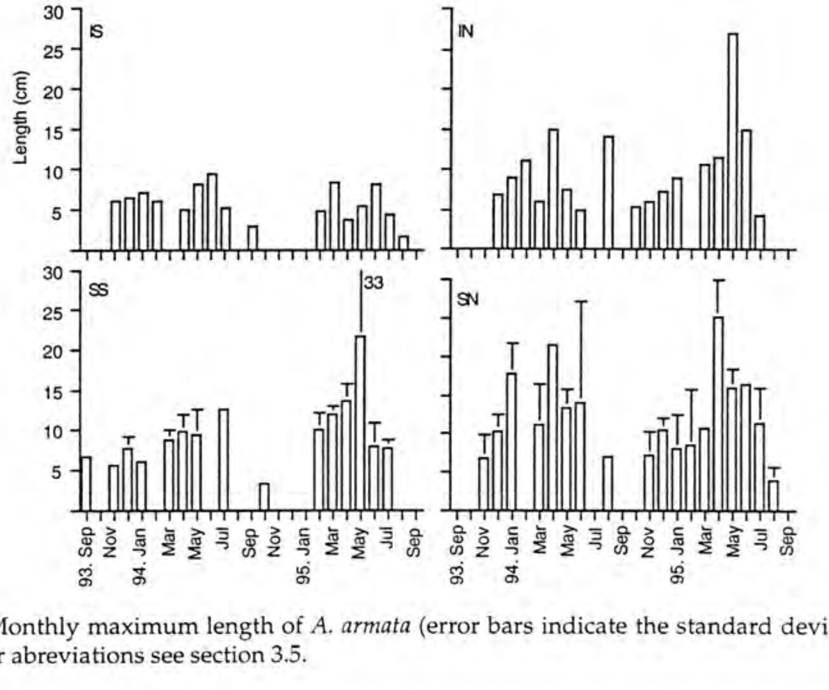


Fig. 51 Monthly maximum length of *A. armata* (error bars indicate the standard deviation). For abreviations see section 3.5.

The *Falkenbergia rufolanosa*-phase was present on both years at both sites, its biomass never exceeding 11.2 g/m2. Intertidally, plants were collected from February to June at São Roque and from January to May at São Vicente. This phase was collected from the subtidal levels between

September and June (except for January) in the south, and from November to May in the north site.

Reproduction: In the intertidal samples, reproductive gametophytes were only found from São Vicente, where female plants were observed from December to May. Tetrasporangia were seen between January and March, again only at São Vicente. In the subtidal, carposporangial plants were present in April and May at São Roque and from January to June at São Vicente. Although looked for, no male plants were found. Tetrasporangia were observed in November and February, but again only at the north site.

In summary, the gametophyte phase was present all year, with larger plants and higher biomass in spring and summer, and the reproduction occurring in winter and spring. The tetrasporophyte phase was also present in all seasons, although tetraspores were only detected in autumn and winter.

Remarks: *Asparagopsis armata* was endemic to the southern Hemisphere until it was introduced into the Atlantic and the Mediterranean early this century (Feldmann & Feldmann, 1942; Guiry & Dawes, 1992). The species is now widely distributed in the eastern North Atlantic from the British Isles south to Senegal, including Canary, Selvage, Madeira and the Azores Islands (Dixon, 1964). In the Mediterranean, the *Falkenbergia* phase is widely distributed (Feldmann & Feldmann, 1942; Furnari & Scammacca, 1970; Güven & Öztig, 1971; Giaccone, 1978; Meñez & Mathieson, 1981; Gallardo *et al.*, 1985; Giaccone *et al.*, 1985; Athanasiadis, 1987), although the gametophyte is only known from the western Mediterranean (e.g. Feldmann & Feldmann, 1942; Gayral, 1958; Meñez & Mathieson, 1981; Aranda *et al.*, 1984; Giaccone *et al.*, 1985). Reproduction in the *Falkenbergia*-phase of *A. armata* is reported to be rare and restricted to autumn in the British Isles (see the works of McLachlan, 1967; Guiry *et al.*, 1979). In Portugal and Morocco, fertile plants were found from December to March (Gayral, 1958; Ardré, 1970). Gametophytes are regularly found on the Atlantic coasts of Morocco (Gayral, 1958), Portugal (Ardré, 1970), Spain (Seoane-Camba, 1965) and France (Feldmann, 1954; Gayral, 1966).

Fragments of both gametangial and tetrasporangial phases occur at all times of the year in the British Isles. Regeneration of whole plants from such fragments occurs most rapidly between July and October. Most gametangial plants are sterile in the British Isles, although fertile material has been collected during summer and early autumn (Dixon & Irvine, 1977).

Tetrasporangia form during the winter months on the Atlantic coasts of France, Spain and Portugal, but so far there has been only one report of their occurrence in the British Isles in October (McLachlan, 1967). Tetrasporangia were present in the *Falkenbergia* plants collected in February and March in mainland Portugal and gonimoblasts were seen in February (Ardré, 1970). Both the gametophyte *A. armata* and the tetrasporophyte *F. rufolanosa* were common and were collected in Madeira throughout the year (Levring, 1974) and in Spain between November and August (Seoane-Camba, 1965). In the north of Spain, fertile plants of the *Falkenbergia*-stage were observed in November and December (Dangeard, 1961) and in France in November, December and September (Feldmann, 1965).

Asparagopsis taxiformis (Delile) Trev., distinguished from *A. armata* by the absence of spiny laterals, was also found during the present study but only in Ponta Delgada harbour .

GELIDIACEAE

Additional references: *Gelidium* and *Pterocladia* (Dixon, 1958, 1959; Kung-Chu, 1961; Santelices, 1991).

Gelidium latifolium (Grev.) Bornet et Thur.

Gelidium latifolium (Grev.) Bornet et Thur. var. *hystrix*
Gelidium corneum (Huds.) J. V. Lamour.
Sphaerococcus corneus C. Agardh
Sphaerococcus corneus C. Agardh var. *pinnatus* C. Agardh
Sphaerococcus corneus C. Agardh var. *pulchellus* C. Agardh

Distinguishing features: Axes predominantly flattened, outline of frond highly irregular; internal rhizoids (= rhizines, thick-walled filaments) distributed in the cortex. Like other species in this genus, *G. latifolium* is highly variable in morphology.

Habitat: Epilithic in lower intertidal pools at both sites, also found in the shallow subtidal at São Roque.

Seasonality: This species was more frequent in São Roque pools, where it was collected between December 1993 and September 1995. The largest plants were up to 8.2 cm long (Fig. 52). Standing crop values ranged between 1 and 35 g/m2 (Fig. 53). At São Vicente only two small (2-3 cm) plants were collected in September 1993 and 1994. Similarly, at the subtidal, plants were also rare and small, only three having been found (December 1993, January and August 1994).

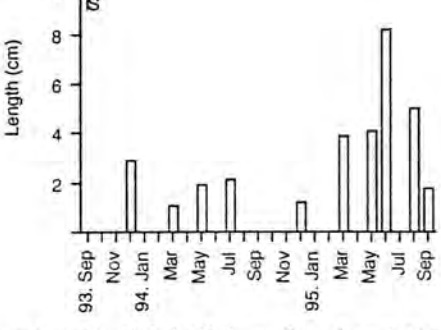


Fig. 52 Monthly maximum length of *G. latifolium*. For abreviations see section 3.5.

Reproduction: Tetrasporangial plants were seen in September, December, March and May from the intertidal and in January 1994 from the subtidal at São Roque. No reproductive plants were found at São Vicente.

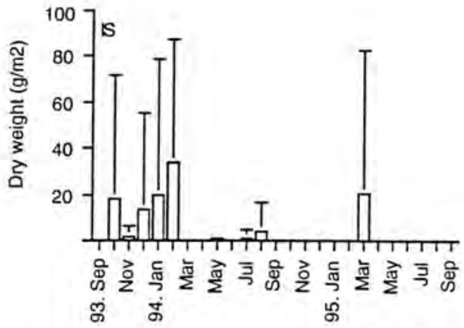


Fig. 53 Monthly biomass (mean + standard deviation) of *G. latifolium*. For abreviations see section 3.5.

Remarks: Present throughout the year in the British Isles (Dixon & Irvine, 1977), France (Gayral, 1966), Spain (Fernández *et al.*, 1987) and mainland Portugal (Ardré, 1970). In Spain this species was more abundant between April and September (Anadón & Fernández, 1986). Its reproductive period changes according to geographic location. In Norway no gametangial plants have ever been found, tetrasporophytes being collected in July and in September (Rueness & Fredriksen, 1989, 1990). In the British Isles, tetrasporangia were produced in fronds of all sizes between May and October, persisting until December, and gametangia were formed between June and August, persisting until December or even April (Dixon & Irvine, 1977). In France, fertile plants were only found in the summer (Gayral, 1966) but, in Spain, tetrasporophytes were present in summer and autumn (Seoane-Camba, 1965). In mainland Portugal tetrasporangial plants were present from April to June and in October, and cystocarps were found in June (Ardré, 1970). In the Aegean Sea reproduction was later in the year, with tetrasporophytic and carposporophytic plants being collected in November (Athanasiadis, 1987).

Gelidium microdon Kützing

Gelidium spinulosum (C. Agardh) J. Agardh
Gelidium spinulosum (C. Agardh) J. Agardh var. *microdon* Kützing
Gelidium spinulosum (C. Agardh) J. Agardh var. *oxyacanthum* J. Agardh
Gelidium pulchellum (Turner) Kützing
Sphaerococcus corneus var. *spinulosus* Agardh

Distinguishing features: Axes predominantly terete, outline of frond highly irregular; irregular branching; internal rhizoids distributed in the cortical and medullary regions.

Habitat: Epilithic on rocks in the upper intertidal at both sites. It was associated with *Fucus spiralis*, making a distinct belt at São Vicente, but only showing a patchy distribution at São Roque.

Seasonality: At São Roque, plants were collected from July 1994 to October 1995, with smaller plants in winter and larger plants in summer (Fig 54). Although frequent it was never abundant, (biomass never exceeding 200 g/m2, Fig. 55). At São Vicente this species was more frequent and more abundant, with a higher biomass, up to 312.5 g/m2 (Fig 55). Large fluctuations in growth were detected throughout the year. Its biomass also was variable but a pattern was present with higher values occurring in late spring and summer.

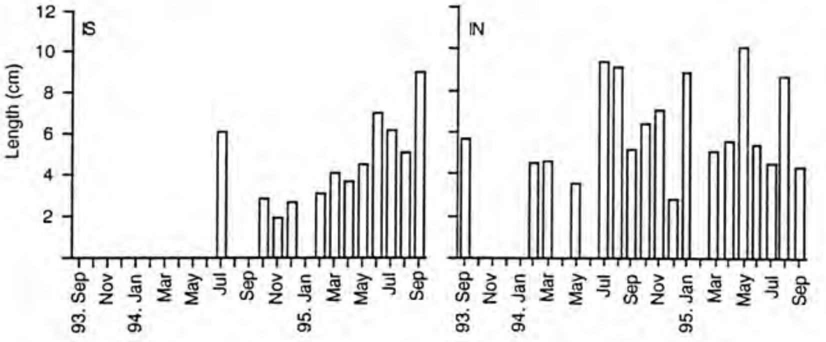


Fig. 54 Monthly maximum length of *G. microdon*. For abreviations see section 3.5.

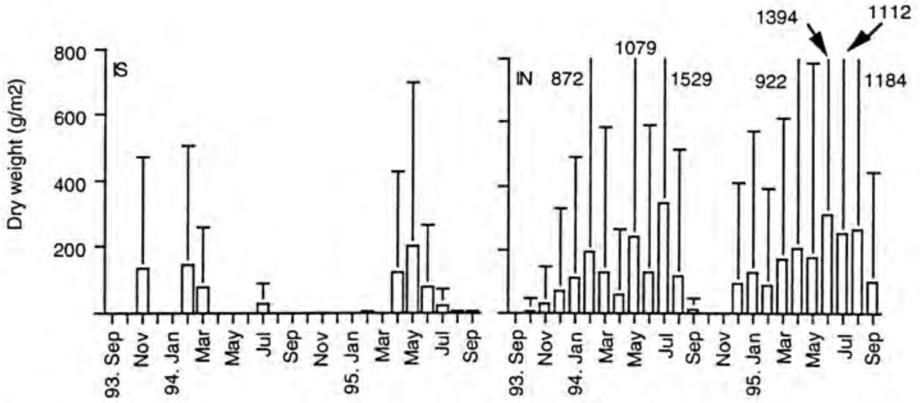


Fig. 55 Monthly biomass (mean + standard deviation) of *G. microdon*. For abreviations see section 3.5.

Reproduction: Tetrasporangial plants were found in December and from April to September in São Roque, and from April to December at São Vicente. No male or female plants were seen.

Remarks: This species was also collected throughout the year in France (Gayral, 1966), Spain (Seoane-Camba, 1965) and mainland Portugal (Ardré, 1970).

Gelidium pusillum (Stackh.) Le Jolis

Gelidium pusillum (Stackh.) Le Jolis var. *umbrosa* O.C. Schmidt
Gelidium filicinum Bory

Additional reference: Kaliaperumal and Rao 1986).

Distinguishing features: Axes predominantly cylindrical, tips spathulate; branching irregular, producing a frond of very variable outline.

Habitat: Epilithic and strictly intertidal, this species was present at both sites.

Seasonality: Although collected throughout the sampling period, this species was never abundant, but had a slightly higher biomass at São Roque (maximum 55.9 g/m2, Fig. 56). The length of the plants, however was greater (up to 2 cm) at São Vicente that at São Roque (maximum 1.1 cm).

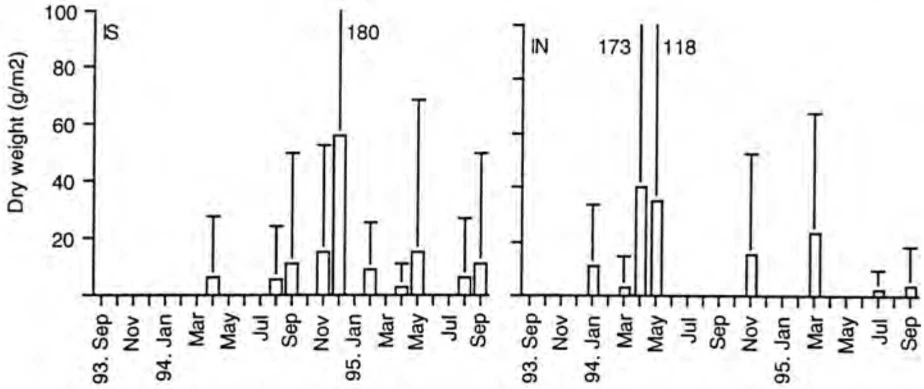


Fig. 56 Monthly biomass (mean + standard deviation) of *G. pusillum*. For abreviations see section 3.5.

Reproduction: No reproductive plants were found. It is likely that annual regeneration of erect axes occurs from a perennial base (Dixon, 1958).

Remarks: Collected throughout the year in the British Isles (Dixon & Irvine, 1977), France (Gayral, 1966), Spain (Seoane-Camba, 1965) and mainland Portugal (Ardré, 1970), but found to be more abundant in November in Spain (Anadón & Fernández, 1986). Tetrasporophyte have never been recorded in France (Gayral, 1966) but were collected in July for Norway (Rueness & Fredriksen, 1990), from June to November in the British Isles (Dixon & Irvine, 1977), in August in the Aegean Sea (Athanasiadis, 1987), and between February and June, and in October in mainland Portugal (Ardré, 1970). Gametophytes with carposporophytes were collected between July and September in the British Isles (Dixon & Irvine, 1977), and in January and June in the Aegean Sea (Athanasiadis, 1987).

Pterocladia capillacea (S. G. Gmel.) Bornet et Thur.

Pterocladia pinnata (Huds.) Papenf.

Additional references: Akatsuka (1973); Fralick and Andrade (1981); Stewart (1984); Rascio *et al.* (1991a, b).

Distinguishing features: Axes predominantly flattened, outline of frond triangular; branching simple or 3-4 times pinnately divided; medulla composed of large filaments intermingled with smaller, thick-walled, refractive filaments (rhizines). Cystocarps are unilocular in this genus, distinct from the bilocular condition in *Gelidium*.

Habitat: Epilithic in the lower intertidal and shallow subtidal (down to 15m), this species is widely distributed in the Azores.

Seasonality: Although collected throughout the sampling period, no seasonal pattern was evident in its growth or biomass. Intertidally, *Pterocladia* was more abundant at São Roque (Wilcoxon test 52, 24 pairs, p=0.005; Fig. 57), although generally larger plants were collected from São Vicente (Fig. 58). However, the differences in size were not significant (Wilcoxon test 106, 23 pairs, p=0.33). Subtidal biomass values were similar at both places (maximum 112.7 g/m2, Fig. 57). As with the intertidal samples, larger subtidal plants were noted from São Vicente (4.7 to 17.2 cm) as opposed to only 3.1 to 9.6 cm in length from São Roque (Fig. 58).

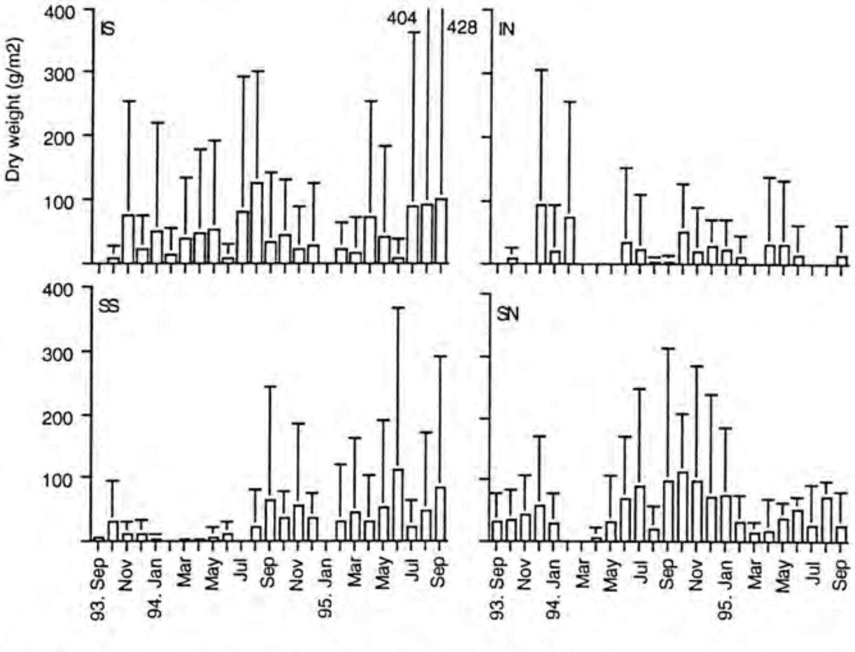


Fig. 57 Monthly biomass (mean + standard deviation) of *P. capillacea*. For abreviations see section 3.5.

Reproduction: Intertidal tetrasporangial plants were found in March 1994 and from August to October at São Roque and from October to December at São Vicente, where only one female plant, with mature cystocarps was collected in April 1995. Only the sporophyte generation was present in the subtidal samples, with tetrasporangial plants being collected from August to December at São Roque and from August to January at São Vicente.

Remarks: This species is commonly found throughout the year in the British Isles (Dixon & Irvine, 1977), France (Gayral, 1966), Italy (Calabrese, 1971; Tolomio *et al.*, 1986), Greece (Abdel-Fattah *et* *al.*, 1973), Spain (Seoane-Camba, 1965), mainland Portugal (Ardré, 1970) and Madeira (Levring, 1974). Dixon (1965, 1973) has pointed out that this species has its northern limit of distribution in the British Isles.

A seasonal pattern seems to occur in growth and abundance, with higher values present between June and October in the British Isles (Dixon & Irvine, 1977) and from July to October in Spain (Anadón & Fernández, 1986). Fralick (1980) and Fralick and Andrade (1981) also regard the summer as the best season for growth of *Pterocladia* in the Azores. However, that was not confirmed by the present study, in which large fluctuations were observed in growth and biomass throughout the year.

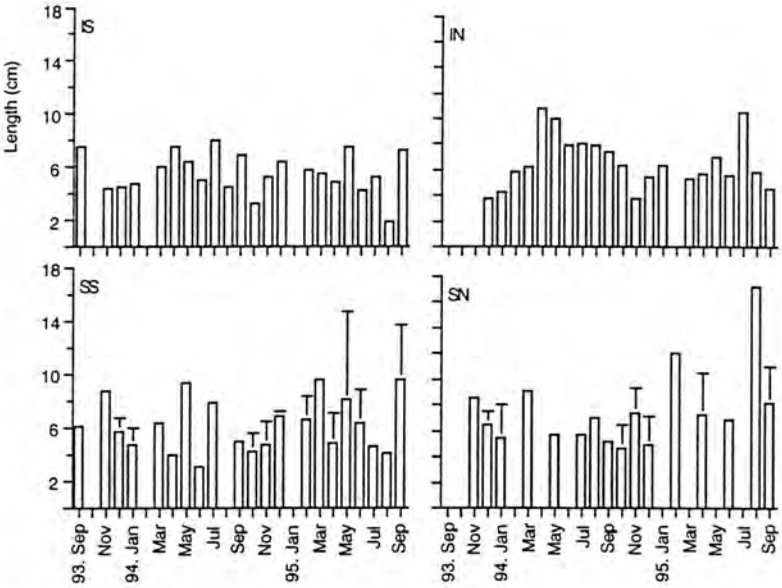


Fig. 58 Monthly maximum length of *P. capillacea* (error bars indicate the standard deviation). For abreviations see section 3.5.

Reproductive structures are unknown in British material (Dixon, 1958), although they have been seen in other localities. On the Atlantic coasts of France and Spain carpogonia and spermatangia develop in June and July, with cystocarps being seen between July and October and tetrasporangia from June to October (Dixon & Irvine, 1977).

In the present study tetrasporophyte plants were observed in summer and autumn, extending the previous period observed by Fralick (1980) and Fralick and Andrade (1981), which was restricted to autumn. These authors never found sexual plants in the Azores and therefore suggested that the reproduction of *P. capillacea* is primarily vegetative in this area. The same is also ventured by Dixon (1965, 1973) for the British Isles, where this species is sterile. During the present study only one female gametophyte was collected, as noted above. However, small portions of female plants have been seen in the gut contents of the littoral herbivore fish, *Sarpa salpa* collected in August 1993 (pers. obs.).

Pterocladia has been commercially exploited since 1961. It has been collected in several islands, both on the lower intertidal and subtidally by means of snorkeling. The agar industry of the Azores comprised two factories, one in São Miguel and one in Terceira. The annual production of agar in São Miguel reached the maximum of the 50t/year, but after 1992 begin decreasing, to be only 12t on 1994. Presently both industries are deactivated, but plants are still harvested and exported to be laborated elsewhere. There are no predictions about the future of this industry on the Azores.

CRYPTONEMIALES

DUMONTIACEAE

Additional reference: *Dudresnaya* (Robins & Kraft, 1985).

Dilsea carnosa (Schmidel) O. Kuntze

Distinguishing features: Erect fronds arising from a small discoid base, terete stipe expanding gradually into a foliose, irregularly split and opaque blade, which is quite thick (up to 700 µm) and tough; mature structure multiaxial (Plate VI.3), medulla compact and composed of thick-walled filaments interspersed with narrow rhizoids; cortex broad, inner part consisting of rounded cells and outer part comprising radial rows of small cells (5-7µm).

Habitat: Epilithic in the lower intertidal at São Roque.

Seasonality: Two plants were collected in May and July 1994, both showing effects of herbivory.

Reproduction: Both plants contained inconspicuous cystocarps (c. 250µm in diameter) scattered over the blade; pericarp and ostioles apparently absent.

Remarks: Perennial in the British Isles where spermatangia were recorded for June, carpogonial branches from May to December (cystocarps maturing in March), and tetrasporangia from January and April (Irvine, 1983). Also perennial in France but fertile plants were collected in winter (Gayral, 1966). Ardré (1970) found *Dilsea* in mainland Portugal in March and October.

Recorded for São Miguel previously by Neto (1991b), this species has its southern limit on the Azores. More detailed investigation of fertile material is required to confirm its identification.

Dudresnaya verticillata (With.) Jolis

Distinguishing features: Erect thallus attached by a discoid base, terete and fragile, very lubricious, translucent, axis with a few percurrent main branches, outline broadly pyramidal, bushy, much branched, branching irregularly alternate.

Habitat: Epilithic in subtidal localities, tolerating sand influence. In the British Isles usually on mobile stones or shells rather than solid rock (Farnham, pers. comm.)

Seasonality: Two plants were collected, one in September 1993 at São Vicente, the other in July 1994 at São Roque.

Reproduction: The plant collected in July was cystocarpic.

Remarks: Summer annual, growth beginning in early spring, though plants not usually conspicuous until June in the British Isles, becoming fertile in July and disappearing in October. Spermatangia recorded for June and August, cystocarps and tetrasporangia for July and August, sometimes occurring on the same individual (Irvine, 1983). Commonly found in the summer in the Aegean Sea (Athanasiadis, 1987), one fertile plant was also collected in Madeira in July (Levring, 1974).

CRYPTONEMIACEAE

Additional references: Abbott, 1967a; Young-Meng, 1969; Guiry, 1978b.

Grateloupia dichotoma J. Agardh

Distinguishing features: Erect fronds arising from a discoid base, expanding into a repeatedly dichotomous flattened blade, lower divisions broader above than below, terminal dichotomies usually divergent. Multiaxial structure with a loose medulla, composed of elongated filaments interspersed with narrower ones, surrounded by a cortex of dichotomously divided rows of cells, the outermost closely packed.

Habitat: Epilithic on open rocks and within crevices, this species was collected from the lower intertidal level at both sites.

Seasonality: More frequent at São Roque, where it was collected in February, May and July 1994, and between May and August 1995, this species was also found at São Vicente, where three plants were collected in September 1993 and in June and July 1994. Larger plants were found in July at both places (Fig. 59). It was never an abundant species, its mean biomass never exceeding 7 g/m2.

Reproduction: Fertile plants were found in September 1993 and in June 1995.

Remarks: Present throughout the year in the British Isles, where cystocarps were recorded for July and September, spermatangia in November and tetrasporangia in March, July and August (Irvine, 1983). The later were found in March at the Canaries (Børgesen, 1929), and in October and March in mainland Portugal (Ardré, 1970).

It was surprising that the related species *G. filicina* was not found at the study sites, since it has been reported from similar habitats in the Azores (Neto, 1990; Tittley *et al.*, in press)

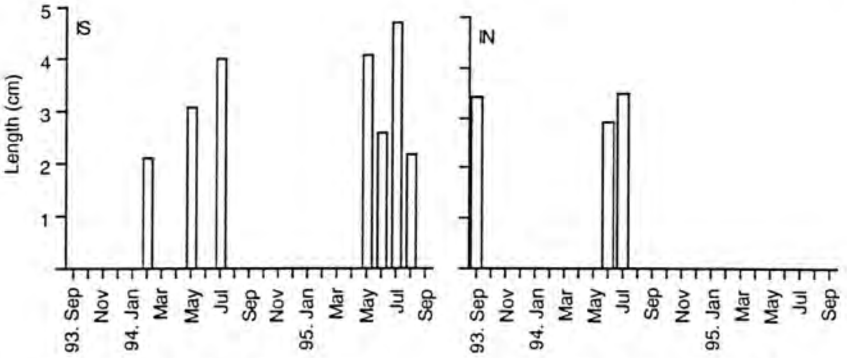


Fig. 59 Monthly maximum length of *G. dichotoma*. For abreviations see section 3.5.

KALLYMENIACEAE

Additional references: Norris (1957); Abbott (1968); *Kallymenia* (Norris, 1957; Codomier, 1972a).

Kallymenia reniformis (Turner) J. Agardh

Callymenia reniformis (Turner) J. Agardh
Halymenia reniformis C. Agardh

Additional reference: Hommersand and Ott (1970).

Distinguishing features: Erect fronds with a terete stipe, attached by a small disc which expands into a thin, almost translucent but strong blade, with undulate margins. Multiaxial structure with a loose medulla, composed of elongated filaments interspersed with rhizoids and large rounded cells, surrounded by a cortex with short radial rows of smaller cells. Also present in the medulla are distinctive stellate cells.

Habitat: Epilithic in tide pools and open rocks in the lower littoral at São Vicente, and extending into the sublittoral down to 15m at both sites.

Seasonality: Three specimens were collected in the north, one in a pool (4.5 cm in length) in June 1994 and two in the subtidal, in October 1993 and January 1994, with lengths of 2 and 3.5 cm, respectively. Two plants were collected from the subtidal of São Roque in August and September 1994.

Reproduction: The plants collected at São Vicente in June and at São Roque in September were female gametophytes, with mature cystocarps (up to 0.5mm in diameter) scattered over the frond. The other plants were not reproductive.

Remarks: Perennial but with new blades developing annually in the British Isles (Irvine, 1983), this species was collected in spring in the northeastern coast of North America (Taylor, 1978), in October in mainland Portugal (Ardré, 1970), and in May and July on Madeira (Levring, 1974). In the British Isles, cystocarps were found from July to November (Irvine *et al.*, 1975) and tetrasporangia between May and November (Irvine, 1983). Levring (1974) observed fertile plants in July on Madeira.

GLOIOSIPHONIACEAE

Schimmelmannia schousboei (J. Agardh) J. Agardh

Schimmelmannia ornata Schoesboe in Kützing

New record for São Miguel. Recorded from Faial and Pico (Fredericq *et al.*, 1992) and Flores (Tittley *et al.*, in press).

Additional references: Mazza (1903, 1913).

Distinguishing features: Erect thallus cartilaginous, flattened and irregularly branched (Plate VII.1), up to 1m long. The transverse section shows a filamentous medulla of loose cells, surrounded by a corticated cortex of small and deeply pigmented cells, separated by mucilage.

Habitat: Only one small specimen (7 cm long) was collected from the subtidal at a depth of 15m in July 1994 at São Vicente. Specimens were much more abundant in July 1996 (pers. obs.).

Seasonality: No data.

Reproduction: The plant was female, with mature cystocarps which were discharging carpospores.

Remarks: Collected in the Mediterranean (Mazza, 1903) and in France (South & Tittley, 1986), this species was recently found in the Basque coast (J. Gorostiaga, pers. comm.) and Madeira (pers. obs.).

PEYSSONNELIACEAE

Additional reference: *Peyssonnelia* (Boudouresque & Denizot, 1975).

Peyssonnelia squamaria (S. G. Gmel.) Dcne

New record for São Miguel. Largely distributed in the archipelago: previously recorded in Faial, Pico, Terceira and Santa Maria (see Neto, 1994) and recently in Flores (Tittley *et al.*, in press).

Distinguishing features: Thallus prostrate and partially calcified, attached to the substratum by multicellular rhizoids; margins curving upwards; a single layer of cells below the basal layer.

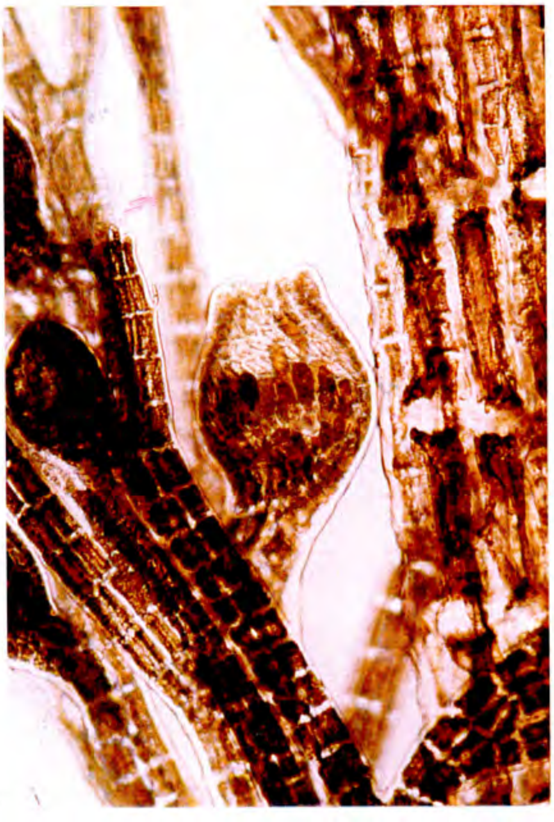
Habitat: Tolerant to sand cover, this species was present in the lower intertidal at São Vicente and

Plate VII 1. *Schimmelmannia schousboei*: Habit of plant (phot. Peter Wirtz).

2. *Polysiphonia brodiaei*: Portion of branch with cystocarp (x100).

1

2



subtidally at both sites, although only frequent at the north.

Seasonality: Only two intertidal plants were collected in June and November 1994 with, respectively, 3.5 and 2 cm in diameter. In the subtidal at São Roque, *P. squamaria* was only found in September 1993 and July 1994 (1.5 and 3.0 cm), whereas at the other site this species was present throughout the sampling period. Biomass and size fluctuated considerably (Figs. 60 and 61).

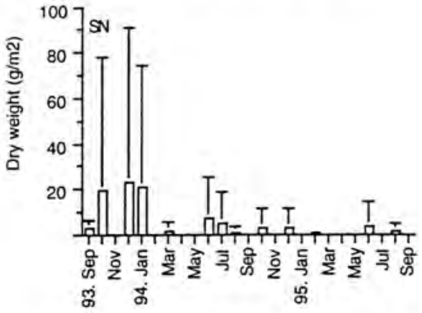


Fig. 60 Monthly biomass (mean + standard deviation) of *P. squamaria*. For abreviations see section 3.5.

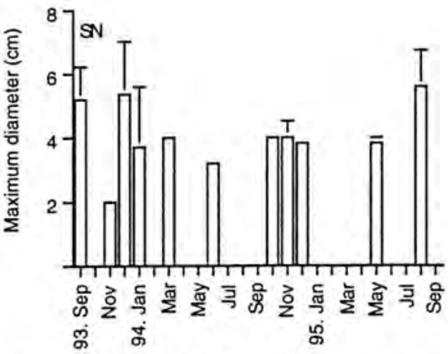


Fig. 61 Monthly maximum diameter of *P. squamaria* (error bars indicate the standard deviation). For abreviations see section 3.5.

Reproduction: Plants were not recognized as fertile but tetrasporangial specimens were collected in July 1996 from São Vicente (pers. obs.).

Remarks: Common in the Aegean Sea, where carpogonial and tetrasporangial plants were observed in August, November and December and where thalli are larger (Athanasiadis, 1987), this species was also collected in April and October in mainland Portugal (Ardré, 1970).

CORALLINALES

CORALLINACEAE

Additional references: Economou-Amilli *et al.* (1990); *Amphiroa* (Norris & Johansen 1981).

Amphiroa beauvoisii J. V. Lamour.

Amphiroa exilis Harv.

New record for São Miguel. Previously recorded in Faial, Pico, Terceira and Santa Maria (see Neto, 1994) and, recently, in Flores (Tittley *et al.*, *in press*).

Distinguishing features: Plants forming erect clumps, branching regularly dichotomous; segments terete towards the base of the branchlets, about 400µm in diameter, becoming flattened above; conceptacles with a pore, scattered over the surface of the segments.

Habitat: One small plant (2.3 cm long), was collected in the subtidal (5m depth) in September 1995 at São Roque.

Seasonality: No data.

Reproduction: The plant was conceptacular.

Remarks: Ardré (1970) found this species between October and April in mainland Portugal, conceptacles being present in April. Common in Madeira, where it was collected throughout the year, the specimens collected in summer being fertile (Levring, 1974).

Corallina elongata Ellis et Sol.
Corallina mediterranea Aresch.

Distinguishing features: Plants attached by extensive crustose bases, branching densely pinnate throughout; average length of intergenicula in main axes less than 1 mm; gaps between successive lateral branches absent or inconspicuous; conceptacles mainly axial and much branched. The morphology of this species varied greatly in different habitats. In tide pools plants were pink and feathery but on exposed rocks they were lighter in colour and growing in a turf form.

Habitat: Either as individual plants or as part of the algal turf, this species was frequently collected at all sampled levels.

Seasonality: *Corallina elongata* was particularly abundant in the intertidal at São Roque (Fig. 62), where it was an important component of the algal turf, although it was also abundant in the tide pools. It was collected throughout the year, with longer plants tending to occur in winter (Fig. 63). The population of São Vicente was more seasonal (generally missing in summer) and less abundant. In the subtidal, this species was also more abundant in the south (Wilcoxon test 5, 24 pairs $p<0.01$), where it was one of the dominant species in the 5 and 10m depth communities. Here the plants were also larger (Fig. 63).

Reproduction: Reproductive plants were collected throughout the year from the intertidal, but only in autumn and winter in the subtidal level at both sites.

Remarks: Collected throughout the year in the British Isles (Irvine & Chamberlain, 1994), Spain

(Seoane-Camba, 1965) and mainland Portugal (Ardré, 1970). Rapid growth reported for north-west Atlantic (New England) in spring and autumn (Conover, 1958). Haas *et al.* (1935) also regarded spring and autumn as being the best growing period for this species in the British Isles. In Spain greater abundance was observed between June and November (Anadón & Fernández, 1986). Growth in the Azores also seems to be seasonal.

Tetrasporangia and cystocarps were recorded in June and August in Norway (Jaasund, 1965). In the British Isles, tetrasporangia have been found throughout the growing season (Haas *et al.*, 1935) but gametangial conceptacles were found to be rare in Britain (Buffham, 1888; Knight & Parke, 1931; Blackler, 1956) and surrounding areas (Rosenvinge, 1917; Suneson, 1943; Hamel & Lemoine, 1953). Athanasiadis (1987) reported tetrasporophytic plants in November and December for the Aegean Sea, while Ardré (1970) found conceptacles between February and July in mainland Portugal.

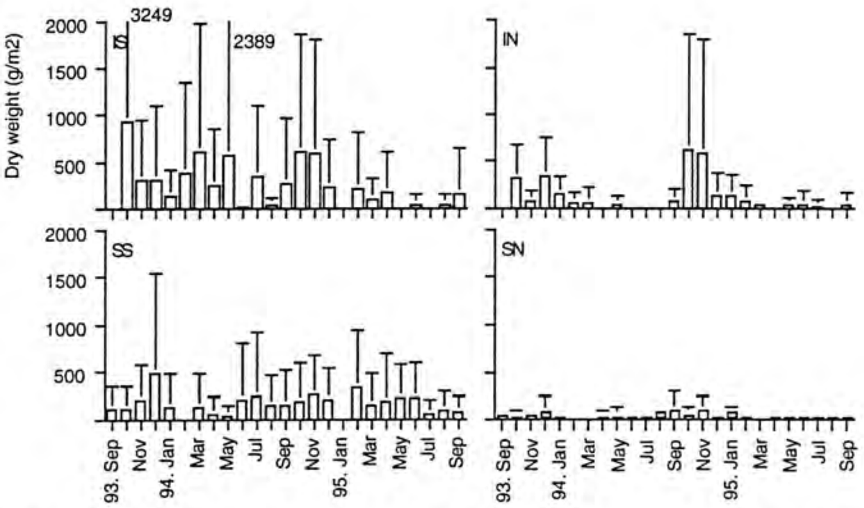


Fig. 62 Monthly biomass (mean + standard deviation) of C. *elongata*. For abreviations see section 3.5.

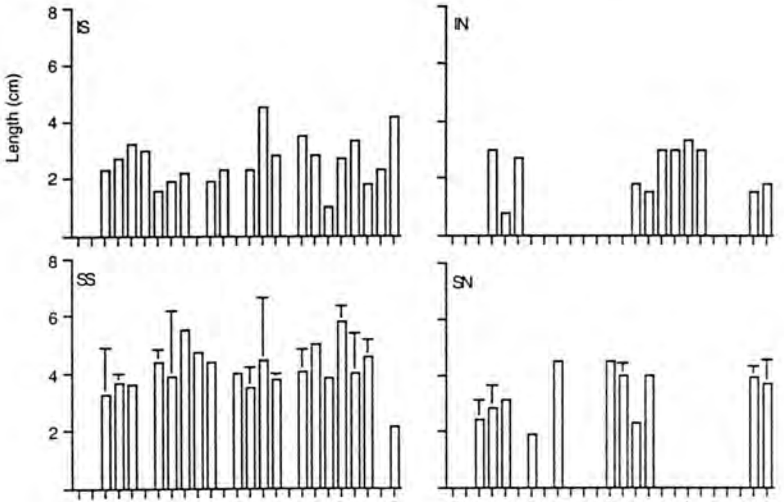


Fig. 63 Monthly maximum length of C. *elongata* (error bars indicate the standard deviation). For abreviations see section 3.5.

Haliptilon virgatum (Zanardini) Garbary et H. W. Johans.

Corallina granifera Ellis et Sol.
Corallina virgata Zanardini

Distinguishing features: Erect plants attached by small crustose bases; main axis dichotomous and densely pinnate; intervals between successive lateral branches absent or inconspicuous.

Habitat: This species was present both in the intertidal and subtidal levels on both sites, although never frequent.

Seasonality: Three plants were collected from the intertidal, one from São Roque in May 1995 (1.7 cm long) and two from the north in December 1994 and May 1995 (1.8 and 4.2 cm in length). Subtidal plants, which were smaller, were collected from São Roque in December 1993, January, July and December 1994 and between July and September 1995 (Fig. 64). Only three subtidal plants were collected from São Vicente between May and September 1995, which were similar in length.

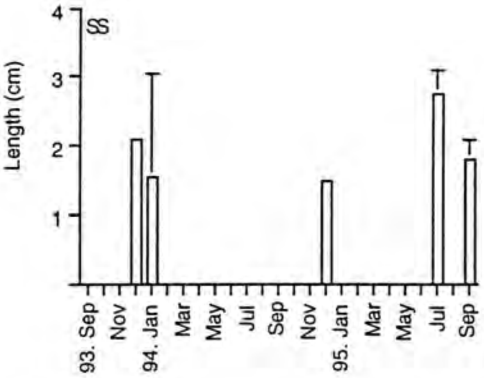


Fig. 64 Monthly maximum length of *H. virgatum* (error bars indicate the standard deviation). For abreviations see section 3.5.

Reproduction: The intertidal plant collected in December was fertile. No sublittoral reproductive plants were seen.

Jania spp.

There are problems in separating species of this genus in the Azores and research focused on this group is needed. In this study a working key, based on personal observations and on the descriptions of Taylor (1967) and Lawson and John (1982), was devised and used for the determination of species. This preliminary key is given in Appendix A15. *Jania adhaerens* and *J. capillacea* are considered as separate species. However, according to Cribb (1983) they are synonymous.

Jania adhaerens J. V. Lamour.

Recorded for many of the Azorean islands (see Neto, 1994), which represent its northern limit in the Atlantic.

Distinguishing features: Plants erect attached by small crustose bases; branching entirely dichotomous at wide angles (> 45°); intervals between successive lateral branches conspicuous. Segments 2-8 times as long as broad, 100-200 µm wide near the base, 30-60 µm wide at the tips.

Habitat: Present in the intertidal zone (low shore pools) at both sites and in the subtidal at São Roque.

Seasonality: A rare species, with only five plants being collected during the sampling period: two from São Vicente (October and November 1994) one from São Roque intertidal (April 1995) and two from the sublittoral (10m depth) in December 1993 and July 1994. Specimens were between 0.8 and 2.8 cm in length.

Reproduction: No reproductive structures were observed.

Remarks: Not recorded by South and Tittley (1986) for any other locality in the north Atlantic but widespread in tropical West Africa (Lawson & John, 1982) and occurring in the Mediterranean (Nizamuddin & Lehnberg, 1970). Price and Scott (1992) record this species as part of the turf flora of the Great Barrier Reef (Australia).

Jania capillacea Harv.

New record for the Azores. Present in Carolina and on the warm and tropical western and eastern Atlantic (Taylor, 1967; Lawson & John, 1982; Price *et al.*, 1992).

Distinguishing features: Distinguished from *J. adhaerens* by the intergenicular segments which are 4-10 times as long as broad and 40-100 µm wide throughout.

Habitat: Epilithic in the sublittoral at both sites.

Seasonality: Like *J. adhaerens* this was also a rare species, having only been collected on four occasions during the sampling period: April and May 1995 at São Roque and in October 1994 and May 1995 at São Vicente. Lengths were similar to *J. adhaerens*, and the mean biomass never exceeded 100 g/m2.

Reproduction: None of the plants was reproductive.

Remarks: Recorded by Taylor (1967, 1978) in the western Atlantic from Virginia to Brazil and by Lawson and John (1982) from west Africa.

Jania crassa J. V. Lamour.
Jania natalensis Harv. Price
Corallina natalensis Kützing

Distinguishing features: Segments 1-3 mm long and 200-450 µm wide throughout. The angle between dichotomies is narrow, always less than 45°.

Habitat: Present at both sites, but especially at São Roque, where it was a major component of the lower littoral algal turf.

Seasonality: This species was only frequent at São Roque, where it was collected for much of the sampling period. Its mean biomass varied considerably, ranging from 14.9 to 1375.7 g/m2 (Fig. 65). Only two other plants were collected from different habitats, one from a tide pool at São Vicente in October 1994, and the other from São Roque sublittoral in the same month. All the specimens collected were of a similar size to those of previous species.

Reproduction: None of the observed plants was reproductive.

Remarks: The Azores represent the known northern limit of this species distribution on the Atlantic.

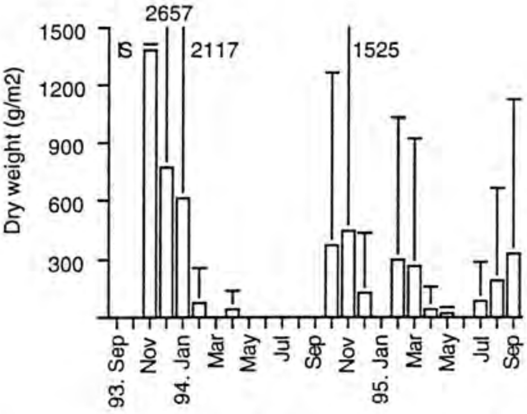


Fig. 65 Monthly biomass (mean + standard deviation) of *J. crassa*. For abreviations see section 3.5.

Jania longifurca Zanardini

Distinguishing features: Distinguished from *J. crassa* mainly by its erect and feathery growth; in the Azorean material, the segments were 2-2.5 mm long and 350-500 µm wide.

Habitat: Epilithic on open rocks and tolerant to sand cover, this species was present at all sampled levels.

Seasonality: In the intertidal it was more frequent at the north site where plants were collected from October 1993 to December 1994 and in September 1995. Here it was a major contributor to the algal turf, with its standing crop varying from 11.9 to 436.8 g/m2 (Fig. 66). South intertidal populations were sporadic and variable. However, in the subtidal zone, *J. longifurca* was more abundant at São Roque, where smaller quantities of plants were consistently collected. Sublittoral populations from São Vicente were the least common and abundant (Fig. 66). Plants were longer (1.5-4.0 cm) than those of the previous species (Fig. 67).

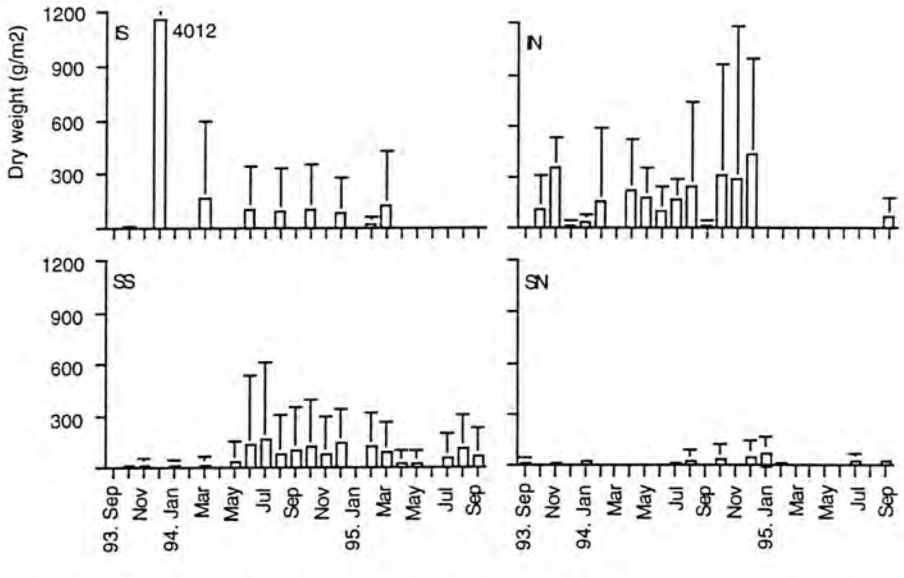


Fig. 66 Monthly biomass (mean + standard deviation) of *J. longifurca*. For abreviations see section 3.5.

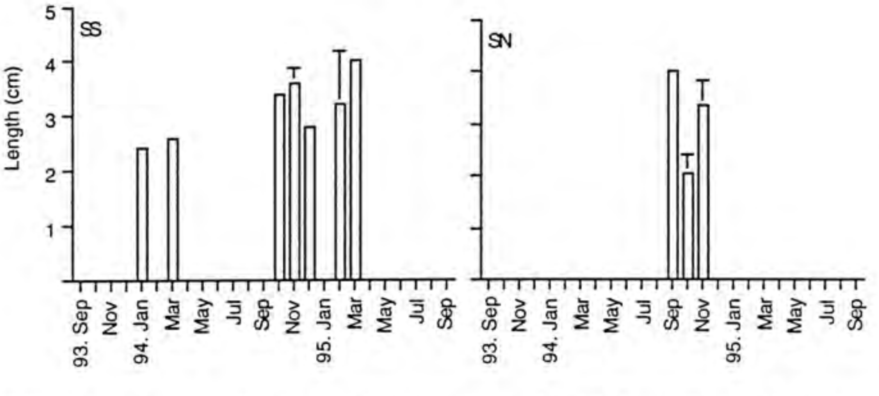


Fig. 67 Monthly maximum length of *J. longifurca* (error bars indicate the standard deviation). For abreviations see section 3.5.

Reproduction: No reproductive plants were observed at any level.

Remarks: Ardré (1970) found it between October and June in mainland Portugal. Athanasiadis (1987) cited previous records of its occurrence in the eastern Mediterranean.

Jania rubens (L.) J. V. Lamour.

Corallina rubens L.
Jania corniculata (L.) J. V. Lamour.
Corallina corniculata L.

Distinguishing features: Small corymbose plants, the segments with acute apices, 1-1.5 mm long, 60-200 µm in diameter. Branching entirely dichotomous at narrow angles (< 45°).

Habitat: Epilithic and tolerant to sand cover, this species was present at all levels sampled.

Seasonality: *Jania rubens* was an important species of the intertidal algal turf at both sites, where it was collected throughout the sampling period, although measurements of standing crop were usually much higher at São Vicente (Fig. 68). Subtidally, *J. rubens* was far less abundant, especially in the south. Plants from this zone were generally smaller than from the intertidal, not exceeding 3.6 cm in length, whereas intertidal ones were sometimes nearly 5 cm (Fig. 69).

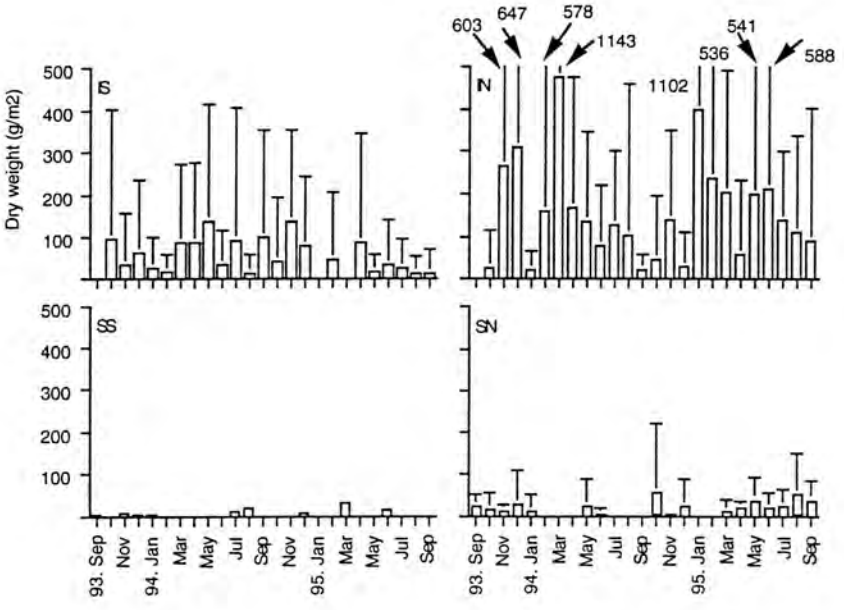


Fig. 68 Monthly biomass (mean + standard deviation) of *J. rubens*. For abreviations see section 3.5.

Reproduction: Fertile plants, with mature conceptacles, were collected from the intertidal in February and October 1995 at São Roque and in January, February and July 1995 at São Vicente. No reproductive plants were found in the subtidal collections.

Remarks: Collected throughout the year in the Aegean Sea (Athanasiadis, 1987), mainland Portugal (Ardré, 1970) and Madeira (Levring, 1974), conceptacles being present throughout the year in the Aegean Sea (Athanasiadis, 1987) but only between February and April in mainland Portugal (Ardré, 1970).

The reproductive phenology for São Miguel is perhaps similar to that of the British Isles, where fertile specimens have been found from spring to autumn (Irvine & Chamberlain, 1994). British specimens differ, however, in being usually epiphytic.

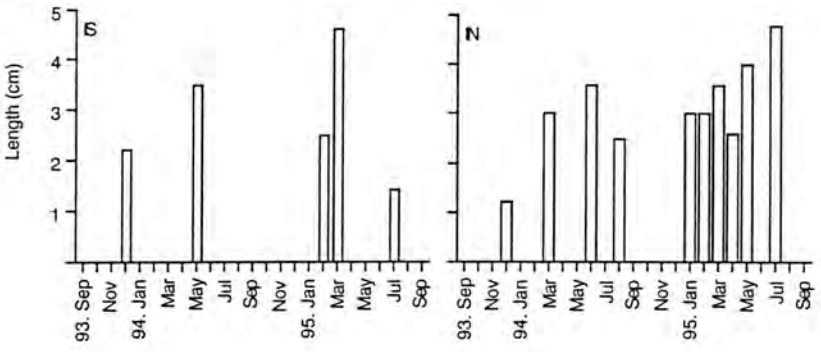


Fig. 69 Monthly maximum length of *J. rubens*. For abreviations see section 3.5.

Jania verrucosa J. V. Lamour.

New record for the Azores. Common on the Atlantic African coasts (Lawson & John, 1982; Price *et al.*, 1992).

Distinguishing features: Small plants growing in dense clumps and mats. Branching dichotomous at narrow angles (< 45°), segments with rounded or cube-shaped apices, less than 1 mm long.

Habitat: This species was present at all sampled levels.

Seasonality: *Jania verrucosa* was particularly important in the subtidal communities of the south site, where it was collected throughout the sampling period, although found to be more abundant in the second year (Fig. 70). Biomass varied between 0.1 to 207.3 g/m2, much lower values than for the intertidal *Jania* turf communities. At São Vicente only one subtidal plant was collected (October 1994). Occasionally collected in the intertidal, it was more frequent at São Roque, where it was found in March, November and December 1994 and between June and September 1995. At São Vicente, only three plants were collected from the intertidal (February and August 1994, and September 1995). Plants were of a similar size to *J. rubens*, with fronds up to 4.3 cm long.

Reproduction: Reproductive plants were present in the intertidal from June to September at São Roque and in September at São Vicente. Like *J. rubens*, no reproductive plants were found in the subtidal.

Remarks: The Azores are the new northern limit of distribution for this species on the Atlantic.

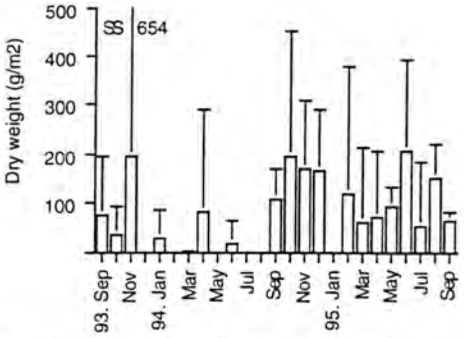


Fig. 70 Monthly biomass (mean + standard deviation) of *J. verrucosa*. For abreviations see section 3.5.

Nongeniculate coralline red algae (Corallinales, Rhodophyta) are abundant and important components of benthic marine communities throughout the world (Woelkerling, 1988). In the Azores twelve species of epilithic/epiphytic "lithothamnia" are recorded (see Neto, 1994). Although ecologically important, they have not been studied here because of sampling and taxonomic difficulties.

GIGARTINALES

Additional reference: Searles (1968).

GYMNOPHLAEACEAE

Additional references: *Platoma* (Kraft & John, 1976; Masuda & Guiry, 1994, 1995); *Predaea* (Kraft & John, 1976; Kraft, 1984; Athanasiadis, 1988); *Nemastoma* (Kraft & John, 1976; Athanasiadis, 1988); *Schizymenia* (Parkinson, 1981).

?Predaea/Platoma/Nemastoma

Distinguishing features: Under this initial determination (ID) is a group of plants presenting features which are common to the three genera mentioned above. All the specimens from this study were characterized by possessing a soft but firm thallus (not easily squashed), somewhat compressed or flattened, and with protuberances. Internally there was a compact filamentous medulla of loosely arranged slender filaments more or less interwoven with rhizoids. No stellate cells (*sensu* Norris, 1957, p.258) were observed at the junction between the cortical and medullary tissues. In some plants prominent gland or secretory cells could be seen within the cortex, while other, apparently similar specimens did not contain this type of cells. Dixon and Irvine (1977) indicated that these gland cells may not always be present in British material of *Schizymenia dubyi*.

Most of the plants collected showed effects of herbivory.

Fertile plants were not found, although looked for, and this prevented proper identification at generic level. According to Kraft and John (1976), the criteria separating these genera, based on critical detail of carposporophyte development, require closer investigation and since then several authors have been studying this group of foliose red algae (Millar & Guiry, 1989; Masuda & Guiry, 1994, 1995, among others).

Habitat: Strictly subtidal, these plants have been found at both sites.

Seasonality: Only four plants were collected during the summer months in both sampling years, one at São Roque (July 1994; 8 cm long) and the others at São Vicente, between June and September. These were somewhat smaller (1.8-3.7 cm in length).

Reproduction: No reproductive structures were seen, as noted above.

?Predaea/Nemastoma

Distinguishing features: The plant included under this ID was very similar to the previous ones in vegetative features. The presence of cystocarps without ostioles scattered over the blade, allowed the exclusion of the genus *Platoma* (Taylor, 1967).

Habitat: Epilithic on the shallow sublittoral and tolerant to sand cover.

Seasonality: The plant was collected in September 1993 at São Roque.

Reproduction: The plant was cystocarpic, see above.

Schizymenia dubyi (Chauv. *ex* Duby) J. Agardh

Schizymenia obovata J. Agardh
Schizymenia undulata J. Agardh

Additional references: Tokida and Masaki (1959); Ardré (1977, 1980); Alongi and Cormaci (1993).

Distinguishing features: Gametophyte thallus is a flattened blade, soft but not easily squashed, irregularly lobed or split. Internally there is a filamentous medulla (Plate VIII.1) and secretory cells could be seen within the cortex. No stellate cells.

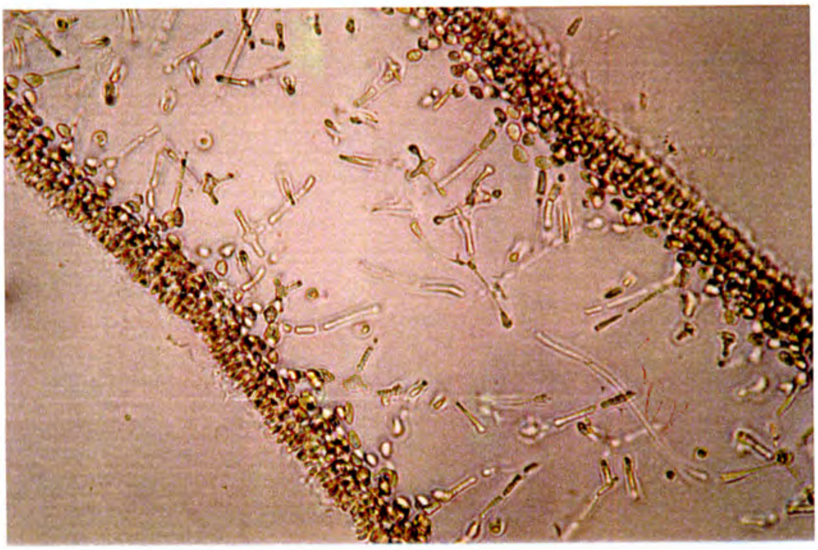
Habitat: Epilithic in open rocks and tolerant to sand cover, this species was present in the lower littoral and shallow sublittoral levels at both sites.

Seasonality: Its occurrence was restricted to spring and summer, and *Schizymenia* was more common in the intertidal at São Roque, where it was collected between May and July in both years. Thallus length varied from 2.5 to 17 cm. Four other plants were collected: two in the sublittoral

Plate VIII 1. *Schizymenia dubyi*: Transverse section through blade region showing filamentous medulla enclosed within outer small cortical cells (x200).

2. *Erythrodermis traillii*: Cross section of blade showing compact medulla of large cells surronded by smaller cortical cells (x200).

3. *Hypnea musciformis*: Transverse section through tetrasporangia showing zonate tetraspores (x400).



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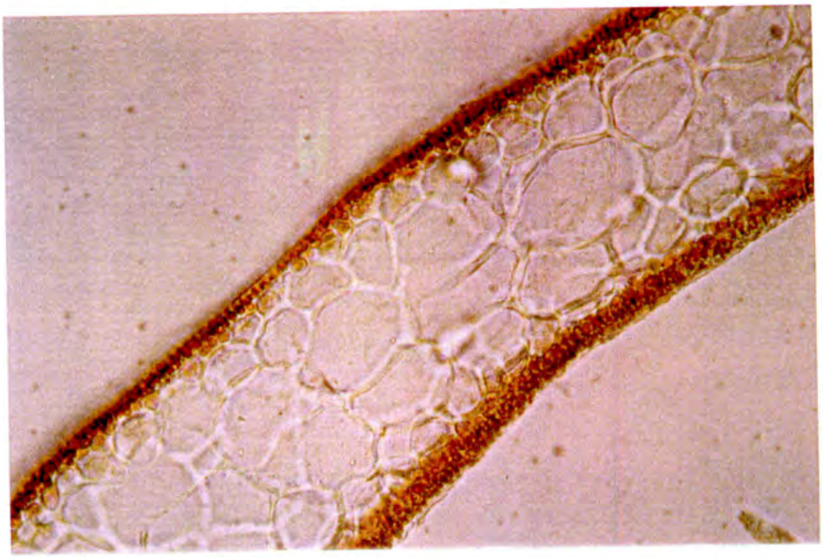

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nearby (July 1994 and May 1995), one in the intertidal at São Vicente in March 1995 and one from the subtidal there in July 1994. Most of the plants had been grazed.

Reproduction: Only one mature cystocarpic plant, was collected in July 1994 at São Roque from the intertidal.

Remarks: Little is known of the seasonal behaviour of this species in British Isles. Dixon and Irvine (1977) recorded thalli between February and October with a peak in May, spermatangia being seen in March and ripe cystocarps from May onwards. The species is perennial in France (Gayral, 1966), and mainland Portugal, where the plants from March, June, August and October contained gonimoblasts (Ardré, 1970). In Madeira it was collected in June and July, both specimens being fertile (Levring, 1974) and in Morocco cystocarpic plants were collected in winter (Gayral, 1958). Tetrasporangial plants have never been found in nature (Ardré, 1977). Its sporophyte is probably *Haematocelis rubens* (Ardré, 1980).

GRACILARIALES

PHYLLOPHORACEAE

Additional reference: Newroth and Markham (1972).

Coccotyus truncatus (Pall.) Wynne et Heine
Phyllophora truncata (Pall.) Zinova

Additional reference: Newroth (1971).

Distinguishing features: Stipe terete more than 10 mm long; blade more or less fan-shaped and branching narrow-angled; transition from blade to stipe gradual; blade often proliferating laterally or apically; carpotetrasporangia in spherical outgrowths at or near the apices.

Habitat: Epilithic in the lower intertidal zone at São Vicente.

Seasonality: Only one vegetative plant has been collected, in September 1993.

Reproduction: No data.

Remarks: Perennial, new growth conspicuous in spring in the British Isles, spermatangia recorded between May and August (spermatia usually released in June) and carpotetrasporangial nemathecia present throughout the year (Dixon & Irvine, 1977). In North America, nemathecia have been observed throughout the year, but tetraspores were only released between November and January; mature spermatangia were observed from May to August and well-developed procarps were present in May and June (Newroth, 1971).

The presence of this species on the Azores represents a large southward extension in distribution. Due to similarities with *P. silicula*, further, ideally fertile, material, is required to confirm this identification, especially since a significant change in distribution is involved.

Erythrodermis traillii (Holmes ex Batters) Guiry et Garbary

Phyllophora traillii Holmes *ex* Batters

Additional reference: Maggs (1989).

Distinguishing features: Thallus an erect frond, dark red in colour, with a terete stipe, 1-3 mm in length, arising from a discoid holdfast. Blades simple or irregularly dichotomously branched. Structure multiaxial, with a compact medulla of large cells, surrounded by smaller cortical cells (Plate VIII.2).

Habitat: Epilithic in the shallow subtidal at São Roque.

Seasonality: A single plant was collected in September 1993.

Reproduction: No reproductive structures were seen.

Remarks: Presumably perennial but little is known about seasonal growth in the British Isles; spermatangia recorded between July and February, spermatia observed to be released in August; cystocarps present throughout the year, carpospores apparently released only in December and February, according to Dixon and Irvine (1977) but also in May and August (Maggs, 1989). Fertile plants observed in winter on the northeastern coasts of North America (Taylor, 1978). This species has its southern limit on the Azores, having previously been recorded throughout the archipelago (see Neto, 1994).

Gymnogongrus crenulatus (Turner) J. Agardh

Distinguishing features: Superficially resembling *Chondrus crispus*, it has been confused with this species in previous works (Piccone, 1889; Gain, 1914; Neto, 1989, 1991a, b; Neto & Baldwin, 1990). *Gymnogongrus crenulatus* can easily be distinguished from *C. crispus* by its non-filamentous medulla and by the thalli which are never iridescent under water. The tetrasporangial phase is a bright red crust (*Erythrodermis alleni*). The gametophytic plant is attached by a disc, from which arise one to several erect fronds which are stipitate below, expanding gradually into flattened blades which are repeatedly dichotomously branched in one plane; the carpotetrasporangial outgrowths are small and scattered over both surfaces of thallus.

Habitat: Only the gametophytic phase was found, in tide pools and on open rocks in the lower intertidal zone of São Roque.

Seasonality: Plants were only collected in May and July 1994, and again in May and July 1995. These were smaller than British specimens, which are up to 10 cm in length (Dixon & Irvine, 1977), and their mean biomass never exceeded 36.8 g/m2.

Reproduction: All plants possessed carpotetrasporangia.

Remarks: Perennial in the British Isles (Dixon & Irvine, 1977), and collected throughout the year in Spain (Seoane-Camba, 1965; Anadón & Fernández, 1986) and mainland Portugal (Ardré, 1970). Carposporangial outgrowths perennial and cystocarps recorded for February and August in British Isles (Dixon & Irvine, 1977). In northern France carpotetraspores are shed in April (Chemin, 1929), although Ardré (1970) found fertile plants throughout the year in mainland Portugal. In Morocco nemathecia were observed in December, February and August (Gayral, 1958).

According to Schotter (1968) plants with internal cystocarps belong to a separate species, *G. devoniensis*. Such plants are rare (Dixon & Irvine, 1977), and were never seen in the Azores.

Gymnogongrus griffithsiae (Turner) G. Martens

Additional reference: Cordeiro-Marino and Poza (1981).

Distinguishing features: Distinguished from *G. crenulatus* by its terete frond, somewhat flattened towards apices and by the carpotetrasporangial outgrowths which in this species are large, sometimes completely encircling the branches.

Habitat: Epilithic in tide pools and on open rocks in the lower intertidal zone, the gametophytic phase of this species was present on both coasts. It is quite common throughout the Azores (see Neto, 1994).

Seasonality: Although sporadic in occurrence and never abundant, this species was collected at both sites. It was more common at São Vicente, with biomass values up to 35.1 g/m2. Plants were infrequently recorded in 1994 from both localities. Fronds were quite small (up to 2.3 mm, Fig. 71), whereas in the British Isles they can be 5 cm long (Dixon & Irvine, 1977). Most plants showed signs of herbivory.

Reproduction: Reproductive plants with carpotetrasporangia were present in March and June 1995 in São Roque and in May 1995 at São Vicente.

Remarks: Monoecious plants, independent macroscopic gametophyte that carries an internal carposporophyte immersed in the thallus, plus an external tetrasporophyte forming a wart on the thallus surface (Cordeiro-Marino, 1981). Perennial, carpotetrasporangial outgrowths present throughout the year in the British Isles where spores are shed between June and December (Gregory, 1934; Dixon & Irvine, 1977). Collected in Spain in all seasons, fertile nemathecia being present between December and June (Seoane-Camba, 1965). Collected in October, March and April in mainland Portugal (Ardré, 1970), the plants in October with tetrasporangia. Athanasiadis (1987) noted the occurrence of a few infertile plants throughout the year in the Aegean Sea. Reproductive plants were collected in early summer on the northeastern coast of North America (Taylor, 1978).

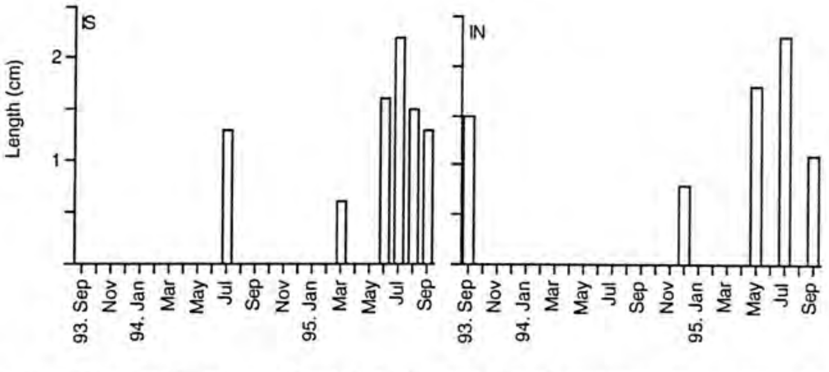


Fig. 71 Monthly maximum length of *G. griffithsiae*. For abreviations see section 3.5.

Phyllophora crispa (Huds.) P. S. Dixon

Additional reference: Newroth (1972).

Distinguishing features: Stipe terete more than 10 mm long; blade more or less fan-shaped, with undulate margins; mature thallus more than 35 mm tall; branching dichotomous.

Habitat: Epilithic on rocks in the low intertidal and subtidal zones, this species was present at both sites.

Seasonality: In total only four plants were collected, one from each level. Both intertidal plants, 4 cm, were found in July 1994. The subtidal plants were collected in September 1993 also from both coasts. These were much longer, up to 16 cm in length.

Reproduction: No reproductive structures were detected.

Remarks: In the British Isles fronds are perennial, with spermatia being released in September and October, and cystocarps recorded between September and March, usually releasing carpospores in January; tetrasporangia recorded between August and March, the tetraspores usually released mainly in January (Newroth, 1972; Dixon & Irvine, 1977). Athanasiadis (1987) mentions the occurrence of a few plants throughout the year in the Aegean Sea, with some outgrowths resembling carposporophytes in the plants collected in November, December and May. Ardré (1970) collected one plant in March in mainland Portugal.

Not listed by South and Tittley (1986) for the Azores, but recorded later by Neto and Azevedo (1990) for Flores, and by Neto (1991) for São Miguel.

PETROCELIDACEAE

Mastocarpus stellatus (Stackh. *in* With.) Guiry *in* Guiry, West, Kim et Masuda
Gigartina stellata (Stackh.) Batters

Additional references: Chen *et al.* (1974); Edelstein *et al.* (1974); Guiry and West (1983); Guiry *et al.* (1984).

Distinguishing features: Thallus cartilaginous attached by a disc. Fronds with narrow stipe-like portion expanding gradually into blades channelled (concavo-convex) throughout and frequently further twisted and contorted. Branching repeatedly dichotomous, sometimes irregular. Mature plants beset with reproductive papillae on one or sometimes both blade surfaces.

Habitat: Epilithic and tolerant to sand cover, in the subtidal level at both sites.

Seasonality: Two plants were collected in September 1993, one at São Roque, the other at São Vicente.

Reproduction: No reproductive structures were seen.

Remarks: Fertile plants are present throughout the year on both sides of the North Atlantic (Marshall *et al.*, 1949; Burns & Mathieson, 1972; Chen *et al.*, 1974). Male plants have been reported from Europe (Marshall *et al.*, 1949) but never from North America (Chen *et al.*, 1974). Plants bearing cystocarps seem to be present all year in North Atlantic populations (Marshall *et al.*, 1949; Burns & Mathieson, 1972; Pybus, 1977) but carpospores are most abundantly liberated from plants collected between October and March (Burns & Mathieson, 1972; Dixon & Irvine, 1977; Guiry & West, 1983). In the British Isles male plants have been recorded between November and September (Dixon & Irvine, 1977; Guiry & West, 1983). Mature gametophytes were collected in winter in the northeastern coast of North America (Taylor, 1978). Collected at all seasons in mainland Portugal (Ardré, 1970), the plants from March, April and between June and October possessed cystocarps.

In New Hampshire, USA, Burns and Mathieson (1972) observed that annual growth was initiated between February and May, depending upon the location, and continued through the summer, with populations reaching their maximum biomass and length during the reproductive period (October to March). The period of maximum growth coincided with increasing sea temperature, from February to July.

GIGARTINACEAE

Additional reference: Hommersand *et al.* (1993).

Chondracanthus acicularis (Roth) Fredericq in Hommersand, Guiry, Fredericq et Leister
Gigartina acicularis (Roth) J. V. Lamour.
Sphaerococcus acicularis C. Agardh

Distinguishing features: Plants forming clumps or mats, irregularly dichotomously or pinnately branched; branches terete, the ultimate often recurved and forming secondary small attachment discs upon contact with a substratum.

Habitat: Epilithic and tolerant to sand cover, this species was collected at all sampled levels, although more frequently in the intertidal where it very commonly formed a dense turf.

Seasonality: At the intertidal, *Chondracanthus acicularis* was collected throughout the sampling period at both places, but was more abundant at São Vicente (Wilcoxon test 54, 25 pairs $p<0.01$), where the mean biomass ranged between 24.1 and 434.3 g/m2, while in the south it never reached 200 g/m2 (Fig. 72). Thalli from São Vicente were also larger, nearly 6 cm in length, as compared to those from São Roque which were just over 4 cm, the largest plants being collected during the summer on both sites (Fig. 73). In the subtidal, this species was less frequent and never abundant but biomass and size were still greater for the São Vicente population (Figs. 72 and 73).

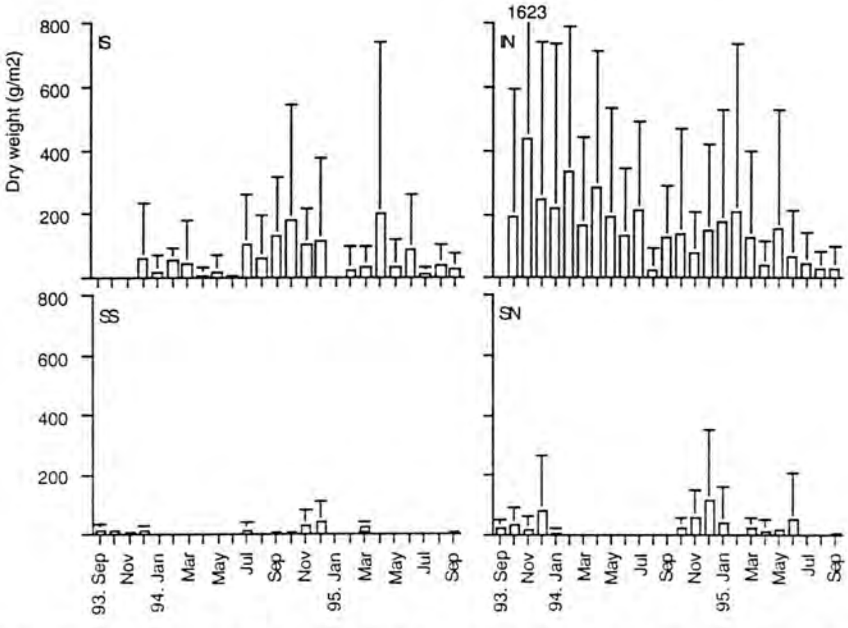


Fig. 72 Monthly biomass (mean + standard deviation) of *C. acicularis*. For abreviations see section 3.5.

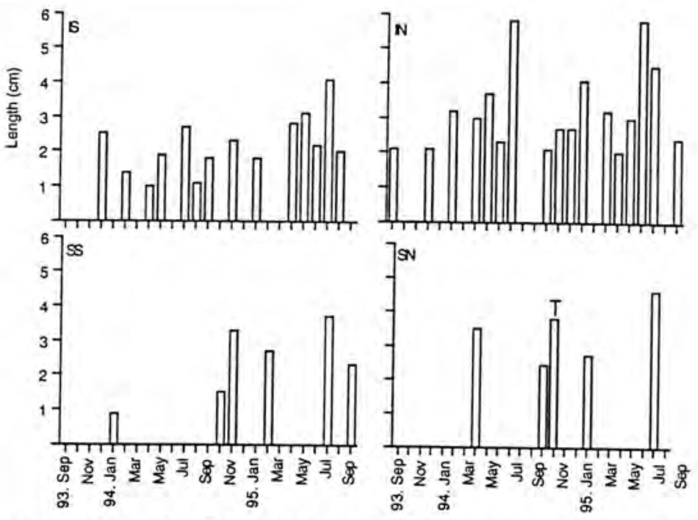


Fig. 73 Monthly maximum length of *C. acicularis* (error bars indicate the standard deviation). For abreviations see section 3.5.

Reproduction: Only one cystocarpic plant was collected in the subtidal at São Roque in November 1994.

Remarks: This species has been collected throughout the year in the Aegean Sea (Athanasiadis, 1987), Spain (Seoane-Camba, 1965; Anadón & Fernández, 1986; Fernández *et al.*, 1987) and mainland Portugal (Ardré, 1970).

Little is known of its seasonal growth and reproduction in the British Isles (Dixon & Irvine, 1977; Guiry 1984); cystocarps were only recorded in January and tetrasporangia in November (Guiry & Cunningham, 1984). In France cystocarps were seen from November to February (Gayral, 1966) and from August to March in Morocco (Gayral, 1958); in Spain cystocarps were seen between December and February and tetrasporophytes between July and September (Seoane-Camba, 1965; Anadón & Fernández, 1986; Fernández *et al.*, 1987). However, in mainland Portugal, only tetrasporangia were observed in October (Ardré, 1970).

Chondracanthus teedii (Roth) Kützing

Gigartina teedii (Roth) J. V. Lamour.
Sphaerococcus teedii C. Agardh

Additional references: Guiry (1984); Guiry and Maggs (1985); Braga (1990).

Distinguishing features: Fronds erect, not re-attaching, thallus flattened, branching dense and more or less pinnate.

Habitat: Epilithic in both intertidal and upper subtidal zones, this species was collected at both sites.

Seasonality: It was neither frequent nor abundant, its mean biomass never exceeding 30 g/m2. Plants were collected between July and September in both years. As with *C. acicularis*, intertidal plants were longer (1.4 to 6.3 cm) than subtidal specimens (2.9 to 3.4 cm). Most of the plants showed effects of herbivory.

Reproduction: Female plants, with cystocarps, were found in both years, from July to September at both levels on the shore. Only one tetrasporic plant was collected from São Vicente intertidal in September 1993.

Remarks: Little is known about the behaviour of the species in Britain because of its rarity but cystocarps have been discovered in August and September, and tetrasporangia in September (Dixon & Irvine, 1977). Later, Guiry (1984) found cystocarpic plants in November in England. Gayral (1966) reported cystocarps for autumn and winter in France. Not common in Spain, where it was only found in November and June (Seoane-Camba, 1965), but was collected in all seasons in mainland Portugal (Ardré, 1970), plants in March and June containing tetrasporangia, while cystocarps were found in the October plants. In Brazil, female plants were found every month but thalli with tetrasporangial sori were restricted to January, May, July and November, and male plants were collected only in September and January (Braga, 1990).

PLOCAMIACEAE

Plocamium cartilagineum (L.) P. S. Dixon

Fucus cartilagineus L.
Plocamium coccineum (Huds.) Lyngbye
Gelidium cartilagineum L.
Delesseria plocamium C. Agardh

Distinguishing features: Plants bushy with the lateral branches a number of times pinnately divided and usually having groups of one to several secund branchlets. The upper branchlets are usually divided once or twice, bearing 3 or 4 subulate teeth on their adaxial side.

Habitat: Mainly epilithic, this species was present at all sampled levels, although always more abundant in the subtidal.

Seasonality: Plants of this species were only occasionally found in lower intertidal pools. At São Roque plants were collected in July 1994 and March 1995, 3.9 and 4.8 cm in length. *Plocamium* was more frequent at São Vicente and the fronds were much longer, the length of plants collected varying from 2.9 to 12.1 cm (Fig. 74). This alga was never abundant in the intertidal, as indicated by its low standing crop values, 0.8 to 4.8 g/m2 in São Roque and 0.1 to 16.3 g/m2 in the north (Fig. 75). Subtidally, *P. cartilagineum* was collected throughout the sampling period at both sites, being more abundant at São Vicente. The largest plants and the highest values of biomass occurred in spring at both places (Figs. 74 and 75).

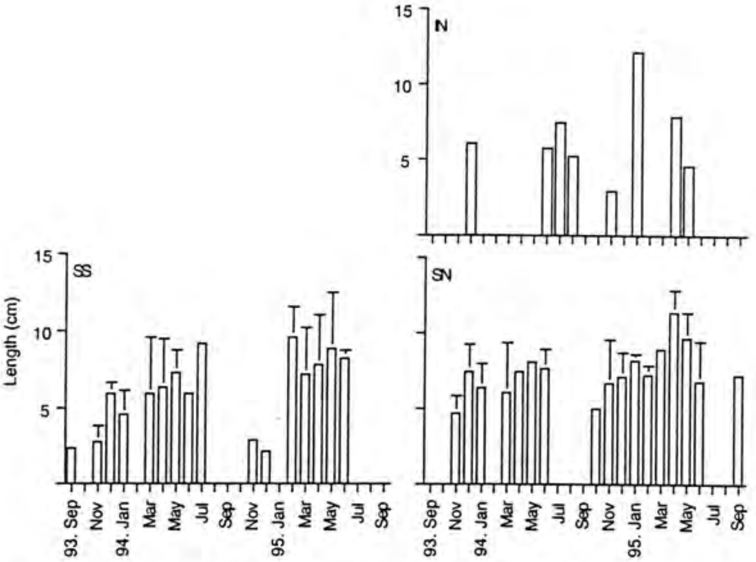


Fig. 74 Monthly maximum length of *P. cartilagineum* (error bars indicate the standard deviation). For abreviations see section 3.5.

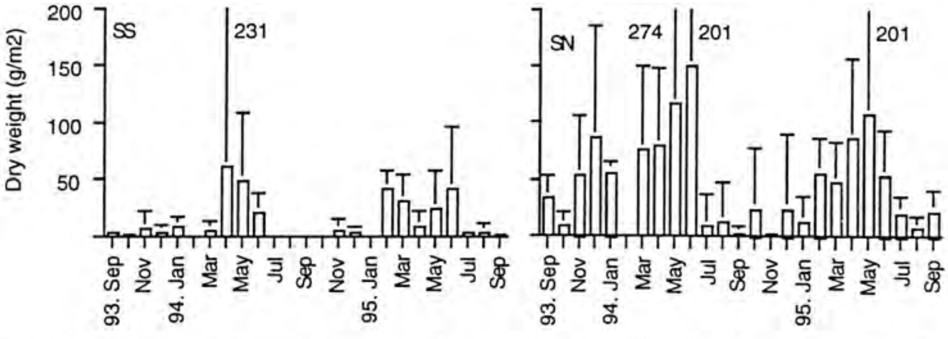


Fig. 75 Monthly biomass (mean + standard deviation) of *P. cartilagineum*. For abreviations see section 3.5.

Reproduction: Intertidal tetrasporic plants were collected in November 1994 and January 1995 at São Vicente. Subtidal tetrasporic plants were present at this site between November and May, and in December 1993 and from February to May at São Roque.

Remarks: Potentially perennial in the British Isles (Dixon & Irvine, 1977), plants of this species were only occasionally collected in the Aegean Sea (Athanasiadis, 1987) but were present throughout the year in Spain (Seoane-Camba, 1965) and mainland Portugal (Ardré, 1970).

In the Isle of Man the largest plants were present in summer and autumn (Kain, 1982), while in Spain they were seen earlier in the year (Seoane-Camba, 1965). Fertile tetrasporophytes were present at all times of the year in Isle of Man but there was a marked seasonality with a peak in fertility in the autumn and a distinct reduction in fertile plants in spring (Kain, 1982). In France, reproductive plants were observed in spring and winter (Gayral, 1966) and in Morocco tetrasporophytes were observed between October and April (Gayral, 1958). In mainland Portugal gonimoblasts were found in October, February and March, and tetrasporangia from February to August (Ardré, 1970).

SPHAEROCOCCACEAE

Sphaerococcus coronopifolius Stackh.

Fucus coronopifolius Gooden. & Woodw.

New record for São Miguel. Previously recorded in Flores and Faial (see Neto, 1994).

Distinguishing features: Thallus cartilaginous, attached by a large disc from which arises an erect flattened frond. Plants repeatedly, irregularly, alternately branched, sometimes partly secund, branches more or less distichous, often curving and fringed with small branchlets, apices acute. Somewhat similar to *Plocamium* (q.v.), but the branching is less secund and the thalli are generally larger and more cartilaginous.

Habitat: Epilithic and tolerant to sand cover, this species was only found in the subtidal at São Vicente.

Seasonality: It was collected throughout the sampling period, the length of the observed plants varying from 7.4 to 24.6 cm (Fig. 76). In contrast, British specimens are no more than 15 cm long (Dixon & Irvine, 1977). Although frequent, *S. coronopifolius* was never abundant, its mean biomass fluctuating between 1.7 and 146.6 g/m2 (Fig. 77). This fluctuation may result from fronds being cast after fruiting, as suggested by Dixon and Irvine (1977).

Reproduction: No male plants were found but female plants were collected between May and November in both years. The tetrasporangia occur in a crustose phase (Maggs & Guiry, 1982), which has not been detected in the Azores.

Remarks: In the British Isles spermatangia have been recorded for August and cystocarps between April and December with a peak in September and October (Dixon & Irvine, 1977). Cystocarpic plants were observed in summer in France (Gayral, 1966) and Morocco (Gayral, 1958), in May in the Aegean Sea (Athanasiadis, 1987). Collected in Spain between April and October, cystocarps being present between April and September (Seoane-Camba, 1965). Collected between October and June in mainland Portugal (Ardré, 1970), the plants from October being cystocarpic. A rare species in Madeira where it was collected only in June, the plant bearing cystocarps (Levring, 1974).

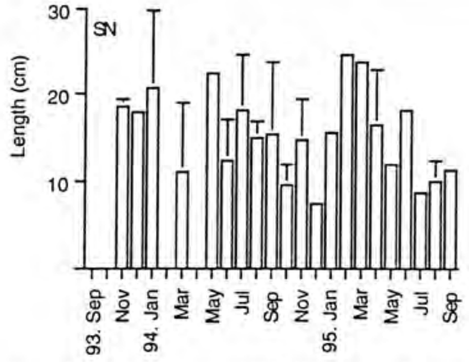


Fig. 76 Monthly maximum length of *S. coronopifolius* (error bars indicate the standard deviation). For abreviations see section 3.5.

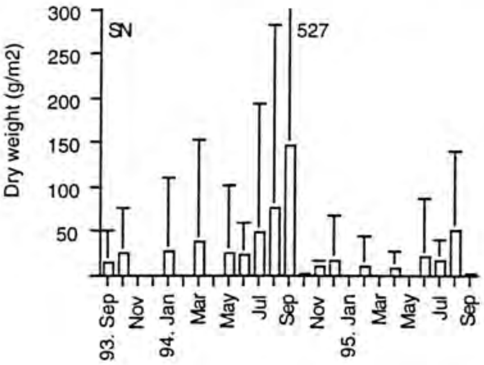


Fig. 77 Monthly biomass (mean + standard deviation) of *S. coronopifolius*. For abreviations see section 3.5.

HYPNEACEAE

Hypnea musciformis (Wulfen *in* Jacq.) J. V. Lamour.

Additional reference: Mishigeni (1976).

Distinguishing features: Plants forming loose bushy clumps or cushion-like patches, often bleached to a greenish colour; branching terete, few to many times irregularly divided, bearing alternately arranged and upwardly curving branchlets, with the tips often swollen and hook-shaped; pseudoparenchymatous medulla; compact cells throughout; no filaments in the cortex.

Habitat: Tolerant to sand cover, this species was collected at all sampled levels.

Seasonality: In the intertidal, this species was collected only twice at São Roque (September 1993 and March 1995), being more frequent at the north site. The length of plants varied between 1.5 and 8.5 cm (Fig. 78) although the mean biomass did not exceed 64 g/m2 (Fig. 79). In the subtidal *H. musciformis* was clearly more frequent and more abundant at São Vicente, (length 2-10.5 cm and biomass up to 220 g/m2, Figs. 78 and 79), than at São Roque (length 1.5-6.4 cm and biomass lower than 70 g/m2).

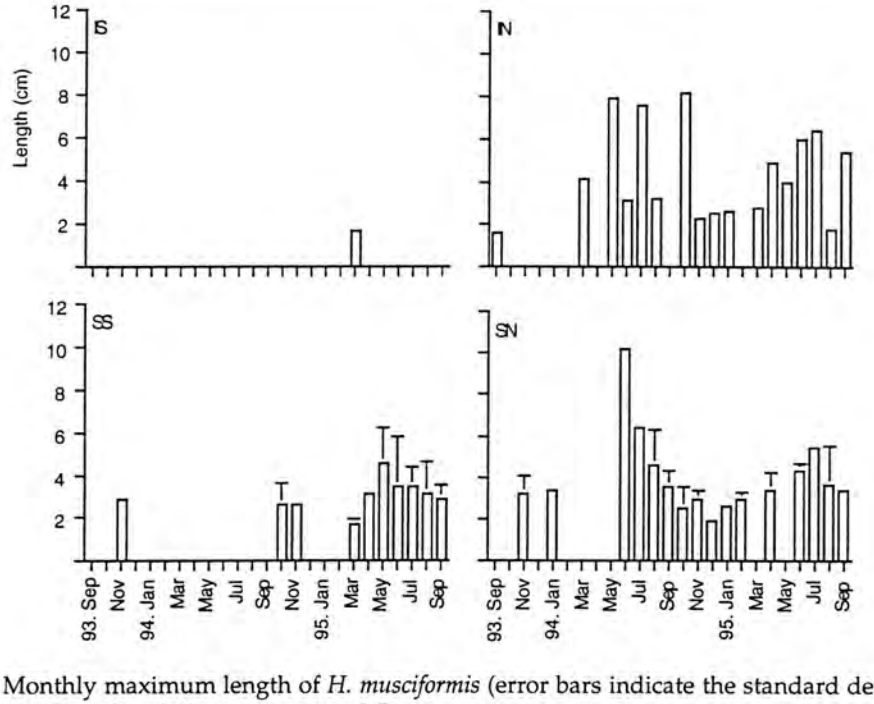


Fig. 78 Monthly maximum length of *H. musciformis* (error bars indicate the standard deviation). For abreviations see section 3.5.

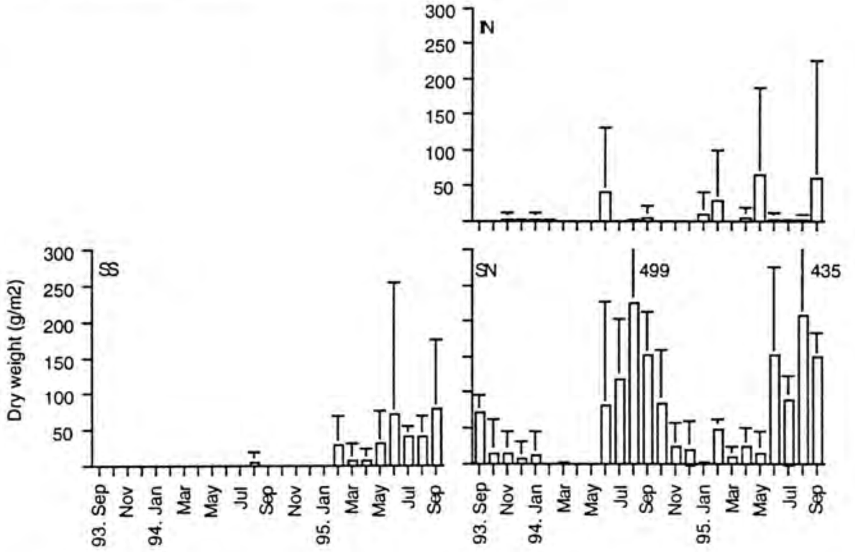


Fig. 79 Monthly biomass (mean + standard deviation) of *H. musciformis*. For abreviations see section 3.5.

Reproduction: Tetrasporic plants (Plate VIII.3) were collected in September 1993 at intertidal south and between June and December of both years at intertidal north. In the subtidal, tetrasporic plants were present between February/March and November at both localities.

Remarks: Collected throughout the year along the northeastern coasts of North America (Taylor, 1978), Brazil (Schenkman, 1989), Aegean Sea (Athanasiadis, 1987), Madeira (Levring, 1974), Canaries (Børgesen, 1929) and Ghana (Lawson, 1957), this species demonstrated a more seasonal occurrence in other localities. In Spain it was found in February and from June to December

(Seoane-Camba, 1965); in mainland Portugal it was collected between February and August (Ardré, 1970) and in Massachusetts and Florida was conspicuously seasonal in occurrence (Conover, 1958; Benz *et al.*, 1979).

Not surprisingly, the abundance of this species also displayed annual fluctuations: in Spain it was more abundant in July and August (Anadón & Fernández, 1986); in Ghana, this species was more abundant between March and September, and less abundant from November to January (Lawson, 1957); in São Paulo, Brazil, its biomass was lower when the sea temperature was maximal (26 and 29°C), the higher biomass values occurring when the temperature was lower (19 and 25°C). Growth was better in winter (July) and spring, when temperature was lower than 25°C (Schenkman, 1989).

Reproductive structures were found in summer in the northeastern coast of North America (Taylor, 1978). No male plants were found in Brazil and cystocarpic specimens were rare, only being collected four times (October, November, May and July); on the other hand, fertile tetrasporophytes occurred throughout the year (Schenkman, 1989). In Spain tetrasporangia were present in the plants collected in June and September (Seoane-Camba, 1965) and in the Aegean Sea tetrasporophytes were present between November and August (Athanasiadis, 1987). In the Canaries fertile plants were common throughout the year (Børgesen, 1929).

CAULACANTHACEAE

Additional reference: Searles (1968).

Caulacanthus ustulatus (Turner) Kützing

Additional reference: Feldmann (1938).

Distinguishing features: Thalli cartilaginous forming tangled clumps 1 to 3 cm high, prostrate branches forming erect laterals at right angle to the main axis and bearing many short spine-like ramuli in all directions. In transverse section there is a distinct main (medullary) axis and a compact cortex surrounding a much looser tissue; no filaments occur in the cortex.

Habitat: Strictly intertidal, this species was present on both sites, but more common at São Roque.

Seasonality: At São Roque, plants were present throughout the sampling period but more abundant in the first year (Fig 80). Its mean biomass varied from 18.3 to 543.9 g/m2, although the plants stayed quite small (Fig. 81). At São Vicente, similarly sized plants were only sporadically collected, as part of the algal turf, with a lower biomass (< 130 g/m2).

Reproduction: Tetrasporic plants were observed between November and June at São Roque and in November only at São Vicente.

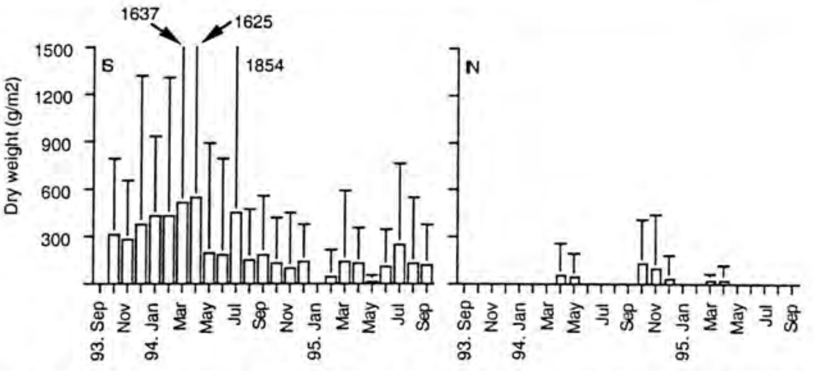


Fig. 80 Monthly biomass (mean + standard deviation) of *C. ustulatus*. For abreviations see section 3.5.

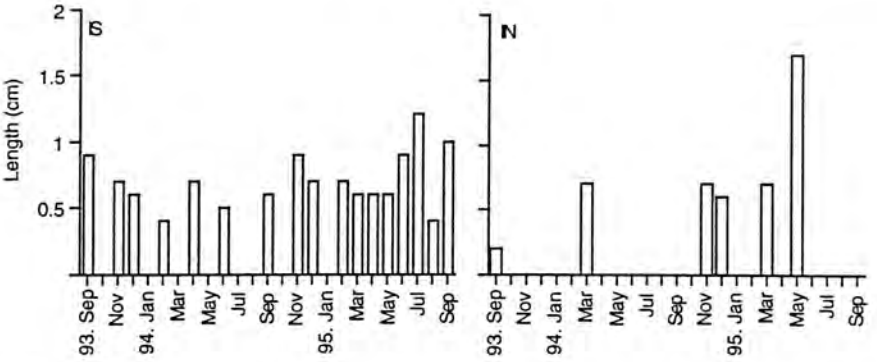


Fig. 81 Monthly maximum length of *C. ustulatus* (error bars indicate the standard deviation). For abreviations see section 3.5.

Remarks: Collected in Spain at all seasons, tetrasporangia seen most of the year (Seoane-Camba, 1965). Reported between October and June in mainland Portugal (Ardré, 1970), tetrasporangia seen from February to August. Common in the Aegean Sea where it was collected throughout the year, tetrasporophytes and plants with carposporophytes being present in the summer (Athanasiadis, 1987). In other parts of the Mediterranean, it is also a common species, growing in a dense and brownish turf form, plants never larger then 3 cm (Lebonché, 1957). Not common, but present in Madeira where it was collected at all seasons (Levring, 1974). Tetrasporangia seen in spring in the western Mediterranean (Feldmann, 1938).

RHODYMENIALES

RHODYMENIACEAE

Additional references: Sparling (1957); *Rhodymenia* (Carruthers, 1893; Guiry, 1977).

Botryocladia botryoides (Wulfen) Feldmann

Chrysymenia uvaria (L.) J. Agardh
Chondria uvaria C. Agardh

Distinguishing features: Plants dark red, growing in semi-prostrate clumps to about 3.5 cm in height. Terete stipes bearing vesicles which are ovoid to pyriform in shape, 2-8 mm in length.

Habitat: Epilithic and growing in crevices and shaded places, this species was present in the intertidal level at São Roque, although never frequent.

Seasonality: Plants (2-3 cm) were collected in March, October and November 1994 and in March 1995.

Reproduction: No data.

Remarks: Commonly found as an epiphyte in the Aegean Sea, where plants were collected throughout the year, tetrasporophytes being present in November and cystocarps in July (Athanasiadis, 1987). Collected in Spain at all seasons (Seoane-Camba, 1965).

Rhodymenia holmesii Ardiss.

Not atributed to the Azores by South and Tittley (1986) but recorded throughout the archipelago, including São Miguel (see Neto, 1994).

Distinguishing features: Plants with an extensive stoloniferous holdfast; thallus tough with both erect and prostrate fronds arising from a basal disc or stolon; blades less than 5 mm broad 10 mm from apex, flat, simple or dichotomously, palmately or irregularly divided, sometimes with proliferations. A transverse section reveals a cortex of radial filaments of 2-5 smaller cells and a compact, pseudoparenchymatous medulla, with large axially elongated cells (Plate IX.1).

Habitat: Epilithic and tolerant to sand cover, this species was present from the lower intertidal to shallow subtidal region at both sites.

Seasonality: Intertidally, this species was only occasionally collected, its mean biomass varying between 9.1 and 40.7 g/m2 at São Vicente and never reaching 32 g/m2 at São Roque (Fig. 82). São Vicente plants were also longer (3.1-9.5 cm) than those from the south (2.2-5 cm). Likewise, in the subtidal, *R. holmesii* was larger on the north coast (length varying from 6 to 9.5 cm) than at São Roque (2.5-4 cm). Biomass values were similar at both localities (21 g/m2).

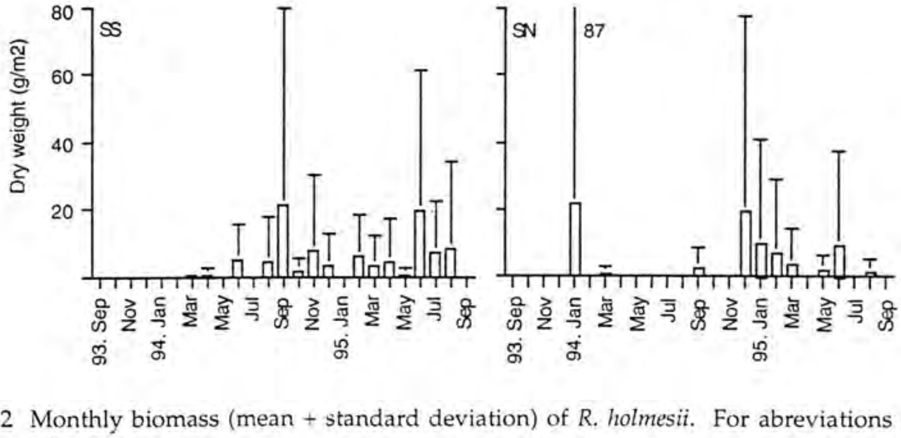


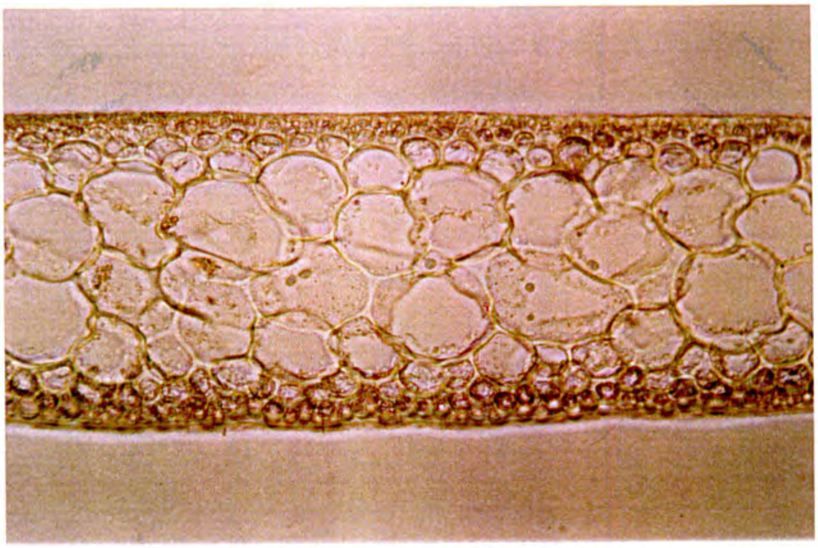
Fig. 82 Monthly biomass (mean + standard deviation) of *R. holmesii*. For abreviations see section 3.5.

Plate IX

1. *Rhodymenia holmesii*: Transverse section through sterile blade region showing pseudoparenchymatous medulla enclosed within a cortex of radial fillaments of 2 - 5 small cells (x200).

2. *Aglaothamnion gallicum*: Portion of plant showing branching and cortication of main axis (x40).

3. *Ceramium ciliatum*: Portion of plant showing multicellular spines in whorls at the nodes and a cystocarp (x100).

1


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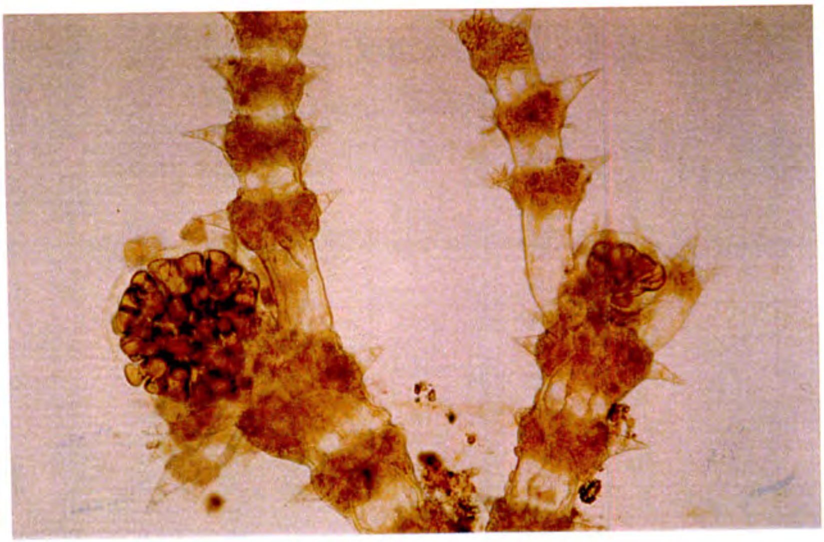


Reproduction: No reproductive plants were observed.

Remarks: Young fronds appear in February and March in the British Isles and reach full size about July; spermatangia have been recorded for November, cystocarps and tetrasporangia for April, June and September (Guiry, 1977; Irvine, 1983).

Rhodymenia pseudopalmata (J. V. Lamour.) P. C. Silva

Rhodymenia palmetta (J. V. Lamour.) Grev.
Sphaerococcus palmetus C. Agardh

Distinguishing features: Distinguished from *R. holmesii* by the absence of extensive stoloniferous growth and by having larger blades (over 5 mm broad 10 mm from apex).

Habitat: Epilithic in the lower intertidal at São Vicente.

Seasonality: One plant (2.5 cm) was collected in June 1994.

Reproduction: No reproductive structures were observed.

Remarks: Stipe and fronds perennial, young plants appearing in February/March in the British Isles, where spermatangia were recorded between June and September. Cystocarps produced from June onwards, sometimes persisting until January or even March, and tetrasporangia recorded between July to November, and January (Irvine, 1983). Collected in November in Spain (Anadón & Fernández, 1986) and between February and October in mainland Portugal (Ardré, 1970), the plants in March, April and October with tetrasporangia.

CHAMPIACEAE

Champia parvula (C. Agardh) Harv.

Distinguishing features: Plants forming small clumps, attached by small discs; branches terete, distichous and alternate or occasionally opposite; septa usually visible externally, causing slight constrictions; apices rounded.

Habitat: Epilithic in the shallow subtidal at São Roque.

Seasonality: One plant was collected in January 1994, 1.8 cm in length.

Reproduction: The plant was tetrasporangial.

Remarks: Widely distributed in tropical seas (Lawson & John, 1982), this species has been collected throughout the year in British Isles (Irvine, 1983), Spain (Seoane-Camba, 1965), mainland Portugal (Ardré, 1970) and the Aegean Sea (Athanasiadis, 1987). In other localities *C. parvula* has a more seasonal occurrence. In France it was only seen from late spring to autumn (Gayral, 1966) and it was collected only a few times in Madeira (Levring, 1974).

In the British Isles spermatangia were recorded between July and October, cystocarps from August to September and tetrasporangia from July to September (Irvine, 1983). Reproductive plants were collected from late spring to autumn in France (Gayral, 1966) and carpogonial branches and terminal spermatangial structures were present in July in the Aegean Sea (Athanasiadis, 1987). In Spain tetraspores were seen in January, March and September (Seoane-Camba, 1965), and in mainland Portugal were present between March and June, while the gametophyte was found in August (Ardré, 1970). In Madeira, specimens with tetraspores and cystocarps were observed in April, May and October (Levring, 1974). In Morocco cystocarpic plants were seen in spring (Gayral, 1958). In the northeastern coasts of North America reproductive plants were collected in summer (Taylor, 1978).

Gastroclonium ovatum (Huds.) Papenf.

New record for São Miguel. Previously reported for Faial and Graciosa (see Neto, 1994).

Distinguishing features: Erect fronds irregularly dichotomously branched bearing vesicle-like branches, usually spherical at first and becoming elongate later.

Habitat: Epilithic and strictly intertidal, this species was present at both sites.

Seasonality: It was never an abundant species, its mean biomass varying between 5.1 and 15.4 g/ m2 at São Roque, and never exceeding 5 g/m2 at Vicente. At the southern site, plants were occasionally collected during both years (Fig. 83). At São Vicente only two, somewhat smaller plants were collected, in October 1994 and January 1995.

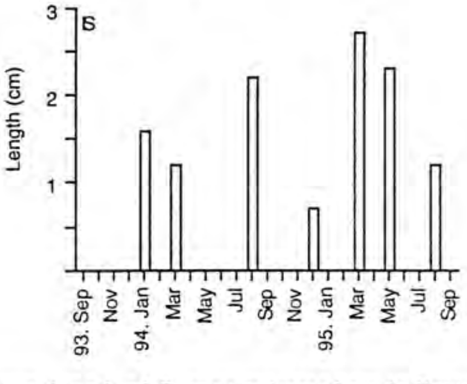


Fig. 83 Monthly maximum length of *G. ovatum* (error bars indicate the standard deviation). For abreviations see section 3.5.

Reproduction: Reproductive plants were only collected at São Roque, a female plant in January

1994, and a plant with polispores in March 1995.

Remarks: Recorded throughout the year in the British Isles (Irvine, 1983), France (Gayral, 1966) and mainland Portugal (Ardré, 1970), this species was only seen in Spain in October (Anadón & Fernández, 1986). In the British Isles spermatangia have been recorded from August to September, cystocarps between May and September, and tetrasporangia from March to December, with a peak in summer (Irvine, 1983). In France reproductive plants were collected from spring to autumn (Gayral, 1966) and in mainland Portugal, tetrasporangia were present in March, April, June and October (Ardré, 1970).

Gastroclonium reflexum (Chauv.) Kützing

New record for the Azores. Largely distributed on the eastern Atlantic, from the British Isles to South Africa, including the Canaries (Ardré, 1970; Irvine, 1983; Price *et al.*, 1988). Also recorded in the eastern Mediterranean (Irvine, 1983).

Distinguishing features: Fronds consisting of a short solid stipe bearing a tuft of terete and reflexed hollow branches, constricted by septa, giving a distinctly beaded appearance; apices acute. Thalli usually iridescent.

Habitat: Epilithic and tolerant to sand cover, this species was present from the lower intertidal to shallow subtidal levels.

Seasonality: This species was only frequent in the intertidal at São Roque, where it was collected in March and April, 1994 and from December 1994 to July 1995, its mean biomass varying between 0.01 and 92.8 g/m2. Most plants varied in length between 0.6 and 1.9 cm (Fig. 84). In the other samples, only four plants were collected: two at São Vicente from the intertidal (December 1994 and September 1995), one in the subtidal at São Roque in September 1995, and another also subtidal, from São Vicente in July 1995.

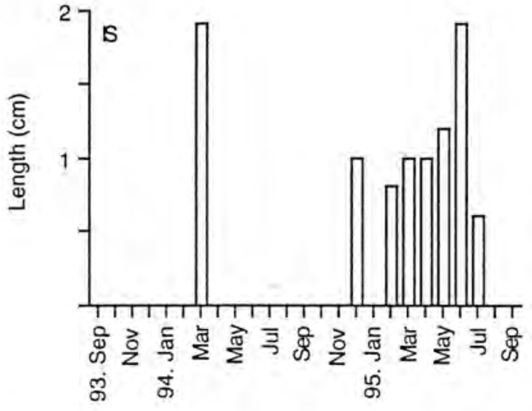


Fig. 84 Monthly maximum length of *G. reflexum*. For abreviations see section 3.5.

Reproduction: Reproductive plants, containing polysporangia, were collected in March and June at São Roque from the intertidal, in October 1995 from the intertidal at São Vicente and in July 1995 from the subtidal there.

Remarks: Plants have been recorded between April and December in the British Isles but reproduction seems to be confined to the summer months, with spermatangia recorded for August, cystocarps from August to September and polysporangia from June to September (Irvine, 1983). Collected from February to April and in October in mainland Portugal (Ardré, 1970).

Lomentaria articulata (Huds.) Lyngbye

Chylocladia articulata Grev.

Distinguishing features: Plant dichotomously branched below and pinnately divided above; fronds terete, conspicuously constricted into hollow segments; lateral branches terete, in whorls at the constrictions; segments cylindrical below, becoming elliptical above.

Habitat: Epilithic in shaded places, this species was present at the intertidal level on both coasts.

Seasonality: It was much more frequent at São Roque, where its mean biomass never exceeded 125 g/m2 and the length of the sampled plants varied from 1.1 to 4.8 cm (Fig. 85). At São Vicente only two plants were collected, in January and May 1995.

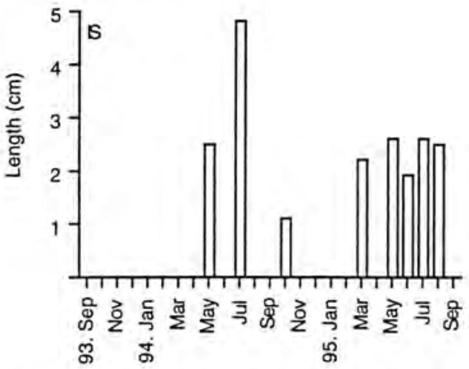


Fig. 85 Monthly maximum length of *L. articulata*. For abreviations see section 3.5.

Reproduction: Tetrasporic plants were present from March to May 1995 at São Roque and one cystocarpic plant was observed in May 1995 at São Vicente.

Remarks: Present all year in the British Isles (Irvine, 1983), France (Gayral, 1966), mainland Portugal (Ardré, 1970) and Morocco (Gayral, 1958). Spermatangia were reported for August, cystocarps for January, April and October, and tetrasporangia throughout the year, with a peak in summer in the British Isles (Irvine, 1983). Fertile plants were observed in summer in France (Gayral, 1966). In Spain and mainland Portugal, tetrasporangia occurred from autumn through spring (Seoane-

Camba, 1965; Ardré, 1970) but cystocarps were only found in February and April in mainland Portugal (Ardré, 1970). In Morocco, tetraspores were seen throughout the year and cystocarps were present in February and June (Gayral, 1958). In the Canaries, tetrasporangia only seen in February by Børgesen (1929).

CERAMIALES

Additional references: Feldmann-Mazoyer (1940); Maggs and Hommersand (1993).

CERAMIACEAE

Additional references: Hommersand (1963); Gordon (1971); Edelstein *et al.* (1974); Parsons (1980); *Aglaothamnion* (L'Hardy-Halos & Rueness, 1990); *Anthithamnion* (L'Hardy-Halos, 1969); *Callithamnion* (Dixon & Price, 1981); *Centroceras* (Hommersand, 1963); *Ceramium* (Dixon, 1960; Edwards, 1973); *Pterothamnion* (Athanasiadis, 1985); *Scagelia* (Athanasiadis & Rueness, 1992).

The genus *Aglaothamnion*, proposed by Feldmann-Mazoyer (1940) to accommodate certain species of *Callithamnion*, has not been fully accepted. However, Maggs and Hommersand (1993), in their British flora, have reinstated this genus on the basis that its species are characterized by having uninucleate vegetative cells, whereas in *Callithamnion sensu stricto* the cells are multinucleate. This distinction can quite easily be seen by using nuclear stains such as aniline blue - see Chapter 3.

Aglaothamnion bipinnatum (P. Crouan & H. Crouan) Feldmann and Mazoyer

New record for São Miguel. Recently recorded in Flores (Tittley *et al.*, in press).

Distinguishing features: Branching alternate and distichous, in one plane; basal cell of lateral branch lacks branchlet. Tetrasporangia sessile, the walls 2 µm thick.

Habitat: Strictly subtidal, this species was present at both sites.

Seasonality: Only present in the first year, it was collected between November to July at São Roque, where the biomass varied between 0.8 and 31.8 g/m2. At São Vicente only two plants were collected, in July and November 1994.

Reproduction: Tetrasporic plants were only observed at São Roque, in December 1993 and July 1994.

Remarks: In Norway, this species was collected between February and December, fertile plants between July and December; the gametophytes were always monoecious, but in most plants spermatangia were produced first, the carpogonia being fertilized by spermatia from the same individual (Rueness & Rueness, 1980). In the British Isles mature thalli have been collected in April and November, the majority of them bearing a mixture of reproductive structures. Some plants were predominantly gametangial and also bore parasporangium-like structures, others were tetrasporophytes bearing spermatangia, occasional unfertilized carpogonia, and parasporangia (Maggs & Hommersand, 1993). Spermatangia, procarps and cystocarps were present in April, May, July, and from September to November; tetrasporangia in April and July and from September to November; and parasporangium-like structures in April, May, July and from September to November (Maggs & Hommersand, 1993).

The Azores represent the known southern limit of distribution for this species.

Aglaothamnion byssoides (Arnott ex Harvey in Hook.) Hardy-Halos et Rueness
Callithamnion byssoides Arnott ex Harvey in Hook.

New record for São Miguel. Previously recorded for Faial (Tittley & Neto, 1994). Recently recorded in Flores (Tittley *et al., in press*).

Distinguishing features: Branching spiral; main axis corticated only at the base.

Habitat: Plants of this species were found in the intertidal and subtidal at both sites, although more commonly at São Roque.

Seasonality: It was never an abundant species, its mean biomass never reaching 2 g/m2. In the intertidal, two plants were collected at São Roque, in February and July 1994, and four at São Vicente, in February 1994, April, May and August 1995. Subtidally, *A. byssoides* was collected at São Roque between October to March in the first sampling year; at São Vicente, it was only present in February and September 1995.

Reproduction: Both generations were present. Intertidal plants from São Roque were cystocarpic, while the ones collected from the subtidal in October and December bore tetrahedral tetrasporangia. Tetrasporangia were also observed in the subtidal plant collected in February 1995 at São Vicente. Bisporangia were not found.

Remarks: In Norway, *A. byssoides* is common in the sublittoral zone from 2 to 20m depth and is best developed and fertile in summer and autumn (Rueness & Rueness, 1980). Thalli are found throughout the year at British Isles, but less abundant in January and March (Rueness & Rueness, 1980). Spermatangia recorded for April and December, procarps and cystocarps in May and December, tetrasporangia in February and December, and bisporangia in May and September (Maggs & Hommersand, 1993). The presence of tetrasporangia on gametangial plants (Feldmann-Mazoyer, 1940; Rueness & Rueness, 1980) or bisporangia amongst gametangia (Rosevinge, 1924) has not been detected in British field material (Dixon & Price, 1981). This species was only collected in May in Madeira (Levring, 1974), and in March in the Canaries (Børgesen, 1930), these plants having tetrasporangia and antheridia, although on separate plants. On the other side of the Atlantic, reproductive plants were collected in the summer on northeastern coasts of North America (Taylor,

1978).

Aglaothamnion gallicum (Nägeli) Halos ex Ardré

New record for the Azores. Recorded on the eastern Atlantic from the British Isles to Morocco, in the Canaries and Mediterranean (Ardré, 1970; Price *et al.*, 1986; Maggs & Hommersand, 1993).

Distinguishing features: Distinguished from *A. bipinnatum* by the abaxial branchlet of the basal cell of each lateral branch and also because its main axis is often densely corticated (Plate IX.2).

Habitat: Only infrequently found, this species was present in the intertidal level on both sites and in the subtidal at São Roque.

Seasonality: In the intertidal at São Roque, two plants were collected, in October 1994 and April 1995. At São Vicente, three plants were found, two in April and one in May 1995. Only two subtidal plants were collected, both in March 1994.

Reproduction: Tetrasporic plants were seen in April 1995 at both sites and also in May of the same year. A female plant was observed in April 1995.

Remarks: Populations were most conspicuous in late summer and autumn in the British Isles, where spermatangia were recorded for September and October, and cystocarps and tetrasporangia in May, September and October (Maggs & Hommersand, 1993). When collected in mainland Portugal in March, the plants were tetrasporangial (Ardré, 1970).

Distributional records of *A. gallicum* are difficult to assess since it has usually been considered conspecific with *A. hookeri* (q.v.).

Aglaothamnion hookeri (Dillwyn) Maggs et Hardy-Halos
Callithamnion hookeri (Dillwyn) Gray

Distinguishing features: Distinguished from *A. byssoides* by having a strongly corticated main axis and by the abaxial branchlet of the lateral branches of the basal cells; first order laterals unbranched at their base, unlike *A. gallicum*; main axis up to 500µm in diameter.

Habitat: This species was only collected at São Vicente, where it was both epilithic and epiphytic in the intertidal and subtidal levels.

Seasonality: In the intertidal, three plants were collected, one in November 1994 and two in April and May 1995. One subtidal plant was collected in September 1993.

Reproduction: Both generations were found in the intertidal material. A cystocarpic plant was seen in October 1994, and a male gametophyte and a tetrasporic plant were observed in April 1995. The subtidal plant collected was also fertile, bearing mature cystocarps.

Remarks: Vegetative and tetrasporophytic thalli have been found throughout the year in the British Isles, spermatangia recorded between January and July and from September to November, and cystocarps recorded in January, February and from April to November (Maggs & Hommersand, 1993). In mainland Portugal this species was collected between February and October, tetrasporangia found from March to July and in October, and cystocarps and spermatangia frequent in June and July (Ardré, 1970). This record requires confirmation, as indeed does further material collected from São Vicente in July 1996. Rueness and Rueness (1982) give the European distribution of verified *A. hookeri* as Norway to North of France.

Aglaothamnion pseudobyssoides (P. Crouan & H. Crouan) Halos

New record for the Azores. Recorded on the eastern Atlantic from the British Isles to mainland Portugal (Ardré, 1970; Maggs & Hommersand, 1993).

Distinguishing features: The plants are delicate and flaccid, and can be distinguished from *A. hookeri* by having a narrower main axis (to 75µm in diameter).

This species has been regarded as synonymous with *A. byssoides* but a sterility barrier exists. Azorean material can be differentiated by *A. byssoides* having broader main axis (up to 150 µm wide) than those of *A. pseudobyssoides*.

Habitat: Although present both intertidally and subtidally, this was a rare species.

Seasonality: Only four plants were collected between March and September 1995, one in the intertidal at São Roque and the others from the subtidal at both sites.

Reproduction: Only the subtidal plant collected in May was reproductive, bearing tetraspores.

Remarks: Observed in the British Isles, where it is strictly subtidal, from June to August, with spermatangia present in July and August, procarps and cystocarps in June and August, and tetrasporangia in July and August (Maggs & Hommersand, 1993). Collected in mainland Portugal between February and June (Ardré, 1970).

The Azores represent the known southern limit of distribution for this species.

Anotrichium barbatum (C. Agardh) Nägeli

New record for the Azores. Largely distributed on the eastern and western Atlantic, and in the Mediterranean (Feldmann-Mazoyer, 1940; Wynne, 1985; Price *et al.*, 1986; Athanasiadis, 1987;

Maggs & Hommersand, 1993).

Distinguishing features: Distinguished from *Bornetia secundiflora* by having axial cells less than 200µm in diameter and, as a consequence, the thalli being less rigid. The filaments comprise pyriform cells, which are swollen distally, and have an apical cell, 50µm in diameter.

Habitat: Occurring in the subtidal level at both sites.

Seasonality: This species was rare, being collected only twice at São Roque (in January and March 1994) and once at São Vicente (in October 1994).

Reproduction: No reproductive structures were seen.

Remarks: Plants have been collected only from May to October in the British Isles, spermatangia being present in August (Buffham, 1891), cystocarps in May and October, and tetrasporangia in June and October (Maggs & Hommersand, 1993). A few plants were collected in the Aegean Sea throughout the year (Athanasiadis, 1987).

Anotrichium furcellatum (J. Agardh) Balldock

New record for the Azores. Largely distributed on the eastern Atlantic, from the British Isles to Africa, including the Canaries. Also recorded in the Mediterranean (Stegenga & Mol, 1983; Price *et al.*, 1986; Maggs & Hommersand, 1993).

Distinguishing features: Distinguished from *A. barbatum* by having cylindrical cells and an apical cell less than 25µm in diameter.

Habitat: Rather more frequent than *A. barbatum*, this species was present at both places.

Seasonality: In the intertidal level, three plants were collected, all at São Vicente (in March, April and May 1995). In the subtidal, seven plants were collected, one in the south site in September 1995, and the others on the north, in September 1993 and 1995, and between January and May of the second year.

Reproduction: Reproductive structures were only observed in the subtidal collections of São Vicente, the plant collected in September 1993 presenting tetraspores, while the one from May 1994 had spermatangia.

Remarks: Plants have been found in September and October in the British Isles, mature tetrasporangia being seen in plants collected in October (Maggs & Hommersand, 1993). Female gametophytes have been observed in Brittany (L'Hardy-Halos, 1968) but males and cystocarps are apparently unknown in Europe where populations reproduce vigorously by secondary attachment and fragmentation (Feldmann-Mazoyer & Meslin, 1939). Tetrasporangia were reported to be rare in France (Feldmann-Mazoyer & Meslin, 1939) and the Netherlands (Stegenga & Mol, 1983).

Antithamnion diminuatum Wolllaston

New record for São Miguel. Previously reported for Faial by Athanasiadis and Tittley (1994).

Distinguishing features: Monosiphonous filaments with whorl-branches alternately and distichously ramified distally; branches up to 600 µm long and provided with up to two pairs of opposite branchlets proximally; gland cells borne on reduced 3-4 celled branchlets.

Habitat: Epiphytic in the lower littoral *Corallina* turf at São Vicente.

Seasonality: One plant was collected in November 1994.

Reproduction: No reproductive structures were seen.

Remarks: This species was found the first time in the Azores at Faial in July 1989 in the same habitat (Tittley & Neto, 1994). It was originally described from southern Australia and subsequently recorded from South Africa, and is thought to be a recent introduction to the Azorean algal flora (Athanasiadis & Tittley, 1994; Tittley & Neto, 1994).

Bornetia secundiflora (J. Agardh) Thur.

New record for São Miguel. Previously reported for Flores by Neto and Baldwin (1990).

Distinguishing features: Thalli monosiphonous, consisting of tufts of rather stiff filaments of cylindrical cells, each with a blunt rounded apex; cells along the axis more or less equal in width; mature axial cells more than 400µm in diameter; reproductive structures rarely present elsewhere.

Habitat: Present at both sites from the lower littoral down to the shallow sublittoral (15m depth).

Seasonality: This species was collected from the intertidal at São Vicente in September 1993 and April 1995 and from the subtidal in November 1994, April and June 1995 at São Roque and in December 1994, February, April and May 1995 at São Vicente. Only small quantities were ever collected (biomass ≤ 3 g/m2).

Reproduction: Only sterile plants were observed, as reported by Dixon (1965) for populations in southern England, where vegetative reproduction is assumed to occur.

Remarks: An annual species in the British Isles (Maggs & Hommersand, 1993), where large plants were found in June and October (Dixon, 1965). In France this species began its development in summer, following into winter (Gayral, 1966). In the Mediterranean reproductive plants, bearing gametangia, cystocarps and tetrasporangia, were collected between September and December (Feldmann-Mazoyer, 1940). In Spain only one tetrasporic plant was collected in April (Seoane-Camba, 1965) but in mainland Portugal plants of this species were collected between March and October, tetrasporangia and mature cystocarps being present on plants collected in March (Ardré, 1970). Collected from December through the summer in Morocco but reproductive structures were only seen in winter and early spring (Gayral, 1958).

Callithamnion corymbosum (Sm.) Lyngbye

Distinguishing features: Thalli delicate, alternately branched, main axis less then 200µm in diameter and forming pink, corymbose tufts.

Habitat: Epilithic and epiphytic in lower littoral pools at São Vicente and in the shallow sublittoral at São Roque.

Seasonality: Plants were collected in September 1993, April 1994 and February 1995 at São Roque and in April and May 1995 at São Vicente.

Reproduction: Both intertidal plants were female gametophytes.

Remarks: Collected throughout the year in the British Isles (Dixon & Price, 1981), Mediterranean (Feldmann-Mazoyer, 1940; Athanasiadis, 1987), and the northeastern coasts of North America (Taylor, 1978), this species was only found between February and October in mainland Portugal (Ardré, 1970).

In the British Isles tetrasporangia and cystocarps occasionally occur on the same thallus (Dixon & Price, 1981). Spermatangia have been recorded in May, July and September, procarps and cystocarps from February to May and in September, and tetrasporangia between February and December (Dixon & Price, 1981; Maggs & Hommersand, 1993). In the Aegean Sea tetrasporophytes and dioecious gametophytes were present in the summer (Athanasiadis, 1987) and in mainland Portugal fertile gametophyte were present in February, April, June and October, while the tetrasporangia were only seen in June (Ardré, 1970). Both generations (spermatangia, cystocarps and tetraspores) were present in March and April in the Canaries (Børgesen, 1930). On the other side of the Atlantic, reproductive plants were seen in summer on the northeastern coasts of North America (Taylor, 1978).

Callithamnion granulatum (Ducluz.) C. Agardh

Callithamnion spongiosum Harv. in Hook.

New record for São Miguel. Previously recorded in Terceira and Santa Maria (see Neto,

1994).

Distinguishing features: Thalli robust, main axis highly corticated and 200-300µm in diameter, spiral branching, the ultimate branchlets 1-4 cells long; zig-zag cells in the main axis; conical apical cell only slightly smaller than its sub-apical cell.

Habitat: This species was only found in the intertidal level, but was present at both sites.

Seasonality: At São Roque, plants were collected from February to July in both years, biomass never exceeding 14 g/m2. At São Vicente, plants were collected from December to May in the first year, and in November, January and May in the second year but biomass was much lower (1-5 g/m2).

Reproduction: Tetrasporic plants were found in February, May and June in the south and in December and January in the north. The gametophyte generation, represented by monoecious plants, was present in March, June and July at São Roque and between February and May at São Vicente.

Remarks: Perennial plant in the British Isles (Price, 1978), gametangial thalli dioecious or less often monoecious. Spermatangia have been recorded for June and from August to October, procarps and cystocarps in May, and between August and September. Tetrasporangia were seen in February, between April and June and from August to October (Maggs & Hommersand, 1993). An annual species in France, fruiting in the summer (Gayral, 1966), and in mainland Portugal, where it was only collected between March and October, fertile gametophytes with spermatangia being present in March and tetrasporangia from April to July (Ardré, 1970). In Morocco plants were collected between January and June (Gayral, 1958).

Callithamnion tetragonum (With.) Gray

Callithamnion tetragonum (With.) Gray var. *divaricata* Rosenv.

Additional reference: Rueness and Rueness (1985).

Distinguishing features: Distinguished from *C. granulatum* by having alternate branching, the ultimate branchlets being more than 6 cells long and by having a minute apical cell cutting off a distinctly larger sub-apical cell.

Habitat: Epiphytic on other algae in the intertidal of both sites.

Seasonality: Only three plants were collected, two at São Roque (February 1994 and June 1995) and one in São Vicente (February 1994).

Reproduction: The plant collected in February 1994 in São Roque was tetrasporic.

Remarks: Found throughout the year in the British Isles (Dixon & Price, 1981) and in the northeastern coasts of North America (Taylor, 1978), this species was collected between February and October in mainland Portugal (Ardré, 1970) and in June in Madeira (Levring, 1974).

In the British Isles spermatangia were recorded for April and between June and September, procarps and cystocarps in April and October, and tetrasporangia in April and December (Dixon & Price, 1981). Plants with mixed cystocarps and tetrasporangia, originally noted by Buffham (1884), are more common in the British Isles than those with only gametangia or tetrasporangia (Maggs & Hommersand, 1993). In Spain tetrasporic plants were collected in February and March, and cystocarps were observed in plants from March (Seoane-Camba, 1965). In mainland Portugal tetrasporangia and cystocarps were seen in February, March and June, and spermatangia in February (Ardré, 1970).

Centroceras clavulatum (C. Agardh) Mont.

Ceramium clavulatum C. Agardh

Additional reference: Hommersand (1963).

Distinguishing features: Plants forming dense tufts or mats of entangled filaments; branching dichotomous; 1-2 celled spines arising at the nodes, increasingly abundant towards the branch apices.

Habitat: Occurring as loose mats or as a component of the algal turf, *Centroceras* was present in all sampled levels. Price and Scott (1992) also found this species to be a component in the algal turf of the Great Barrier Reef (Australia).

Seasonality: Plants were only frequent at the intertidal north, being collected throughout the year, the mean biomass varying from 10 to 150 g/m2 (Fig. 86). At the other levels plants were only sporadically collected, their mean biomass rarely exceeding 100 g/m2.

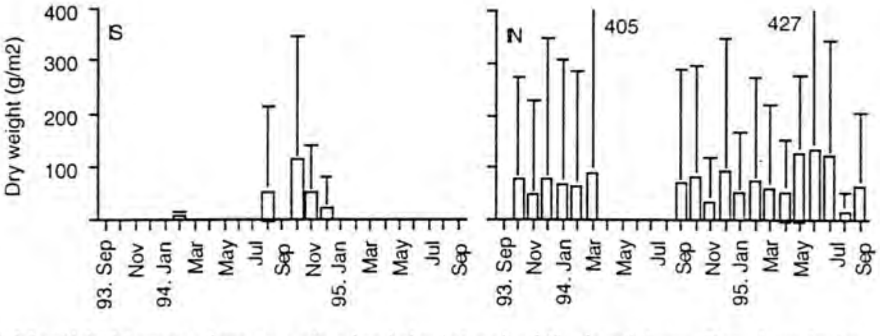


Fig. 86 Monthly biomass (mean + standard deviation) of *C. clavulatum*. For abreviations see section 3.5.

Reproduction: No reproductive plants were ever found.

Remarks: In the Mediterranean this species was present throughout the year, although reproductive structures were never found, its propagation being strictly vegetative (Feldmann-Mazoyer, 1940). In mainland Portugal it was collected in October and February (Ardré, 1970). Common in Madeira where it was collected throughout the year (Levring, 1974), some tetrasporic plants have been found in summer collections (pers. obs.). Collected at all seasons in Spain (Seoane-Camba, 1965) and from November to March in Morocco (Gayral, 1958), but never found fertile in those localities.

Ceramium botryocarpum Griffiths ex Harv.

New record for the Azores. Recorded in the northeast Atlantic from the British Isles to North of Spain (Maggs & Hommersand, 1993).

Distinguishing features: Plants growing in tufts with an extensive prostrate system of axes (cf. *C. nodulosum*, q.v.); main axis of mature thalli entirely corticated; axis branching at intervals of 6 segments; branching irregular; no spines; periaxial cells typically 6.

Habitat: Strictly intertidal, this species was present at both sites.

Seasonality: Plants were collected in December 1993, January 1994, from April to July 1994 and in March and April 1995 at São Roque and from January to April 1994 at São Vicente. Standing crop values were low ($\leq$15 g/m2).

Reproduction: Tetrasporic plants were seen at São Roque between February and June.

Remarks: Large thalli have been observed between March and September in the British Isles, spermatangia, cystocarps and tetrasporangia being seen throughout this period (Maggs & Hommersand, 1993).

The Azores represent the known southern limit of distribution for this species.

Ceramium ciliatum (Ellis) Ducluz.

Distinguishing features: Main axis with multicellular spines occurring in conspicuous whorls at the nodes (Plate IX.3).

Habitat: Present only in lower littoral pools of both sites.

Seasonality: Although collected in both years, this species was much more abundant in the first year, when its mean biomass peaked at 250 g/m2. In the second year, the biomass was much lower (Fig. 87).

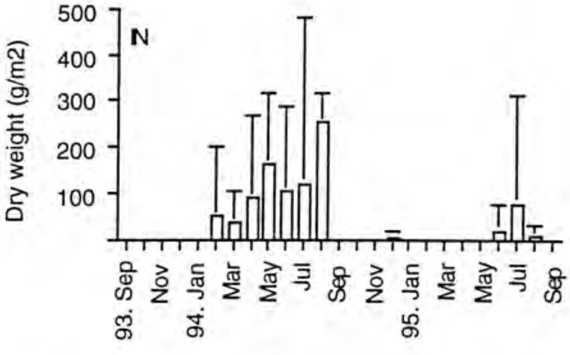


Fig. 87 Monthly biomass (mean + standard deviation) of *C. ciliatum*. For abreviations see section 3.5.

Reproduction: A tetrasporic plant was collected in April 1994. Male plants were seen in May of both years and in November 1994. Only one female gametophyte was observed in November 1994.

Remarks: This species, only noted from February to November in the British Isles (Maggs & Hommersand, 1993), has been collected in Spain, mainland Portugal and Madeira throughout the year (Seoane-Camba, 1965; Ardré, 1970; Levring, 1974). Sporadically collected in the Aegean Sea (Athanasiadis, 1987), it was seen in spring and summer in France (Gayral, 1966) and in winter and spring in Morocco (Gayral, 1958).

In the British Isles spermatangia have never been recorded, cystocarps were observed in May and June and tetrasporangia in March, from May to July and from September to November (Maggs & Hommersand, 1993). In Spain tetrasporangia were seen in February, April, July and August (Seoane-Camba, 1965) and in mainland Portugal in February, April, June and October (Ardré, 1970). In Madeira fertile plants were seen from April through the summer (Levring, 1974), while in Morocco sporangia and cystocarps were only seen in spring (Gayral, 1958). In the Canaries tetrasporic plants were collected in January and March (Børgesen, 1930).

Ceramium cimbricum H. Peteren in Rosenvinge

Ceramium fastigiatum Harv.

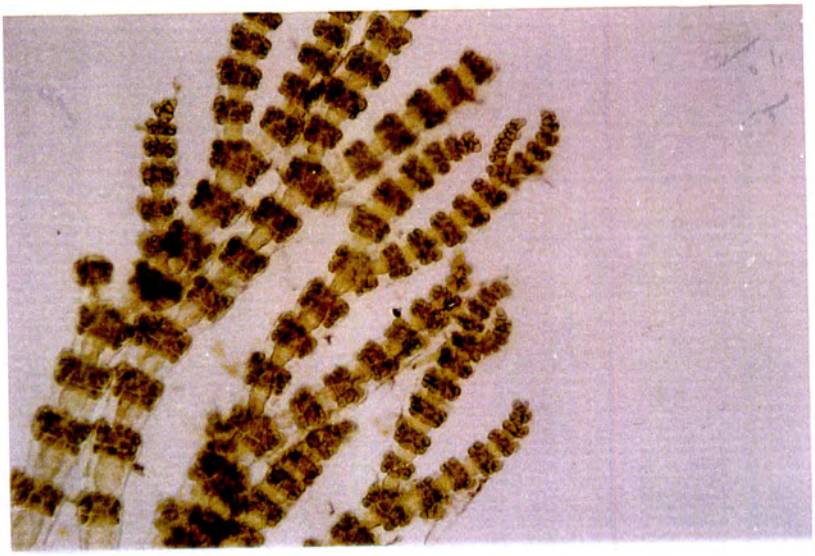
New record for São Miguel. Previously recorded in Flores (Neto, 1994; Tittley *et al.*, in press).

Distinguishing features: Main axis of mature thalli incompletely corticated; no spines; multicellular rhizoids; apices pseudodichotomously branched, straight or slightly incurved (Plate X.1); periaxial cells 4 to 6; tetrasporangia immersed.

Habitat: Strictly intertidal, this species was present at both sites.

Plate X

1. *Ceramium cimbricum*: Portion of plant showing branching and apices straight or slightly incurved (x40).
2. *Ceramium pallidum*: Terminal region of branches showing incurved apices and a cystocarp (x40).
3. *Ceramium strictum*: Portion of branch showing tetrasporangia in rings around the nodes (x200).



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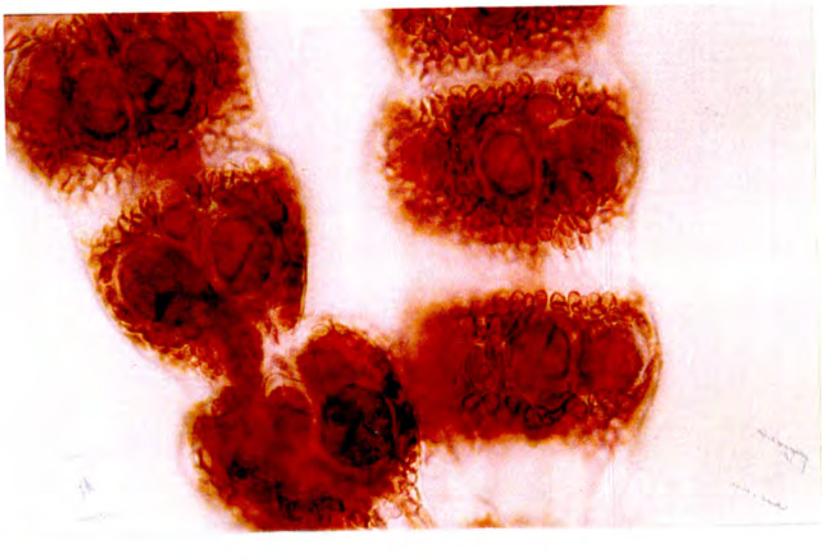


3

Seasonality: It was collected in February, June and July 1994 at São Roque and in October 1994 and in April, June and September 1995 at São Vicente.

Reproduction: Tetrasporic plants were found in October 1994 and April 1995, and a female plant was present in April 1995, all at São Vicente.

Remarks: In the British Isles creeping thalli occur throughout the year, forming larger erect axes in May and September. Spermatangia and tetrasporangia have been recorded between May and September, and cystocarps from June to September (Maggs & Hommersand, 1993). Reproductive plants were collected on northeastern coasts of North America in the late summer (Taylor, 1978).

Ceramium circinatum (Kützing) J. Agardh

New record for the Azores. Largely distributed on the western Atlantic, also recorded on the northeast Atlantic, from Scandinavia to North of Spain and in the Mediterranean (Feldmann-Mazoyer, 1940; Taylor, 1978; Price *et al.*, 1986; Athanasiadis, 1987). Recently reported for the British Isles by Maggs and Hommersand (1993).

Distinguishing features: Distinguished from C. *cimbricum* by having typically 10 periaxial cells.

Habitat: Epiphytic in the intertidal algal turf at São Roque. Also recently found at São Vicente (July 1996).

Seasonality: Two plants were collected in March 1994 and April 1995.

Reproduction: No reproductive structures were seen.

Remarks: Reproductive plants were collected in the summer in the northeastern coasts of North America (Taylor, 1978), while in the Aegean Sea infertile plants were collected throughout the year (Athanasiadis, 1987).

Ceramium deslongchampii Chauv. ex Duby

Ceramium strictum (Kützing) Harv.

New record for São Miguel. Previously reported for Terceira (see Neto, 1994).

Additional reference: Rueness (1973).

Distinguishing features: Distinguished from C. *cimbricum* by the tetrasporangia being uncovered by the cortex.

Habitat: Present in the intertidal level at both sites.

Seasonality: This species was more frequent at the southern site, where plants were occasionally collected. Its mean biomass ranged between 1.6 and 135.1 g/m2 (Fig. 88). In the north only two plants were collected, (March and May 1994).

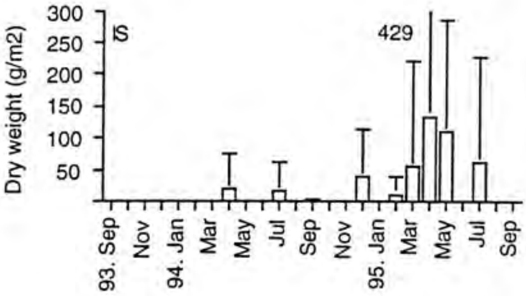


Fig. 88 Monthly biomass (mean + standard deviation) of *C. deslongchampii*. For abreviations see section 3.5.

Reproduction: Only one tetrasporic plant was collected in May 1994 at São Vicente.

Remarks: This species has been collected throughout the year in the British Isles (Maggs & Hommersand, 1993) and on the northeastern coasts of North America (Taylor, 1978). Spermatangia were found in March and from May to July, cystocarps in March and May and tetrasporangia between March and August in the British Isles (Maggs & Hommersand, 1993). In North America reproductive plants were collected in the summer (Taylor, 1978).

Ceramium diaphanum (Lightf.) Roth

New record for São Miguel. Previously recorded for Faial, Pico, Graciosa and Terceira (see Neto, 1994).

Additional reference: Rueness and Boo (1994).

Distinguishing features: Distinguished from *C. cimbricum* by having strongly enrolled apices and by the protruding cortical bands.

Habitat: Present in the intertidal level on both sites.

Seasonality: It was a rare species, only collected in March 1994 at São Roque and in September 1993 and 1995 at São Vicente.

Reproduction: No reproductive structures were observed.

Remarks: Present throughout the year in France (Gayral, 1966), Aegean Sea (Athanasiadis, 1987) and Morocco (Gayral, 1958), this species was collected in June and December in Spain (Anadón & Fernández, 1986), between February and October in mainland Portugal (Ardré, 1970) and in spring and summer on the northeastern coasts of North America (Taylor, 1978). Reproductive plants were seen in March in the Canaries (Børgesen, 1930), in summer in France (Gayral, 1966), Aegean Sea (Athanasiadis, 1987), Morocco (Gayral, 1958) and northeastern coasts of North America (Taylor, 1978). In the Mediterranean gametophyte plants were collected most of the year (Feldmann-Mazoyer, 1940). In mainland Portugal tetrasporangia were present in March, June and October, cystocarps and spermatangia in March and October (Ardré, 1970).

Ceramium echionotum J. Agardh

Distinguishing features: Axis with single-celled spines present on cortical bands near the apices.

Habitat: Present in the intertidal at São Vicente and in the subtidal at both sites.

Seasonality: Never abundant, its mean biomass did not exceed 1 g/m2. This species was found in the intertidal in July 1994 and in the subtidal levels in July and December 1994 and February and June 1995 at São Roque and in June and October 1994 at São Vicente.

Reproduction: Only the plant collected in February in the south was fertile, bearing tetraspores.

Remarks: Present at all seasons in the British Isles (Maggs & Hommersand, 1993), Spain (Anadón & Fernández, 1986) and mainland Portugal (Ardré, 1970), this species was only collected a few times in Madeira (Levring, 1974) and between February and November in Morocco (Gayral, 1958). In the British Isles spermatangia were recorded in February and August, cystocarps in July and October, and tetrasporangia in June and October (Maggs & Hommersand, 1993). Tetrasporangia were seen in Spain from September to December (Seoane-Camba, 1965), in mainland Portugal in February, April, June, July and October (Ardré, 1970) and in March at Tenerife, Canaries (Børgesen, 1930). In Madeira, fertile specimens were found from March through the summer (Levring, 1974). In Morocco, tetrasporophytes were seen in spring, and cystocarps in February and in November (Gayral, 1958).

Ceramium flaccidum (Kützing) Ardissone

New record for the Azores. Largely distributed on the Atlantic, also recorded in the Mediterranean (Seoane-Camba, 1965; Wynne, 1985; Price *et al.*, 1986; Athanasiadis, 1987; Maggs & Hommersand, 1993).

Distinguishing features: Main axis of mature thalli incompletely corticated; no spines; unicellular rhizoids; apices obviously alternately branched every 5-6 segments.

Habitat: Epilithic in the lower intertidal at São Roque.

Seasonality: Infrequent, this species was only collected in July 1994 and in March, June and July 1995.

Reproduction: No reproductive structures were seen.

Remarks: Collected throughout the year in the British Isles (Maggs & Hommersand, 1993), Spain (Seoane-Camba, 1965) and Aegean Sea (Athanasiadis, 1987). In the British Isles larger plants were collected in June and November, spermatangia and cystocarps being recorded in September (Harvey, 1948; Buffham, 1888) and tetrasporangia from July to September (Maggs & Hommersand, 1993). In Spain sporangia were seen in October (Seoane-Camba, 1965).

Ceramium nodulosum (Lightf.) Ducluz.
Ceramium rubrum (Huds.) C. Agardh
Ceramium arborescens J. Agardh

Distinguishing features: Distinguished from *C. botryocarpum* (q.v.) by its individual growth (never forming tufts) and by having inconspicuous adventitious branching.

Habitat: Epilithic in the lower intertidal of both coasts.

Seasonality: Collected in January 1994 at São Roque, and in April 1995 at São Vicente.

Reproduction: Both plants were sterile.

Remarks: Present throughout the year in the British Isles (Maggs & Hommersand, 1993), Spain (Seoane-Camba, 1965), mainland Portugal (Ardré, 1970) and on the northeastern coasts of North America (Taylor, 1978). Spermatangia recorded in the British Isles in January, March and April, June, August and September (Maggs & Hommersand, 1993). Tetrasporangia present between December and August, and cystocarps between December and October in Spain (Seoane-Camba, 1965). In mainland Portugal tetrasporangia were seen from February to July and in October and cystocarps from February to June (Ardré, 1970), while on the northeastern coasts of North America reproductive plants were only found in the summer (Taylor, 1978).

Ceramium pallidum (Nägeli ex Kützing) Maggs & Hommersand

New record for the Azores. Common in the British Isles (Maggs & Hommersand, 1993).

Distinguishing features: Main axis of mature thalli entirely corticated; no spines; axis with regular branching every 4-8 segments; 6-7 periaxial cells.

Habitat: This species was present in the intertidal level at both sites.

Seasonality: At São Roque, it was collected in both sampling years, between March and December, its mean biomass varying between 6.6 and 256 g/m2 (Fig. 89). At São Vicente it was less common, only being present between March and June, again in both years.

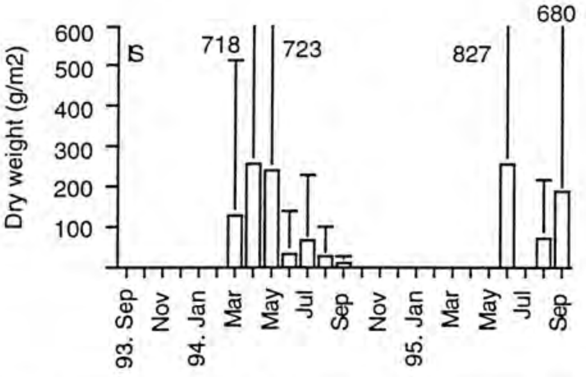


Fig. 89 Monthly biomass (mean + standard deviation) of C. *pallidum*. For abreviations see section 3.5.

Reproduction: Both generations were found, with female plants (Plate X.2) present in July 1994 in the south and in April in the north site, and tetrasporic plants present from March to October at São Roque and from March to May at São Vicente.

Remarks: Present throughout the year in the British Isles, cystocarps and spermatangia have been seen for most of the year, and tetrasporangia between January and May and from July to November (Maggs & Hommersand, 1993).

The Azores represent the known southern limit of distribution for this species.

Ceramium secundatum Lyngbye

New record for the Azores. Common in the British Isles (Maggs & Hommersand, 1993). Because of the confusion with the former C. *rubrum* complex, the geographical distribution of this species cannot be assessed at present.

Additional reference: Boo and Rueness (1994).

Distinguishing features: Distinguished from C. *pallidum* by having axis branching at intervals of 10-18 segments. Periaxial cells typically 8.

Habitat: Epilithic in intertidal pools at São Roque.

Seasonality: A rare species, it was only collected in February and July 1994, and in June and September 1995.

Reproduction: All the plants, except the one from September, were tetrasporic.

Remarks: Present throughout the year in the British Isles, spermatangia recorded between February and December, cystocarps between March and September and in December, and tetrasporangia seen from February to April, between July and September and in December (Maggs & Hommersand, 1993).

The Azores represent the known southern limit of distribution for this species.

Ceramium strictum sensu Harv.

New record for São Miguel. Recorded for Terceira by Larkum (1960) but this identification requires confirmation as it could have referred to the *C. diaphanum/strictum* complex.

Distinguishing features: Distinguished from *C. diaphanum* by the cortical bands, which do not protrude beyond the axial cells, and also by the tetrasporangia that in this species form rings around the nodes (Plate X.3). All the specimens observed had an extensive basal rhizoidal system and ellipsoidal tetrasporangia.

Habitat: Growing on rocks and other algae, this species was found in the intertidal level at both sites.

Seasonality: It was collected in April and from June to August 1994 at São Roque, and in May 1995 at São Vicente. Biomass was low, less than 100 g/m2.

Reproduction: Tetrasporic plants were collected in April and July at São Roque and in May at São Vicente.

Remarks: Sexual and tetrasporic plants were collected in summer and autumn in Norway (Rueness, 1973). In the British Isles spermatangia were seen in April, June and July, while cystocarps and tetrasporangia were restricted to July (Maggs & Hommersand, 1993). Not common, but collected a few times in Madeira, fertile plants present from April throughout the summer (Levring, 1974).

Compsothamnion decompositum (J. Agardh) Maggs & L'Hardy-Halos

New record for the Azores. Common in the northeast Atlantic (Maggs & Hommersand, 1993).

Distinguishing features: Thalli monosiphonous and ecorticate throughout; main axis wider than branches, bearing laterals in an alternate arrangement in one plane; cells multinucleate.

Habitat: Strictly subtidal, epiphytic on a range of other algae.

Seasonality: This species was found in September 1993 at São Vicente and in September 1995 at São Roque.

Reproduction: Both plants were tetrasporangial.

Remarks: In the British Isles, tetrasporangial and spermatangial thalli were observed in July and August (Maggs & Hommersand, 1993).

The Azores represent the known southern limit of distribution for this species.

Griffithsia corallinoides (L.) Batters

New record for São Miguel. Previously recorded by Neto and Baldwin (1990) for Flores.

Distinguishing features: Distinguished from *Bornetia secundiflora* by its pyriform cells and flaccid texture of the filaments. Elsewhere reproductive structures are usually present.

Habitat: Mixed with other species in the intertidal algal turf at São Vicente.

Seasonality: Only one plant was collected in November 1994.

Reproduction: No reproductive structures were observed.

Remarks: In the British Isles mature plants can be found in abundance throughout the year. Spermatangia have been recorded for February, from April to June and October, cystocarps between May and October, and tetrasporangia throughout the year (Maggs & Hommersand, 1993). Ardré (1970) reported *G. corallinoides* for mainland Portugal and indicated that records from further south in the Atlantic (Canaries, Morocco) should be verified. So, the Azores would appear to represent its southern limit in distribution at present.

Pterothamnion crispum (Ducluz.) Nägeli

New record for São Miguel. Previously recorded in Faial (Tittley & Neto, 1994) and Flores (Tittley *et al.*, in press).

Additional reference: Athanasiadis (1985).

Distinguishing features: Thalli consisting of small tufts of erect axes, attached by loose, spreading rhizoidal filaments, delicate and flaccid in texture. Whorl-branches paired and distichously arranged.

Habitat: Mainly epiphytic, this species was collected from the intertidal and subtidal levels of both coasts.

Seasonality: *Pterothamnion crispum* was only occasionally collected in the intertidal. This species was more common subtidally, being collected over most of the sampling period on both coasts. Although common, it was never abundant, its mean biomass not exceeding 19.7 g/m2 (Fig. 90).

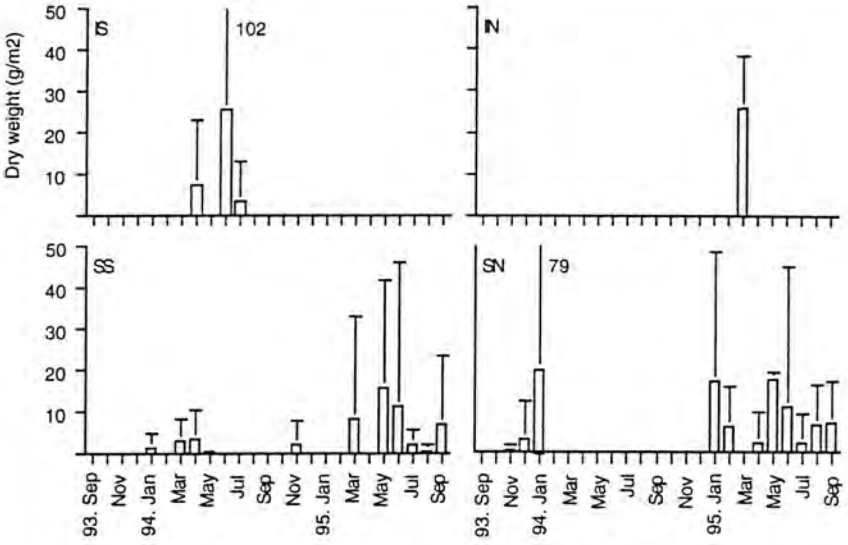


Fig. 90 Monthly biomass (mean + standard deviation) of *P. crispum*. For abreviations see section 3.5.

Reproduction: Tetrasporic plants were collected in February and March 1995 at São Vicente from the intertidal and between January and September from the subtidal. At São Roque sublittoral, tetrasporic plants were not found before March but occurred until September. Female plants were only found in the subtidal, in October 1994 at São Vicente, and in April 1995 at São Roque, where one male plant was collected in July 1994.

Remarks: In the British Isles this species can be found throughout the year. Spermatangia were recorded between July and October, procarps and cystocarps in July, and from August to October, and tetrasporangia in July and between September and October (Maggs & Hommersand, 1993). Infertile and tetrasporophyte plants were collected in the Aegean Sea throughout the year, the later being present in the collections from November to December (Athanasiadis, 1987).

Pterothamnion plumula (Ellis) Nägeli

Antithamnion plumula (Ellis) Thur. ex Le Jolis

New record for São Miguel. Previously recorded in Terceira by Schmidt (1929b).

Additional reference: Sundene (1975).

Distinguishing features: Distinguished from *P. crispum* by its whorl-branches that bear branchlets in a secund arrangement (Plate XI.1).

Habitat: Occurring only in the subtidal level, this species was present at both sites.

Seasonality: Plants were collected in January 1994, March and April 1995 at São Roque and in December 1993 and May 1995 at São Vicente.

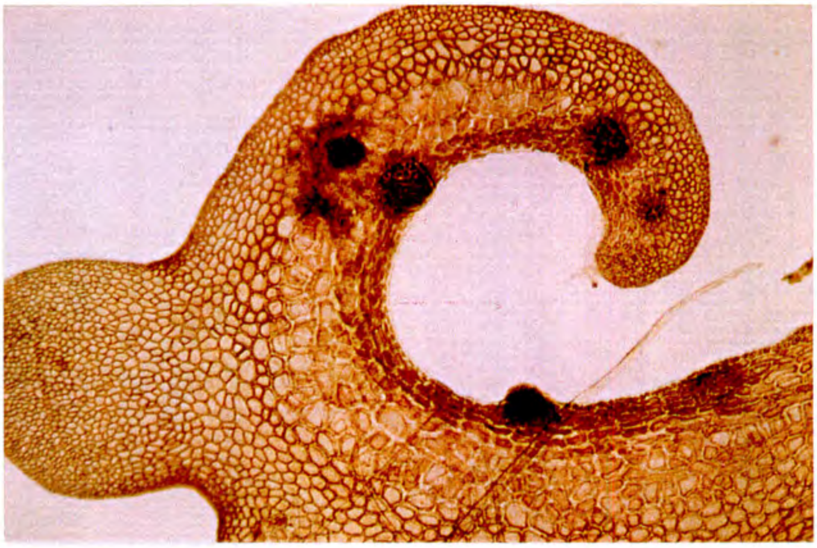
Plate XI

1. *Pterothamnion plumula*: Portion of plant showing branching (x100).

2. *Acrosorium venulosum*: Portion of thallus showing hook-like outgrowth (x40).

3. *Dasya hutchinsiae*: Terminal region of plant showing stichidial segments (x40).

1



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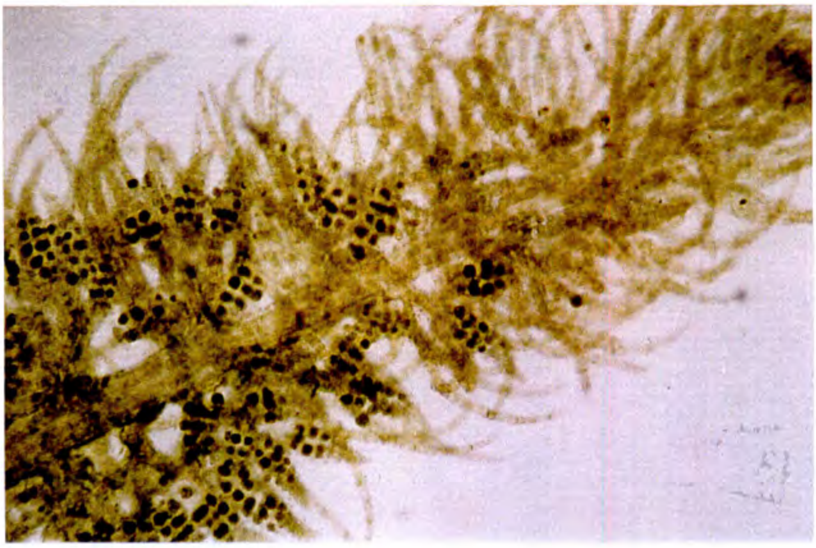


3

Reproduction: Male plants were found in December 1993 in the north and in January 1994 at São Roque.

Remarks: Mature plants occur throughout the year in the British Isles, with spermatangia and tetrasporangia recorded between February and December, procarps and cystocarps in February, from March to June and in December (Maggs & Hommersand, 1993). Collected throughout the year in France, fertile from spring to autumn (Gayral, 1966) and in July and October in Spain, tetraspores being present in both occasions (Seoane-Camba, 1965).

Mediterranean and Australasian records require confirmation (Athanasiadis, 1990).

The Azores represent this species known southern limit in distribution.

Scagelia pylaisaei (Mont.) Wynne

New record for the Azores. Common on the north Atlantic (Maggs & Hommersand, 1993).

Distinguishing features: The whorl branches formed in whorls of 2-3 on each axial cell and covered with paired branchlets (which distinguishes this species from *S. pusilla*) and tiny gland cells adjacent to single branchlet cells (which distinguishes this species from *Antithamnion cruciatum*).

Habitat: Epilithic/epiphytic in both intertidal and subtidal zones, this species was present at both sites, but was more frequent in the north.

Seasonality: At São Roque, it was collected only once in March 1995 from the subtidal. At São Vicente, three intertidal plants were collected (April, May and September 1995), while subtidal plants were collected from October 1994 to January 1995.

Reproduction: Only two reproductive plants were seen, both subtidal at São Vicente, one with cystocarps in November 1994 and the other with tetraspores in January 1995.

Remarks: Reproductive material was collected in June in the British Isles (Maggs & Hommersand, 1993). This species has its known southern limit of occurrence on the Azores.

Scageliopsis patens (Wollaston)

New record for São Miguel. Previously recorded for Faial by Tittley and Neto (1994).

Distinguishing features: Thallus with a well-developed prostrate system giving rise to erect axes, attached by multicellular rhizoids developed from periaxial cells and cells of the prostrate axes; three whorl branches produced per axial cell; these branches are subdichotomously ramified; one or two gland cells on each whorl-branch, strictly borne on apical cells.

Habitat: Epilithic and intertidal at São Vicente.

Seasonality: Only one plant was collected in March 1995.

Reproduction: No reproductive structures were noticed.

Remarks: This species, first described from South Africa, was collected only on another occasion in the Azores, in July 1989 at Faial, between 6 and 40m depth, isolated or as part of the sublittoral algal turf (Athanasiadis & Tittley, 1994; Tittley & Neto, 1994). It constitutes a probable introduction to the algal flora of the Azores.

Spermothamnion repens (Dillwyn) Rosenv.

Spermothamnion turneri (Mert. in Roth) Aresch.
Callithamnion turneri (Mert. in Roth) C. Agardh

New record for São Miguel. Previously recorded for Terceira (see Neto, 1994).

Additional reference: Rueness (1971).

Distinguishing features: Thalli monosiphonous and ecorticate throughout; paired or whorl branches present; axial cell less than 150μm diameter; gland cells absent.

Habitat: Strictly subtidal, this species was present on both sites.

Seasonality: Sparse in occurrence, its mean biomass less than 4 g/m2. Plants were collected in December 1994 and April 1995 at São Roque, and in October and November 1994 and May 1995 at São Vicente.

Reproduction: No reproductive structures were seen.

Remarks: Tetrasporangial thalli and sterile plants common in Norway, as well as some specimens with gonimoblasts, but no male plants, or plants bearing more than one kind of reproductive organs, were seen (Rueness, 1971). In the British Isles large mature thalli occur in March and September, spermatangia and cystocarps being recorded between April and August and tetrasporangia from May to September and in December. Tetrasporangia have often been found on gametophytes (Maggs & Hommersand, 1993). Collected in the Aegean Sea throughout the year, tetrasporophytes being present in the collections from June, August, November and December and monoecious gametophytes with spermatangia, procarps and carposporophytes collected in the summer (Athanasiadis, 1987). In other locations in the Mediterranean, plants were collected in winter and early spring, most of them tetrasporic but sexual plants were never seen (Feldmann-Mazoyer, 1940). In mainland Portugal, this species was collected in June, the plants bearing tetrasporangia (Ardré, 1970). Collected in March in the Canaries, tetraspores and spermatangia seen on separate plants (Børgesen, 1930).

Sphondylothamnion multifidum (Hudson) Nägeli

New record for São Miguel. Previously recorded for Faial by Tittley and Neto (1994).

Additional reference: Gordon and Womersley (1966).

Distinguishing features: Thalli monosiphonous and ecorticate throughout; paired or whorl branches present; axial cell more than 500µm diameter.

Habitat: Epiphytic in the subtidal at São Vicente.

Seasonality: Only one plant was collected in October 1993.

Reproduction: The plant was sterile.

Remarks: Present throughout the year in the British Isles (Maggs & Hommersand, 1993) and the Mediterranean (Feldmann-Mazoyer, 1940; Athanasiadis, 1987), this species was collected between April and June at mainland Portugal (Ardré, 1970) and in March at the Canaries (Børgesen, 1930). In the British Isles spermatangia were recorded in July, procarps and cystocarps between July and September, and tetrasporangia from June to September (Maggs & Hommersand, 1993). In the Mediterranean tetraspores were seen in May and June (Feldmann-Mazoyer, 1940) and in mainland Portugal, the plants from June and July had numerous tetrasporangia (Ardré, 1970).

Wrangelia penicillata (C. Agardh) C. Agardh

New record for the Azores. Largely distributed in the Atlantic, also recorded in the Mediterranean (Feldmann-Mazoyer, 1940; Taylor, 1967; Levring, 1974; Lawson & John, 1982; Wynne, 1985; Athanasiadis, 1987; Boudouresque *et al.*, 1992).

Distinguishing features: Plants usually solitary, stiff and erect; branching alternate and distichous, with well-developed cortication often pseudoparenchymatous; branchlets terminating in an acute spine.

Habitat: Only seen in the subtidal level, where it was rare.

Seasonality: Although present at both sites, only two plants were collected, in December 1994 at São Vicente, and in August 1995 at São Roque.

Reproduction: The plant collected at São Vicente was tetrasporic.

Remarks: Collected throughout the year in the Mediterranean (Feldmann-Mazoyer, 1940; Athanasiadis, 1987), this species was also found a few times in Madeira (Levring, 1974). Tetrasporophytes seen in November and December in the Aegean Sea (Athanasiadis, 1987). In other locations in the Mediterranean, sexual plants were seen from winter through summer

(Feldmann-Mazoyer, 1940) and in Madeira, fertile plants were present from April to October (Levring, 1974).

DELESSERIACEAE

Additional references: Wagner (1954); *Acrosorium, Radicilingua, Cryptopleura* (Wynne, 1989); *Hypoglossum* (Wynne, 1988).

Acrosorium venulosum (Zanardini) Kylin

Acrosorium uncinatum sensu Kylin
Nitophyllum uncinatum (Turn.) J. Agardh

Distinguishing features: Thalli membranous and translucent without a conspicuous midrib, but with microscopic veins forming a network throughout blade; thalli attached by peg-like holdfasts from the lower surfaces. Blade margins may bear hook-like outgrowths (Plate XI.2).

Habitat: Mainly epiphytic, this species was collected in the intertidal and subtidal levels at both sites, although it was much more common subtidally.

Seasonality: At the intertidal of São Roque, only one plant was collected, in July 1994. At São Vicente, four plants were collected from the intertidal in June and October 1994 and in January and July 1995. In the subtidal *A. venulosum* was more frequent in the second year on both localities. In the south plants were collected in January and July 1994 and between October 1994 and September 1995, their mean biomass varying from 1.3 to 4.8 g/m2. At São Vicente, this species was collected between September and November 1993 and January 1994 and between June 1994 and September 1995. Biomass values were similar.

Reproduction: Subtidal tetrasporic plants were present in February 1995 at São Roque and in December and January at São Vicente. One male plant was collected in July 1994 at São Vicente. Surprisingly, no reproductive plants were found in the intertidal.

Remarks: In the British Isles individual blades are annual, with tetrasporangia formed between July and October, but gametangia have never been observed there (Maggs & Hommersand, 1993). Collected throughout the year in the Aegean Sea (Athanasiadis, 1987), Spain (Seoane-Camba, 1965), mainland Portugal (Ardré, 1970), Madeira (Levring, 1974) and Canaries (Børgesen, 1930), only tetrasporophytic plants being observed. Tetrasporangia were seen in mainland Portugal in June (Ardré, 1970), Morocco in winter (Gayral, 1958) and in the Canaries in March (Børgesen, 1930).

Apoglossum ruscifolium (Turner) J. Agardh

New record for São Miguel. Previously recorded for Faial by Tittley and Neto (1994).

Distinguishing features: Distinguished from *Hypoglossum hypoglossoides* (q.v.) by the presence of lateral veins and also by having blade cells less than 20µm long. The apices of *Apoglossum* are much more rounded.

Habitat: Epiphytic on other subtidal algae at São Roque.

Seasonality: Only two plants were collected, in July 1994 and May 1995.

Reproduction: No reproductive structures were seen.

Remarks: Present throughout the year in the British Isles (Maggs & Hommersand, 1993) and in the Aegean Sea (Athanasiadis, 1987), this species has a more seasonal occurrence in other localities: in Spain it was collected in October (Seoane-Camba, 1965) and in mainland Portugal between March and October (Ardré, 1970).

In the British Isles spermatangia were recorded in February, between June and August and from October to December, cystocarps in February and between June and December, and tetrasporangia in February and December (Maggs & Hommersand, 1993). In the Aegean Sea gametophytes, with spermatangial sori, were seen in November and May (Athanasiadis, 1987). In Spain tetrasporangia were seen in October (Seoane-Camba, 1965) and, in mainland Portugal, cystocarps and spermatangia were present in April and June, and tetrasporangia were seen from April to July and in October (Ardré, 1970). In Morocco tetrasporophytes were found in December and from February to July, and the cystocarps only in July (Gayral, 1958).

This species may reach its southern limit of distribution on the Azores.

Cryptopleura ramosa (Huds.) Kylin *ex* L. M. Newton

Acrosorium reptans (P. Crouan et H. Crouan) Kylin
Nitophyllum laceratum (S. G. Gmel.) Grev.
Delesseria lacerata (S. G. Gmel.) C. Agardh
Fucus laceratus (S. G. Gmel.)

Distinguishing features: Thalli membranous and translucent without a conspicuous midrib, but with veins present throughout blade; prostrate blades with rounded apices, attached by peg-like holdfasts from lower surfaces. *Cryptopleura* is similar to *Acrosorium venulosum* (q.v.) but the former has larger veins, especially at the base of the thalli and any hooks are always lateral (both marginal and terminal in *A. venulosum*).

Habitat: Both epiphytic and epilithic, this species was found at all the levels sampled.

Seasonality: Collected only a few times (September 1993, February and June 1994 and May 1995), it was never abundant at any level, with its mean biomass never exceeding 45 g/m2 in the intertidal, and 12 g/m2 in the subtidal (Fig. 91).

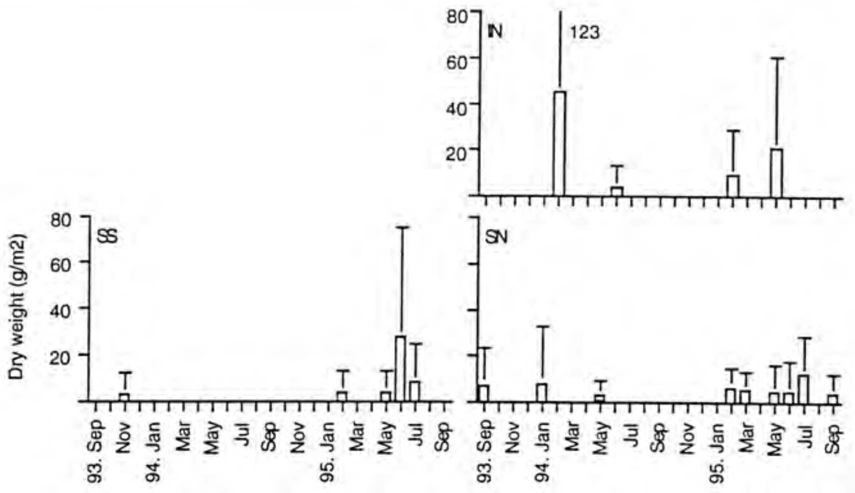


Fig. 91 Monthly biomass (mean + standard deviation) of *C. ramosa*. For abreviations see section 3.5.

Reproduction: No reproductive plants were observed.

Remarks: In the British Isles and mainland Portugal mature plants can be found throughout the year (Maggs & Hommersand, 1993; Ardré, 1970). In the British Isles spermatangia have been recorded between February and November, cystocarps from January to March and December, and tetrasporangia throughout the year (Maggs & Hommersand, 1993). Kain (1982) reported female plants for most of the year on the Isle of Man. In France reproductive plants were found in summer and autumn (Gayral, 1966), while in Spain only one tetrasporic plant was seen in September (Seoane-Camba, 1965). In mainland Portugal tetrasporangia were present from February to July and in October but spermatangia and cystocarps were only seen in March (Ardré, 1970) and August (Rodrigues, 1957). Only a few specimens collected in Madeira, cystocarpic plants present in October and tetraspores found in October and May (Levring, 1974).

The adelphoparasite, *Gonimophyllum buffhami* Batters, found on *Cryptopleura* elsewhere, was not encountered.

Drachiella heterocarpa (Chauvin ex Duby) Maggs & Hommersand

New record for the Azores. Present in the northeastern Atlantic from the British Isles to North of Spain (South & Tittley, 1986; Maggs & Hommersand, 1993).

Distinguishing features: Thallus membranous and translucent (mainly 1 cell thick) without a conspicuous midrib or microscopic veins but with polystromatic thickenings towards the base; tetrasporangial sori minute and inconspicuous.

Habitat: Mainly epiphytic, this species was present in the intertidal level at both sites and in the subtidal at São Vicente.

Seasonality: *Drachiella* was collected only in 1994: in July at São Roque, between February and August at São Vicente in the intertidal and in January in the subtidal there. Biomass was low ($\leq$ 49 g/m2).

Reproduction: Reproductive plants were only found in the intertidal at São Vicente, one tetrasporophyte in February and a female in June.

Remarks: Tetrasporangial sori are present from April to June in the British Isles (Maggs & Hommersand, 1993).

The Azores represent the known southern limit of distribution for this species.

Haraldiophyllum bonnemaisonii (Kylin) A. Zinova

New record for the Azores. Largely distributed on the eastern Atlantic (Price *et al.*, 1992; Maggs & Hommersand, 1993).

Distinguishing features: Distinguished from *Drachiella heterocarpa* (q.v.) by the tetrasporangial sori that are conspicuous over the upper part of mature blades and also by the cystocarps that lack a projecting ostiole. In *Drachiella* specialized tetrasporangial bladelets are formed basally. Plastid morphology also differs between these two genera: ribbon-shaped in *Drachiella* and discoidal in *Haraldiophyllum*.

Habitat: Present in both intertidal and subtidal levels at both sites.

Seasonality: Rarely encountered. Only six plants were collected: one in the intertidal at São Roque (June 1995), three at São Vicente in the intertidal (June 1994, January and May 1995), one in the subtidal at São Roque (June 1995) and one at São Vicente subtidal (December 1994).

Reproduction: Most plants were reproductive, with the tetrasporophyte generation occurring in January, May and June 1995, and a female plant occurring in June 1994.

Remarks: Basal parts of thalli are probably perennial in the British Isles, forming new blades in early spring. Spermatangia have been recorded in April, August and September, cystocarps in June, October and November and tetrasporangia in April and between June and October (Maggs & Hommersand, 1993).

Hypoglossum hypoglossoides (Stackh.) Collins et Herv.

Delesseria hypoglossum (Woodw.) J. V. Lamour
Hypoglossum woodwardii Kützing

Distinguishing features: Thalli membranous and translucent with a conspicuous midrib from base to apex of blades but no lateral microveins; cells of blade larger than 60µm long and thalli with pointed apices.

Habitat: This epilithic species was collected from the intertidal and subtidal levels at the two sites.

Seasonality: In the intertidal, one plant was found at São Roque (February 1994), and four at São Vicente (February, March and June 1994 and April 1995). In the subtidal, four plants were collected at São Roque (October 1993, February, May and September 1995) and five at the north site (September 1993, July and December 1994, February and April 1995).

Reproduction: Tetrasporic plants were found subtidally in April and September 1995. One gametophyte, bearing spermatangia, was observed in July 1994 in the subtidal at São Vicente.

Remarks: On sheltered shores of the British Isles mature plants can be found throughout the year. Spermatangia have been recorded in February, April, May to July and October, cystocarps in January, February to May and September, and tetrasporangia between February and November (Maggs & Hommersand, 1993). Also collected throughout the year in the Aegean Sea, tetrasporophytes and gametophytes with carposporophytes being present in November and December (Athanasiadis, 1987). Tetrasporic plants collected in February in Spain (Seoane-Camba, 1965). In mainland Portugal plants of this species were collected between February and August, fertile gametophytes being present in June and tetrasporangia seen from February to June (Ardré, 1970) and in August (Palminha, 1958). Not common, but collected a few times in Madeira between April and July (Levring, 1974). Tetrasporic plants collected in March in the Canaries (Børgesen, 1930). An annual species in Morocco, sporangia are present in summer and cystocarps in winter (Gayral, 1958).

Nitophyllum punctatum (Stackh.) Grev.

Distinguishing features: Distinguished from *Haraldiophyllum* (q.v.) by having tetrasporangia larger than 100µm in diameter and by having larger cystocarps with a projecting ostiole.

Habitat: Epilithic and tolerant to sand cover, this species was found only at São Vicente, where it was present in lower littoral pools, extending into the shallow sublittoral.

Seasonality: Collected in November 1993 in the intertidal, and in September 1993 and July 1994 in the subtidal, it was uncommon (biomass ≤ 14 g/m2).

Reproduction: Tetrasporic plants were only found subtidally in September and October 1993, while the only female plant was collected at the intertidal in October 1993.

Remarks: Mature plants can be found throughout the year in sheltered habitats in the British Isles. Maggs and Hommersand (1993) reported spermatangia from February to May and from September to December, cystocarps in February, April to October and December, and tetrasporangia in January, February, April to September, November and December. Reproductive structures were seen in spring and summer in France (Gayral, 1966). In Spain it was only found in January, the plant containing tetrasporangia (Seoane-Camba, 1965) but was collected throughout the year in the Aegean Sea, gametophytes being present between July and December (Athanasiadis, 1987). Plants of this species were collected in mainland Portugal between April and October; spermatangia were seen in June, July and October and tetrasporangia from March to July and in October (Ardré, 1970). In Morocco tetraspores were observed in winter and cystocarps in summer (Gayral, 1958).

Radicilingua thysanorhizans (Holmes) Papenfuss

New record for the Azores. Recorded in the eastern Atlantic from the British Isles to mainland Portugal, also referred in the Mediterranean (Ardré, 1970; Maggs & Hommersand, 1993).

Distinguishing features: Distinguished from *Cryptopleura ramosa* by having the thalli attached by small enrolled marginal projections that develop at irregular intervals. Although originally considered conspecific with *Acrosorium venulosum* (see Wynne, 1989), even sterile specimens can be separated by such features as plastid shape and attachment structures.

Habitat: Mainly epiphytic, this species was present from the intertidal to subtidal levels at both sites.

Seasonality: At São Roque plants were collected in February, March and May 1994 from the intertidal, and in September 1993, April and May 1995 from the subtidal. At São Vicente plants were collected in December 1994 and May 1995 subtidally.

Reproduction: Only one reproductive plant with mature cystocarps was found in the subtidal in September 1993.

Remarks: In the British Isles, small plants become apparent in April and May, maturing in June and August. Spermatangia have been recorded in June, cystocarps in June and July and tetrasporangia from January to May and in August (Maggs & Hommersand, 1993). In mainland Portugal tetrasporophyte plants were collected in February (Ardré, 1970).

The Azores represent the known southern limit of distribution for this species.

Taenioma nanum (Kützing) Papenfuss

New record for São Miguel. Recorded for Faial by Tittley and Neto (1994). South and Tittley only record this species for the Iberian peninsula in the North Atlantic but *T. nanum* is listed by Wynne (1985) for the sub-tropical western Atlantic.

Distinguishing features: Plants usually growing in a turf with other small algae, an erect system of branches arising from a prostrate system. Branching alternate, with a branch and a branchlet usually borne on every third segment of the erect segment; branchlets terminating invariably in 2 long hairs.

Habitat: Epilithic on exposed rocks in the lower intertidal of north site.

Seasonality: This species was only collected in February 1994 and May 1995.

Reproduction: No reproductive structures were detected.

DASYACEAE

Additional reference: Parsons (1975).

Dasya corymbifera J. Agardh

New record for São Miguel. Previously recorded for Faial, Pico and Santa Maria (see Neto, 1994).

Distinguishing features: Four tetrasporangia per stichidial segment. Pseudo-laterals branched from suprabasal and all of the next few cells.

Habitat: Epiphytic on other intertidal algae at São Roque.

Seasonality: Only one plant was collected, in October 1994.

Reproduction: The plant presented stichidia with tetrasporangia.

Remarks: Plants have been collected only between July and October in the British Isles, cystocarps being recorded in August, and tetrasporangia between July and October (Maggs & Hommersand, 1993). Infertile and tetrasporophyte plants were collected in the Aegean Sea throughout the year, spermatangial plants being present in the summer (Athanasiadis, 1987). Common in Madeira where it was collected throughout the year (Levring, 1974).

Dasya hutchinsiae Harv. in Hook.

New record for the Azores. Largely distributed in the eastern Atlantic, including Madeira and the Canaries (Ardré, 1970; Levring, 1974; Price *et al.*, 1986; Maggs & Hommersand, 1993). Also recorded in the Mediterranean (Athanasiadis, 1987).

Distinguishing features: Each stichidial segment contains five tetrasporangia (Plate XI.3). Pseudo-laterals branched from immersed basal cell and also branched from all of the next few cells.

Habitat: Mainly epiphytic, this species was present in the intertidal at São Vicente and in the subtidal at both sites.

Seasonality: At São Roque in the subtidal plants were collected in September and December 1993, October and December 1994, and in March and August 1995. At São Vicente, three plants were collected from the intertidal (September 1993, March and May 1995). From the subtidal plants were collected in October and November 1994 and in September 1995.

Reproduction: Plants bearing stichidia with tetrasporangia were only found at São Vicente, in September 1993 and May 1995 in the intertidal, and in October 1994 in the subtidal.

Remarks: Mature plants have been collected throughout the year in the British Isles, spermatangia recorded in June and July, cystocarps from June to September and tetrasporangia between May and October (Maggs & Hommersand, 1993). Vegetative plants were collected in the Aegean Sea throughout the year (Athanasiadis, 1987). In mainland Portugal this species was collected in February, June, July and October, the plants from June having tetrasporangia and cystocarps (Ardré, 1970). Collected a few times in Madeira, fertile plants being found between April and July (Levring, 1974).

Dasya ocellata (Grat.) Harv. *in* Hook.

Distinguishing features: Distinguished from *D. hutchinsiae* by the more restricted branching of the pseudo-laterals cells.

Habitat: Epiphytic on other algae in the intertidal level at both sites and in the subtidal at São Vicente.

Seasonality: Only three plants were collected, two in May 1995, one on each coast, and one subtidally in November 1994.

Reproduction: All these plants had tetrasporangial stichidia.

Remarks: Male and female plants unknown in the British Isles, but tetrasporophytes have been collected from July to November (Maggs & Hommersand, 1993). Collected throughout the year in the Aegean Sea (Athanasiadis, 1987) it was also seen in Spain in October, February and June, with stichidia present in October (Seoane-Camba, 1965). Collected between February and October in mainland Portugal (Ardré, 1970), it was also collected a few times in Madeira, fertile plants present between July and October (Levring, 1974). One plant with stichidia collected in March in Tenerife, Canaries (Børgesen, 1930).

RHODOMELACEAE

Additional references: Scagel (1953); Hommersand (1963); *Brongniartella* (Parsons, 1980); *Chondria* (Feldmann, 1964; Gordon-Mills & Womersley, 1987); *Laurencia* (Saito & Womersley, 1974; Gil-Rodríguez & Haroun, 1992; Robaina *et al.*, 1992; Hernández-González & Gil-Rodríguez, 1994; Nam & Saito, 1994); *Polysiphonia* (Batten, 1922; Lauret, 1970; Kapraun *et al.*, 1983).

Brongniartella byssoides (Gooden. & Woodw.)

New record for the Azores. Largely distributed in the eastern Atlantic, also recorded in the Mediterranean (Gayral, 1966; Ardré, 1970; Maggs & Hommersand, 1993).

Distinguishing features: Distinguished from *Dasya* by the absence of cortication in the main axis and by the tetrasporangia that are borne in vegetative lateral branches.

Habitat: Epiphytic on other subtidal species at São Vicente.

Seasonality: Only one plant was collected in September 1993.

Reproduction: No reproductive structures were seen.

Remarks: Collected in mainland Portugal only in March (Ardré, 1970), it is more common in the British Isles, where spermatangia have been recorded from May to September, cystocarps from June to September, and tetrasporangia in May and from July to September (Maggs & Hommersand, 1993).

The Azores represent the known southern limit of distribution for this species.

Chondria coerulescens (J. Agardh) Falkenberg.

New record for the Azores. Largely distributed in the eastern Atlantic, including Madeira and the Canaries (Gayral, 1958, 1966; Seoane-Camba, 1965; Ardré, 1970; Price *et al.*, 1986; Maggs & Hommersand, 1993). Also recorded in the Mediterranean (Athanasiadis, 1987).

Distinguishing features: Apices obtuse, terminating in a shallow depression; young plants showing a vivid, metallic blue iridescence when alive; wart-like aborted branch initials spirally borne on the axes.

Habitat: Strictly intertidal, this species was present at both sites.

Seasonality: It was present only in the second sampling year, being more frequent and abundant in the south. Here plants were collected from July 1994 to September 1995, and were quite small in length (1.5-2.4 cm, Fig. 92), as compared to English specimens which can be up to 8 cm long. The standing crop varied between 10 to 130 g/m2 (Fig. 93). At São Vicente, the plants were slightly larger but with a lower biomass.

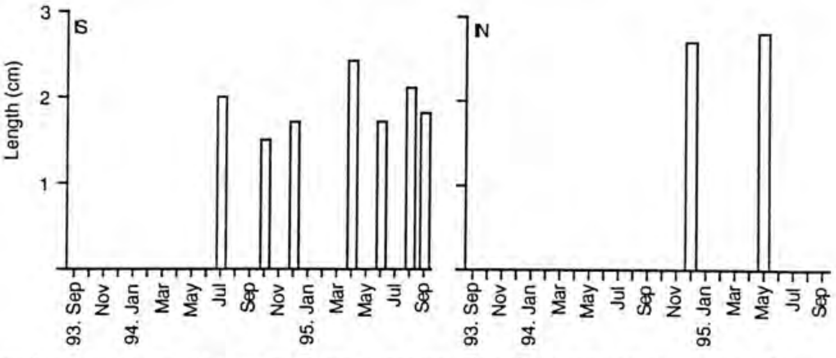


Fig. 92 Monthly maximum length of *C. coerulescens*. For abreviations see section 3.5.

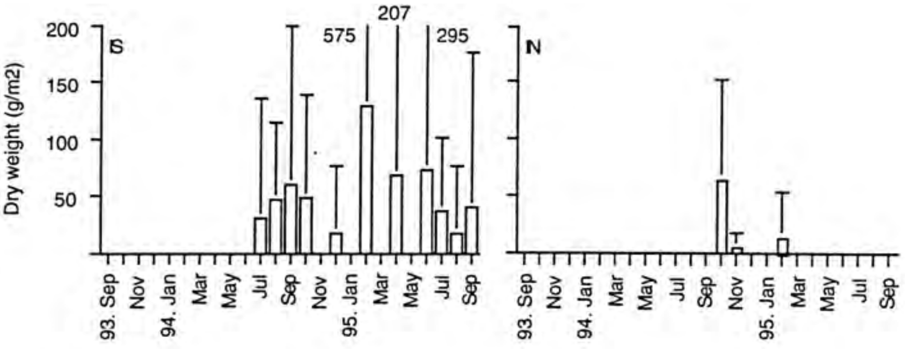


Fig. 93 Monthly biomass (mean + standard deviation) of *C. coerulescens*. For abreviations see section 3.5.

Reproduction: Tetrasporic plants were found in October and June at São Roque and in December at São Vicente. Only one cystocarpic plant was collected in July 1994 at the south site.

Remarks: Collected between May and October in the British Isles, thalli bear spermatangia in June, and cystocarps in July and September (Maggs & Hommersand, 1993). Present in the Aegean Sea throughout the year, spermatangial structures being seen in June (Athanasiadis, 1987). Collected in Spain between July and February, tetrasporangia seen in September and February (Seoane-Camba, 1965). Collected from March to June and in October in mainland Portugal, tetrasporangia observed in March, April and June (Ardré, 1970).

Chondria dasyphylla (Woodw.) C. Agardh

Distinguishing features: Distinguished from *C. coerulescens* by the absence of iridescence and by the absence of aborted branch initials.

Habitat: Epilithic but strictly intertidal, this species was present at both places.

Seasonality: Collected in March 1994 at São Roque and in January, April and September 1995 at

São Vicente, it was uncommon, its mean biomass not exceeding 65 g/m2, i.e. similar to *C. coerulescens*.

Reproduction: Tetrasporic plants were only seen in the north in September 1995. A male plant was found in the south in March 1994.

Remarks: In the British Isles spermatangia were recorded from April to October, cystocarps between May and August and in October, and tetrasporangia from April to June and in October (Maggs & Hommersand, 1993). Infertile plants were collected throughout the year in the Aegean Sea (Athanasiadis, 1987) and were seen in March and June in mainland Portugal (Ardré, 1970). Well-developed but non-reproductive plants were collected in Morocco in the summer (Gayral, 1958), but only one female plant was collected in the Canaries in March (Børgesen, 1930). Collected throughout the year on the northeastern coasts of North America, although reproductive plants were only found in the summer (Taylor, 1978).

Laurencia hybrida (DC.) Lenormand *ex* Duby

Additional reference: Nam and Saito (1994).

Distinguishing features: Holdfast discoid, lacking stolons; main axis terete or slightly compressed; apices with a circular pit or depression.

Habitat: Never present in the subtidal, this species was only collected from the intertidal level at both sites.

Seasonality: It was more frequent at São Vicente, where plants were present in December 1993, January, April and May 1994, from January to April and in September 1995 (Fig. 94). At São Roque, *L. hybrida* was only collected in July, October and December 1994. Plants were bigger at São Vicente (up to 6.8 cm) than at São Roque (3.6 cm maximum).

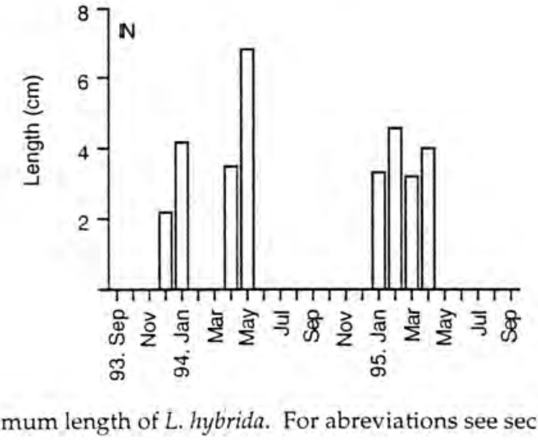


Fig. 94 Monthly maximum length of *L. hybrida*. For abreviations see section 3.5.

Reproduction: Tetrasporic plants were present in July 1994 at São Roque and in April 1995 at São Vicente. Only one female plant was collected, in March 1995 at the north site.

Remarks: Annual or perennial at Clare Island (Ireland), reproductive in spring and disappearing in May (Cotton, 1912), this species is present most of the year in the British Isles, spermatangia occurring from November to June, cystocarps maturing from May to July, and tetrasporangia present between December and July (Maggs & Hommersand, 1993). Collected in Spain between December and February, all plants being tetrasporangial (Seoane-Camba, 1965), and in March, April and June in mainland Portugal (Ardré, 1970).

Laurencia obtusa (Huds.) J. V. Lamour.

Laurencia obtusa var. *pyramidata* (Bory) J. Agardh

Distinguishing features: Holdfast stoloniferous; secondary pit connections and spherical hyaline bodies ("corps en cerise") present in the outer cortex; axes terete; apices with circular depressions.

Habitat: Epilithic on exposed rocks in the lower intertidal, this species was present at both sites. Also present in the shallow subtidal north in June 1995. Elsewhere this species is usually epiphytic (Newton, 1962).

Seasonality: It was more abundant at São Vicente, where it was present throughout the sampling period (Fig. 95). In the south, plants were never larger then 3.6 cm, being much larger in the north (Wilcoxon test 15, 15 pairs, p=0.01; Fig. 96).

Reproduction: Most plants were reproductive, the sporophyte generation dominating and present throughout the year at São Vicente, and between May and July at São Roque. Gametophyte plants were only found at the north site, in May, July and November 1994, and were all female.

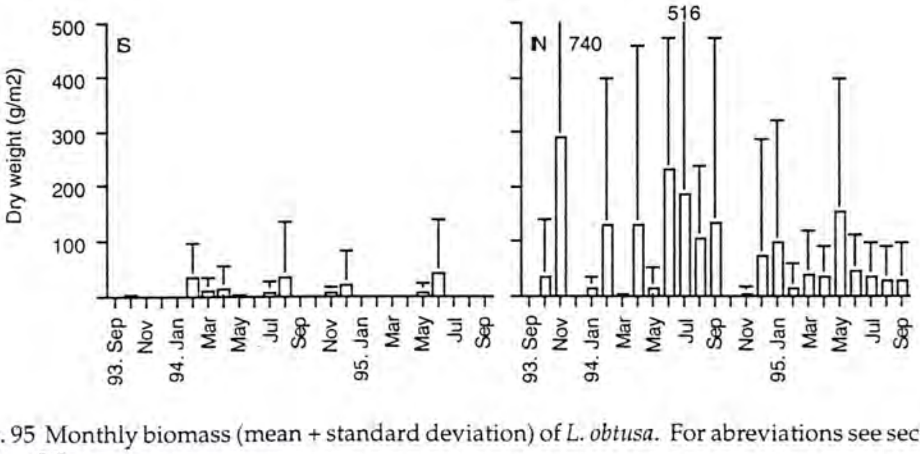


Fig. 95 Monthly biomass (mean + standard deviation) of *L. obtusa*. For abreviations see section 3.5.

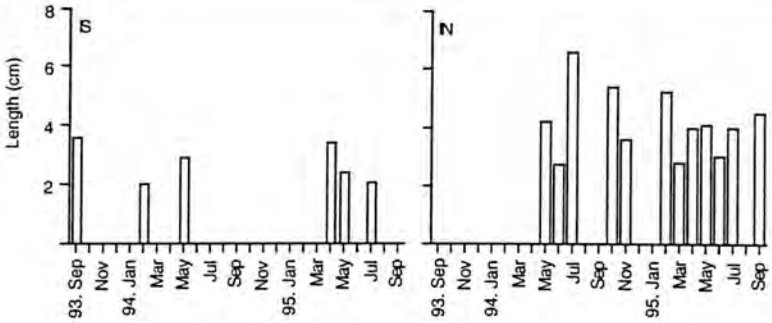


Fig. 96 Monthly maximum length of *L. obtusa*. For abreviations see section 3.5.

Remarks: Plants are found throughout the year in the British Isles (Maggs & Hommersand, 1993), Aegean Sea (Athanasiadis, 1987) and Madeira (Levring, 1974). In the British Isles spermatangia occur in February, between May and July and in September, cystocarps from July to October, and tetrasporangia from April to September (Maggs & Hommersand, 1993). In Spain only one tetrasporic plant was collected in June (Seoane-Camba, 1965), while in mainland Portugal this species was present between March to July and in October, tetrasporangia present in summer only (Ardré, 1970). In Madeira fertile plants were found between May and October (Levring, 1974) but in the Canaries tetrasporic plants were common for most of the year (Børgesen, 1930).

Osmundia pinnatifida (Huds.) Stackh.
Laurencia pinnatifida (Huds.) J. V. Lamour.
Chondria pinnatifida (Huds.) C. Agardh

Distinguishing features: Distinguished from *L. obtusa* by the absence of secondary pit connections in the outer cortex and by having compressed axes.

Habitat: More commonly found in the intertidal zone, this species was also present in the subtidal level at both sites, although according to Maggs and Hommersand (1993) it never grows subtidally.

Seasonality: *Osmundia pinnatifida* was collected intertidally throughout the year on both sites. Its biomass was greater in the south (Fig. 97). This difference nevertheless was not significant (Wilcoxon test 107, 25 pairs, p=0.13). The length of plants was from 2 to 7 cm, the ones from the intertidal south being larger (Fig. 98, Wilcoxon test 11, 18 pairs, p=0.001). This species was always rare in the subtidal, as indicated by the low standing crop values (2 g/m2 in the south and 24 g/m2 in the north).

Reproduction: No reproductive plants were observed in the subtidal but most intertidal plants were tetrasporic.

Remarks: Collected in Spain between November and May and in August (Anadón & Fernández,

1986) and throughout the year in mainland Portugal (Ardré, 1970) and northern Tenerife, Canaries (Hernández-Gonzalez & Gil-Rodrigues, 1994). In the British Isles, spermatangia were recorded in February and June, cystocarps from March to June and tetrasporangia from October to December and in June (Maggs & Hommersand, 1993). Fertile plants were reported in winter and spring in France (Gayral, 1966) and tetraspores seen in Spain between January and March (Seoane-Camba, 1965). In mainland Portugal, tetrasporangia are present all year, and spermatangia and cystocarps found for most of the year but are absent in summer (Ardré, 1970). Tetrasporophytes and male plants present all year round in the Canaries, but female plants only observed between November and June (Hernández-Gonzalez & Gil-Rodrigues, 1994). Fertile plants observed in autumn and winter in Morocco (Gayral, 1958).

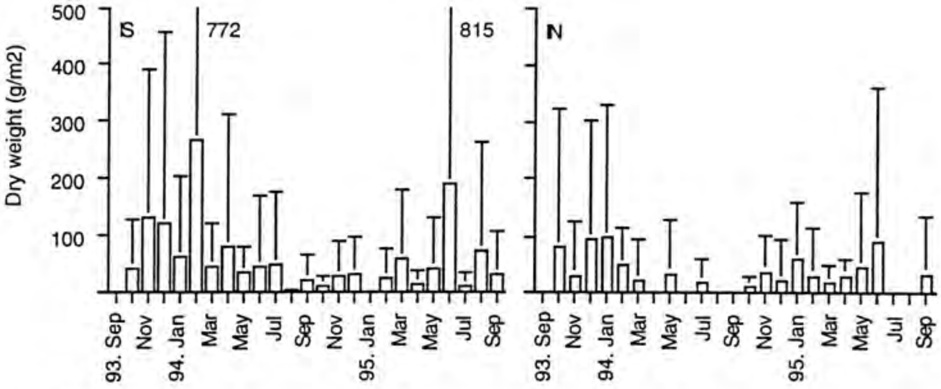


Fig. 97 Monthly biomass (mean + standard deviation) of *O. pinnatifida*. For abreviations see section 3.5.

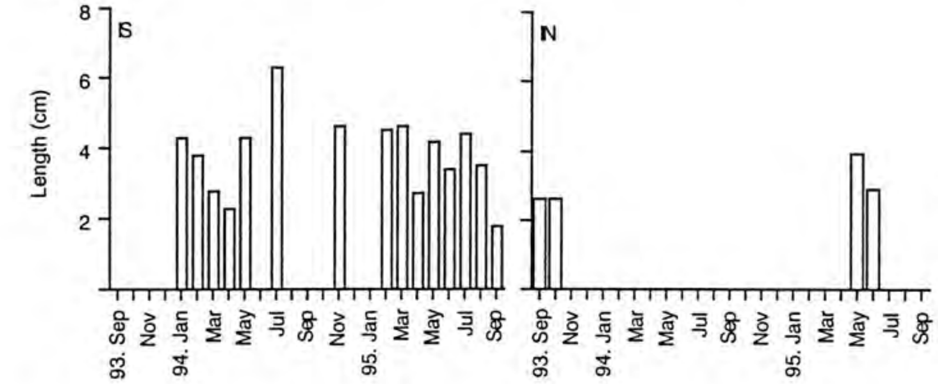


Fig. 98 Monthly maximum length of *O. pinnatifida*. For abreviations see section 3.5.

Lophosiphonia reptabunda (Suhr in Kützing) Kylin

New record for São Miguel. Previously recorded for Faial and Pico by Tittley and Neto (1994).

Distinguishing features: Plants forming small tufts with other algae; erect branches sparingly recurved and sometimes having a series of hairs on the convex side; 8-10 periaxial (= pericentral) cells.

Habitat: Epiphytic in the lower littoral algal turf at São Vicente.

Seasonality: Only one plant was collected in April 1995.

Reproduction: No reproductive structures were seen.

Remarks: This species was frequently found in mainland Portugal between February and October, with tetrasporangia seen in February, April and October, spermatangia in April and cystocarps in June (Ardré, 1970). Collected throughout the year in the Aegean Sea, cystocarps being present in August (Athanasiadis, 1987), it was also common at all seasons in Spain, tetraspores present in March (Seoane-Camba, 1965).

Polysiphonia atlantica Kapraun et J. N. Norris
Polysiphonia macrocarpa Harv. *in* Mackay

Distinguishing features: Thalli forming rounded cushions; main axis lacking cortication, never more than 75µm wide and with 4 periaxial cells; conspicuous rhizoids mainly on the prostrate axes; spermatangial axis lacking sterile terminal cells.

Habitat: Epiphytic on other algae in the subtidal at São Vicente.

Seasonality: One plant was collected in November 1993.

Reproduction: The plant was cystocarpic.

Remarks: Present throughout the year in British Isles (Maggs & Hommersand, 1993) and in mainland Portugal (Ardré, 1970), it was only seen twice in Madeira in April and July, both specimens being fertile (Levring, 1974). On the Atlantic coasts of Colombia and Venezuela plants of this species were collected only in June and July (Kapraun *et al.*, 1983). Although reproducing in summer in England (Maggs & Hommersand, 1993), on the Atlantic coasts of France (Gayral, 1966), and North Carolina (Kapraun, 1977b), it reproduces in winter and in spring in mainland Portugal (Ardré, 1970), Morocco (Gayral, 1958), Canaries (Børgesen, 1930), West Indies (Børgesen, 1916) and Brazil (Oliveira & Ugadim, 1976). Maximum growth was observed between June and September in North Carolina (Kapraun, 1977).

Polysiphonia brodiaei (Dillwyn) Spreng.

New record for São Miguel. Previously recorded for Faial and Pico (Tittley & Neto, 1994) and Flores (Tittley *et al.*, *in press*).

Distinguishing features: Main axis straight, heavily corticated near the base, bearing laterals spirally; prostrate axis well developed; 6 periaxial cells (Plate VII.2).

Habitat: Epiphytic in the lower intertidal algal turf at São Vicente.

Seasonality: One plant was collected in April 1995.

Reproduction: This plant was cystocarpic.

Remarks: Found throughout the year in British Isles, spermatangia and tetrasporangia recorded from March to October and December, and cystocarps between April and October and in December (Maggs & Hommersand, 1993). Collected in France in April and August (Lauret, 1970) and in mainland Portugal in March and June, the plant from March with tetrasporangia, the one from June having cystocarps (Ardré, 1970). Seen in June in Madeira, the plant was tetrasporangial (Levring, 1974).

Polysiphonia denudata (Dillwyn) Grev. *ex* Harv. *in* Hook.

New record for São Miguel. Previously recorded for Corvo and Santa Maria (see Neto, 1994).

Distinguishing features: Distinguished from *P. brodiaei* by having dichotomously branched main axes and by lacking prostrate axis; 5-7 periaxial cells.

Habitat: Rarely encountered, this species was present from the lower intertidal to the shallow subtidal at both sites.

Seasonality: At São Roque, plants were collected in March 1995 from the intertidal, and in April 1994 and March 1995 from the subtidal. At São Vicente, only a few plants were found in the subtidal (September 1993, October 1994, August and September 1995) but in the intertidal, more plants were collected between October 1994 and May 1995.

Reproduction: Tetrasporic plants were only seen in the intertidal at both sites, in March 1995 at the south and in May 1995 at the north.

Remarks: Present from April to November in the British Isles (Maggs & Hommersand, 1993), and between January and October in mainland Portugal (Ardré, 1970), this species was collected a few times in Madeira but only in July, all plants being fertile (Levring, 1974). Also recorded for West Africa (Lawson & John, 1982). In the British Isles Maggs and Hommersand (1993) recorded spermatangia from May to November, cystocarps and tetrasporangia in April, from June to September and in November. On the French Mediterranean coasts, Lauret (1970) reported maximum growth and reproduction in summer, with most plants being tetrasporic. In mainland Portugal, tetrasporangia were found in February, March, April and October, and cystocarps and spermatangia were present in April and October (Ardré, 1970). Locally abundant in North Carolina where it can reproduce throughout the year, although tetrasporophytes were most common from November to March and male and female gametophyte in winter and early spring (Edwards & Kapraun, 1973; Kapraun, 1977). Taylor (1978) reported sexual reproduction in late summer in New England, where it is dormant during the winter (Hehre & Mathieson, 1970). In Florida, Phillips (1960) found a winter and spring reproductive seasonality.

Polysiphonia elongata (Huds.) Spreng.

Distinguishing features: Main axes with basal cortication and with 4 periaxial cells.

Habitat: Epiphytic on other algae at São Vicente in the subtidal.

Seasonality: Only one plant was collected in November 1994.

Reproduction: The plant was a male gametophyte.

Remarks: Present throughout the year in British Isles (Maggs & Hommersand, 1993), Aegean Sea (Athanasiadis, 1987), Madeira (Levring, 1974) and northeastern coasts of North America (Taylor, 1978), this species was collected between February and April, in June and October in mainland Portugal (Ardré, 1970). Spermatangia were recorded from February to October in the British Isles, and cystocarps and tetrasporangia from February to April and in December (Maggs & Hommersand, 1993). In mainland Portugal cystocarps were seen in October (Ardré, 1970) and in July (Palminha, 1958), but on the northeastern coasts of North America, Taylor (1978) found reproductive plants at all seasons.

Polysiphonia foetidissima Cocks ex Bornet

New record for the Azores. Largely distributed in the Atlantic and the Mediterranean (Batten, 1922; Taylor, 1967; Ardré, 1970; Wynne, 1985; Price *et al.*, 1986; Maggs & Hommersand, 1993; Lawson *et al.*, 1995).

Distinguishing features: Distinguished from *P. denudata* by having 7-8 periaxial cells. Main axes less than 40µm wide and ecorticate, with straight apices and spiral branching.

Habitat: Subtidal epiphyte at São Vicente.

Seasonality: Only one plant was collected in December 1993.

Reproduction: The plant was a male gametophyte.

Remarks: In the British Isles the only records refer to the original collection made by Cocks last century. All plants were collected in autumn and were tetrasporangial (Maggs & Hommersand, 1993). In mainland Portugal tetrasporangial plants were found in June (Ardré, 1970). The Adriatic (Ardré, 1970) and Bermudas (Taylor, 1970; Wynne, 1985) records require confirmation (Farnham, pers. comm.).

There have been no other reports of gametangial plants of this species, which may be of restricted seasonal occurrence (Farnham, pers. comm.).

Polysiphonia fucoides (Huds.) Grev.

Polysiphonia nigrescens (Huds.) Grev. ex Harv. *in* Hook.

Distinguishing features: Although morphologically variable, *P. fucoides* is a distinctive species within this problematic genus. The main axis is corticated near the base and has 11-21 periaxial cells, bearing much-branched laterals in an irregularly spiral to regularly alternate and distichous arrangement.

Habitat: Epilithic in the subtidal at São Vicente.

Seasonality: Two plants were collected in January and May 1995.

Reproduction: Both plants were vegetative.

Remarks: Found throughout the year in the British Isles (Maggs & Hommersand, 1993), Madeira (Levring, 1974) and the northeastern coasts of North America (Kapraun, 1977; Taylor, 1978), this species was only seen in March in mainland Portugal (Ardré, 1970). Spermatangia were recorded from January to July and in November in British Isles, cystocarps from January to June and from August to November, and tetrasporangia between January and November (Maggs & Hommersand, 1993). In Madeira fertile plants were restricted to April and May (Levring, 1974) and on the northeastern coasts of North America reproductive plants were seen in spring and summer (Kapraun, 1977; Taylor, 1978).

Polysiphonia furcellata (C. Agardh) Harv. in Hook.

New record for the Azores. Largely distributed in the eastern Atlantic, also recorded in the Mediterranean (Feldmann, 1954; Ardré, 1970; Lauret, 1970; Athanasiadis, 1987; Maggs & Hommersand, 1993; Lawson *et al.*, 1995).

Distinguishing features: Distinguished from *P. foetidissima* by having dichotomous branching and young branches with apices paired and incurved, resembling *Ceramium*.

Habitat: Epiphytic on the algal turf in the lower intertidal at São Vicente.

Seasonality: One plant was found in March 1994.

Reproduction: The plant was non-reproductive.

Remarks: Thalli present throughout the year in the British Isles (Maggs & Hommersand, 1993), French Mediterranean coast (Lauret, 1970) and the Aegean Sea (Athanasiadis, 1987), but this species was only collected in March, April and October in mainland Portugal, where cystocarps were seen in April and tetrasporangia in March (Ardré, 1970). In British Isles reproduction occurs by fragmentation and the formation of specialized propagules, which have been observed in June, July and September (Maggs & Hommersand, 1993). According to Maggs and Hommersand (1993), reports of tetrasporangia and gametangia from Brittany and Portugal (Feldmann, 1954; Ardré, 1970) may involve *P. ceramiaeformis*, which was previously considered conspecific with this species.

Symphyocladia marchantioides (Harv.) Falkenb.

Distinguishing features: Thalli flat, prostrate, and composed of coalescent polysiphonous axes (Plate XII.1). Transverse section shows two layers of 6-8 periaxial cells with an intervening row of central cells. The later appears as veins transversing the thallus. Alternate branching. Attachment by rhizoids developed from the lower surfaces of the periaxial cells.

Habitat: Mostly epiphytic on *Zonaria tournefortii* but sometimes epilithic, this species was present in the intertidal and subtidal levels at both sites, although more abundantly in the north.

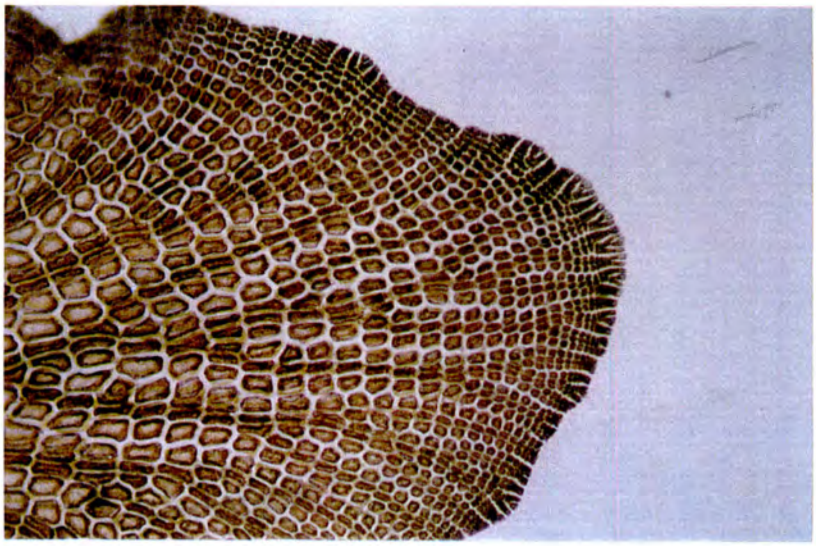
Seasonality: At the intertidal level *S. marchantioides* was present for much of the sampling period on both sites, its mean biomass being greater at São Vicente (2.9-70 g/m2) than at São Roque (2.3-47.6 g/m2). In the subtidal, this species was also collected throughout the sampling period, again being more abundant on the north site (Fig. 99, Wilcoxon test 17, 24 pairs $p<0.01$).

Reproduction: Tetrasporic plants were only found in 1995, in May at intertidal north, in August at subtidal south and in March at subtidal north.

Remarks: Widely distributed in all the islands within the archipelago (see Neto, 1994), this species was first recorded by Ardré *et al.* (1974). According to these authors it constitutes an introduction from New Zealand to the seaweed flora of the Azores and probably to the North Atlantic, not being recorded anywhere else by South and Tittley (1986) and Wynne (1985).

Plate XII

1. *Symphyocladia marchantioides*: Portion of thallus showing the coalescent polysiphorous axes (x 40).
2. ?*Callophylis*: Transverse section through sterile blade showing outer, small celled, cortex and inner large celled medulla (x200).
3. ?*Chondrymenia*: Cross section of blade showing outer compact cortex and filamentous medulla with the medullary filaments interwoven with rhizoids (x200).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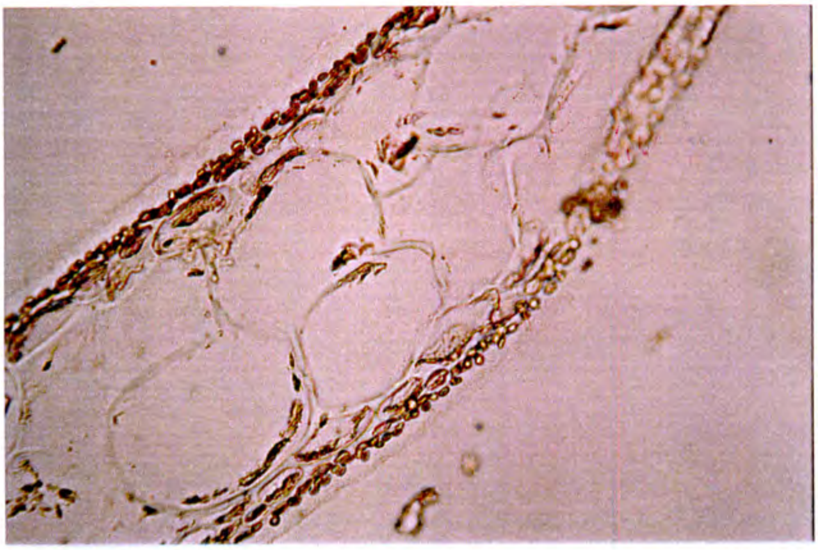
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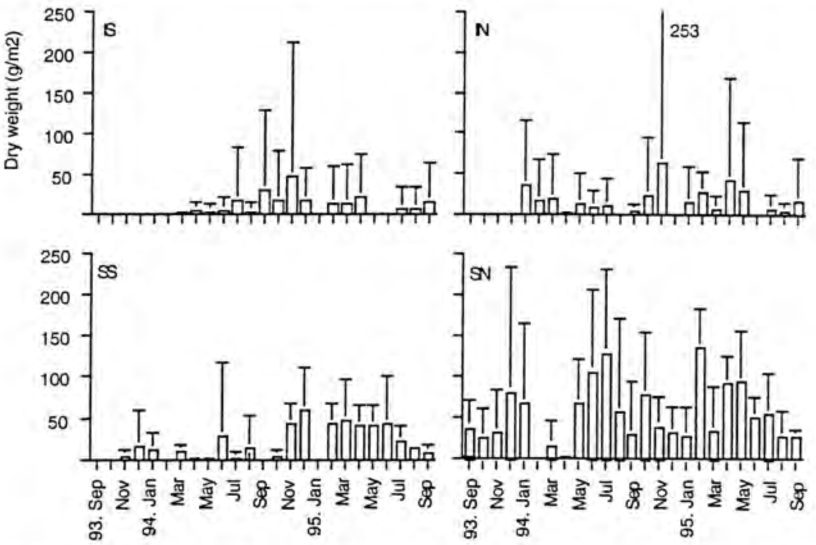


Fig. 99 Monthly biomass (mean + standard deviation) of *S. marchantioides*. For abreviations see section 3.5.

Sebdenia prox.

Distinguishing features: Thalli (10-15 cm in length) soft, slippery but tough, somewhat flattened, branching mainly dichotomous. The transverse section reveals an outer layer of small cortical cells, an inner layer of larger cortical cells and an internal filamentous medulla with stellate cells. All these anatomical features suggest *Sebdenia* in the Gigartinales, except for the presence in some plants of gland cells within the cortex. This genus has been investigated by Balakrishnan (1961) and Codomier (1972b), who describe reproductive ampullae, which are not accessory, and tetraspores which are zonate. Like many others plants from this study, these collections need further work. It is necessary to find reproductive plants so as to elucidate the systematic position and identity of this distinctive species.

Habitat: The plants referred to here were only seen in the subtidal level (15m) at São Vicente, attached to stones.

Seasonality: Three plants were collected during the sampling period (August and November 1994 and July 1995). All showed effects of herbivory.

Reproduction: None of the observed plants was found to be reproductive, despite intensive investigation of sections and squash preparations.

?*Callophyllis* sp.

Distinguishing features: Thalli (c. 2-4 cm high) usually flattened, attached by a small disc, profusely and irregularly branched, with a few dichotomies. Numerous marginal proliferations. Plants somewhat gelatinous (and slippery sometimes) but also tough. The transverse section (Plate XII.2) shows an outer layer of small cortical cells covering an inner layer of large and rounded colourless cells (cellular or pseudoparenchymatous type of medulla). There are no medullary filaments. Although a "working" denomination of *Callophyllis* has been adopted for convenience because of morphological similarity with many species in this genus, the absence of filaments from the medulla precludes *Callophyllis* from being considered further (Norris, 1957). No reproductive structures were found in the specimens.

Habitat: This species was only present at São Roque, where it was epilithic on rocks in the subtidal zone (5-15m).

Seasonality: Two plants were collected during the sampling period, in May and June 1994 (c. respectively 3.5 and 2.3 cm).

Reproduction: None of the observed plants was fertile.

?Chondrymenia

Distinguishing features: The plants included under this determination show large similarities to the genus above: thallus erect with an expanded, irregularly lobed or split blade, soft but tough; compact cortex, with smaller cells outwards; filamentous medulla, with the medullary filaments interwoven with rhizoids; no gland cells; no stellate cells (Plate XII.3). A positive determination has not yet been possible, even when female plants were available. The external morphology resemble *Meredithia mycrophylla* (J. Agardh) J. Agardh (Cryptonemiales), which has been recorded for the Azores (Neto *et al.*, 1991). There is also a possibility that all the observed material is *Chondrymenia lobata* (Meneghini) Zanardini (Gigartinales), a species only known from the Mediterranean (Boudouresque *et al.*, 1992). If this is so, then this represents a new record for the Azores and North Atlantic Ocean.

The genera *Cryptonemia* and *Kallymenia* show some features in common with this indeterminate foliose red but are characterized anatomically by the occurrence of stellate cells and a very thin cortex (1-3 cells thick), as described by Chiang (1969) for the former and by Norris (1957) and Irvine (1983) for the later.

Habitat: Epilithic in the subtidal level, plants were found at both sites, although more commonly at São Vicente.

Seasonality: In the south only three plants were collected (May, August and November 1994), varying in length between 4 and 5.3 cm. At São Vicente, although not always present, plants of this group were collected throughout the sampling period. Mean biomass was between 0.1 and 63 g/m2 (Fig. 100) and the length of plants varied from 2.5 to 7.5 cm (Fig. 101).

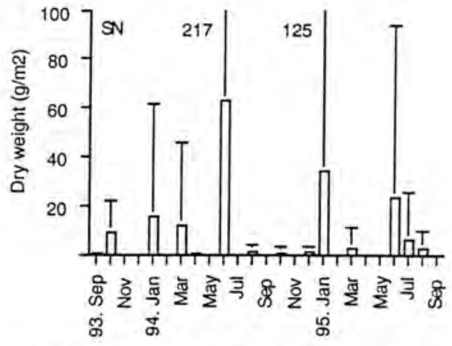


Fig. 100 Monthly biomass (mean + standard deviation) of ?*Chondrymenia*. For abreviations see section 3.5.

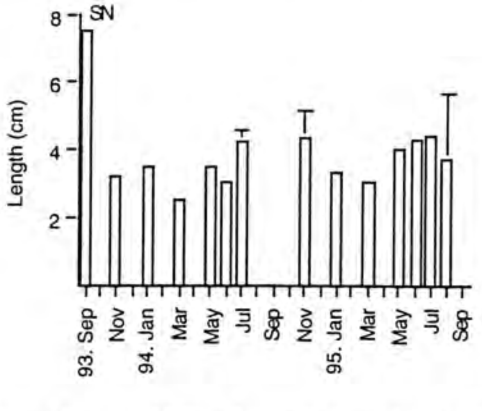


Fig. 101 Monthly maximum length of ?*Chondrymenia* (error bars indicate the standard deviation). For abreviations see section 3.5.

Reproduction: No reproductive plants were seen at São Roque, but female plants with mature cystocarps were found from July to September at São Vicente, suggesting that reproduction takes place in the summer. It was difficult to make satisfactory preparations to investigate the structure of the cystocarp.

"Menia" nd

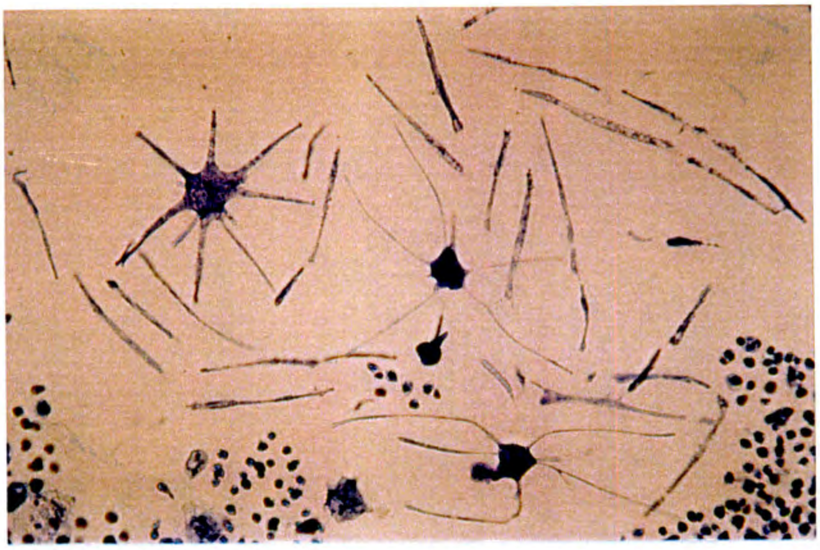
Distinguishing features: This designation includes a group of plants which present characteristics in common with several genera of foliose red algae e.g. *Schizymenia, Kallymenia, Halymenia, Cryptonemia*. All the plants considered in this group are soft and slippery, although not easily squashed and the thallus is compressed. The transverse section shows an outer layer of small cortical cells; inner layer of large and rounded cortical cells; internal filamentous medulla with stellate cells (Plate XIII.1). Specimens usually showed signs of having been grazed.

The distinction between "Menia" nd (1) and "Menia" nd (2) was based on the absence of gland cells in the former, but which in "Menia" nd (2) were abundant and very distinctive (Plate XIII.2), being laterally sessile on the medullary filaments.

Plate XIII 1-2. "Menia"nd: Internal filamentous medulla (squashed preparation stained in aniline bue), showing (1) stellate cells (x200) and (2) medullary gland cells (x400).

3. *Caulacanthus ustulatus*: Plants growing in a monospecific turf on the eulittoral of São Roque.

1



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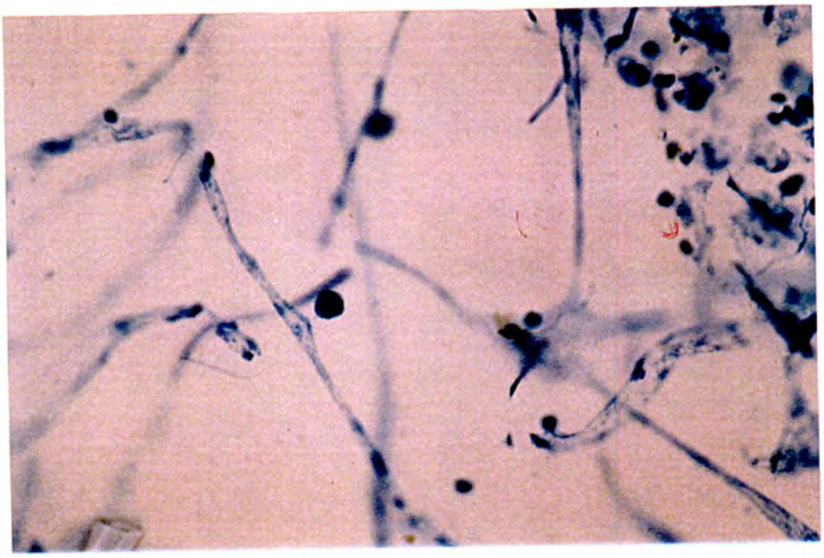

3

Detailed investigation, especially concentrating on carposporophyte development, of all these foliose red algae is required to resolve the taxonomic problems indicated here, as was notably done by Abbott (1967a, b, 1968).

"Menia" nd (1)

Habitat: Subtidally at both localities.

Seasonality: Three plants were collected: in March 1994 at São Roque, and in September 1993 and January 1994 at São Vicente, their lengths varying between 5 and 9 cm.

Reproduction: The plants from March and September were fertile, containing cruciate tetrasporangia immersed in the outer cortex.

"Menia" nd (2)

Habitat: Strictly subtidal, plants of this group were collected at both sites, although more commonly at São Vicente.

Seasonality: Three plants were collected at São Roque between April and July 1994, varying in length from 8 to 15 cm. At São Vicente, four plants were collected (September and October 1993, June and August 1994), which were slightly larger (8.5-18.5 cm).

Reproduction: No reproductive plants were seen at São Roque. At São Vicente, the plant collected in October 1993 was tetrasporic (cruciately divided sporangia) and the plants from June and August 1994 were both females, bearing cystocarps without pores scattered over the blade.

4.4 General biological and biogeographical remarks

Excluding the "problematic taxa", 156 species, belonging to 19 orders and 41 families, have been identified. The present study adds 29 new algal records for the Azores (4 species of Chlorophyta, 2 Phaeophyta and 23 Rhodophyta) and 39 new records for the island of São Miguel (5 Chlorophyta, 7 Phaeophyta and 27 Rhodophyta). The known algal flora of São Miguel was thus increased by 68 species, totalling now 191 records (33 Chlorophyta, 34 Phaeophyta and 124 Rhodophyta). The 307 species of marine macroalgae listed for the Azores by Neto (1994) are now increased to 336 (52 Chlorophyta, 68 Phaeophyta and 216 Rhodophyta).

As with the Macaronesian region in general (Levring, 1974; Gil-Rodríguez & Afonso-Carrillo, 1980; Prud'homme van Reine, 1988), the results of the present study demonstrate a seaweed flora clearly dominated by members of Rhodophyta. This had been previously referred for the Azores (Neto, 1994).

Feldmann (1937) proposed that the affinities of a marine flora could be ascertained by comparing the number of species of red algae (R) to the number of brown algae (P), high values of the R/P ratio being indicative of warm-temperate floras and, conversely, low values indicating cold-water floras. Later, Cheney (1977) amended this ratio by incorporating the number of green algal species (C): (R+C)/P. In warmer waters, there is a general increase in numbers of red and green algae, together with a decrease in number of browns. Thus, floristic ratios of less than 3 indicate a cold or temperate flora, while values above 5-6 represent a tropical flora (Earll & Farnham, 1983).

The application of this floristic ratio to the flora of the present study (SMG) and to that of the Azores in general (Table III) reveals the presence of a sub-tropical flora, similarly to the Canaries and Trinidad (data from Earll & Farnham, 1983).

Table III. Floristic ratios for sevreal regions on the Atlantic Ocean (R, C and P, number of species of, respectively, red, green and brown algae).

Place	R	C	P	R+C+P	(R+C)/P	R/P	References
British Isles	334	115	207	656	2.2	1.6	Parke and Dixon (1976)
mainland Portugal	246	60	98	404	3.1	2.5	Ardré (1970)
W. Mediterranean	175	40	65	280	3.3	2.7	Coppejans (1980)
Azores	216	52	68	336	3.9	3.2	Neto (1994, the present study)
São Miguel	124	33	34	191	4.6	3.6	Neto (1994, the present study)
Canaries	202	69	55	326	4.9	3.7	Børgesen (1925, 1926, 1927, 1929, 1930)
Jamaica	161	123	47	331	6.0	3.4	Chapman (1961, 1963)
Trinidad	71	38	24	133	4.5	3.0	Richardson (1975)

Most of the species identified in the present study are eurythermal, and have a wide range of distribution in the North Atlantic (Table I). Some can even be found from the Arctic to the Tropics (ACWT) i.e. they are cosmopolitan in distribution, such as *Bryopsis hypnoides*.

The cold water component of the Azorean flora contains species present in the Arctic and cold temperate regions (AC), with the Azores representing their southern limit of distribution (*Coccotyus truncatus, Scagelia pylaisaei*). *Sphaerotrichia divaricata* is in this group but is also present in the Mediterranean. A larger number of species is absent from the Arctic but present from the cold temperate regions to the Tropics (CWT) e.g. *Padina pavonica.* Other eurythermal species are present from the Arctic through the warm temperate regions, where the Azores are included (ACW). Among these, *Erythrodermis traillii, Dilsea carnosa,* and *Brongniartella byssoides* have their southern limit of occurrence in the Azores, the later being also present in the Mediterranean.

A few warm-temperate and tropical (WT) species were found: *Cystoseira abies-marina, Botryocladia botryoides, Jania longifurca* and *Peyssonnelia squamaria,* the former being strictly Macaronesian (González & Afonso-Carrillo, 1990). Two tropical species were present, *J. crassa* and *J. verrucosa,* both having their northern limit on the Azores.

Another group of species presented a strictly temperate distribution. Among them, only *Codium elisabethae* was exclusively from the warm temperate regions (W). This species is only known from the Azores and Madeira. It was regarded as endemic to the Azores by Schmidt (1931), but was found later at Porto Santo, Madeira archipelago (Audiffred & Prud'homme van Reine, 1985; Prud'homme van Reine, 1988). A larger number of species was present in both cold and warm temperate regions (CW). Among them, *Chaetomorpha mediterranea, Codium vermilara, Aglaothamnion bipinnatum, A. pseudobyssoides, Ceramium botryocarpum. Compsothamnion decompositum* and *Drachiella heterocarpa,* have their southern limit of occurrence in the Azores. *Zanardinia prototypus* and *Radicilingua thysanorhizans* also belong to this group but occur north of the Azores in the Mediterranean. *Ceramium pallidum* and *C. secundatum,* two cold temperate (C) species, were present in the collections, the Azores constituting now their southern limit of distribution.

The Azorean algal flora has therefore a mixed nature of cold and warm water species, some of them having here their southern or northern limit of distribution.

Several species have been referred to as representing possible recent introductions to the Azorean algal flora: *Symphyocladia marchantioides* (Ardré *et al.*, 1974), *Endarachne binghamiae* (Yoneshique, 1985; Tittley & Neto, 1994), *Antithamnion diminuatum* and *Scageliopsis patens* (Athanasiadis & Tittley, 1994), *Sphaerotrichia divaricata* (Neto, 1991b), *Codium fragile* (Tittley *et al.*, in press) and *Codium vermilara*, the later reported here for the first time.

The majority of species from the present study (92) is amphi-Atlantic. Some (35) are only present in the eastern Atlantic and the Mediterranean, e.g. *Codium vermilara, Cystoseira foeniculaceus, Taonia atomaria, Corallina elongata, Ceramium ciliatum.* A few (12) are exclusively from the eastern Atlantic, such as *Chaetomorpha mediterranea, Rhodymenia holmesii, Ceramium botryocarpum.* None of the species was exclusively from the western Atlantic. As a whole, the seaweed flora of this study revealed larger similarities with the eastern Atlantic.

The comparison of the seaweed flora of São Miguel, Faial (central group) and Flores (western group), based on the checklist of Neto (1994), with the additions of Tittley *et al.* (in press) and of the present study, revealed no major differences between those three islands (Table IV).

Table IV. Comparison among the seaweed flora of the islands of São Miguel (SMG), Faial (FAI) and Flores (FLW), using the Sørensen coefficient of similarity (S_S, upper diagonal), and the Jaccard coefficient of similarity (S_J, lower diagonal).

	FLW	FAI	SMG
FLW	_	0.54	0.55
FAI	0.37	_	0.55
SMG	0.38	0.38	_

Some of the taxa considered in the present study were restricted to the intertidal level. Amongst these, two were restricted to the upper littoral (*Fucus spiralis, Gelidium microdon*); a few were found only in tide pools (*Sphaerotrichia divaricata, Sargassum cymosum, S. filipendula, Cystoseira humilis, Gymnogongrus crenulatus*); others were only seen in the algal turf that covered the rocks at the lower intertidal (*Antithamnion diminuatum, Callithamnion granulatum, C. tetragonum, Ceramium botryocarpum, C. cimbricum, C. deslongchampii, C. diaphanum, C. flaccidum, C. nodulosum, C. pallidum, C. secundatum, C. strictum, Griffithsia corallinoides, Scageliopsis patens, Taenioma nanum, Dasya corymbifera, Lophosiphonia reptabunda, Polysiphonia brodiaei, P. furcellata*); a few were exclusively found in crevices and shaded places (*Gastroclonium ovatum, Lomentaria articulata* and, in most cases, *Botryocladia botryoides* and *Grateloupia dichotoma*). Most of them were, however, found on the open rocks (*Enteromorpha intestinalis, E. muscoides, Chaetomorpha linum, C. mediterranea, Cladophora coelothrix, C. hutchinsiae, C. laetevirens, C. lehmanniana, Ectocarpus siliculosus, Hincksia mitchelliae, Zanardinia prototypus, Endarachne binghamiae, Scytosiphon lomentaria, Fucus spiralis, Nemalion helminthoides, Gelidium microdon, G. pusillum, Dilsea carnosa, Coccotyus truncatus, Gymnogongrus griffithsiae, Caulacanthus ustulatus, Rhodymenia pseudopalmata, Chondria coerulescens, C. dasyphylla, Laurencia hybrida, L. obtusa*).

Certain other taxa were exclusively found in the subtidal zone (*Anadyomene stellata, Valonia utricularis, Codium decorticatum, C. elisabethae, C. fragile, C. vermilara, Halopteris filicina, Cladostephus spongiosus, Dictyopteris membranacea, Stypopodium zonale, Taonia atomaria, Carpomitra costata,* rosette *Sargassum* type *acinarium, Liagora distenta, L. viscida, Schimmelmania schousboei, Amphiroa beauvoisii, Jania capillacea, Dudresnaya verticillata, Erythrodermis traillii, Mastocarpus stellatus, Sphaerococcus coronopifolius, Champia parvula, Aglaothamnion bipinnatum, Anotrichium barbatum, Compsothamnion decompositum, Pterothamnion plumula, Spermothamnion repens, Sphondylothamnion multifidum, Wrangelia penicillata, Apoglossum ruscifolium, Brongniartella byssoides, Polysiphonia atlantica, P. elongata, P. foetidissima, P. fucoides*). Amongst these, *Codium fragile, Carpomitra* and *Schimmelmania* were only present at the 15m depth level.

Some species were present throughout the year, although some variations were observed on their abundance and size.

In the Chlorophyta, *Enteromorpha muscoides, Ulva rigida, Chaetomorpha linum, Cladophora coelothrix, C. prolifera, Valonia utricularis, Bryopsis hypnoides, Codium adhaerens* and *C. elisabethae* were collected all year round. *Ulva* and *Bryopsis* presented a seasonal pattern of growth, with larger plants present respectively in summer and spring. Other species presented a seasonal pattern in their reproduction. *Enteromorpha muscoides* was reproductive in winter and early spring, while *C. linum* was fertile in summer. *Codium adhaerens* was reproductive in late summer and autumn and *C. elisabethae* was fertile in autumn and winter.

The remaining Chlorophyta were present only at certain times of the year. Species present in summer included *Cladophora lehmanniana* and *Codium fragile*; *Anadyomene stellata* was found in spring and summer, while *Codium decorticatum* was present in summer and autumn. *Chaetomorpha mediterranea* was only seen once in winter and *Codium vermilara* was restricted to autumn.

Brown algae collected all year round included: *Halopteris filicina, Stypocaulon scoparia, Dictyota* *dichotoma, Padina pavonica, Taonia atomaria, Zonaria tournefortii, Colpomenia sinuosa, Hydroclathrus clathratus, Fucus spiralis*, rosette *Sargassum* type *hystrix, Sargassum filipendula* and *Cystoseira abies-marina*. Larger plants and higher values of biomass occurred in spring and summer for most of them (e.g. *D. dichotoma, P. pavonica, T. atomaria, C. sinuosa,* H. *clathratus, S. filipendula*). In addition, most were reproductive at all seasons, exceptions being *T. atomaria* (reproductive period restricted to late spring and summer), and rosette *Sargassum* type *hystrix* (only reproductive in summer).

Other Phaeophyta had a more restricted occurrence. Occurring exclusively in one season were: *Ectocarpus siliculosus, Zanardinia prototypus, Dictyopteris membranacea, Stypopodium zonale, Scytosiphon lomentaria* and *Cystoseira humilis* (in spring); *Hincksia mitchelliae, Carpomitra costata* and rosette *Sargassum* type *acinarium* (in summer); *Cladostephus spongiosus* (in autumn); *Sargassum cymosum* (winter). *Sphaerotrichia divaricata* was collected in winter and spring.

Many of the red algae were only occasionally found but many others were abundant and frequently present in the collections. Species collected throughout the year included *Asparagopsis armata, Gelidium latifolium, G. microdon, Pterocladia capillacea, Peyssonnelia squamaria, Corallina elongata, Jania crassa, J. longifurca, J. rubens, J. verrucosa, Chondracanthus acicularis, Plocamium cartilagineum, Sphaerococcus coronopifolius, Hypnea musciformis, Caulacanthus ustulatus, Lomentaria articulata, Centroceras clavulatum, Pterothamnion crispum, Chondria coerulescens, Laurencia obtusa, Osmundia pinnatifida* and *Symphyocladia marchantioides*. Most of them underwent large fluctuations in size and biomass over the year. For a small number of species a seasonal pattern was detected, with larger plants and higher values of biomass occurring in spring and/or summer (e.g. *Asparagopsis, Gelidium microdon, Chondracanthus acicularis* and *Plocamium*). A seasonal pattern was also observed in the reproduction of some species. *Jania verrucosa* was only reproductive in summer while *Pterocladia* was tetrasporic in summer and autumn. A longer reproductive period was shown by other species: *G. microdon* tetrasporophytes and *Sphaerococcus* female plants were seen from spring to autumn; *Jania rubens* was fertile from summer to winter; *Plocamium* and *Caulacanthus ustulatus* were tetrasporic from autumn to spring and *Pterothamnion crispum* from winter to summer; the gametophyte of *Asparagopsis* was present in winter and spring, while the tetrasporophyte was seen earlier, in autumn and winter.

As in the other divisions, some red algae had a seasonal occurrence. Those occurring only in summer included *Liagora divaricata, L. distenta, Nemalion helminthoides, Schimmelmannia schousboei, Dudresnaya verticillata, Amphiroa beauvoisii, Schizymenia dubyi, Erythrodermis traillii, Phyllophora crispa, Chondracanthus teedii, Rhodymenia pseudopalmata* and *Compsothamnion decompositum*. Species occurring only in autumn were *Antithamnion diminuatum, Griffithsia corallinoides, Sphondylothamnion multifidum, Dasya corymbifera, Polysiphonia atlantica* and *P. elongata*. *Champia parvula, Ceramium circinatum, Scageliopsis patens* and *Polysiphonia furcellata* were winter species. Species restricted to spring included *Lophosiphonia reptabunda, Polysiphonia brodiaei* and *P. fucoides*. Other taxa had a longer period of occurrence: *Anotrichium barbatum* was present in autumn and winter; *Callithamnion corymbosum* and *Ceramium nodulosum* in winter and spring, *C. flaccidum, C. strictum*, and *Apoglossum ruscifolium* in spring and summer; *Nitophyllum punctatum* in summer and autumn.

Despite the seasonality showed by several species in their biomass and size, it is worth noting that different species had different seasonal patterns and in most cases the periods of maximum biomass and size of different species did not coincide. Most species were more abundant in spring and summer, the months in which the seawater temperature and the day length were either higher or increasing (cf. Figs. 2 and 3). A few species were more abundant in summer/ autumn, others in autumn/winter, and others in winter/spring. Some species had a more restricted period of abundance, e.g. *Corallina elongata* and *Jania crassa* in autumn, *Gelidium latifolium* in winter.

The same was observed for the size of the plants. Although large fluctuations were usually detected over the sampling period, most species did not demonstrate a clear pattern in their growth. Species showing seasonality usually had larger plants in spring and summer, although some were restricted to this later season. In a few instances, the larger plants occurred in winter/spring e.g. *Plocamium cartilagineum*.

Reproductive seasonality was observed in many species during the present study. Some species were characterized by a prolonged fertile period (*Gelidium microdon, Jania rubens, Caulacanthus ustulatus, Plocamium cartilagineum, Sphaerococcus coronopifolius, Pterothamnion crispum*), *Fucus spiralis* being fertile throughout the year. Others were reproductive only over two seasons: *Taonia atomaria* in spring and summer; *Codium adhaerens* and *Pterocladia capillacea* in summer and autumn; *Codium elisabethae* and the tetrasporophyte of *Asparagopsis armata* in autumn and winter; *Enteromorpha muscoides* and the gametophyte of *A. armata* in winter and early spring. A few had their reproduction restricted to a short period in the year: *Chaetomorpha linum*, rosette *Sargassum* type *hystrix* and *Jania verrucosa* in summer; *Chondracanthus acicularis* in autumn.

5. ECOLOGY AND DYNAMICS OF THE ALGAL COMMUNITIES

Traditional models of community organization have emphasized the dynamic interactions involving resource availability, competition for these resources, and patterns of disturbance as the primary processes regulating structure in natural communities (MacArthur, 1972; Connell, 1975; Menge & Sutherland, 1976). Others have argued that these models are incomplete for many marine systems because they neglect the importance of certain extrinsic factors such as patterns of immigration of new species and propagules (Dayton, 1979; Underwood & Denley, 1984; Menge & Sutherland, 1987). These are extremely important, as well as the settlement rates of larvae and algae spores.

The structure of vegetation is defined by three components: the vertical arrangement of species, i.e. the stratification of the vegetation; the horizontal arrangement of species, i.e. the spatial distribution of individuals; and, finally, the abundance of each species. The later component of vegetation can be expressed in several ways, ranging from a direct count of the number of individuals in an area (density) to the dry weight of vegetable material produced in a given area (yield) (Kershaw, 1973).

5.1 Intertidal communities

The shore constitutes the border between sea and land, and exhibits a gradient in many environmental factors. The organisms living within this border are only present in part of this littoral area, forming distinct zones at different vertical levels on the shore. A regular distribution of species and communities is particularly obvious on rocky shores, as has long been recognized by marine biologists. According to Stephenson and Stephenson (1949), the various physical and chemical gradients across the air/water interface may account for the distribution of communities into horizontal, apparently homogeneous fringes with sharp boundaries (zonation), although biotic factors, such as competition, are now also considered to be important (Chapman, 1973).

Zonation patterns of the littoral region have been studied all over the world (Gilsén, 1929; Chapman, 1946, 1957, 1962; Stephenson & Stephenson 1949, 1972; Feldmann, 1951; Chapman & Trevarthen, 1953; Gessner, 1955; Southward, 1958; Schwenke, 1960; Lewis, 1972; Pérès, 1982; see also Thomas, 1985), with further comparisons made between sheltered and exposed sites (Lewis, 1972), and between different types of substratum (den Hartog, 1959).

There are several papers describing the zonation patterns in different areas of the Azores (Schmidt, 1931; Larkum, 1960; Pryor, 1967b; Ardré *et al.*, 1973; Castro & Viegas, 1987; Hawkins *et al.*, 1990; Neto & Azevedo, 1990; Neto, 1992a; Neto & Tittley, 1995; Tittley *et al.*, in press). This chapter presents a new and more detailed characterization of those patterns on the island of São Miguel. A survey of the vertical distribution of the different organisms in the intertidal zone of São Roque and São Vicente was carried out over a two year period and the major zones characterizing each coast were identified. The major difference between these two sites is that São Vicente is assumed to be more exposed to wave action.

5.1.1 Zonation

At both sites (Figs. 102 and 103), five distinct zones were found, although a high degree of overlap was noted in some instances, such as *Chthamalus* occurring within the lower littorinids zone at São Roque (Fig. 102). High up in the shore there was a zone with littorinids (*Littorina striata* King and *Melaraphe neritoides* (L.)), followed by one dominated by barnacles (*Chthamalus stellatus* (Poli)). The algal populations formed three distinct bands: below (on the south coast) or overlapping the upper fringe of the barnacles zone (in the north), was a distinct fringe of *Fucus spiralis* and *Gelidium microdon*, followed by a turf zone. This comprised two fairly distinct subzones, the upper one an almost monospecific turf of *Caulacanthus ustulatus*, the lower comprising a multispecific turf dominated by coralline algae at São Roque and by *Centroceras clavulatum* in the north. The lower intertidal algal zone, which continued subtidally, was dominated by frondose algae, mainly articulated corallines, *Asparagopsis* and *Pterocladia*.

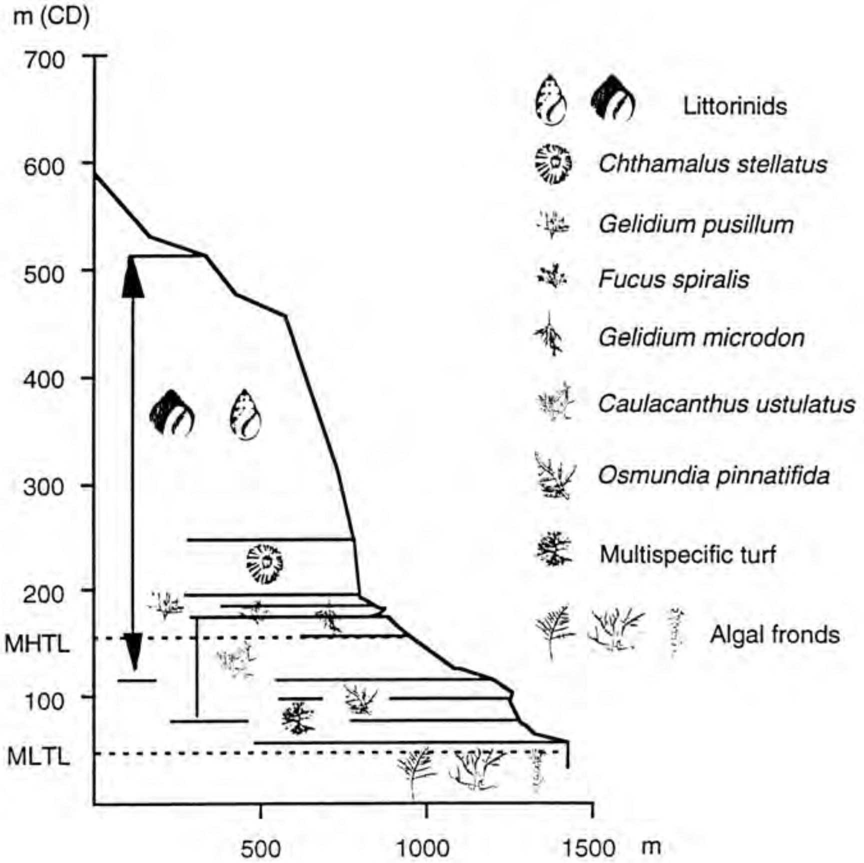

Fig. 102 Schematic profile of the intertidal station of São Roque with the vertical distribution of the dominant organisms (MLTL - mean low tide level; MHTL - mean high tide level; CD - chart datum, Azores).

All the zones were present throughout the year and, although some annual fluctuations were detected in their upper and lower limits, most species showed a well established vertical position on the shore. The major differences between the two coasts were the upper limit of the littorinids, which was higher at São Roque, and the physiognomy of the *Fucus spiralis / Gelidium microdon* zone, which was patchy at São Roque but continuous at São Vicente.

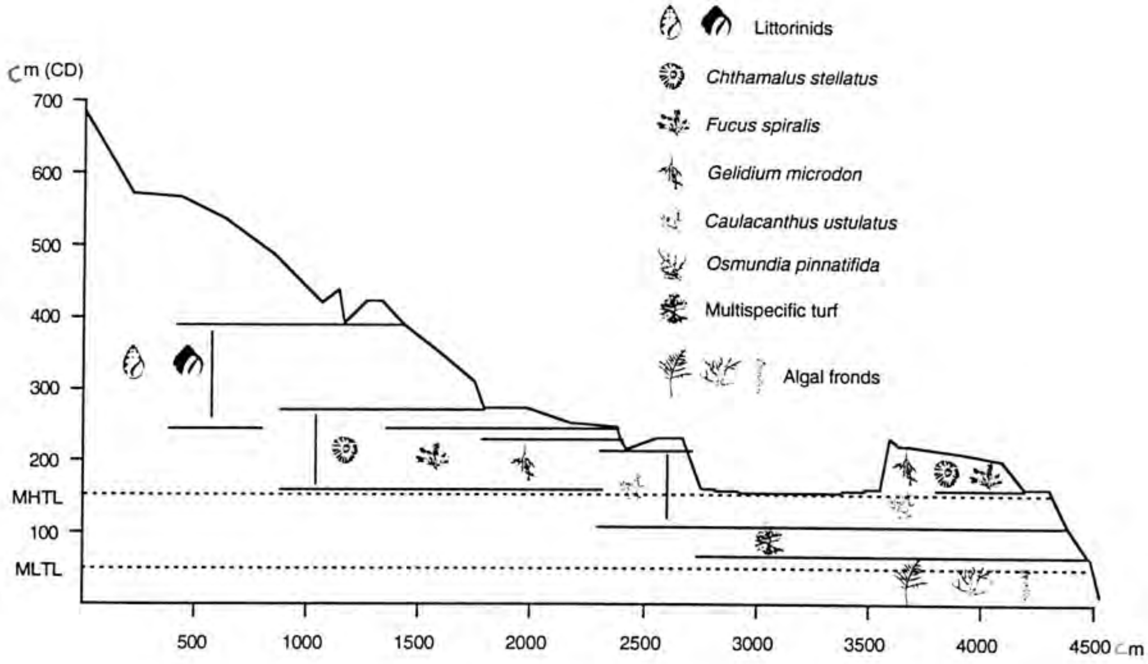

Fig. 103 Schematic profile of the intertidal station of São Vicente with the vertical distribution of the dominant organisms (MLTL - mean low tide level; MHTL - mean high tide level; CD - chart datum, Azores).

This zonation pattern follows the general scheme established by Neto (1992a) for the littoral zone of the island of São Miguel. The main differences reported here are the presence of the distinct fringe of *Fucus spiralis / Gelidium microdon* and the monospecific turf of *Caulacanthus ustulatus*. At São Roque, a narrow band of another *Gelidium* (*G. pusillum*) was present for most of the year below the barnacles zone, overlapping the algal fringe of *Fucus spiralis / Gelidium microdon*. A few limpets (*Patella* spp.) were seen at both sites, but no proper limpet gardens were detected over the two year period of investigation.

A multispecific turf covered the rocks in the lower eulittoral zone of both coasts. At São Roque it was dominated by coralline algae, together with the accompanying species *Osmundia pinnatifida, Chaetomorpha linum, Gastroclonium reflexum, Chondria sp.* and *Ceramium pallidum*. At São Vicente, this turf was dominated by *Centroceras clavulatum, Ceramium ciliatum* and coralline algae. Other noteworthy species included *Chondracanthus acicularis* and *Colpomenia sinuosa*. The later species was found growing epiphytically on the coralline algae of the turf, as was also observed by Lawson and Norton (1971) at Tenerife (Canaries).

The lower littoral level (sublittoral fringe), characterized by erect frondose algae, at São Roque started at MLTL. It was dominated by the articulated corallines *Corallina elongata* and *Jania* *crassa* throughout the sampling period. Other important species at this level were *Pterocladia capillacea, Asparagopsis armata, Jania rubens, Laurencia obtusa, Ulva rigida* and *Ceramium pallidum.* At São Vicente, this community was dominated by *Pterocladia capillacea, Centroceras clavulatum, Corallina elongata* and *Stypocaulon scoparia.* Other, mainly perennial, species present at this level for much of the sampling period included *Laurencia obtusa, Osmundia pinnatifida* and *Ceramium ciliatum.* Many of these species such as *Pterocladia, Asparagopsis* and *Stypocaulon* extended into the subtidal zone.

5.1.2 Community structure

Reference to almost any ecological journal or book will show the continuing lack of agreement on what constitutes stability and how it is related to diversity (Odum, 1971, 1975; Orians, 1975; Menge & Sutherland, 1976; McNaughton, 1977). On rocky shores, environmental stress by physical factors can be important (Sanders, 1968; Dayton, 1971; Lewis & Bowman, 1975; Bowman & Lewis, 1977), but biological interactions appear to provide many of the reasons for the community patterns (Connell, 1972, 1975). In a simple system with high environmental stress (Menge, 1976), interspecific competition for space is important in wave-exposed areas, while predation is important in sheltered ones. In more complex communities both herbivory and competition for space operate on different facets of the community or at a different tidal levels (e.g. Connell, 1970; Luckens, 1975; Branch, 1976; Menge & Sutherland, 1976). However, experimental removal of a dominant predator or grazer results in an increase in biomass and often reduces species diversity (Paine, 1966, 1971; Paine & Vadas, 1969; Connell & Orias, 1964; McNaughton, 1977).

Classically, intertidal ecology has been concerned with very elaborate descriptions of the vertical distributions of species in relation to tidal fluctuations (Chapman, 1973). However, the larger scale of community stability is determined by the aggregate of separate patch dynamics, by the types of interactions between the patches and, especially, by the physical regimes that strongly influence so many of these relationships. Such patches are influenced by such factors as physical stress and disturbance, competition or predation, or dispersal and behaviour (Dayton *et al.*, 1984). It should be emphasized that most intertidal communities are not so strongly demarcated but rather are influenced by a continuum of many factors and more typically lie somewhere between these physically disturbed and more benign extremes (Littler & Littler, 1981). Physical disturbance can determine algal biomass and community structure (Fisher *et al.*, 1982; Robinson & Minshall, 1986; Power & Stewart, 1987; Dudley & D'Antonio, 1991).

Only a few studies have been done on the structure of the intertidal communities of the Azores. Earlier, Neto (1991b, 1992a) studied the algal communities dominating the lower eulittoral and the upper infralittoral zones of two places of the island of São Miguel. That study was done over a year period and the effects of geographic location (on the island) and time were analysed. Neto and Tittley (1995) and Tittley *et al.* (in press), on the islands of Faial and Flores respectively, studied the species associations and abundance of several intertidal communities, but only in the summer.

This is a further contribution to the study of the intertidal communities of the Azores. A more detailed account of this present investigation is to be given by Neto and Farnham (in prep.).

With the exception of the *Fucus spiralis / Gelidium microdon* association, which was sporadic at São Roque, the algal populations of both coasts were similar in physiognomy, although differing somewhat in species composition. In the present study, the benthic algal vegetation of the upper and lower levels of the eulittoral zone of each coast is described, and the effects of vertical position on shore, geographic location (on the island) and time are analysed. In São Roque, these levels were dominated respectively by the *Caulacanthus* turf (Plate XIII.3), and the erect Corallinaceae turf. In São Vicente, the upper eulittoral zone was dominated by the *Fucus spiralis / Gelidium microdon* association and the lower eulittoral by the *Centroceras* / erect Corallinaceae turf.

5.1.2.1 Composition and floristic analyses

Intertidal communities of both coasts varied both in species composition and dominance, the lower levels having a higher number of species and higher equitability (Fig. 104).

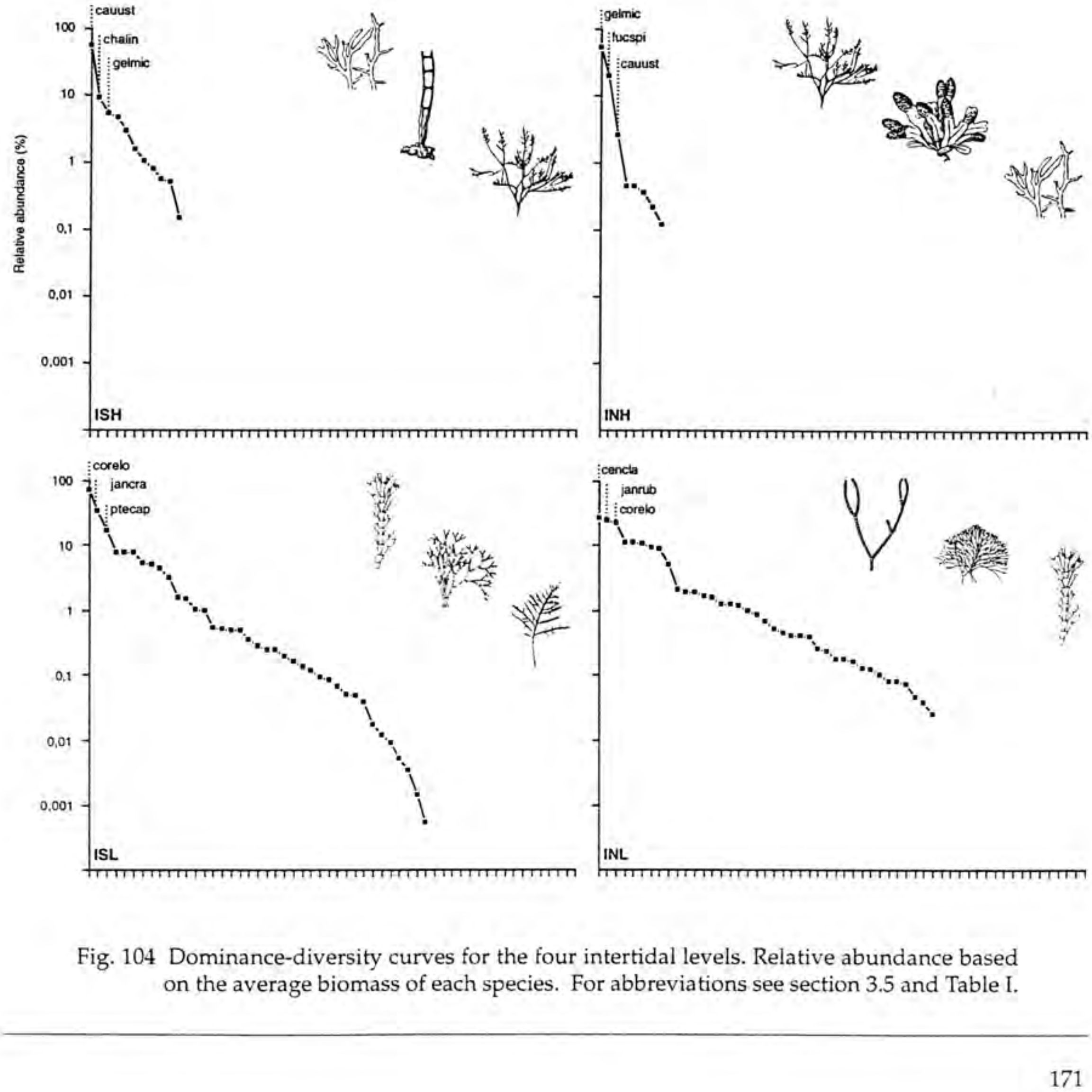

Fig. 104 Dominance-diversity curves for the four intertidal levels. Relative abundance based on the average biomass of each species. For abbreviations see section 3.5 and Table I.

The lower turf zone at São Vicente had the higher number of species, with their biomass being more uniformly distributed among its component species, whereas the upper algal turf zone in the same site was characterized by the lowest species diversity and equitability.

The Shannon diversity index values (Fig. 105) confirm the above observations. Comparing all the four levels (upper and lower zones at the two sites), the upper eulittoral at São Vicente was the one with a low diversity, the lower level at the same place being, on the other hand, the one with both a high number of species and high diversity.

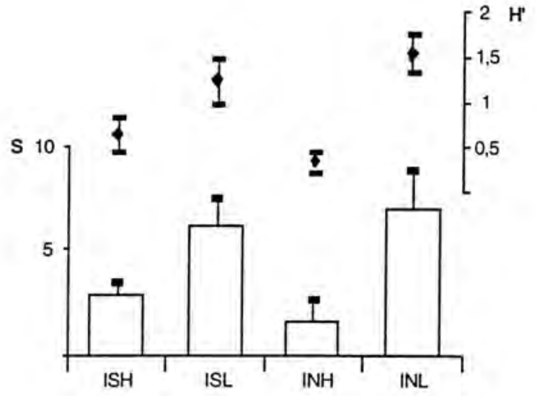

Fig. 105 Mean diversity on the four intertidal levels: number of species (S) + standard deviation; Shannon diversity index (H') ± standard deviation. For abbreviations see section 3.5.

At São Vicente, the upper eulittoral was dominated by the *F. spiralis/G. microdon* association during all the sampling period, with only a few subordinate or associated species. *Gelidium microdon* was always dominant, responsible for 69% of the total mean biomass, while *F. spiralis* contributed only 26% (Fig. 106). At São Roque, the comparable zone was dominated by a turf of *Caulacanthus ustulatus*, but some accompanying species were present during much of the year, accounting for 34% of the total mean biomass. The lower eulittoral turf from both coasts was always more diverse, although dominated by only two or three species. In the south, the erect coralline algae (*Corallina elongata* and *Jania crassa*) were dominant and responsible for over 60% of the total mean biomass. At the north site, *Centroceras clavulatum* was the most abundant species (although only 19%) but, as a group, the erect coralline algae (here including *C. elongata, Jania rubens* and *J. longifurca*) were very important, providing nearly 40% of the total mean biomass.

A cluster analyses, using the Euclidean distance between the mean biomass of each species at the various levels, was performed. This analyses grouped the levels by their vertical position on the shore, separating the upper from the lower ones, independently of their location on opposite coasts of the island (Fig 107 A). The TWINSPAN analyses of the same data confirmed the cluster analyses, separating the upper from the lower levels (Fig. 107 B). The same outcome was obtained when both analysis were repeated with presence/absence data (Fig. 108).

Both multivariate methods, using either quantitative or qualitative data, gave more importance to the vertical position of the levels on the shore, than to their location on the island.

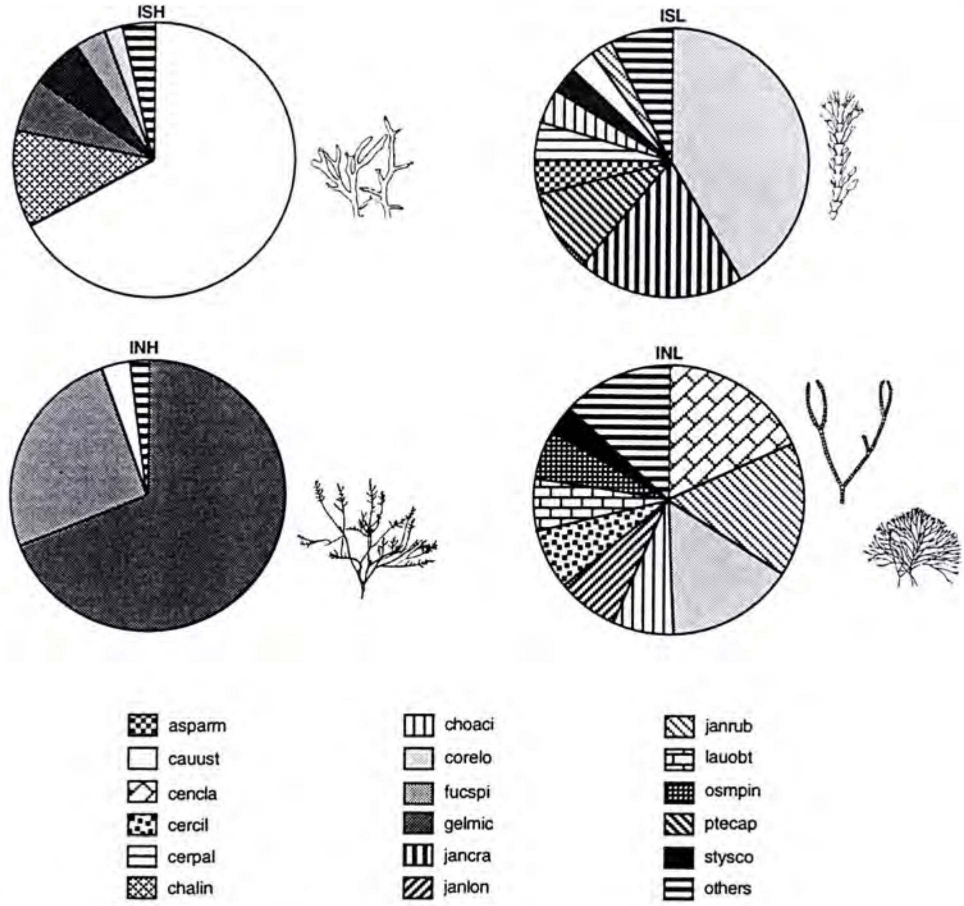

Fig. 106 Relative biomass of the algal species of the four intertidal levels. For abbreviations see section 3.5 and Table I.

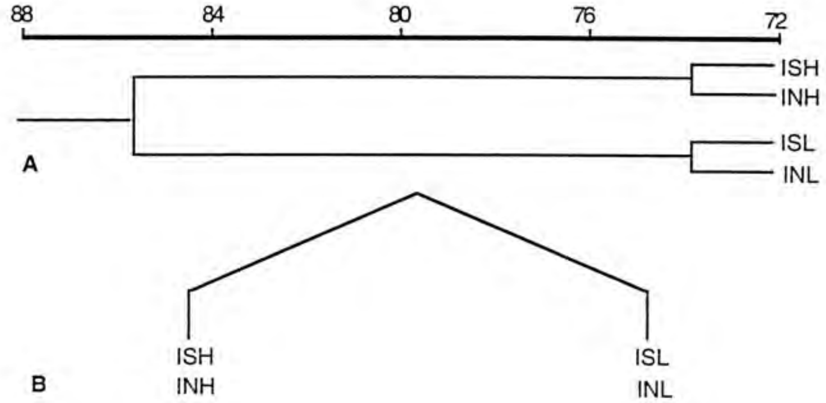

Fig. 107 Multivariate analyses of the species-abundance matrix of the four intertidal levels: (A) cluster analyses, based on the Euclidean distance; (B) TWINSPAN. For abbreviations see section 3.5.

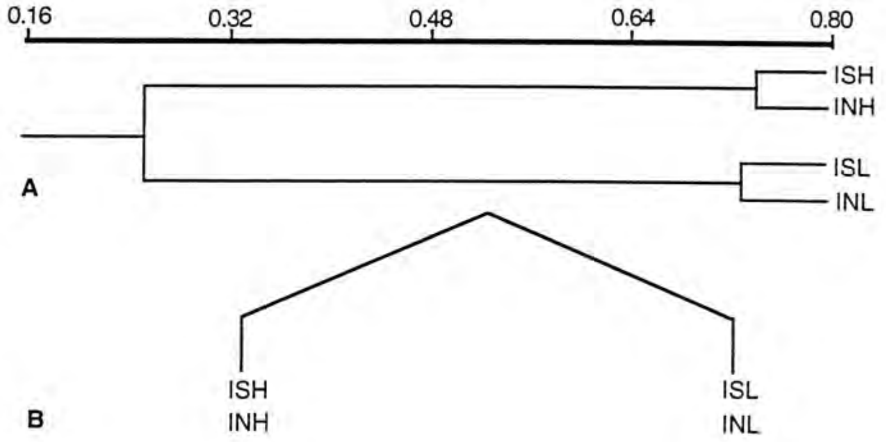

Fig. 108 Multivariate analyses of the species presence/absence matrix of the four intertidal levels: (A) cluster analyses, based on the Sørensen index of Similarity; (B) TWINSPAN. For abbreviations see section 3.5.

5.1.2.2. Changes over time

A general pattern was observed in the mean monthly biomass values at the four intertidal algal communities.

In São Roque, the pattern was more pronounced at the lower level. Here, and in both years, the mean biomass was higher in September/October, decreasing towards the winter and spring, to be lower in late spring (Fig. 109). This pattern basically followed the ones of *Corallina elongata* and *Jania crassa* which both showed large variations on their biomass over the sampling period (Figs 62 and 65), but were more abundant in autumn and had a low biomass in the late spring. In the upper intertidal, the mean biomass was higher during the first sampling year, following the pattern of *Caulacanthus ustulatus* (Fig. 81). It was higher in late autumn/winter, lower values of biomass occurring in August. In the second year, no clear pattern was apparent, although the biomass was higher in spring.

In São Vicente, the upper level presented a clear pattern of seasonal changes in biomass, with the higher values occurring in spring and the lower ones being present in late summer (Fig. 110). A similar pattern was also observed for *Gelidium microdon*, the dominant species at this level (Fig. 55). *Fucus*, the second most abundant seaweed in this community, was also important, being mainly responsible for the relatively high values of biomass observed in autumn/winter on the first year (Fig. 40). In the lower intertidal, large fluctuations were observed but a pattern was nevertheless apparent: the biomass was higher in late summer/early autumn, and then decreased to a minimum in winter (March 1994, February 1995), increasing again towards spring and summer. The temporal variation in biomass of the three main species (*Centroceras clavulatum*, *Jania rubens*, *Corallina elongata*) coincided with the above described pattern (Figs. 86, 68 and 62).

For the upper eulittoral, the lower values of biomass were in general present in the summer

(August/September), on both coasts. The opposite was observed for the lower eulittoral, where the biomass was higher in late summer/early autumn.

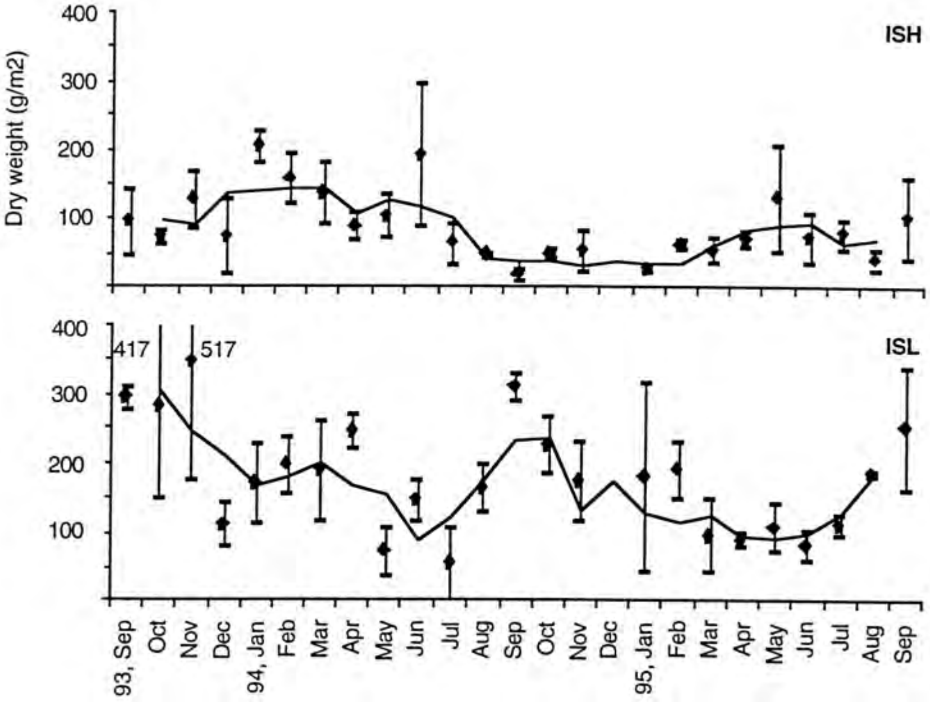

Fig. 109 Monthly mean algal biomass (± standard deviation) on the intertidal of São Roque (the line indicates the moving average (3)). For abbreviations see section 3.5.

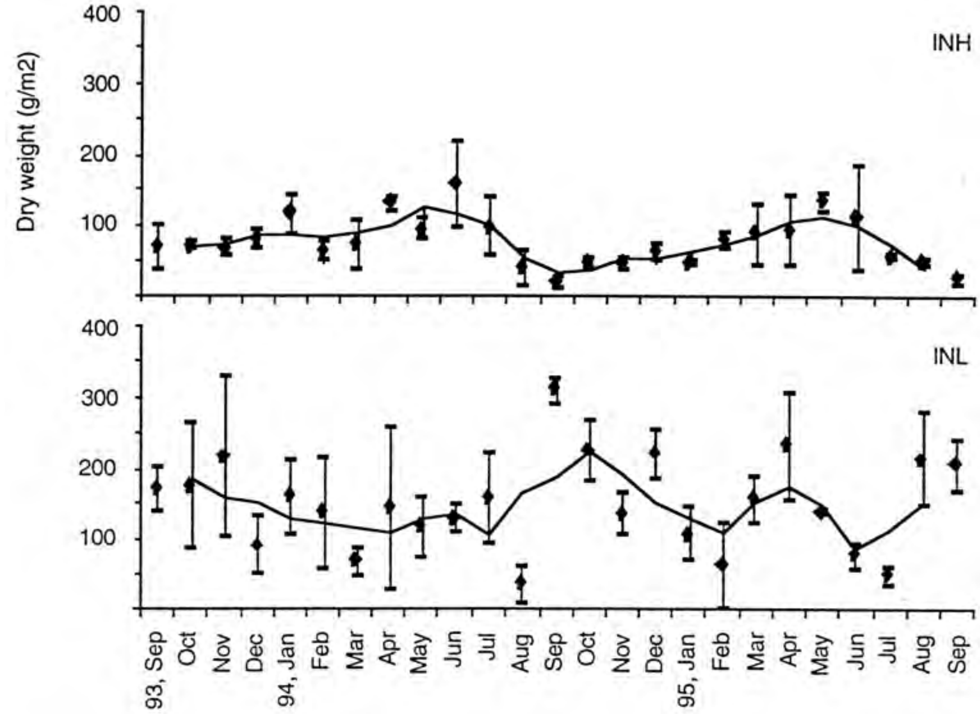

Fig. 110 Monthly mean algal biomass (± standard deviation) on the intertidal of São Vicente (the line indicates the moving average (3)). For abbreviations see section 3.5.

Annual variations were observed both on the number of species and diversity at all intertidal communities (Figs. 111 to 114). At the upper shore level of São Roque, with only a small number of species (1-5) involved, there was little variation in the mean monthly number of species and, therefore, in diversity. This zone was similar at São Vicente but with even less diversity. The lower shore community at both localities contained generally more species throughout the year and a higher diversity, but, again, no clear pattern was visible.

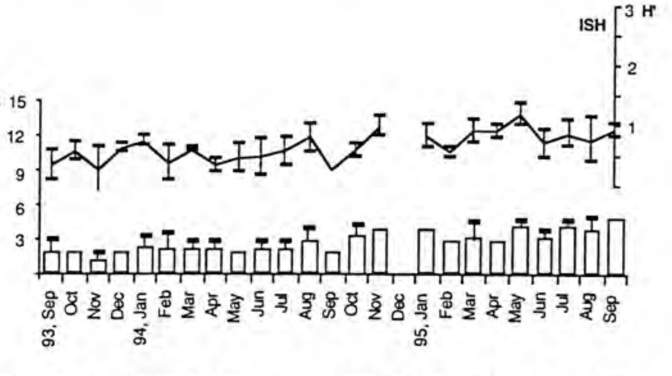

Fig. 111 Monthly mean diversity on the upper eulittoral of São Roque (ISH): number of species (S) + standard deviation; Shannon diversity index (H') ± standard deviation.

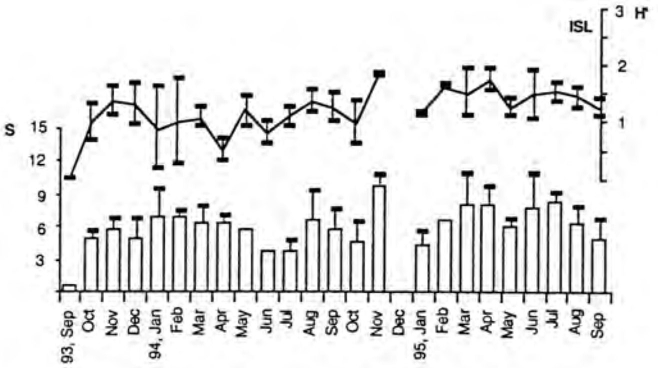

Fig. 112 Monthly mean diversity on the lower eulittoral of São Roque (ISL): number of species (S) + standard deviation; Shannon diversity index (H') ± standard deviation.

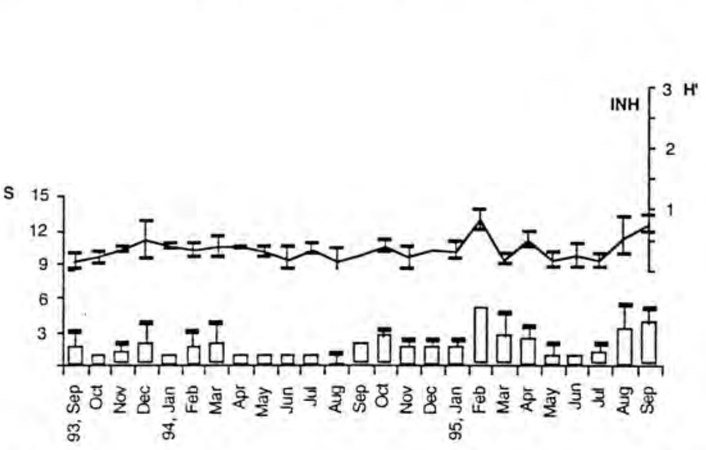

Fig. 113 Monthly mean diversity on the upper eulittoral of São Vicente (INH): number of species (S) + standard deviation; Shannon diversity index (H') ± standard deviation.

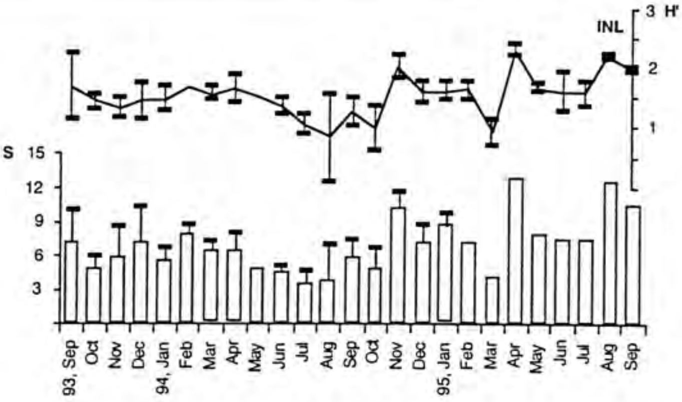

Fig. 114 Monthly mean diversity on the lower eulittoral of São Vicente (INL): number of species (S) + standard deviation; Shannon diversity index (H') ± standard deviation.

An attempt was made to detect variations in species composition at the different levels between the two years in which they were surveyed. For each level, the mean biomass of each species was calculated for the two years separately.

With the exception of the north lower intertidal, no major differences were observed on the algal biomass of the dominant species between the two years (Figs. 115 to 118).

At São Roque, *Caulacanthus* was dominant on the upper level in both years, although more abundant on the first year, and responsible for the almost monospecific turf collected for most of the sampling period (Fig. 115). At the low intertidal level (Fig. 116), *Corallina elongata* and *Jania crassa* were the dominant species in both years, with the former being also much more abundant in the first year. During the second year, *Pterocladia* became more abundant, being the third most abundant species, very similar to *J. crassa* in value.

At São Vicente, *Gelidium microdon* was the dominant species of the upper level in both years, followed by *Fucus spiralis*. Differences were observed on their mean biomass between the two years, with the former remaining dominant during the second year, while the later decreased from the first to the second year (Fig. 117). At the lower eulittoral, differences were observed in the abundance of the dominant species between the two years (Fig. 118). *Centroceras* and *Jania rubens* were very abundant in the turf in both years, being the dominant species on the first year, and respectively the second and third more abundant species on the second year. *Corallina elongata*, not very important in the first year, become the dominant species in the second year. *Stypocaulon scoparia*, not even present on the first year, showed a large increase of biomass on the second year, whereas the biomass of *Jania longifurca* was much reduced in the second year.

Despite these differences, a cluster analyses (Euclidean distance between the eight points-four levels in two successive years) grouped together the two successive years of each level (Fig. 119). This indicates that differences between years for one given community are smaller than those between communities, at least on a short term basis.

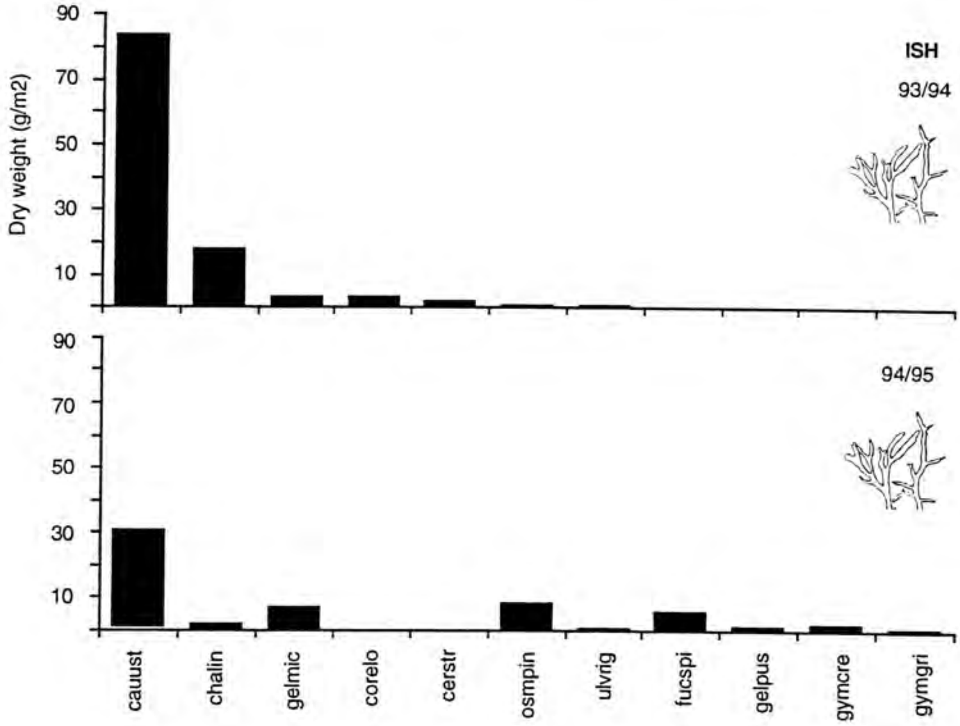

Fig. 115 Yearly mean biomass of the algal species collected on the upper eulittoral of São Roque (ISH). For species abbreviations see Table I.

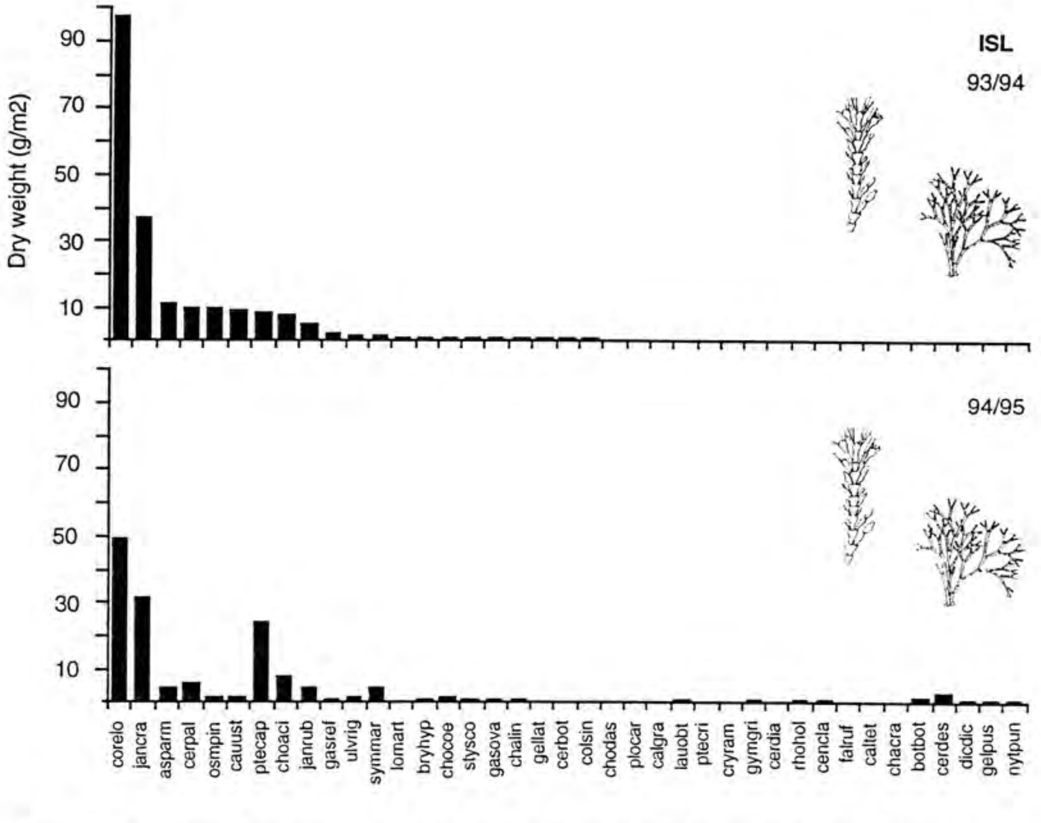

Fig. 116 Yearly mean biomass of the algal species collected on the lower eulittoral of São Roque (ISL). For species abbreviations see Table I.

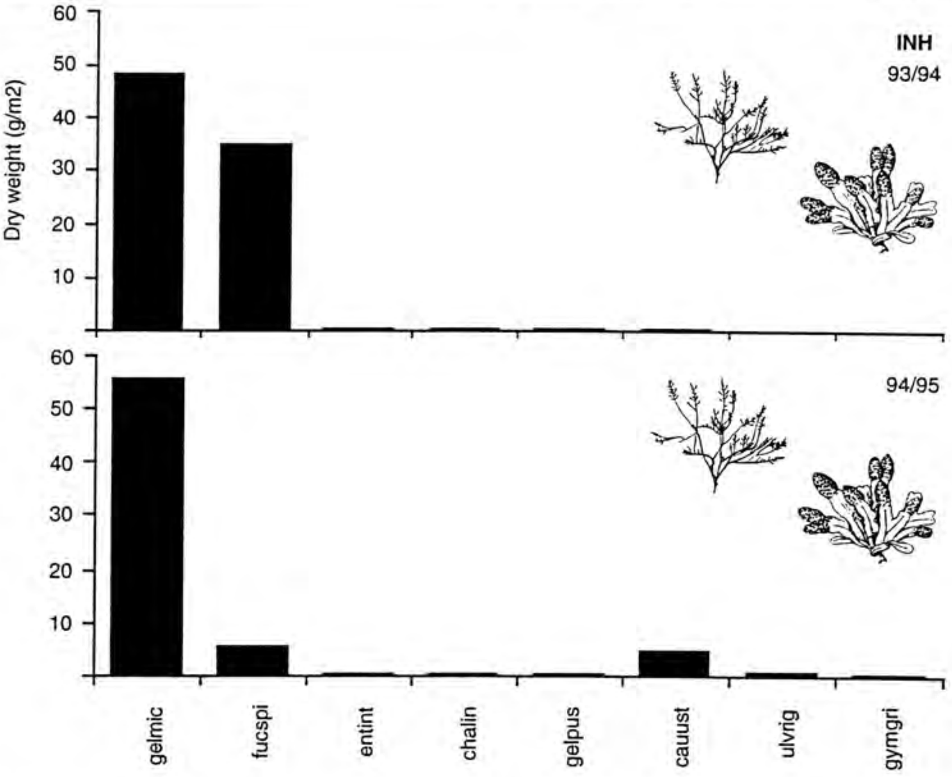

Fig. 117 Yearly mean biomass of the algal species collected on the upper eulittoral of São Vicente (INH). For species abbreviations see Table I.

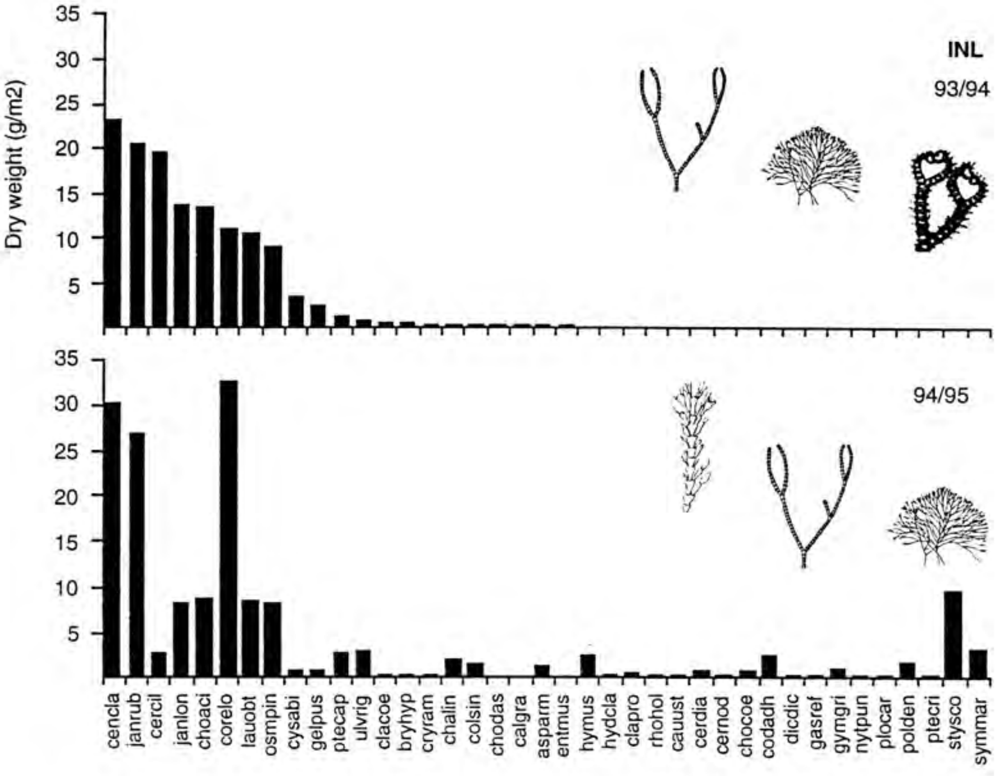

Fig. 118 Yearly mean biomass of the algal species collected on the lower eulittoral of São Vicente (INL). For species abbreviations see Table I.

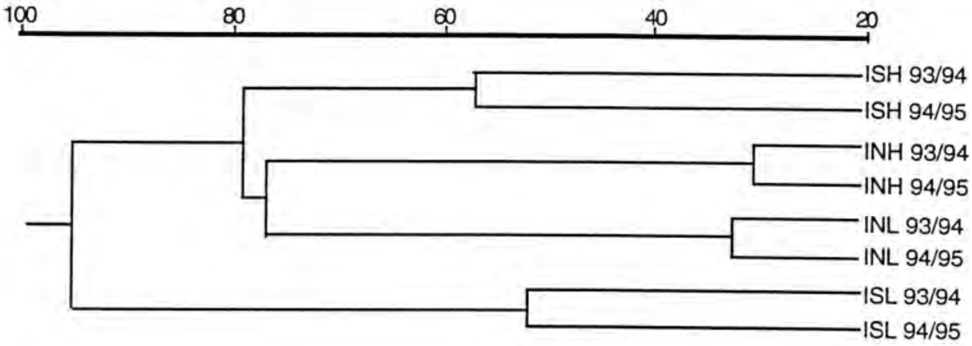

Fig. 119 Similarities between the intertidal communities of the two successive years (cluster analyses based on the Euclidean distance). For abbreviations see section 3.5.

5.2 Subtidal communities

The shallow, rocky subtidal zone (0-30 m deep) has more seaweed species and greater macroalgal biomass than any other marine habitat (Foster *et al.*, 1985). Subtidal algal communities, worldwide, have been relatively little studied (Anderson & Stegenga, 1989), and little is known of the biotic associations and dynamics of these communities (John *et al.*, 1977). Russell (1972) and Chapman (1973) have both suggested that it is necessary to use a quantitative and systematic approach in investigations of such communities if unifying concepts are to emerge.

In the past, with few exceptions (Neuschul, 1967; Sanders, 1968, 1969; Hughes & Thomas, 1971; van den Hoek *et al.*, 1975; Sears & Wilce, 1975), investigations, such as the account by Tittley *et al.* (1985b), have been largely descriptive rather than quantitative and predictive.

There are two basically different approaches to the definition of the importance of particular species in the maintenance of the structure of a community. One approach emphasizes a descriptive, usually numerical, definition of importance based on sampling studies designed to measure the relative abundance, biomass, or productivity of the species in a community (Whittaker, 1965; McNaughton, 1968); such studies yield various measures of diversity with the quantitatively important species referred to as "dominant". A second approach to the study of community organization emphasizes a functional definition of disproportionately important species based on the relative impact these species can exert on other species in the community (Paine, 1969a; Dayton, 1971). The later approach is similar to that of Clements (1936) and Weaver and Clements (1938), who considered as dominant those plant species exerting an important, competitive control on the abundance and distribution of other species in the community (Dayton, 1975). The identification of community patterns must precede attempts to understand how they are produced and maintained.

At present there is almost no information on the subtidal communities occurring off the coast of the Azores. This is the first quantitative account of the subtidal benthic communities of the littoral of São Miguel island. The benthic algal vegetation of two bays is described and the effects of depth, geographic location (on the island) and time are analysed.

5.2.1 Composition and floristic analyses

Subtidal communities from both São Roque and São Vicente, and from the three depth levels on each coast, varied both in species composition and dominance.

The 15m depth community at São Roque contained the highest number of species, with the biomass being more uniformly distributed among the different species, despite the importance of *Stypocaulon scoparia* (Fig. 120). In contrast, the 5m community of the same location had a low number of species and lower equitability, the biomass being concentrated on a few dominant species. The remaining levels presented intermediate situations between these two. Figure 121 illustrates these observations. The low number of species and diversity observed at 5m S increases towards the 10 and 15m S levels.

At São Vicente, no major differences were observed in these values among the three levels, although there was a lower number of species at 10m, and a relatively low diversity at the 15m level (Figs. 120 and 121).

Differences in species composition and abundance occurred among all studied levels, although more marked at São Roque. Here, the 5m S level was dominated by erect coralline algae (*Corallina elongata*, *Jania longifurca* and *J. verrucosa*), which continued down to the 10m level, where they were also dominant species, although *Stypocaulon scoparia* had become equally important (Fig. 122). At a depth of 15m, the coralline algae lost their importance and the brown algae (*S. scoparia* and *Dictyota dichotoma*) became the dominant species. Other important species were *Pterocladia capillacea* at 5m depth, *Symphyocladia marchantioides* at 10 and 15m depth, and *Asparagopsis armata* at all levels.

At São Vicente, dominance was shared by a larger number of species (Fig. 122). At 5m, *S. scoparia* was the most abundant species (15% of the mean total biomass) but other species were also almost equally important: *A. armata* (13%), *Hypnea musciformis* (12%) and *P. capillacea* (11%). At 10m depth, *H. musciformis* became the dominant species, followed by *A. armata* (11%) and *S. marchantioides* (10%). *Stypocaulon* diminished, and *Sphaerococcus coronopifolius* and *Zonaria tournefortii* become important species. *Zonaria* became more and more abundant with depth to be the dominant species at the 15m depth community (29%), followed by *S. marchantioides* (10%). *Stypocaulon* became again a relatively important species at this level (9%), with a similar abundance value as at 10m. As on the south site, brown algae were dominant at the lower levels, in contrast to the littoral/sublittoral fringe, where the red were prevalent.

A depth-related gradient was observed in the community structure of both sites (Fig. 123). This gradient was more distinct at São Roque, where the erect coralline algae, dominant at lower depths (5 and 10m levels), were rare at 15m depth. On the other hand, *S. scoparia*, a species with low biomass at 5m, became more important with depth, to be the dominant species at the 15m level.

At São Vicente, a more gradual transition was observed between the two shallower levels, with *S. scoparia* and *P. capillacea* losing their importance with depth, while *S. marchantioides* gradually became slightly more abundant. *Asparagopsis* was the second most important species at both levels, while *Zonaria*, absent at 5m, became more and more important with depth and was clearly the dominant species at 15m level, followed by *Symphyocladia* and *Stypocaulon*. *Hypnea* and *Sphaerococcus* were most abundant at 10m.

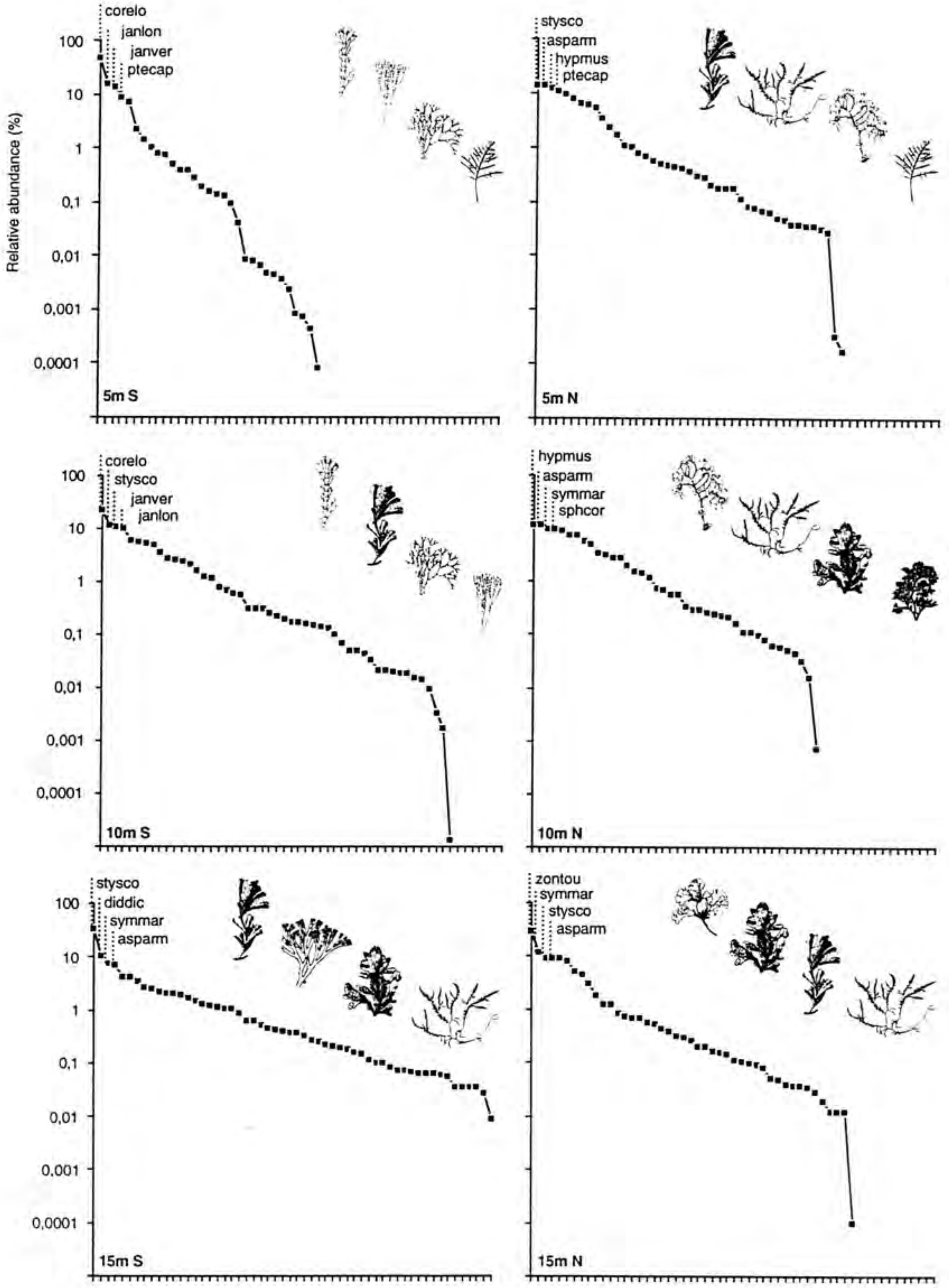

Fig. 120 Dominance-diversity curves for the six subtidal levels. Relative abundance based on the average biomass of each species. For abbreviations see section 3.5 and Table I.

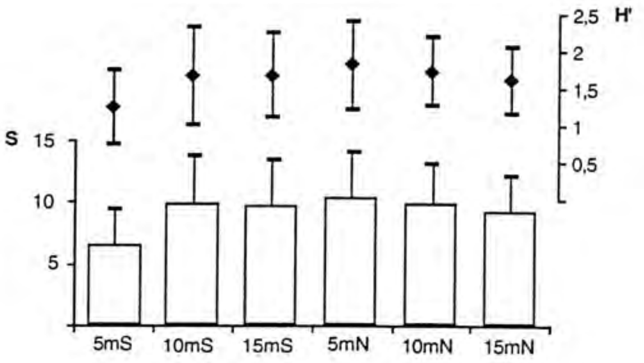

Fig. 121 Mean diversity on the six subtidal levels: number of species (S) + standard deviation; Shannon diversity index (H') ± standard deviation. For abbreviations see section 3.5.

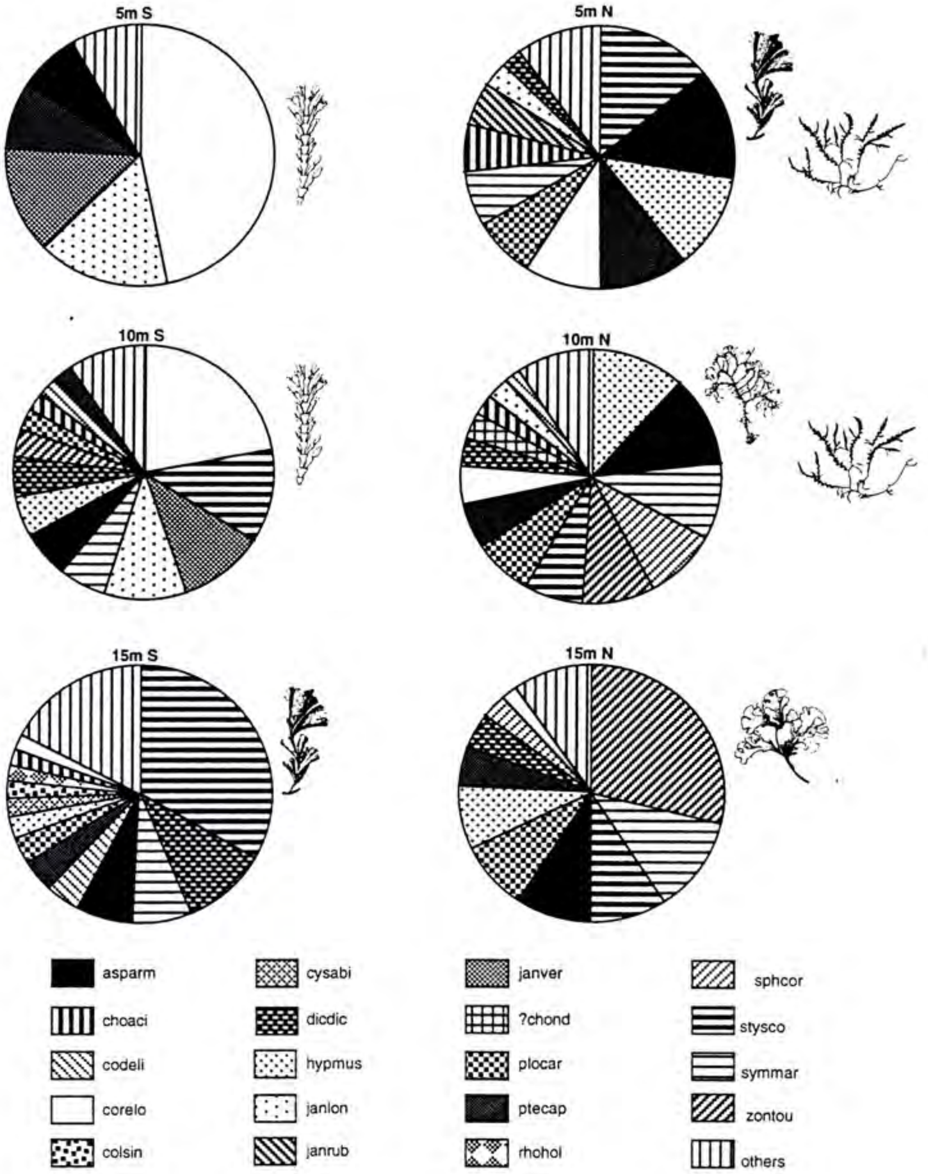

Fig. 122 Relative biomass of the algal species of the six subtidal levels. For abbreviations see section 3.5 and Table I.

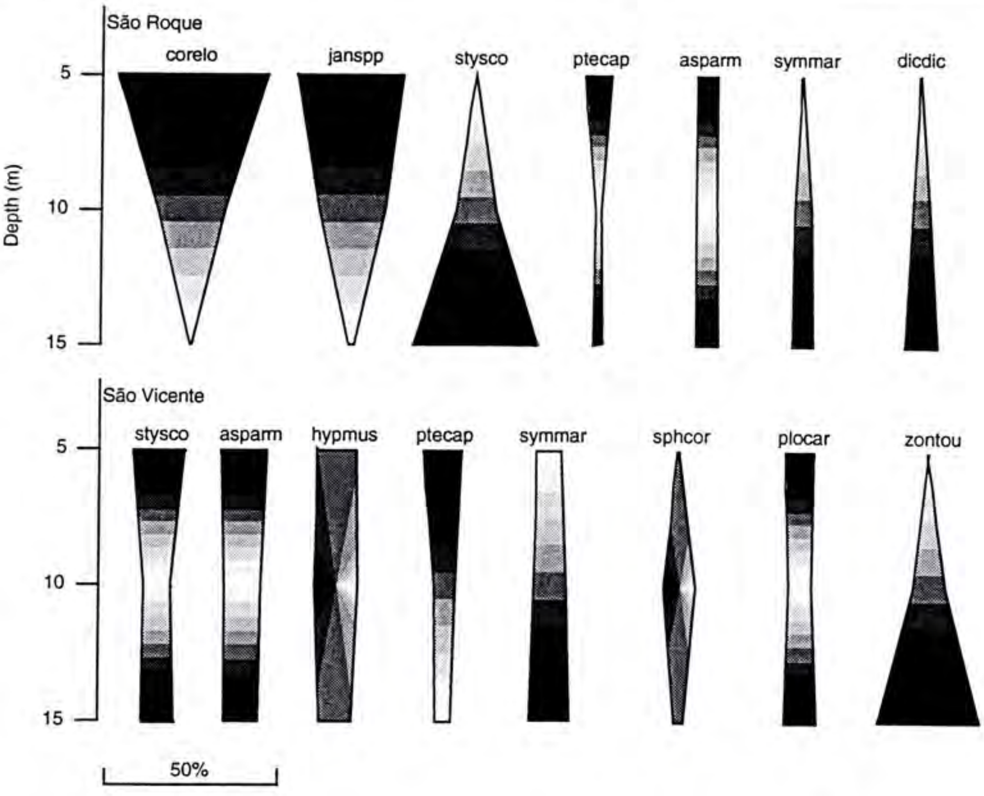

Fig. 123 Depth-related differences in species abundance. Relative abundance (based on average biomass) of the more common species at each depth level. For abbreviations see section 3.5.

On both coasts there was a clear dominance of the red algae at the shallower levels, while the brown algae dominated the 15m depth levels.

The six depth levels (three at each site) were compared using several multivariate methods. To start with, a data matrix with the mean biomass of each species was made. A cluster analyses, based on the Euclidean distance between the various depth levels, separated the 5m level at São Roque from all the other levels (Fig. 124 A). The second division separated the other shallow water level (5m N) from the 10 and 15 m levels of both sites. The final division separated the 10 and 15m levels of each site. The TWINSPAN analyses of the same data (Fig. 124 B) produced slightly different groupings: the first dichotomy separated the north from the south; the second dichotomy separated, in the north, the 5m level from the deeper ones, and in the south, the 15m from the shallower ones.

The presence/absence matrix of the same data was also analysed and it produced different groupings. The cluster analyses, using Sorensen's Index of Similarity (Fig. 125 A), separated also in the first place the 5m S level from all the others, included the 10 and 15m S in one group and all the north coast levels in another. The final division separated the 15m N from the 5 and 10m N levels. TWINSPAN analyses of the same data produced a similar grouping but at different levels (Fig. 125 B). The first dichotomy separated the two deeper levels of south coast from all the others, and only the second dichotomy separated the 5m S from the north levels. The third dichotomy separated on north coast, the 15m from the two shallower ones (5 and 10m N).

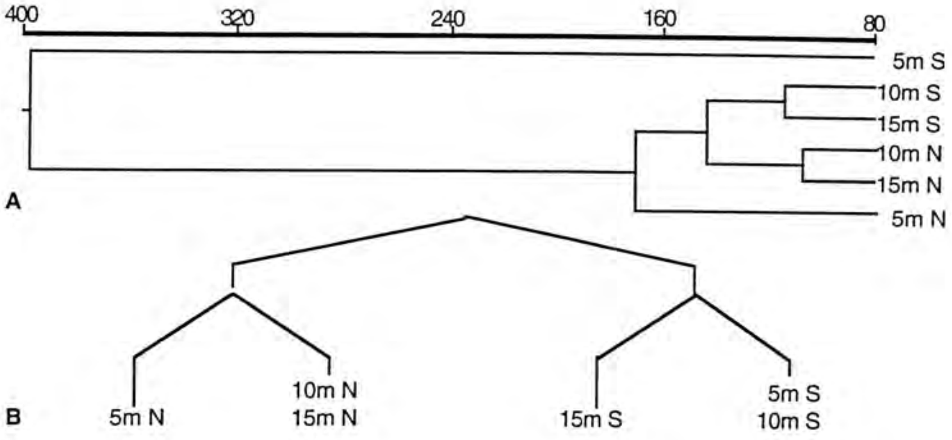

Fig. 124 Multivariate analyses of the species-abundance matrix of the six subtidal levels: (A) cluster analyses, based on the Euclidean distance; (B) TWINSPAN. For abbreviations see section 3.5.

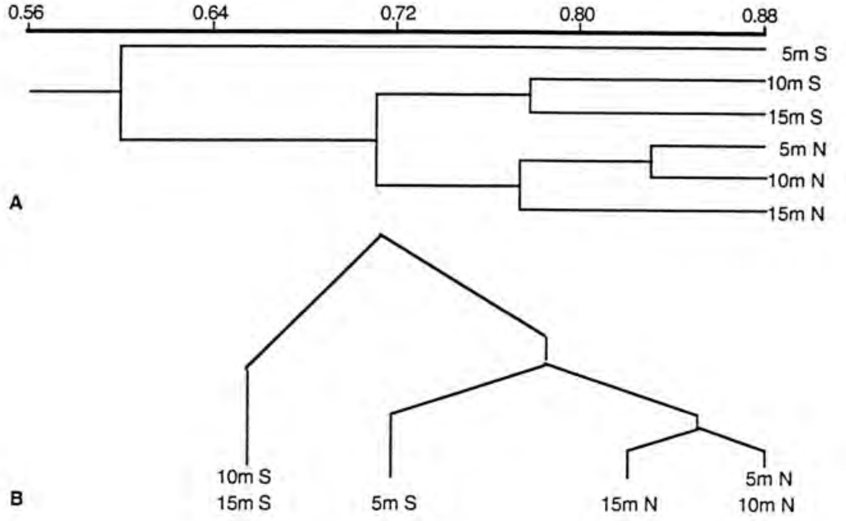

Fig. 125 Multivariate analyses of the species presence/absence matrix of the six subtidal levels: (A) cluster analyses, based on the Sørensen's index of Similarity; (B) TWINSPAN. For abbreviations see section 3.5.

In summary, it can be stated that different methods separated firstly the south site form the north, and secondly the depth levels sampled at each site. The differences between the algal associations at the different depths suggests that there is a real difference in community organization as related to depth. The depth gradient of species abundance and diversity mentioned above was also seen on these analyses: some grouped the 5 and 10 m levels, other grouped the 10 and 15 m, but the 5 and 15 m were never grouped together.

The results of the multivariate analyses confirm the occurrence of basic qualitative and quantitative differences between the two localities. Within each of these localities, a depth-related gradient of species diversity and biomass was emphasized.

5.2.2 Changes over time

No clear pattern was seen on the temporal changes in biomass of the south coast communities (Fig. 126) but a general pattern was observed for the three depths at São Vicente (Fig. 127).

For the 5 and 10m depth levels at São Roque, the mean biomass was apparently lower during the first sampling year but the difference was not significant (Wilcoxon test 13, 11 pairs, p>0.05; Wilcoxon test 14, 11 pairs, p>0.05, respectively). At the 15 m depth, the fluctuations in the total mean biomass were always less pronounced, but again no clear pattern was detected through the sampling period (Fig. 126). As expected, no relation was seen among these temporal fluctuations of algal biomass and the fluctuations in seawater temperature and hours of daylight over the same period (R=0.01 and R=0.22, 21 d.f., n.s.).

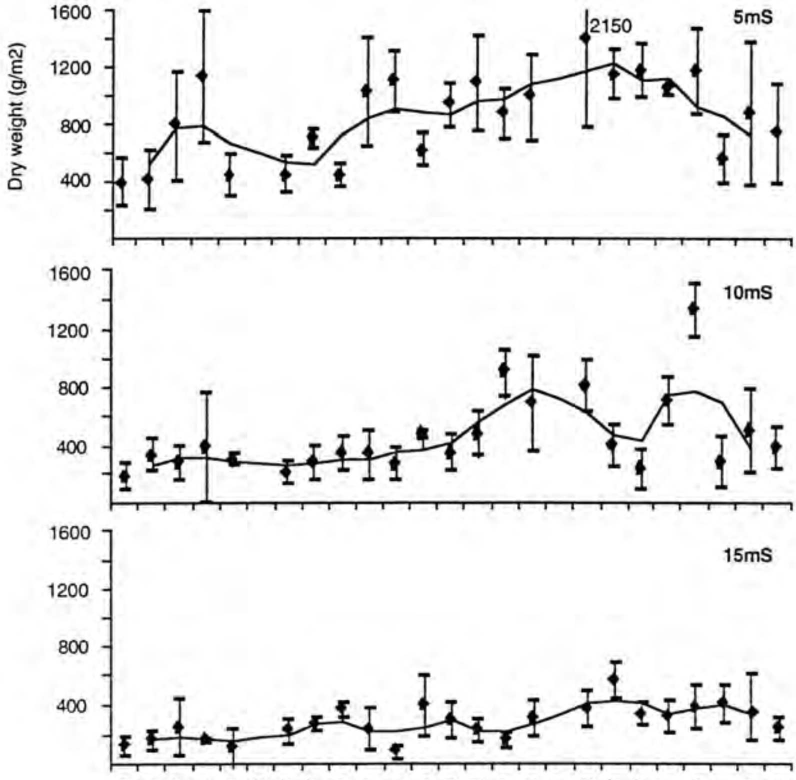

Fig. 126 Monthly mean algal biomass (± standard deviation) on the subtidal of São Roque (the line indicates the moving average (3)). For abbreviations see section 3.5.

At São Vicente a general pattern was evident (Fig. 127), with maximum values of biomass occurring in spring (1994) or summer (1995) at the three depth levels and lower biomass occurring in late winter (5 and 10 m depth) or late autumn (15 m depth). The maxima and minima of algal biomass, day length and seawater temperature generally coincide. The correlation between the mean algal biomass and those environmental variables was positive, significant (number of hours of light, R=0.55, 21 d.f., $p<0.01$) or not (seawater temperature, R=0.31, 21 d.f., n.s.).

The seasonality observed at São Vicente is caused by the coincidence of seasonal growth patterns of the dominant species of each level. All of them exhibited higher values in spring (*A. armata, P. cartilagineum, S. marchantioides*, cf. Figs. 50, 75 and 99) or summer (*S. scoparia, Z. tournefortii, P. capillacea, S. coronopifolius, H. musciformis, S. marchantioides*, cf. Figs. 28, 35, 57, 77, 79 and 99).

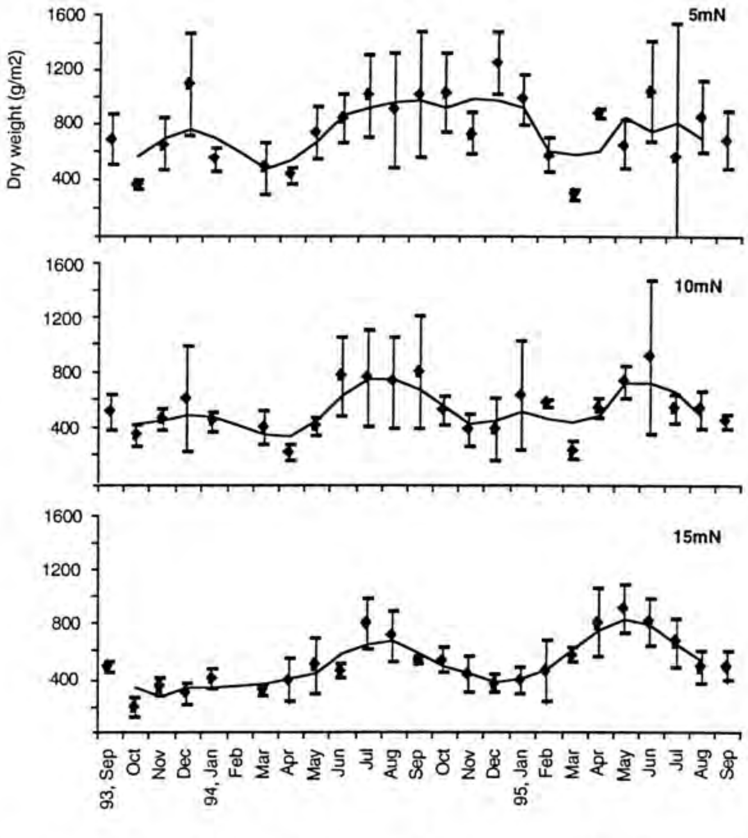

Fig. 127 Monthly mean algal biomass (± standard deviation) on the subtidal of São Vicente (the line indicates the moving average (3)). For abbreviations see section 3.5.

No pattern was found in the temporal variation of the mean diversity and mean number of species over the two year period at any of the studied communities (Figs. 128 and 129). At São Roque there were large variations in these patterns throughout the year at all levels. The mean monthly number of species varied between 3-12 at 5m, 9-17 at 10m, and 4-18 at 15m depth, the later being the level with the highest diversity. At São Vicente the mean number of species was never lower than 5 at any level. Large variations on both number of species and diversity occurred over the sampling period, but no major differences were detected between the three depth levels.

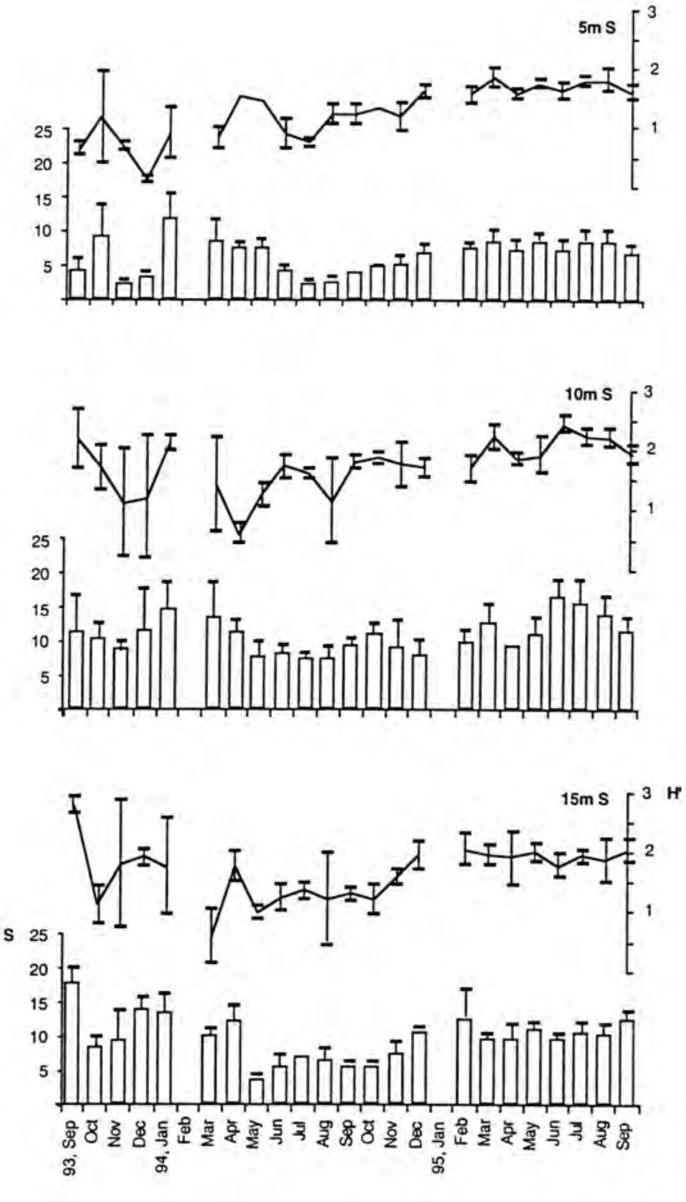

Fig. 128 Monthly mean diversity on the three depth levels of São Roque: number of species (S) + standard deviation; Shannon diversity index (H') ± standard deviation. For abbreviations see section 3.5.

As for the intertidal, an attempt was made to detect variations on the species composition of each depth level between the two years. For each level, the total mean biomass of each species was calculated for the two years separately.

Although variations were observed between the algal biomass of the dominant/more important species between the two years, no major differences were seen on the structure of the algal communities (Figs. 130 to 135).

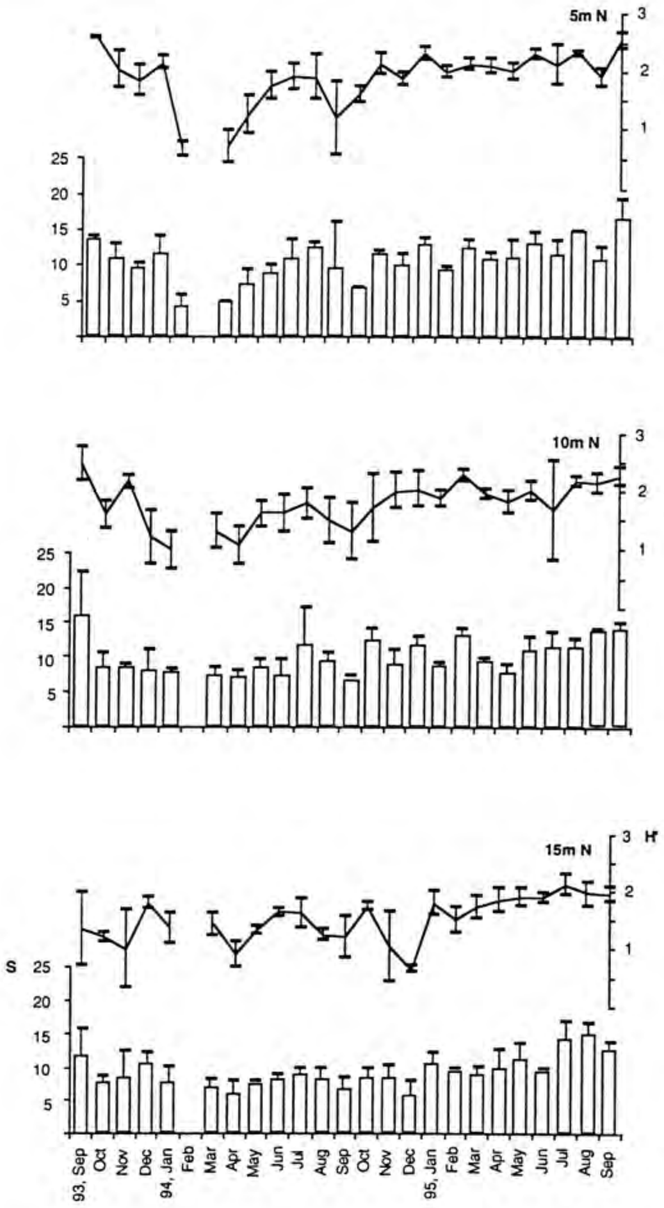

Fig. 129 Monthly mean diversity on the three depth levels of São Vicente: number of species (S) + standard deviation; Shannon diversity index (H') ± standard deviation. For abbreviations see section 3.5.

At São Roque (Fig. 130), the 5m level was dominated by *Corallina elongata* in both years, although in the second year *Jania* spp., *Pterocladia capillacea* and *Asparagopsis armata* became more important. At 10m depth, *Stypocaulon scoparia*, the dominant species in the first year, lost its importance on the second year, to be replaced by *C. elongata* (second most important species in the first year) and *Jania* spp. (Fig. 131). The remaining important species also showed fluctuations in their biomass between the two years. At 15m depth, *S. scoparia* was the dominant species for all the sampling period, especially during the second year (Fig. 132). Variations were observed in the biomass of other important species between the two years: *D. dichotoma*, *A. armata* and *P.*

cartilagineum decreased in biomass, while *S. marchantioides, C. elisabethae* and *H. musciformis* increased it.

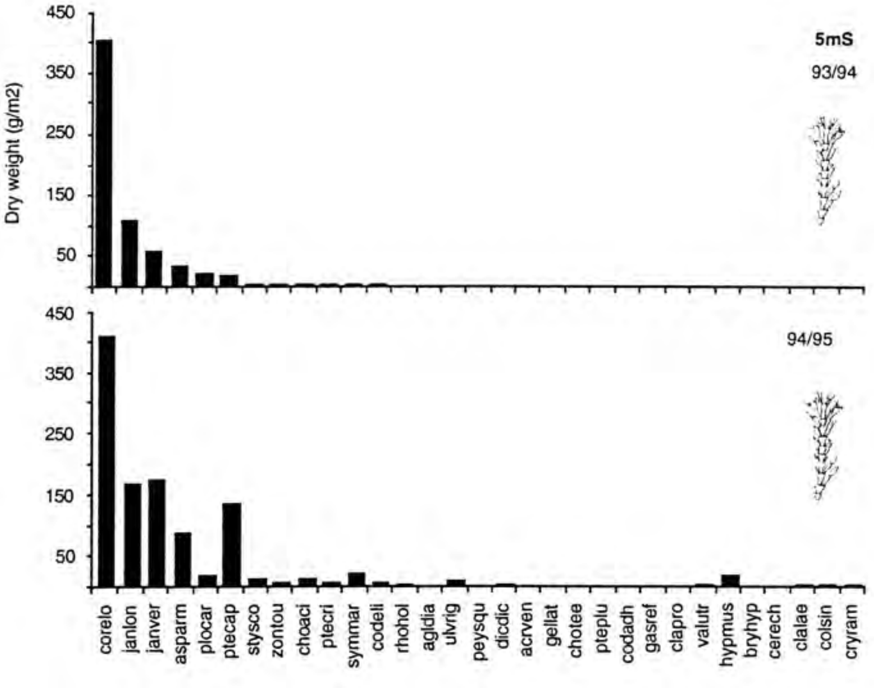

Fig. 130 Yearly mean biomass of the algal species collected on the 5m depth level of São Roque (5m S). For species abbreviations see Table I.

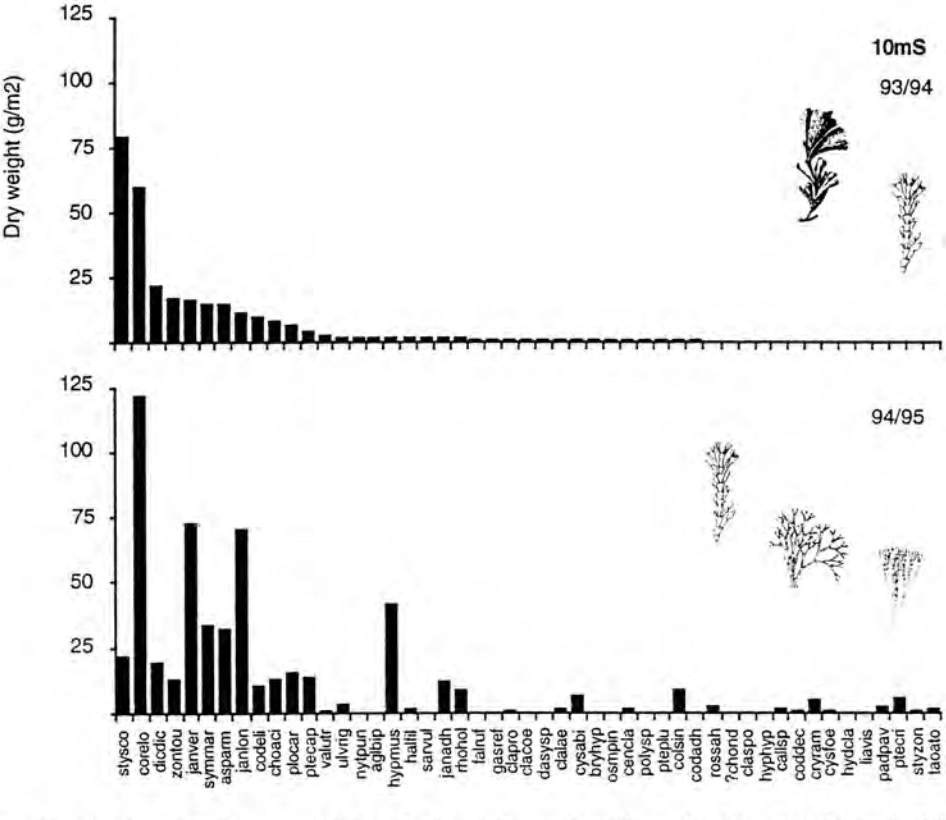

Fig. 131 Yearly mean biomass of the algal species collected on the 10m depth level of São Roque (10m S). For species abbreviations see Table I.

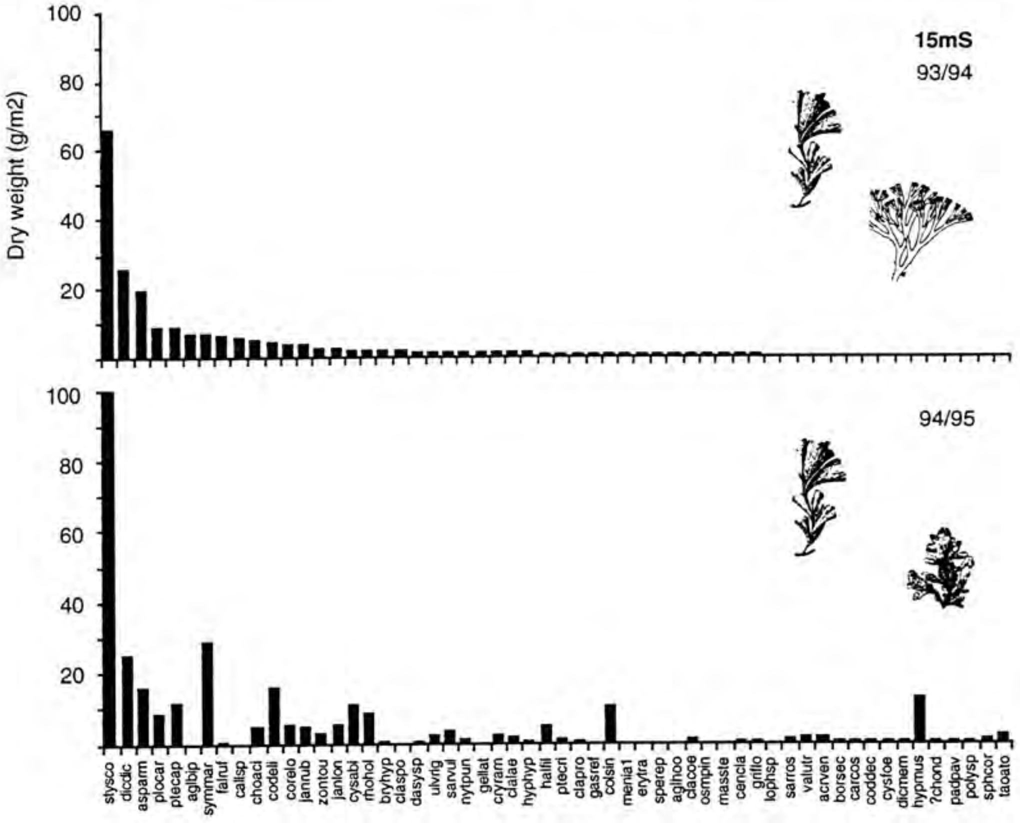

Fig. 132 Yearly mean biomass of the algal species collected on the 15m depth level of São Roque (15m S). For species abbreviations see Table I.

At São Vicente, with the exception of the 15m level, in which *Zonaria tournefortii* was the dominant species in both years, followed by *S. marchantioides* (Fig. 135), differences were observed on the biomass of the more important species between the two years. At 5m depth, *Asparagopsis* was the dominant species in the first year, followed by *S. scoparia*, *Plocamium cartilagineum* and *Hypnea musciformis*, but in the second year *S. scoparia* and *H. musciformis* were co-dominant (Fig. 133). At 10m depth, dominance was distributed over a larger number of species, *Asparagopsis* being more abundant in the first year, while *Hypnea* dominated in the second year (Fig. 134).

The matrix of the mean biomass of each species present at the different levels in the two successive years was submitted to a cluster analyses, using the Euclidean distance as dissimilarity measure. Its output can be seen in Figure 136.

The results in general agree with the ones produced by the cluster analyses of the global data, both years considered (see Fig. 124 A). Again the 5m S level was first separated from all the others, followed by the 5m N. Then, with the exception to the second year of 10m S, the 10 and 15m depth levels of each coast were grouped together. As expected, and again with the exception to the second year of 10m S, the two successive years of the same level were always grouped together. These results show a great similarity between the communities at the same depths and place over two successive years. This indicates a high degree of stability in community organization, at least on a short term basis.

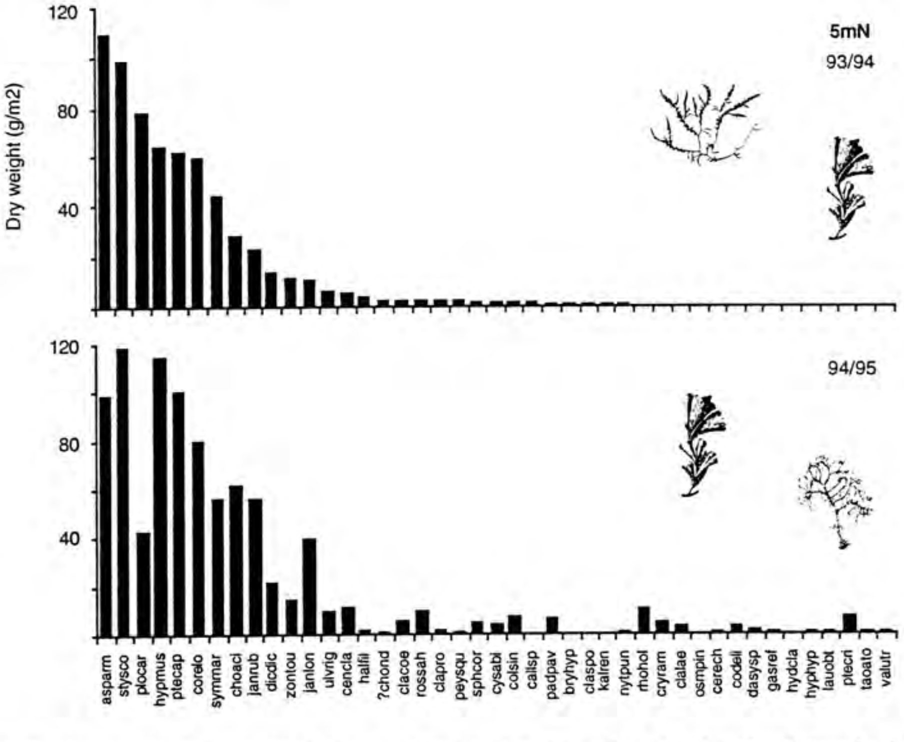

Fig. 133 Yearly mean biomass of the algal species collected on the 5m depth level of São Vicente (5m N). For species abbreviations see Table I.

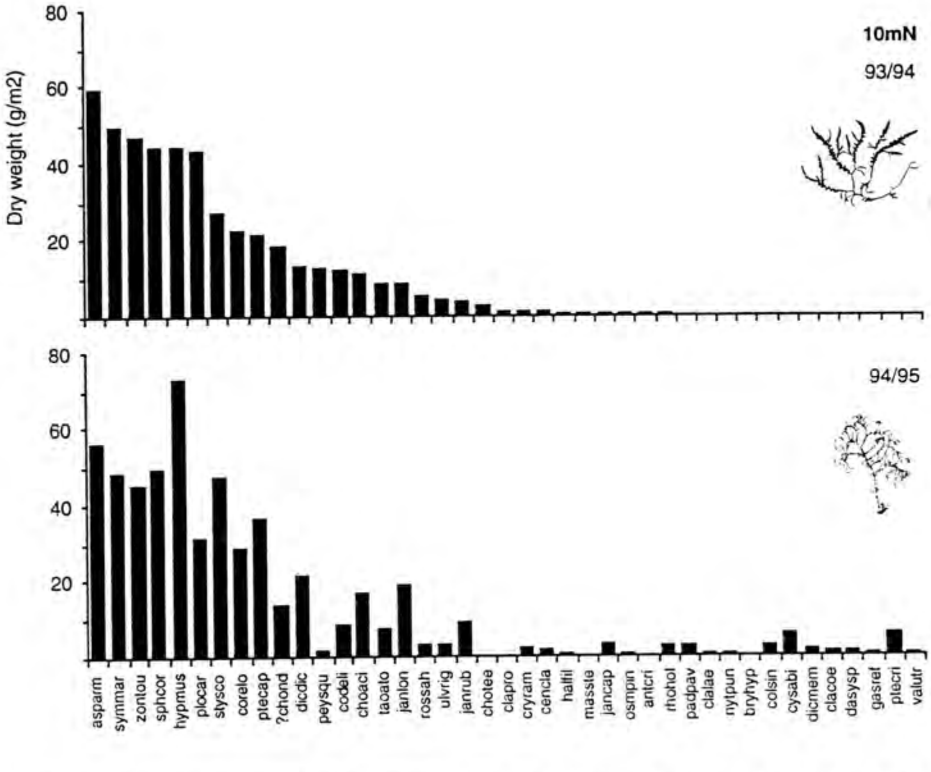

Fig. 134 Yearly mean biomass of the algal species collected on the 10m depth level of São Vicente (10m N). For species abbreviations see Table I.

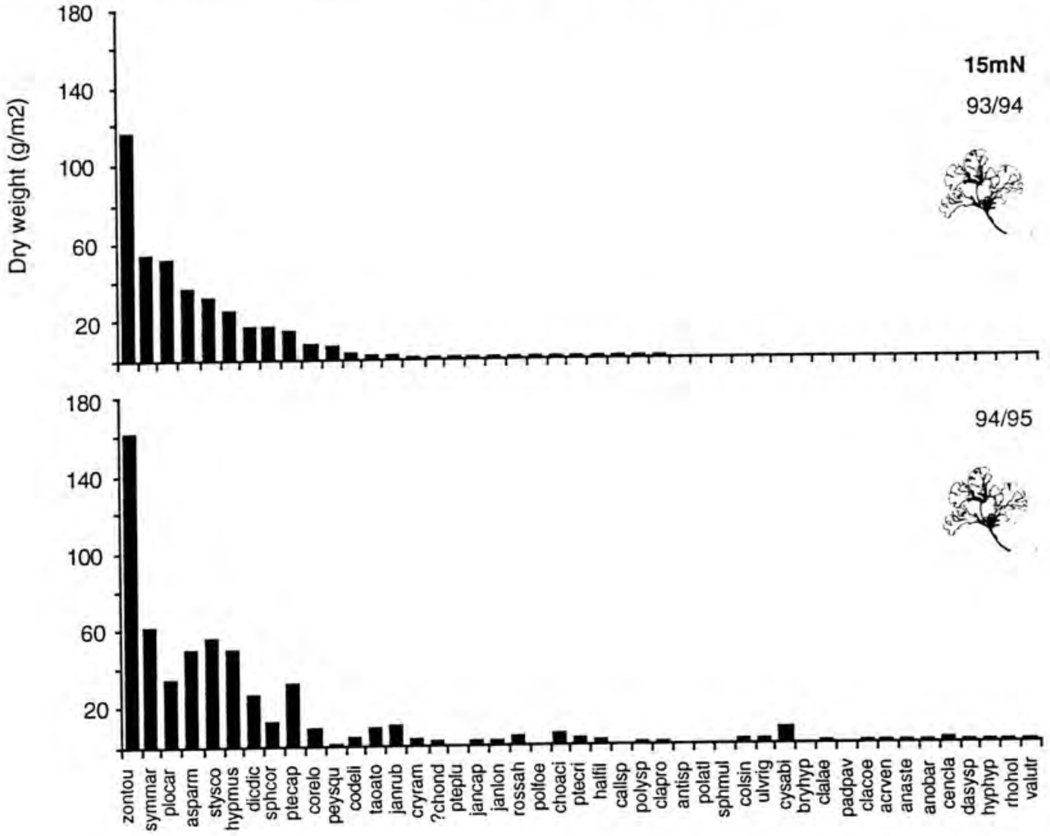

Fig. 135 Yearly mean biomass of the algal species collected on the 15m depth level of São Vicente (15m N). For species abbreviations see Table I.

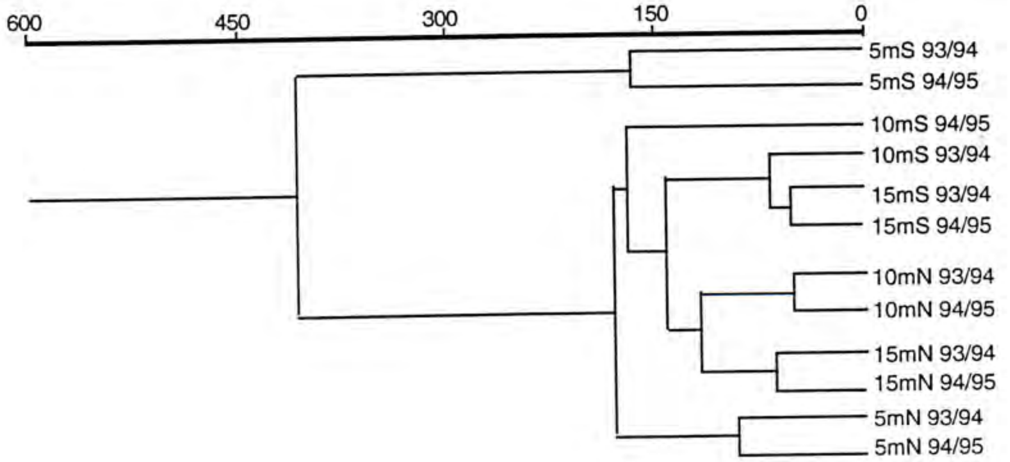

Fig. 136 Similarities between the subtidal communities of the two successive years (cluster analyses based on the Euclidean distance). For abbreviations see section 3.5.

6. DISCUSSION

Until very recently the Azorean algal flora was poorly known, the published information being mostly the result of expeditions by visiting scientists restricted to short periods of time, and mainly focused on the intertidal region. Many species now known to occur on the islands were missed from such restricted investigations.

This work is the first long-term study of the Azorean algal communities. The list of species of the island of São Miguel produced in Chapter 4, although fairly comprehensive, is certainly incomplete: the field work was only focused in two places of the island, and even there some species might have been missed. Some groups (see below) were also deliberately not included in the present work. Even so, this study adds 68 new records for the island of São Miguel and 29 new for the Azores, the marine algal flora of the archipelago now totalling 336 species. This number will certainly increase with further taxonomic and ecological studies. Further work and collections elsewhere on the island may reveal new communities, and will undoubtedly discover numerous algae, especially filamentous types. Microscopic algae in all divisions are diverse and await specialist attention e.g. the various endophytic green algae, such as *Acrochaete* spp., which have been observed in filamentous red algae. Furthermore, little attention has yet been given to the crustose types, such as the ecologically important calcareous red crusts ("lithothamnia"). The recent floristic account of this group by Irvine and Chamberlain (1994) will facilitate this study. Investigation of the crustose morphological growth form will not only increase the number of species of the marine flora of the Azores, but will also clarify aspects of the life histories of many species, particularly certain heteromorphic brown algae, such as *Scytosiphon lomentaria*. The correct identification of the undetermined taxa will also increase the known number of Azorean algae. Of the material presenting difficulty in identification are the soft-gelatinous, foliose reds, superficially resembling *Schizymenia, Platoma, Nemastoma, Predaea* or *Sebdenia*. Further studies, concentrating on the reproduction (especially carposporophyte development) of these entities are needed.

Some of the new records for the Azores revealed by this study may represent recent introductions, especially for those species known to be expanding their distribution. A good example is the green alga *Codium fragile*, regarded as a recent introduction to many places. This species is considered to be easily dispersed as a fouling organism on ships (Coffin & Stickney, 1967; Hillson, 1976). Other suggested mechanisms for its dispersal include transport on the shells of commercial oysters moved along the coasts of America for relocation (Wood, 1962; Coffin & Stickney, 1967; Malinowski, 1974), fishing nets, and packages of fishery products. Dawson and Foster (1982) have suggested that *Codium* may have been introduced in bait worm packing to San Francisco bay. The striking capacity in dispersal potential of *Codium* has also been noted by many other workers (Borden & Stein, 1969; Moeller, 1969; Churchill & Moeller, 1972; Fralick & Mathieson,1973; Ramus, 1972; Malinowski, 1974; Hanisak, 1979). From a probable northwest Pacific origin, *C. fragile* first appeared in the northeast Atlantic Ocean (early 1800's according to Silva, 1955, 1957), perhaps as a result of dispersal as a fouling organism. Carlton and Scanlon (1985) noted the first records of *Codium* in different regions, as follows: northwest Atlantic Ocean (1957, New York), southwest Pacific Ocean (1973, New Zealand), northeast Pacific Ocean (1977, San Francisco Bay), and stated that its vigour in colonizing Atlantic and Mediterranean Europe, and in continuing to expand in North America and New Zealand suggests that further expansions are highly probable. On the other hand, the fact that both *C. fragile* and *C. vermilara* occur only in the sublittoral may explain why these two species had not previously been recorded for the Azores.

Sphaerotrichia divaricata was only recently (Neto, 1991a, b) recorded for the Azores, extending its southern limit of occurrence in the Atlantic. The presence of this species on the Mediterranean was subsequently considered to be due to an introduction (Peters *et al.*, 1993). It is possible that the same is true for the Azores.

The warm temperate conditions of the Azores may allow other species to colonize local shores. With the exception of species with narrow limits of tolerance, many algae might find conditions suitable for their establishment on the Azores. Only comparative ecophysiological studies between algae from the Azores and from elsewhere would confirm this hypothesis.

Because of the isolation and relatively recent age of the archipelago, the local marine communities may be considered as "open" (i.e. offering less competition) and thereby vulnerable to invasion by introduced species, if they manage to be transported to the islands (most benthic marine algae are assumed to be unable to disperse their propagules very far). With the probable increase in ships and boats (both commercial and recreational) coming to the Azores in recent times, it is likely that the introduction of new species will continue and even increase. Such exotic species could be transported either as fouling on hulls or in ballast water.

However, considering that the Azorean seaweed flora is still incompletely known, it is premature to make any statement about putative introductions. Some phycologists have recently recorded for the Azores species from distant places but it has not been possible to state their precise geographic origins and vectors involved (see Ardré *et al.*, 1974 for *Symphyocladia marchantioides*; Yoneshique, 1985, Tittley & Neto, 1994 for *Endarachne binghamiae;* Athanasiadis & Tittley, 1994 for *Scageliopsis patens* and *Antithamnion diminuatum*).

It is also possible that some of the Azorean algae differ sufficiently from the same species as found elsewhere to warrant infraspecific taxonomic recognition. For example, specimens of *Laurencia obtusa* were found to be epilithic here but epiphytic elsewhere (Newton, 1962). Molecular biological studies might be the key for the solution of many of the taxonomic questions involving the Azorean seaweed flora. There is a clear need for a floristic account of the Azorean marine macroalgae, as currently most identifications have to be based on the interpretation of species described elsewhere, which makes the identification of local species less reliable.

When compared to other major land masses in the North Atlantic (see Tittley *et al.*, 1990), the Azorean algal flora can be considered as relatively depauperate. As pointed out in Chapter 2, the Azores are young oceanic islands which, according to Smith (1992), have fewer algal species than islands of intermediate age and which occupy an isolated mid-Atlantic position. However, when comparing the Azores with other Atlantic islands groups, the algal flora of the former can be regarded as quite rich, as pointed out by Tittley and Neto (1995). This is indicated in Table V. This species richness may be ascribed to the range of habitats available on the Azores. Azorean shores provide biotopes significant to global biodiversity, considering their location in the middle of the Atlantic Ocean.

Table V. Species-richness of the algal flora of several Atlantic Islands.

	Number of species	References
Faroes	223	Irvine (1982)
Shetland	301	Irvine (1980)
Azores	336	Neto (1994, present study)
Madeira	364	Neto *et al.* (in prep.)
Canaries	572	Reyes *et al.*, 1994
Ascension	120	Price & John (1978)
Tristan da Cunha	115	Baardeseth (1941)
South Georgia	101	John et al. (1994a)

Overall analyses of the flora of the present study (Table I) reveals large similarities with the eastern Atlantic. The majority of the species is amphiatlantic e.g. *Bryopsis hypnoides*, but the remaining are shared exclusively with the eastern Atlantic e.g. *Aglaothamnion bipinnatum*, a few being also present in the Mediterranean, e.g. *Plocamium cartilagineum*. Not one of the species found in the present study is exclusively shared with the western Atlantic.

Feldmann (1946) classified the Azorean algal flora as boreal and poor in species, and placed the archipelago with the other Macaronesian islands (except the Cape Verde islands) in the Lusitano-African region, mentioning the similarities between the Azorean flora and the ones from the Mediterranean, Europe and Africa. More recently, van den Hoek (1984) included the Azorean archipelago in his Warm Temperate NE Atlantic region. Van den Hoek (1987) stated that the Azorean algal flora is closely related to those from the NE Europe and NW Africa, and says that, since these islands were never connected to any continent, the colonization of their shores had to be done by dispersion mechanisms across the Atlantic Ocean. Prud'homme van Reine (1988) assigned the Azores to an intermediary position between the subtropical Macaronesian islands (Madeira, Selvages and Canaries) and the warm temperate Euroafrican coasts. In contrast, the Cape Verdean seaweed flora is characterized as tropical on account of the predominance of algal species with a tropical distribution (Feldmann, 1946; van den Hoek, 1975, 1984). Lawson and John (1982), however, stated that the Cape Verde Islands belong to the Warm Temperate African flora, and included in the same group the Canarian, the Mauritanean and the Senegalese floras. Prud'homme van Reine and van den Hoek (1988), moreover, found a distinct east American imprint for the Cape Verdean seaweed flora and later these same authors (Prud'homme van Reine & van den

Hoek, 1990) observed greater affinity between the seaweed flora of the Azores and the ones from Morocco and the British Isles than to the ones from America and Cape Verde. Tittley *et al.* (1990), however, observed more affinity between the Azorean flora and the one from Virginia, USA, and explained this as due to dispersal mechanisms of algal propagules by the Gulf Stream Current. On the other hand, Prud'homme van Reine (1988), cited the proximity between the Azores and the NE African coast as a reason to explain the affinities between these two floras.

According to Prud'homme van Reine and van den Hoek (1990), recent discussions about the biogeographic status of Macaronesia has resulted in two different opinions concerning the land flora. Sunding (1979) included in Macaronesia the Azores and Madeira archipelagos, the Canary Islands, the Cape Verde Islands and part of Morocco (the so-called Macaronesian enclave). Lobin (1982) suggested that the use of the term Macaronesia in biogeography should be avoided and proposed that, in a strict geographic sense only, the designation "Macaronesian Islands" could still be maintained to include all the mid-Atlantic islands together. In marine biogeography the concept "Macaronesia" is not often used. Feldmann (1946), in his study on the marine floras of what he called "îles atlantides", discussed the seaweeds of the same mid-Atlantic archipelagos as mentioned by Lobin (1982). According to Feldmann, the marine flora of the Cape Verde islands is tropical, while all other archipelagos have seaweed floras which are part of the Lusitano-African Region. Van den Hoek (1975) included the Canary Islands in his Canaries Province of the warm temperate Mediterranean-Atlantic Region, while Lawson (1978) included the seaweed floras of the Salvage and the Canary Islands in his warm temperate African marine algal flora, together with the floras of subtropical west Africa and of the Cape Verde Islands. More recently Prud'homme van Reine (1988) and Prud'homme van Reine and van den Hoek (1988) stressed the individual position of the assembled seaweed flora of the Cape Verde islands and a different position for the Azores. Prud'homme van Reine and van den Hoek (1990) used the designation Macaronesia *sensu stricto* for the Madeira archipelago, Salvage and Canary Islands. They emphasized the intermediate position of the Azorean flora between the floras of Macaronesia *s.s.* and those of cooler warm temperate Eurafrican coasts.

Benthic marine algae are dispersed by different kinds of propagules such as spores, gametes, zygotes and detached thallus (Hoffmann & Ugarte, 1985). Algae produce large numbers of propagules (Round, 1981) but few evaluations have been made of the production and number of propagules arriving in coastal habitats. Spatial and temporal variations were observed by Hoffmann and Ugarte (1985) in the diversity and abundance of propagules of benthic macroalgae in seawater collected from the shore, as well as in offshore seawater in central Chile. Differences in dispersal ranges might be related to specific spore dispersability (Coon *et al.*, 1972; Dayton, 1973; Paine, 1979; Amsler & Searles, 1980) or spore viability (Jones & Babb, 1968; Round, 1981). Differences in reproductive periodicity, dispersal shadows, and numbers of propagules produced may be important in the colonization of areas, and might therefore play a role in structuring the patchiness characteristic of coastal biota (Hoffmann & Ugarte, 1985). It has been postulated that opportunistic algae produce large numbers of spores over extended periods, while late successional species are characterized by a more marked seasonal variability and the release of smaller numbers of propagules (Littler & Littler, 1980). Opportunistic algae appear to have large dispersal shadows, while the opposite occurs in perennial algae (Amsler & Searles, 1980; Hoffmann & Ugarte, 1985). Hundreds to several thousands of propagules may be present in each litre of seawater (Hoffmann & Ugarte, 1985).

Less is known about how well algae are able to concentrate spatially and mix their gametes, because this will depend on the hydrodynamic environment, which is poorly characterized for many algae. Water movements can mix male and female gametes, thereby increasing the probability of fertilization. On the other hand, most water movements will dilute the concentration of gametes, so as to decrease the probability of fertilization (Brawley & Johnson, 1992).

Currents play an important role in the transportation of propagules. Oliveira *et al.* (1979) stress the importance of the Current of Brazil in the introduction of northeastern species to lower latitudes of the littoral of Brazil. They also state the importance of floating *Sargassum* plants in the transportation of many other species along the coast of Brazil. These plants will carry many others as epiphytes, which may liberate reproductive cells that, if encountering favourable environmental conditions, can settle and therefore colonize a new area. Woelkerling (1975) and van den Hoek (1987) also highlighted the role of the floating macroalgae in the transportation of many other benthic species of seaweeds.

According to Cook (1980), the dispersal phase in most plants is relatively short: seeds and spores typically show a clustered distribution near the parent plants. This appears to be particularly true for marine algae, the spores of which are short-lived, owing to the lack of a protective outer covering, characteristic of seeds of higher plants. In addition, sinking rates of spores should also be considered, which directly affect spores' time in the water column (Coon *et al.*, 1972; Okuda & Neushul, 1981). The ability of swarmers of *Enteromorpha intestinalis* to be motile for up to eight days (Jones & Babb, 1968) suggests that considerable dispersal of this alga, and other species releasing motile stages, could take place in the plankton. Mobility of spores is different at different groups. Unlike the non-flagellated spores of red algae, the flagellated zoospores of brown algae are highly motile (Suto, 1950). Many summer annuals are thought to overwinter as multicellular sporelings (Dixon, 1960) and these are the phases which may survive transportation by vectors from one country to another. According to Reed *et al.* (1988), episodes of long-distance dispersal are important for two reasons: firstly, they tend to restore local populations and maintain the integrity of distribution of species; secondly, long-distance dispersal should promote genetic diversity within populations and decrease it between them. Rates of immigration are lower for more distant islands than those closer to a source of propagules (MacArthur & Wilson, 1963). Factors required for a successful introduction include: suitable vector(s); survival during the transit period; arrival in a new region providing the same or similar habitats to those in the place of origin; the establishment of a large enough breeding stock from either a single massive inoculum or from a repetitious series of invasions; suitable conditions and vectors for the further spread of the introduced species (Farnham, 1978; Ribera & Boudouresque, 1995).

The ecological factors affecting settlement and recruitment of marine benthic organisms are very important and have been widely emphasized in recent years (Hawkins & Hartnoll, 1982, 1983; Underwood & Denley, 1984; Connell, 1985; Roughgarden *et al.*, 1985; Lewin, 1986; Menge & Sutherland, 1987; Underwood & Fairweather, 1989). Variability in initial density of settlers and in post-settlement mortality may strongly affect the colonization, distribution and abundance of adult populations (Cecchi & Cinelli, 1992).

On the other hand, for some algae (e.g. *Gelidium, Pterocladia*) there is evidence that they rarely recruit from propagules (Sousa, 1980; Montalva & Santelices, 1981; Jernakoff, 1986). The lack of viable propagules in many gelidioid algae may be due to infertility of propagules (Santelices, 1974) or to the outcompetition of germlings by ephemeral algae (Jernakoff, 1986). The colonization of new regions by these species would, thus, depend on other factors.

During the last decade, experimental research has shown that the geographic distribution of seaweeds species is to a large extent controlled by seawater temperatures (see Breeman, 1988 for review). Specifically, it has been suggested that some species require cold water to survive, others warm water (Setchell, 1915, 1920; Chapman, 1943; Silva, 1959, 1960; Edwards & Kapraun, 1973; van den Hoek, 1975, 1982b, c, 1984; Lubenco, 1980; McLachlan & Bird, 1984; Cambridge *et al.*, 1984, 1987; Searles, 1984; Yarish *et al.*, 1984; Breeman, 1988; Bot *et al.*, 1990; Pakker *et al.*, 1995).

Investigations on the temperature tolerance of the components of local algal floras at as many stations as possible may increase our knowledge of the different aspects of the geographical distribution of these components (Edwards, 1969, 1970, 1979; Kapraun, 1977a, b, 1978, 1979; Kapraun & Zechman, 1982; Yarish & Edwards, 1982). It might be possible to estimate whether or not, and to what extent, a species can shift its survival limits during the year. Comparisons of the temperature survival ranges of a given species at different localities may reveal whether or not it is genetically flexible enough throughout its distribution range to form temperature ecotypes and by this to enlarge its overall distribution (Lüning, 1984). According to this author, considering the small fossilization potential of seaweeds, one may find that the temperature characteristics of species, genera, or even families have been so stable over millions of years that the temperature behaviour may be used as a "fossil trait".

Pakker *et al.* (1995) noticed that the temperature responses of species from tropical localities are more stenothermal than had previously been documented (McLachlan & Bird, 1984; Cambridge *et al.*, 1987, Lüning, 1990). Apparently, responses to high temperature may reflect temperature adaptations to extreme conditions on the shore. In contrast, Pakker *et al.* (1995) noticed in their experiments that subtidal and intertidal species did not differ significantly in responses to low temperatures. According to them, western Atlantic species appear to be significantly less tolerant to low temperatures than species having an amphi-Atlantic distribution.

Some striking distribution patterns have been recognized in the tropical and warm-temperate Atlantic regions (Prud'homme van Reine & van den Hoek, 1990; Haroun *et al.*, 1993). Many amphi-Atlantic seaweeds with a tropical to warm-temperate distribution have a predominantly tropical distribution in the western Atlantic but occupy warm-temperate regions in the eastern

Atlantic (van den Hoek, 1979, 1982a; Prud'homme van Reine & van den Hoek, 1990). Sea surfaces temperatures in the different regions along the Atlantic and Mediterranean coasts show considerable differences. Disjunct populations which experience different seawater temperatures may develop local, genetically fixed adaptations to these temperature regimes (ecotypic differentiation: see Bolton, 1983; Novaczek & Breeman, 1990; Pakker & Breeman, 1996).

The geographic distribution boundaries of benthic algal species can then be defined according to limiting temperatures, either as a growth (or reproductive) limit in the growing season, and/or as a lethal limit in the adverse season (van den Hoek, 1982c; Breeman, 1988). Conclusions can then be drawn about the biogeographic affinities of certain taxa, and possibly of an entire flora, based on phenological observations and responses of those taxa to environmental parameters.

It is important to point out the close similarity of the temperature values for the Madeira, Salvage, and Canary Islands, considered as Macaronesian *s.s.* (cf. Prud'homme van Reine & van den Hoek, 1988). In summer the sea temperature in the Azores is almost the same as in those more southern islands, but during winter much lower values are recorded. Most probably, winter temperature is a lethal limit for most subtropical species as suggested by Wirtz and Martins (1993). The temperature in the Cape Verde Islands is always much higher than in the other archipelagos. Therefore, higher number of tropical to subtropical species are encountered in this archipelago (Haroun & Prud'homme van Reine, 1993). The larger numbers of species present in the Macaronesian *s.s.* islands would therefore be the result of their closer vicinity to donor areas and/or warmer temperature regime.

According to Prud'homme van Reine and van den Hoek (1988) the richness of the Macaronesian *s.s.* seaweed flora may have resulted from its lesser susceptibility to extinction by lowered Cenozoic temperatures and the presence of more diverse coastlines.

Those who have recognized a warm temperate flora along the mid-Atlantic coasts have had difficulty specifying its boundaries, particularly the northern and western boundaries (Stephenson & Stephenson, 1952; van den Hoek, 1975; Kapraun, 1980). Van den Hoek (1975) recognized a sharp distinction between the warm temperate Carolinean region and the cold temperate Atlantic-Boreal region to the north. His data indicated that the warm and the cold temperate Carolinean and the tropical Atlantic regions both show greater similarities to the warm temperate Mediterranean-Atlantic region to the east than to the northern floras. According to van den Hoek (1984), a major question is whether recent transoceanic dispersal of seaweed species between the Caribbean and warm temperate Europe and West Africa provides a better explanation of the similarity between the floras of their rhodophytan genera.

The marked differences between disjunct floras have been attributed to historical factors such as the configuration of oceans and continents in the geological past and paleoclimatic events (van den Hoek, 1984; Breeman, 1988).

The North Atlantic Ocean has undergone major geological and climatic changes since its formation in the Mesozoic (Hommersand, 1990). These changes are reflected in the composition and floristic relationships of its seaweed floras. Hommersand (1986) suggested that many taxa in the northern hemisphere on both European and American coasts were derived originally from South Africa since the Miocene. According to him it is clear that long-distance transport of marine algae (with or without subsequent speciation) has occurred in the past and may account for the origin of large numbers of disjunct species and/or closely related species in widely separated floras.

Amphiatlantic tropical to warm-temperate Mediterranean seaweed species show ecotypic differentiation which is thought to be a result of cold adaptation of isolated populations in the eastern Mediterranean during the last glaciation (Pakker & Breeman, 1996).

According to Crowley and North (1991) even in warm geologic periods, like the mid-Cretaceous, when seawater temperatures at high latitudes were considerably higher than now, seawater temperatures in the tropics are believed to have been in the same range as they are today. The lowered temperatures during the Pleistocene glaciations, along the eastern coasts of tropical Atlantic and Pacific Oceans, have both permitted exchange of some temperate species between hemispheres and eliminated stenothermic tropical species along the eastern coasts (van den Hoek, 1982b). According to recent reconstruction of global paleotemperatures during the last glaciation, mainly based on assemblages of microfossils in sediment scores taken from the seabed (McIntyre *et al.*, 1972; McIntyre, 1976), low temperatures are considered to have extended much further towards the equator than at present, along the coasts of the Pacific and Atlantic Oceans, thus indicating increased upwelling and advection of cool water (van den Hoek, 1982b). According to this author, a combination of glacial lowering of surface water temperature and an increase in thickness of the euphotic layer (with mean monthly temperatures in its deepest parts varying between 20 and 15°C) could have allowed the passage of temperate species along equatorial western Africa. Possibly the sea level lowered by c. 100 m would have brought submerged seamounts within reach of the euphotic layer. These could thus function as stepping stones for the dispersal of temperate benthic algae across the equator. However, this hypothetical combination of 2-8°C lowered glacial surface temperatures and an increase in depth range of the euphotic layer cannot explain the absence, by elimination, of stenothermal tropical algal species along the east Atlantic coast, as these species could probably reproduce and survive in surface waters which are 2-8°C cooler than at present along equatorial African coasts. Possibly intermittent catastrophic cold spells lowered the surface temperature to 10-15°C in the course of the numerous glaciations. These cannot be traced in the microfossil record but could have been responsible for a gradual extinction of stenothermal tropical species (van den Hoek, 1982b).

According to van den Hoek (1984), the two North Atlantic warm temperate floras are not at all related. Nonetheless, uninterrupted coastlines and an island chain in the north (the Greenland-Scotland Ridge) could be invoked to explain exchange of warm temperate genera between NW and NE Atlantic coasts during warm early Miocene and possibly still earlier warm periods. If a warm temperate NW Atlantic flora has ever existed, its disappearance could be explained by the present and Pleistocene nature of the southeast American coasts, where long sediment shores are inhospitable to benthic algal growth, and where scattered offshore reefs are inhabited by an impoverished extension of the rich NW Atlantic tropical flora. Flora migrations enforced by the Pleistocene glaciations could have enhanced this impoverishment.

Although all the Macaronesian archipelagos are of volcanic origin, other geographic characteristics, especially their distance to the nearest continent and their age, are different. According to Haroun and Prud'homme van Reine (1993), the impoverished *Laurencia* and *Hypnea* florula present in the Azores, compared to other Macaronesian archipelagos, seems largely due to the isolated position of the former area, which is located at a considerable distance from other shores. This seems to be the reason for the apparent poverty of the Azorean algal flora, which has been characterized as consisting of chance survivors of occasional invasions by long-range dispersal (van den Hoek, 1987; Prud'homme van Reine, 1988).

Within the archipelago, comparison between the island of São Miguel and the islands of Faial and Flores (Chapter 4), revealed no significant differences, suggesting a large uniformity among its component islands. DECORANA analyses of the separate island floras of the Azores archipelago revealed a single cluster of sites (Tittley & Neto, 1995), with a gradual change between the extremes from east (São Miguel Island) to the west (Flores and Corvo). However, these observations need confirmation and future research is required. Studies of the phytoplankton occurring in Azorean waters, associated with studies of the major currents influencing the archipelago, would be extremely important for a better understanding of the mechanisms acting on macroalgal dispersion and colonization of the Azorean shores.

Of the 19 littoral associations recorded by Schmidt (1931), and named after their dominant alga, only a few were found at the two study sites: *"Enteromorpha"*, *"Gelidium microdon"*, *"Laurencia obtusa"*, "*Caulacanthus ustulatus* - *Chondracantus acicularis* - Ceramiaceae" (this one only at the south site), and *"Corallina elongata"*.

The different distributions encountered for many algae, being exclusively intertidal or subtidal in the sites studied, is an interesting result of the present study. For many alga, the available data are not sufficient to allow any explanation. But for others, I believe that interspecific competition, associated with tolerance limits for each species, plays an important role on the exclusion of certain species from one of the levels. An example can be seen with the larger brown algae e.g. *Sargassum* and *Cystoseira*. On Azorean shores they are limited to tide pools, and only very rarely colonize the lower intertidal, whereas elsewhere in Macaronesia they dominate the lower intertidal level (e.g. Madeira: Augier, 1985; Bianchi *et al.*, in press; pers. obs; Canaries: Gil-Rodríguez, 1980; González & Afonso-Carrillo, 1990). The *Cystoseira* belt in the lower intertidal is also common in the Mediterranean (Giaccone & Bruni, 1973; Garcia Carrascosa, 1987). It is known that *Cystoseira* species are very intolerant to desiccation (Edwards *et al.*, 1985), and this together with competition for space against subtidal algae, may explain their restriction to tide pools at the study sites.

Many species occurring in the intertidal level were only found in the turf populations. This growth strategy as a turf form has been observed elsewhere in the Atlantic Ocean, from the Cape Verde Islands (Otero-Schmitt, 1993), the Canary Islands (Lawson & Norton, 1971), West Africa (Lawson & John, 1982), the Caribbean (Rogers & Salesky, 1981) and Brazil (Oliveira & Mayral, 1976). In the Pacific Ocean turf species have been described from California and Mexico (Stewart, 1982, 1989), and Chile (Santelices & Abbott, 1978). Price and Scott (1992) decribed the red algae of the turf algal flora of the Great Barrier Reef, Australia. Neuschul and Dahl (1967) defined turfs on the California coasts as being a taxonomically complex mixture of small algae and developmental forms of large algae.

Stewart (1982) commented that "turf" is a convenient term to describe mats of small algal thalli in warm temperate and tropical regions. The thalli of species living in a turf are adapted for vegetative spread through the algal mat using multiple attachments to anchor the plants. Observations made during the present study also concur with those of Stewart (1982, 1989) that algal thalli in the intertidal turf intertwine and reattach to one another. Stewart (1989) observed on Californian shores that some alga like *Centroceras*, *Ceramium* and *Cryptopleura* spp. repeatedly reattach by means of discs or peg-like haptera that develop between two touching algal surfaces. Moreover, *Centroceras* and *Ceramium* spp. attach to algal surfaces with tufts of rhizoids that develop at nodes. This was also observed in the intertidal turf of the present study sites. Plants of *Hypnea* and *Laurencia* form thallus-to-thallus fusions without the development of distinct structures. *Jania* spp. form very small holdfast crusts on *Corallina* axes and rock surfaces. These algae can therefore always find surfaces for attachment, and can increase in abundance rapidly whenever environmental conditions are conductive to their growth. Epiphytes were found to be a major component (both in diversity of species and biomass) of the turf at various times of the year and considerable difficulties were encountered in identifying many of the constituent species.

The algal turf that covers rocks at the lower intertidal in the study sites and other localities on Azorean shores is very rich in species diversity; only very rarely is a monospecific turf found (see Chapman, 1955; Larkum, 1960; Pryor, 1967b; Neto & Azevedo, 1990; Neto, 1991b, 1992a; Neto & Tittley, 1995; Tittley *et al.*, in press). Comparisons with turf constituents identified by Stewart (1982) from California and also from elsewhere in the Atlantic (West Africa, Lawson *et al.*, 1975, Lawson & John, 1977; Brazil, Oliveira & Mayral, 1976) revealed common elements at the generic level, mainly red algae: *Gelidium*, *Corallina*, *Jania*, *Hypnea*, *Chondracanthus*, *Centroceras*, *Ceramium*, *Chondria*, *Laurencia* and *Polysiphonia*. The dominance of the coralline algae is probably related to the survival strategies of these plants, that allow their persistence in the algal turf. These forms of calcified thalli are well able to resist abrasion grazing, and the compact mat formed retains water, providing a suitable habitat including surfaces for attachment of other algae.

The success of *Corallina* species in becoming established over rock surfaces and in persisting from year to year as the dominant algal species in the turf on California shores was shown not to result from competitive exclusion of other species but as being the result of several attributes (Stewart, 1989). The basal crusts of these plants can survive more than one year under sand. The apical meristem, as in all red algae, retains the growing portion of the plant above the sediment when sand covers the basal axes, which enables the plants to restore their pigments and grow within less than two weeks following burial (Stewart, 1989). This growth of new erect axes from persistent crusts regenerates damaged thalli. Littler and Kauker (1984) comment that the ability of *Corallina officinalis* to regenerate from resistant vegetative portions is advantageous in that it allows the retention of significant primary space during physical disturbances as well as permitting a more rapid recovery to predisturbance levels following damage. Dayton (1975) observed that when large overstory algae were removed in the northeastern Pacific, understory individuals of *C. officinalis* partially survived when exposed to moderate desiccation, since the encrusting holdfast systems remained alive, although the articulated, erect fronds died and fell off. These crustose portions can spread laterally by means of apical cell divisions along the margins and continue producing new uprights if conditions remain favourable. The lateral growth from basal crusts increases the surface initially occupied by single thalli. However, until new fertile uprights are produced, the crustose bases remain sexually and assexually inactive (Dayton, 1975). The upright portions have a decided competitive advantage in exploiting light and nutrients as compared to strictly crustose species (Littler & Kauker, 1984). The calcified thalli probably resist abrasion better than do thin, soft thalli. Judging by the difficulty Stewart (1989) found in removing crusts from the substratum, *Corallina* is probably seldom removed from rocks unless the rock itself splits and is broken away. This was the only way that Stewart (1989) considered *Corallina* to be disturbed. The morphology and branching pattern of these plants produce a compact mat that retains water, traps sand, and provides secondary surfaces for numerous epiphytes, all means of resisting desiccation. A perennial life history and slow rates, both applicable to *Corallina*, are among the predicted characteristics of plants in habitats of high stress but not widespread disturbance. Finally, Littler and Murray (1978) have argued that low calorific values for coralline algae are of survival value against grazing stress.

The causative factors in turf formation still remain unclear. They may be physical/environmental or the result of plant-animal interactions such as grazing by invertebrates or fish. The grazing pressure by these animals may be one of the prime factors determining algal abundance and species composition in many benthic habitats in tropical and subtropical waters (Randall, 1961, 1965; Earle, 1972; Sammarco *et al.*, 1974; Vine, 1974; Vermeij, 1975; John *et al.*, 1977).

The reasons why so many species grow in a turf form on Azorean intertidal shores is probably related to:

i) the high interspecific competition for space that occurs in the littoral of the Azores;
ii) the retention of water during low tide periods, reducing desiccation;
iii) the damage caused by the wave-action.

The autecological observations (Chapter 4) revealed interesting results for many species, both in their growth and reproduction.

Certain species were present all year round (e.g. *Codium elisabethae*) and some did not exhibit any obvious seasonality in their size or biomass, such as *Zonaria tournefortii*. Others were restricted to particular periods of the year e.g. *Anadyomene stellata*, in spring and summer; *Ectocarpus siliculosus* in spring; *Hincksia mitchelliae* in summer; *Cladostephus spongiosus* in autumn; *Gastroclonium reflexum* only present between February and July; *Aglaothamnion bipinnatum*, collected only from December to July; *Callithamnion granulatum* only seen between November and July. Their absence at different times of the year can be related to the biology of each species, and/ or to errors associated to the sampling method. Many of these species are small plants (as with most Ceramiaceae) and occur in low numbers in the communities, thus being easy to miss from the collections.

Most species however showed a well-established seasonality in their growth and reproduction, which is probably related to environmental conditions.

According to Stewart (1984), natural environmental conditions varying with season include factors that can be correlated with both high and low initial growth rates of marine algae. Relationships between environmental factors and the abundance and seasonality of seaweeds have been widely discussed (Guiry *et al.*, 1987b; Maggs & Guiry, 1987; Brophy & Murray, 1989; Egan *et al.*, 1989; Kautsky & van der Maarel, 1990). Several studies have indicated that temperature, light intensity and salinity are the dominant factors affecting algal distribution and growth (Gessner, 1970; Hellebust, 1970; Jerlov, 1970; Gessner & Schramm, 1971; Soeder & Stengel, 1974; Santelices, 1977; Bird *et al.*, 1979; Hanisak, 1979; Druehl, 1981; Lüning, 1981; Friedlander & Zelikovitch, 1984). Chapman (1964) emphasized that strong tidal currents can affect the growth and size of seaweeds, and that competition for space is very severe in areas with strong tidal currents. The same was also stated by Round (1973).

Kaine (1984) believes that many species have become highly adapted to the seasons so that they effectively anticipate favourable periods. Annual and ephemeral species seem to respond to these periods as the opportunity arises. Guiry *et al.* (1987a) observed no differences in the upper temperature tolerance of *Chondracanthus teedii* from the Atlantic and Mediterranean. Inhibition of photosynthesis, particularly in the Rhodophyta, by high irradiance has been demonstrated many times (Mathieson & Dawes, 1974; Mathieson & Norall, 1975a, b; King & Schramm, 1976; Ramus & Rosenberg, 1980). As has been pointed out by Lewis (1972), the length of tidal exposure, degree of insolation and other variable factors, such as rainfall, probably affect the growth of algae more than the actual sea temperatures.

Rico (1991) demonstrated that, in *Gelidium latifolium*, abundance and reproductive patterns can be related to environmental factors. In his work with plants from Asturias (northern Spain) he found that maximum biomass values were coincident with summer seawater temperature, longer day lengths and lower nutrient concentrations; on the other hand, maximum reproduction was found to occur in winter, when seawater temperature was at its lowest and day lengths were shorter. The same has been reported for other intertidal *Gelidium* species (Montalva & Santelices, 1981). In the present study a different situation was found. Higher biomass values of *G. latifolium* occurred in late winter, and tetrasporophytic plants were present all year round. However, *G. microdon* was more abundant in spring/early summer, with the larger plants occurring in early summer.

High irradiance is known to have a limiting effect on the growth of some species. There is considerable evidence for frequent limitation in growth of *Plocamium cartilagineum* in England. Erect axes in a deeper population did not appear to grow during the darkest months (Kain, 1987). On the other hand, there was strong evidence for inhibition by summer daylight for a population in shallow water. *Plocamium* was described as a "shade lover" by Boudouresque (1969, 1970) merely from the evidence of its habitat. This was confirmed later by Kain (1960, 1987), Smith (1967) and Lüning (1970). It clearly can inhabit shallow water but is found under the laminarians and it extends into deeper water of more than 20m (Kain, 1961; Norton, 1968; Norton *et al.*, 1969). In the present study, *P. cartilagineum* was also only occasionally found in the intertidal level, being more abundant subtidally at the deepest level surveyed at São Vicente (15m N), where it was most of the time growing in the shade of *Zonaria tournefortii*. Larger *Plocamium* plants were found in late winter and spring, and the higher values of biomass in spring, when both sea water temperature and hours of light values were increasing. Their size begun to decrease after July, when these factors were higher.

Santelices' (1978) study of Hawaiian Gelidiaceae showed that the effect of temperature on growth rates was relatively unimportant compared with the effects of light intensity and water movement. Despite an occasional field observation of short recovery periods of apparently more rapid growth, *P. capillacea* regularly behaved in southern California as a characteristically slow-growing perennial plant in natural populations (Dixon, 1966; Stewart, 1968), and in laboratory cultures (Stewart, 1984). In the present study, large fluctuations were observed in frond size and standing crops of *P. capillacea* over the year, the higher biomass occurring in late summer/autumn. Fralick and Andrade (1981) found larger plants in summer in Terceira Island. Personal observations in previous years in other localities on São Miguel Island revealed that, although having slow growth rates most of the year, this species can growth very fast in the summer months. This growth is merely vegetative and was observed in commercially exploited beds of *P. capillacea* on the northeast part of the island, where plants were harvested in early July and again in late September. These months correspond to the higher values of temperature and day length, and to low wave action. Dixon (1965) promoted the concept that vegetative propagation and perennation are of major importance to the long-term persistence of certain algae. He cited one patch of *Pterocladia* that survived on the shore for at least 36 years by seasonally perennating from prostrate basal remnants. According to Stewart (1984), two related explanations seem plausible to justify the dominance of vegetative propagation in *Pterocladia*: prior environmental stress has direct detrimental effects and reproduction adversely influences vegetative growth. Both depend on seasonal factors. She found thalli with tetrasporangial sori throughout the summer months, during the period that cultures grew slowly, and proposes an inverse relation between reproductive and vegetative growth at this time of year.

Other species are known to be influenced by the wave action. In *Plocamium* the longer upright portions may disappear in autumn if they are subjected to wave action but they may survive all year round in deep water (Kain, 1987). A very different seasonal strategy, with several cohorts arising each year, is shown by *Asparagopsis armata* (Aranda *et al.*, 1984). Morphology of *Cladophora* spp. has been linked to hydrodynamic factors (Dodds & Gudder, 1992). Branching of marine *Cladophora* may become more pronounced with increased wave energy (van den Hoek, 1963, 1982a) and cells may become shorter with more turbulence (Ronnberg & Lax, 1980).

No data on the wave action were recorded during the present study. However, Neto (1991b), using data from 1988/89, observed that on São Miguel wave action was higher between October and April, and always more intense on the north coast. Late autumn to early spring is also the period of the year in which the effect of the wind is stronger (Instituto Hidrográfico, 1981), and both the seawater temperature and the number of hours of light are lower. This was the period in which most plants were smaller and exhibit lower values of biomass. The abrasive effect of wave action affecting the intertidal and shallow subtidal plants may be partly responsible for this.

The erect coralline algae presented a seasonal pattern in their biomass at the intertidal level but the same was not observed on the subtidal populations. The erect corallines showed much greater variation in biomass on the intertidal samples than on the sublittoral ones. Bearing in mind their perennial (and slow) growth patterns, the large fluctuations found in biomass and the lack of seasonality seen in the subtidal level probably reflect the sampling method used. The type of sampling theoretically required to obtain the unbiased results necessary to establish the community structure (Southwood, 1966; Littler & Littler, 1985) is very limited in getting information for each species of the community and not always desirable for communities with marked patchiness (Littler & Littler, 1985). For that, it would be necessary to sample each population separately and follow its development over a certain period of time. That was not possible in the present study.

A considerable variation was observed in the morphology of *Corallina elongata*. In tide pools the plants were pink and delicate, but on exposed rocks they were lighter in colour and growing in turf form. This can be related to the exposure to wave action, which was lower in tide pools than in the open rocks. In spite of these observed differences in morphology, no significant differences were observed in frond length over the year. At most levels, larger plants were present in summer but no clear pattern was evident. Variability, both in morphology and in vegetative anatomy, was observed also by Codomier (1969) studying the morphology and systematic of *Kallymenia microphylla* from the Atlantic and Mediterranean. He concluded that the great variation found in this species depended largely on the age of thallus and the type of substratum on which it grows. Hommersand and Ott (1970), studying a number of Atlantic and European specimens classified as *K. reniformis*, also observed great variability, both in morphology and in vegetative and reproductive anatomy.

The work of Lawson (1957) in Ghana suggested that the effects of tides can outweigh seasonal changes in temperature and insolation. *Hypnea musciformis* populations were most abundant during the spring and sparsest in winter, even though this is a tropical region with little seasonal variation. When tide-induced exposure to the air occurs during the day, the resulting high-temperatures, direct insolation and desiccation, can destroy *Hypnea musciformis* even in winter months (Mishigeni, 1977). In Hawaii the extreme low tides are most frequent during the months of January to May but are completely absent from August to November. These months of low tides were also the times of rapid decline in *Hypnea* standing crops (Mishigeni, 1977). These results seem to be controlled by tidal behaviour, substantiating Lawson's observations in Ghana. McQuaid (1985) found that intertidal algal biomass in Cape Cod was strongly influenced by tidal regime.

In the communities studied on São Miguel, *H. musciformis* although mainly subtidal, was also more abundant in summer, the larger plants occurring in spring and summer. Other species presenting a similar pattern were *Sphaerococcus coronopifolius* and *Ceramium ciliatum*, the former restricted to the sublittoral and the later species only being present in the intertidal at São Vicente. Other intertidal species, e.g. *Laurencia obtusa* and *Osmundia pinnatifida*, were more abundant in spring, the later being also abundant in winter. *Centroceras clavulatum*, the dominant turf species in the lower intertidal at São Vicente, was dominant in spring and summer, as were most lower intertidal and subtidal species. I believe that factors such as seawater temperature, insolation and desiccation are more responsible for these results than the prevailing tidal regime. Owing to the small tidal amplitudes that characterize Azorean shores, it is not common to find large mortalities in intertidal algal populations even during the summer months. However, that situation can occur on some calm and very hot summer days. In the study sites this summer desiccation was not observed. It has, nevertheless, been seen at other localities in *Ulva* and *Enteromorpha* populations in the eulittoral zone and also in turf populations dominated by *Laurencia* spp. in the sublittoral fringe.

Seawater temperature, day length and wave action, undergoing cyclic fluctuations over the year, are the main factors which can be related to algal seasonality. The maximum growth in spring and summer exhibited by most species corresponded to the period of the year in which the values of seawater temperature and number of hours of light were either increasing or maximal. Furthermore, these are the seasons in which wave action is usually lower.

The reproductive seasonality observed in some of the species during the present study has been observed elsewhere and can be related to many factors.

Reproductive seasonality in algae can result from variation in the environmental factors that satisfy their physiological requirements (Brawley & Johnson, 1992). In macroalgae, light plays a major role in the induction of reproduction (reviewed by Santelices, 1990). Photoperiod appears to be the predominant property of light used as cue in macroalgae (reviewed by Dring, 1984, 1988), as it is undoubtedly the most reliable cue for gametogenesis in long-lived algae. Gametogenesis can be induced by both short-day and long-day conditions (Guiry & Cunningham, 1984; Clayton *et al.*, 1987; Wiencke & Clayton, 1990; Dring, 1984; Kain & Norton, 1990). Temperature is also commonly thought to affect reproduction, although its direct role in the field is often unclear due to simultaneous (correlated) changes in other environmental factors that may be the true factor responsible for reproductive induction (e.g. nutrients levels, Deysher & Dean, 1986a, b; Kain, 1989).

Guiry and Cunningham (1984) demonstrated that *Chondracanthus acicularis* shows a combination of photoperiodic and temperature control of gamete formation. Gametogenesis is confined to a narrow temperature and photoperiod range (14 to 18°C; night lengths ≥ 12h), a combination of conditions that confines the formation of gametangia to the autumn in the British Isles. On the other hand, the formation of tetrasporangia does not seem to be limited by day length. In the present study, only one reproductive plant of *C. acicularis* was found. It was a female gametophyte, and it was collected in autumn (November), when the environmental conditions are similar to the ones described by Guiry and Cunningham (1984). Surprisingly, no tetrasporophytic plants were seen but the sporangia are small and immersed in the thallus, and so could have been overlooked.

Temperature can determine the development of haploid stages of some brown algae: at low temperatures, gametes are produced, whereas at higher temperatures, development leads to zoospores (Müller, 1981; Novaczek *et al.*, 1986; Peters & Müller, 1986). In the present study, this was only observed in a few brown algae (*Ectocarpus siliculosus*, *Hydroclathrus clathratus*, *Scytosiphon lomentaria*, and *Dictyopteris membranacea*). A similar situation was observed in the red alga *Asparagopsis armata*: the gametophyte was fertile in winter/spring, when the seawater temperature is lower, and the fertile tetrasporophytes were present in autumn/winter, when the temperature is still high.

There are other factors influencing reproductive events. In the brown alga *Dictyota dichotoma*, a periodicity of gamete release has been observed following the tide cycle (Williams, 1898, 1904, 1905; Lewis, 1910) or a lunar periodicity (Hoyt, 1907, 1927) but no such rhythmicity was seen in the production and release of spores (Fritsch, 1977b; Round, 1981). Similarly, the release of gametes was periodic in *Enteromorpha intestinalis*, showing a maximum around spring tides (Christie & Evans, 1962), whereas the release of zoospores was not (Pringle, 1986).

The question remains as to whether reproduction occurs as a direct response to conditions that meet the physiological requirements for reproduction or weather environmental factors are used to coordinate the timing of reproduction so that other ecological benefits are obtained.

Growth of perennial species is usually a direct response to factors fulfilling primary physiological requirements, while reproduction is the result of multiple interactive complex processes activated by "trigger" signals, such as short day length or low temperature (Lüning & Dieck, 1989). The existence of this restricted "reproductive window" is frequent in Rhodophytes, as pointed out by Maggs and Guiry (1987) and Breeman and Guiry (1989).

It is important to appreciate that the presence of reproductive structures does not necessarily indicate existence of viable spores or gametes (Maggs & Guiry, 1987). Studies on the viability of spores have to be made, although this has seldom been reported in the literature. It is also important to consider, in further field studies, the effect of microclimatic local conditions, caused by tidal cycles, wave action, etc.

The seasonal behaviour, growth and reproductive periods of the species found in this work are incomplete because, although all plants were carefully observed, the sampling methodology of this work was not designed for that purpose. Much remains to be achieved in these aspects, which will be best tackled through detailed autecological studies of individual species.

Some of the intertidal biotopes present in this study appear similar to those described in Hiscock's (1995) "Classification of benthic marine biotopes of the north-east Atlantic" and were provisionally identified as follows: i) at upper eulittoral levels occurred the equivalent to the "Barnacles & *Patella vulgata*" biotope (BP), although limpets are now very rare on the Azorean shores; ii) in shallow midlittoral pools, "coralline crusts & *Corallina*" (COR); iii) at lower eulittoral levels, the "*Corallina*" (RED.COR) and "Red algal turf" (RED) biotopes were also common, together with COR. On the other hand, *Fucus spiralis*, although present, does not form such a distinct biotope (FSP) as is common on most shores in the North Atlantic. The sublittoral fringe at the study sites supports biotopes characterized by either *Corallina elongata, Pterocladia capillacea, Asparagopsis armata, Centroceras clavulatum* and/or *Stypocaulon scoparia*, a very different situation from that occurring on northern Atlantic shores, where the large kelps are dominant. These large brown algae do not occur in the Azores, except for the record of *Laminaria ochroleuca* Bach. Pyl. (Ardré *et al.*, 1973; pers. obs.) for Formigas islets, below 40 m depth.

The overall pattern of zonation found in the present study is quite different from that of Bermuda and other tropical areas within the Caribbean (see van Loenhoud & van de Sande, 1977; Thomas, 1985; Brattström, 1992), and also from other areas of the North Atlantic (Stephenson & Stephenson 1949, 1972; Southward, 1958; Lewis, 1972; Pérès & Piccard, 1964; Pérès, 1967; Ardré, 1971; Lubchenco, 1980; Mathieson *et al.*, 1981; Norton, 1985, among many others). On the other hand, it is similar to the one occurring in Tenerife, also characterized by a littoral fringe dominated by littorinids, a littoral zone dominated by barnacles and two types of turf (the upper algal turf of *Caulacanthus ustulatus* and *Ulva* sp., and the lower turf of corallines), and a sublittoral fringe dominated by algal fronds (see Lawson & Norton, 1971). The same general pattern was also found on the intertidal zone of Madeira Island (pers. obs.) and in other islands of the Azores (Larkum, 1960; Pryor, 1967a, b; Neto & Azevedo, 1990; Neto & Tittley, 1995; Tittley *et al.*, in press).

This study adds a new algal zone (the *Fucus spiralis/Gelidium microdon* association) to the zonation pattern previously described for the littoral of São Miguel by Neto (1991b, 1992a). Recent personal observations on the seashore showed that this zone is common in several other places on the island.

Fucus spiralis, when present elsewhere, is quite common higher up on the shore where, in sheltered and moderately exposed shores, it can make a continuous and large belt (Lewis, 1972; Niemeck & Mathieson, 1976; Gayral & Cosson, 1986; Robertson, 1987; Hawkins & Jones, 1992).

In places with a well-established population of *F. spiralis*, Chapman (1989) comments that the strongest effect on the recruitment success of the species is intraspecific competition (adults vs. juveniles), rather than grazing. On exposed shores, if present, the plants are smaller and occupy only a small belt or are organized in patches (Gayral, 1966). Apparently, the degree of exposure inhibits the attachment of zygotes and, according to Niemeck and Mathieson (1976), rocks with cracks and fissures probably provide some degree of protection for developing zygotes, sporelings and adult plants. This agrees with the observation of Lawson and Norton (1971) in Tenerife (Canary Islands), where *F. spiralis*, although restricted to small patches, was present on exposed rocks but it was absent on a sheltered zone of boulders nearby. The presence of only small patches of *Fucus* at the south site and of larger patches in the north is probably due to a combination of the above mentioned factors. This would also explain its absence in several places of the island where either the degree of exposure is higher or the rock is smooth, with no cracks or crevices or, if these exist, they are filled by sand all the time. Another aspect to consider is that littorinids consume *Fucus* sporelings (Menge, 1975; Lubchenco, 1980) and may prevent *Fucus* from becoming established if they are abundant enough.

On the other hand, according to Gayral (1966), *Gelidium microdon* is quite common on exposed shores, where it occurs in the low intertidal. In the Azores, however, this species, when present, always forms either a continuous belt (São Vicente) or small patches (São Roque) in the upper intertidal, very commonly associated with *F. spiralis*. The reason for this is not known. A survey of the seashores around São Miguel Island and an evaluation of the main ecological parameters are needed in order to understand the factors controlling the formation of this algal zone.

The monospecific turf of *Caulacanthus ustulatus* has been also observed on the Mediterranean and Atlantic coasts of France (Lebonché, 1957), and in the Canaries (Lawson & Norton, 1971). This species is adapted to withstand large emersion periods and tends to occur on exposed shores, where it extends up the shore to the upper intertidal (Lebonché, 1957). Its lower limit is variable but *C. ustulatus* can be found within the lowest intertidal zone. In fact, although forming monospecific mats most of the time in France, *C. ustulatus* was also found associated with other species in the lower littoral zone (Lebonché, 1957). In Tenerife this species was mainly found below the barnacle zone, forming a distinct fringe (Lawson & Norton, 1971). In the study sites these two situations were detected, mainly on the south coast, where this species was present from the upper eulittoral down to the upper sublittoral fringe, as part of the multispecific coralline turf.

The coralline zone, found dominating the lower eulittoral zone, is common on other European coasts. Intertidal belts of *Corallina elongata* have been seen on the Spanish Atlantic coast (Sierra & Fernández, 1984b), Mediterranean (Ballesteros, 1982), Madeira (Bianchi *et al.*, in press; pers. obs.), and the Canaries (Elejabeita *et al.*, 1992).

Only a few foliose and frondose algae were present in the intertidal, and only at the lower level. This is common on the Azorean shores, where frondose growth does not seem to be a good strategy in the intertidal zone. In fact, the lower eulittoral zone of the Azorean coasts is dominated by well-established algal populations, growing in a turf form. This type of growth seems to be a better adaptation both to the wave action in winter and desiccation in summer. Many other species can grow as epiphytes, especially on the turf species, which provide a suitable habitat (increased space for settlement and protection). The ability of many algae to grow as epiphytes seems to be very important on Azorean shores, which in most cases are very narrow in extent, thereby offering a reduced space for the settlement of propagules.

According to Kensler (1966) and Zaneveld (1969), among the factors most likely to influence the pattern of littoral zonation of benthic species are desiccation resistance, temperatures tolerance, responses to differences in time of immersion which may influence the nutrient absorption and growth and, to a smaller degree, response to differences in incident illumination at different shore levels. It is generally accepted that a more or less regular vertical water movement is responsible for the feature of zonation (van Loenhoud & van de Sande, 1977). Less important is whether this movement is caused by tides, wave action or a combination of these, because in all these instances a completely developed littoral zonation can be found (e.g. Southward, 1958; Lewis, 1958; Stephensen & Stephensen, 1972). The amplitude of waves found around the Netherlands Antilles is generally greater than the average tidal range. For this reason, the zonation in Aruba and in Curaçao is accentuated by wave action rather than by tidal movements.

Field observations have suggested the importance of desiccation in determining upper limits. Many algae, including fucoides, extend further upshore wherever they are protected from desiccation by repeated wave splash (Burrows *et al.*, 1954; Lewis, 1972), by an overlying canopy of larger algae (Fisher, 1929; Menge, 1975) or by inhabiting shady places or north-facing slopes (Johnson & Skutch, 1928; Fisher, 1929; Zaneveld, 1937; Hatton, 1938; Norton *et al.*, 1971; Schonbeck & Norton, 1978).

The shore profile can modify several aspects of zonation by influencing wave movements. Because of the profile, certain habitats may exist (crevices, tide pools), in which some species can become established beyond their usual range in distribution.

The nature of the substratum may also have a certain influence on littoral zonation (den Hartog, 1959; Lewis, 1972). According to Mathieson *et al.* (1981), the type of substratum, such as rocky outcrops, boulders, cobbles, pebbles, shells and mud, found at a location determines the presence or absence of many species. The deposition of mud and/or sand on rocky substrata can drastically reduce the vegetation of an area by smothering germlings and reducing their attachment.

Sunlight and shading may influence littoral zonation with regard to species composition as well as to the position of the zones (Lewis, 1972). Light intensity can restrict the distribution of algae (Connell, 1972).

The effects of both abiotic (physico-chemical) and biological factors seem to be equally significant in determining the establishment and maintenance of zonation of littoral populations. It generally seems that the lower limits are usually caused by either competition or predation or both, while the upper limits are mainly physically determined (Hawkins & Hartnoll, 1983a).

A variety of factors may therefore be responsible for the different zonation patterns recorded. Some species may simply be responding to wave action. Many forms are probably restricted because of adverse hydrographic conditions. Druehl (1967) demonstrated that the upper limits of some algae in a British Columbia inlet reflected their intolerance to the high temperature and low salinity of the surface waters.

A certain degree of overlapping between the different populations, mainly in the eulittoral zone was observed at both study sites, as was indicated in Chapter 5. This was also observed by McQuaid (1985) in Cape Cod, richness being greatest in the mid-shore zones. In the present study, this can be related to the small extent of the intertidal zone of the study sites, associated with the steep slope and the small tidal amplitudes that characterize Azorean shores. This tidal regime causes short periods of emersion which, associated with the prevailing high wave action, would allow the extension up the shore of species that usually occur further down. This could explain the intertidal presence at the study sites of species typically subtidal elsewhere e.g. *Sargassum* spp.

At the study sites there is at present low grazing activity. Marques (1984) observed an important degradation caused by the sea-urchin *Arbaxia lixula* (L.), on subtidal communities on Graciosa Island. With the exception of the crustose corallines, the algal cover was completely destroyed by grazing. Such bare areas ("barrens") have never been described in other published information on Azorean algal communities. Further studies are needed to determine the location and extension of these areas, and the ecological factors involved in their maintenance. The sea-urchin *Paracentrotus lividus* Lamarck, although often occurring in large numbers in the algal turf zone, does not maintain bare areas, as seen in other places (see Lawrence, 1975; Hawkins & Hartnoll, 1983b). These sea urchins are small and restricted to holes, and are only abundant when the rock is soft or if there are fissures and crevices. In hard rock with smooth surfaces, their presence is restricted to tide pools. They probably feed primarily on drift algae, which can be caught on their spines and transferred via pedicellaria to the mouth (Hawkins *et al.*, 1990). Limpets (*Patella* spp.) used to be abundant at the eulittoral level of Azorean shores, but have recently been overexploited (Martins *et al.*, 1987, 1988) in all the islands and, despite protective measures, do not seem to be able to recover to their original levels (Hawkins *et al.*, 1990; pers. obs.). Overgrowth by the algal turf may be a delaying factor in the recovering of the limpet populations. Without the grazing activity of these organisms, the algal turf has developed dramatically and easily covered all the free space, leaving very few bare spaces. This dense algal cover may inhibit the colonization by sessile animals. This is probably also the reason why the barnacle *Chthamalus stellatus* did not extend to the lower eulittoral at the study sites. Without the grazing activity of limpets to keep the substratum free from algae, sessile animals such as barnacles cannot also become established. It may also help explain the difficulty in defining the boundary between the eulittoral and sublittoral fringe. This agrees with the observations of many researchers elsewhere (Hatton, 1938; Barnes, 1955; Southward, 1964; Dayton, 1971; Southward & Southward, 1978; Denley & Underwood, 1979; Underwood, 1980; Underwood & Jernakoff, 1981; Hawkins & Hartnoll, 1983; Branch *et al.*,

1992).

The absence of herbivores would also allow subtidal algae to grow up into the lower intertidal (Southward & Southward, 1978). Experimental work in New South Wales (Australia) by Underwood (1980) revealed that the absence of herbivores in the eulittoral zone is followed by a rapid colonization by algae, that will extend further up shore, above their normal limits of distribution. In these situations, the upper limit would also be controlled by abiotic factors and the tolerance limits of each species, as discussed above.

As pointed out by Dayton (1971, 1975), the habitat is a two-dimensional surface for seaweeds and space is the primary limiting resource. The substratum serves only as a place of attachment, the inorganic nutrients being supplied by the surrounding water (Mann, 1973).

Some species are characterized by different morphological types according to the different phases of their life cycle. The relative importance of resources and competitive processes among species would be expected to differ among these morphological types (Denley & Dayton, 1985). For example, encrusting forms can pre-empt space, inhibiting the settlement of spores of other species. In contrast, a frondose alga exploits space for settlement of another species over a much wider area by whiplash effects. For some propagules available settlement space is not enough. It has to be the right kind of space (Morse, 1992). Spores of some species may settle only on hard substrata, such as bare rock or encrusting algae, whereas spores of others may settle only epiphytically on upright algae. Yet others may attach to both primary and secondary substrata. The distinction among these requirements for establishment and growth is integral to an understanding of competitive interactions among species (Denley & Dayton, 1985). Also, the dispersive properties of spores of different species and the timing of their release affect their ability to colonize areas (Hutchins, 1952; Foster, 1975a). Their development and persistence are controlled by grazing, predation, competition and disturbance (Forster, 1975b; Schonbeck & Norton, 1978; Underwood, 1992). The importance of interspecific competition varies with different settlements from year to year (Connell, 1985; Lively *et al.*, 1993). In addition, predation and herbivory by the mobile members of intertidal communities are known to vary in both space and time, especially in tropical and subtropical areas (Garrity & Levings, 1981; Underwood *et al.*, 1983; Fairweather *et al.*, 1984; Fairweather, 1988; Brawly, 1992).

Although biological interactions directly structure many communities, the intensities and directions of these interactions are sharpened by underlying physical factors. The types of interactions also depend on the species present, which in turn reflect the biogeography of the area (Hawkins *et al.*, 1992).

Qualitative and quantitative differences were found between the two localities on opposite coasts of the island, and within these according to the vertical position on the shores (intertidal communities) or the depth (subtidal communities).

In the intertidal, major differences were observed between the species composition of the upper and lower levels. The multivariate analyses gave more emphasis to the vertical position of a zone on the shore than to its location on the island. This agrees with the observations made on the zonation survey, and also with the observations on the species composition and abundance. In fact, the physiognomy of the two coasts was very similar, the major differences being more in terms of species dominance than composition. The *Fucus spiralis / Gelidium microdon* association and *Caulacanthus ustulatus* turf are good examples. These results can be easily understood, when considering that the vertical distribution of species on a shore depends on several abiotic factors, such as insolation and desiccation, associated with the algal tolerance limits to these factors. Only the species well adapted to withstand desiccation and long emersion periods will survive in the upper intertidal. Depending on other factors (e.g. exposure to wave action), the upper limits can extend further upshore but populations will remain mainly the same.

The reasons why some species show different abundances or physiognomy, according to their location on São Miguel, are related to other factors which were previously discussed. For many species however, it was not possible to arrive at any conclusion based only on the present study. It is not possible, for example, to conclude why the *Caulacanthus* turf extends so high on the shore and why the *Fucus spiralis / Gelidium microdon* association is reduced to small patches on the south coast site, while a totally different situation is present on the north coast.

For the subtidal surveys, the analyses suggests the occurrence of four different communities, although it is not possible to say where they have their limits. It is however possible to state that the 5 and 15m depth levels of both coasts belong to different communities, as they were never grouped together. The classification of the 10m depth, on the other hand, is not clear. Some analyses grouped this level with the 5m communities, others with the 15m depth communities. Nevertheless, it is a fact that, for both sites, the transition between the 5 and 15 m communities is gradual. This suggests the presence of two well-established communities at each coast (5 and 15m) and a large transition zone, where gradual changes occur, both in species composition and abundance. This ordination of the communities studied along a depth gradient was expected, mainly because most descriptive studies of subtidal communities emphasize changes along such a gradient (Schiel & Foster, 1986), since factors such as light and water movement (wave-exposure) are likely to be inversely related to increasing depth (Anderson & Stegenga, 1989). However, the fact that most species were found over a wide depth range, and that these ranges widely overlap, suggest that the vegetation changes with depth in the study areas are continuous. The same was observed by John *et al.* (1977) in Ghana. They also concluded that, of all the factors analysed in their study, depth was the predominant environmental factor conditioning algal distribution.

The principal effect of depth was at the level of the relative abundance of the different species and not as much on their presence/absence, although some species were only present at the shallowest levels e.g. articulated coralline algae, others only at the deeper ones e.g. *Stypocaulon scoparia*. It should be pointed out that at São Vicente, algae are known to grow down to at least 40m (e.g. *Zonaria tournefortii*) and these deeper communities have yet to be described.

It seems possible to expect that deeper-water species will be separated from shallower-water species, and that a mixture of the two will prevail at intermediate depth, but no predictions can be made from this study, concerning the particular associations that might occur at a given depth. The restriction to shallow water of certain species is probably related to changes in the quantity and quality of light, associated with increased depth. Conversely, the restriction to deeper water of many other species may be due either to intolerance to rough, turbulent water, or to an inability to compete with the abundant shallow-water plants.

It is worth noting the different distribution of red and brown algae, with the first group dominating the shallower levels and the later dominating the deeper levels on both coasts. Neto and Tittley (1995) mention *Zonaria tournefortii* as restricted to deep water (30m) on the island of Faial. However, only the nature reserve of Monte da Guia was studied, so it is impossible to know if this is a valid statement for all the island. On the other hand, Tittley *et al.* (in press) found this species dominating the subtidal communities of Flores Island, from shallow to deep water levels (5 to 30m). Furthermore, the extensive Corallinaceae-dominated turfs that in the present study extend from the intertidal to shallow sublittoral (10m depth) were mostly intertidal on Flores (Tittley *et al.*, in press), but in Faial extended deeper, down to about 30m depth (Neto & Tittley, 1995).

Subtidal luxuriant communities of brown algae have been found elsewhere. In Madeira, Bianchi *et al.* (in press) also record the dominance of *Z. tournefortii* in relatively sheltered locations, from 5 to 15m depth. This species is also abundant in Mediterranean subtidal communities (Garcia Carrascosa, 1987), where *Dictyopteris membranacea* is another dominant species (Ballesteros *et al.*, 1984; Boisset & Garcia Carrascosa, 1987; Morri *et al.*, 1988; Balduzzi *et al.*, 1994).

The dominance of *Corallina elongata* in the intertidal algal turf at both coasts and in the 5 and 10m communities at São Roque agrees with observations made elsewhere. This species also characterizes a very distinct community in the lower intertidal and shallow subtidal levels of other geographic regions, e.g. France (Boudouresque, 1971a), western Mediterranean (Giaccone, 1970; Verlaque & Tine, 1979; Ballesteros *et al.*, 1984; Perera, 1986), and eastern Mediterranean (Ballesteros, 1988), and the Canaries (Pinedo *et al.*, 1992; Reyes *et al.*, 1994). In Madeira, this species has been considered midlittoral by Levring (1974) and infralittoral by Augier (1985). This distribution of *C. elongata* is probably related to the fact that this species, because of its calcified thallus, is particularly well adapted to environments with high wave action (Cabioch, 1972; Littler & Doty, 1975; Littler, 1976; Vadas, 1977; Littler & Littler, 1980; Littler & Kauker, 1984; Ballesteros, 1988). The communities of *C. elongata* in those localities are generally characterized by low biodiversity, as was also observed in the present study.

The presence of different communities at different localities agrees with previous personal observations on the island of São Miguel, where the algal communities vary both in species composition and dominance according to their location. The eastern and western coasts of the island have different communities from the ones studied here, and it would be important to extend this study to those localities. Coupled with the study of the conditioning abiotic factors, e.g. type of substrata, wave action, currents and light penetration (turbidity), this would make possible the definition of the various algal communities and map their distribution around the island. It would also be of interest to extend the study to other islands in the archipelago, and see if an uniform pattern could be recognized.

A preliminary survey, carried out on the western island of Flores in July and August 1995, revealed no major differences in the physiognomy of the intertidal communities around this island. In all the sites visited, the mid and lower eulittoral zones were covered by an algal turf, whose composition varied according to the location and vertical position on the shore. Upper littoral turfs were also dominated by *Caulacanthus*, as on São Miguel Island. Lower intertidal turfs were dominated by erect coralline algae and *Centroceras*, although *Laurencia* spp. were also important (see Tittley *et al.*, in press). An earlier expedition to Faial and Pico in July 1989 revealed similar communities (Tittley & Neto, 1994). Thus, it can be suggested that a basic pattern of littoral zonation and community organization probably occurs throughout the archipelago, with local modifications.

As expected, considering the perennial nature of the dominant species, stability was observed in the communities studied, which did not exhibit major differences in species composition and abundance over the two years of investigation. Surveillance over several years of rocky shores elsewhere, especially in temperate regions of the North Atlantic, indicate general stability of littoral communities, although fluctuations and cyclic changes have been observed (Lewis, 1977; Hartnoll & Hawkins, 1985; Little & Kitching, 1996). However, on those moderately exposed European shores, equivalent to the sites studied on São Miguel Island, rather more variation in mosaic structure was detected (Hartnoll & Hawkins, 1985). It would however be interesting to continue this present study so as to be able to evaluate long-term fluctuations. This should be complemented by monitoring the major environmental parameters. With the global change and related variations occurring all the time in the environmental factors, it is not possible to predict how the communities will be in, say, 20 years time. In the present case, and on a short-term basis, it is possible to state that we are dealing with relatively stable communities.

The annual fluctuations observed in the total mean biomass of the communities studied followed, in general, the pattern of the dominant species. At each level on the shore, these usually presented concurrent periods of growth. At the lower intertidal and subtidal levels, the higher values of biomass and larger plants were present in spring and summer, following the seasonal fluctuations of the main abiotic factors (sea temperature and day length). This was previously found by Neto (1992a) for other intertidal turf communities on the island of São Miguel. The correlation analyses between algal biomass and hours of light and seawater temperature, was however surprisingly weak, as was also observed by McQuaid (1985) in Cape Cod.

In contrast, summer was the period of the year in which the biomass was lower in the upper intertidal. This is the hottest season in the Azores, when the air temperature and the number of hours of daylight are highest. These two factors are known to be responsible for the desiccation that occurs in intertidal algae in the summer periods (Lewis, 1972; Mishigeni, 1977). These factors would have less effect on the lower intertidal algae of the studied sites. Considering the small tide amplitude occurring on the Azorean shores and the narrow intertidal zone, the algal populations at this lower level are never exposed for long periods. On the other hand, the turf-growing form is also a good defence mechanism against desiccation (see Stewart, 1989). Without the problem of desiccation, the plants can grow when the light and temperature conditions are optimal.

The decrease in biomass detected in the lower intertidal and subtidal communities in the winter months is probably related to the high wave action that occurs then. Plants are ripped from the rocks by erosion, and the combined accelerational and drag forces caused by wave action (Gaylord *et al.*, 1994). On the other hand, the higher wave action in winter time causes higher humidity in the upper intertidal and contributes to the increase in biomass of the upper intertidal plants, despite the shorter day length and lower temperatures.

No major differences were observed in the number of species and diversity during the year or between the two years, at any level, both in the intertidal and subtidal communities. This had also been observed by John *et al.* (1977) in Ghana and provides further support to the concept of stable communities, as discussed above.

The fluctuations observed over the sampling period are probably caused in part by the random collections, associated with the seasonality of the different species in each community. The lower diversity present at some levels is probably due to the dominance of one or two species over the sampling period (e.g. the erect coralline algae at São Roque, 5m depth).

7. CONCLUSIONS

The present study is a baseline description of the structure of marine algal communities on São Miguel, complemented with observations on the biology and ecology of the species involved. Two sites were selected, São Roque on the south coast and São Vicente on the more exposed north coast. Although no definite conclusions were possible, this study does allow the generation of appropriate hypotheses for future testing by controlled experiments in both the field and the laboratory.

Twenty nine new records have been added to the marine algal flora of the Azores which now totals 336 species. Despite increasing the number of species known from the Azorean shores, this study was geographically restricted, only small portions of specific habitats having been surveyed. Further and more detailed work, following a systematic sampling approach, developed in this study, involving investigation of different habitats, will likely reveal communities and species not previously encountered.

Research directed to specific types of growth and to difficult taxa is also necessary and will much probably reveal further additions to the benthic marine macroalgal flora of the Azores. The revision of the endemic species described by Schmidt (1931), the development of molecular biological studies and the elaboration of a general key for the Azorean benthic macroalgae are of major importance at this moment.

The biogeographically mixed nature of the Azorean algal flora, and its great affinity with the eastern Atlantic, were confirmed but other components were also identified from the western Atlantic and Mediterranean floras. Studies of the propagules present in the Azorean waters, associated with studies of the currents influencing the archipelago, would help to understand the mechanisms acting on macroalgal dispersion and colonization of Azorean shores. Possible alien species, such as *Codium fragile* and *Antithamnium diminuatum*, were recorded. Their mode of introduction and any ecological impact should be monitored.

Some species exhibited different ecological preferences, when compared to their other locations in the Atlantic. These are probably related to the high interspecific competition characterizing the Azorean marine communities, associated with the major environmental factors acting locally, and the tolerance limits of each species. The understanding of these preferences and of the littoral zonation, and their relations with the environmental factors requires intensive experimental research, related to small-scale measurements of local hydrodynamic conditions and other abiotic factors.

For the first time in the Azores observations were made on the occurrence, growth, biomass and reproduction of several algal species. A seasonal pattern was seen in the biomass and size of most species: commonly these patterns were correlated with day length and seawater temperature. Reproductive seasonality was also observed, with some species having a prolonged fertile period, others being fertile only for one or two seasons of the year.

The minimal areas for destructive sampling on both intertidal and subtidal benthic algal communities were established, being respectively 100 and 2500 cm^2. These were already tested in several places in São Miguel and elsewhere in the archipelago, and I recommend them for further studies on the Azorean marine algal communities.

Qualitative and quantitative differences were observed between the two localities, in both intertidal and subtidal communities.

At São Roque the turf form predominated over the frondose type of growth, from the upper eulittoral down to 10m depth. At São Vicente the turf dominated only the lower eulittoral level. Subtidally the frondose growth was dominant at all levels. The upper eulittoral was dominated by the *F. spiralis/G. microdon* association, which is described here for the first time.

The erect coralline algae were always dominant in the turf communities studied, both in the lower intertidal and subtidally.

Turf algal assemblages, with numerous epiphytes, still remain incompletely described for the Azores, although they are dominant in the intertidal zone of all the islands. Observations made during this investigation on the communities studied, as compared to elsewhere on the island, and even on other islands, showed that they are well established and represent climax vegetation. Experimental work, involving clearance, recolonization and exclusion, may yield important clues to the understanding of the factors controlling the formation of this type of algal growth on Azorean shores.

Geographical position and depth were identified as important factors in the structure of the subtidal algal communities. Four different communities were thus recognized: two shallow-water (5m) and two deep-water ones (15m). Many factors can be related to the differences observed, e.g. wave action, light, substratum. In further investigations on the algal communities of the Azores, the main factors acting should be identified and investigated.

The red algae dominated the lower littoral and shallow sublittoral levels, while the brown algae were dominant deeper.

Lower intertidal and sublittoral communities presented highest values of biomass in summer and lowest in winter/spring. The persistence of this pattern on Azorean shores is probable but further research is still necessary. If confirmed, these natural seasonal evolutions will be important for the management of the littoral ecosystems of the Azores.

The communities studied were seen to be stable on a short-term basis, at least. Whether this stability will continue over a longer period can only be ascertained by further investigation, e.g. implementing a non-destructive type of monitoring.

The annual changes observed in the communities reflects the biology of the species involved. A better understanding of the dynamics of the algal communities will necessarily involve further research into the biology of the species dominating Azorean shores. Studies involving a small-scale evaluation of the major littoral currents, complemented with identification of the propagules available in the water, the use of artificial substrata for settlement of propagules, and the growth of spores/gametes in laboratory, are very important to complement the present study, by understanding better the algal mechanisms of dispersion on the Azorean shores and the life histories of many species. This survey should be followed by investigation of both sexual and asexual reproduction in the field and laboratory that will help to explain colonization and abundance. In addition, the relative importance of competition between epiphytes and their hosts and the role of herbivores has yet to be established. This probably varies between systems and also helds a clue to the understanding of the dynamic of these communities. Finally, expanding these studies to other islands and to longer periods of time will help to draw a global picture of the dynamic of the algal-dominated marine communities of the Azorean shores.

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APPENDICES

A1. Quadrat scraping data (dry weight, g/m2) from the upper eulittoral of São Roque

		93.Sep			Oct			Nov			Dec			94. Jan			Feb			Mar			Apr		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Caulacanthus ustulatus	cauust	101,560	35,820	18,060	60,690	55,300	41,820	55,020	116,000	172,500	14,820	96,700	42,890	87,740	136,230	124,620	152,310	109,720	137,440	72,100	136,300	95,100	59,800	78,800	100,100
Ceramium strictum sensu Harvey	cerstr																								
Chaetomorpha linum	chalin				20,230	7,370	27,880	36,680			4,940	32,230	28,600	5,850	90,820	83,080	0,110			24,000	45,400	31,700	4,000	5,300	6,700
Corallina elongata	corelo			119,570																					
Fucus spiralis	fucspi																								
Gelidium microdon	gelmic													87,740			44,900								
Gelidium pusillum	gelpus																								
Gymnogongrus crenulatus	gymcre																								
Gymnogongrus griffithsiae	gymgri																								
Osmundia pinnatifida	osmpin														0,360			23,070				0,500	4,000		
Ulva rigida	ulvrig		7,500	0,600														0,110							
Total dry weight (g/m2)		101,560	43,320	138,230	80,920	62,670	69,700	91,700	116,000	172,500	19,760	128,930	71,490	181,330	227,410	207,700	197,320	132,900	137,440	96,100	181,700	127,300	67,800	84,100	106,800
Mean dry weight (g/m2)			94,370			71,097			126,733			73,393			205,480			155,887			135,033			86,233	
sd			47,862			9,205			41,456			54,610			23,120			35,954			43,321			19,587	
Number of species (S)		1	2	3	2	2	2	2	1	1	2	2	2	3	3	2	3	3	1	2	2	3	3	2	2
Mean number of species			2,000			2,000			1,333			2,000			2,667			2,333			2,333			2,333	
sd			1,000			0,000			0,577			0,000			0,577			1,155			0,577			0,577	

		94.May			Jun			Jul			Aug			Sep			Oct			Nov			95. Jan		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Caulacanthus ustulatus	cauust	90,400	66,800	56,700	284,710	157,930	56,290	30,870	55,720	38,450	37,030	32,940	18,930	11,200	12,040	25,330	39,830	36,020	44,900	14,950	21,980	58,490	21,850	16,500	19,920
Ceramium strictum sensu Harvey	cerstr						37,530				12,340	10,980	18,930												
Chaetomorpha linum	chalin	12,100	4,500	75,600	18,980	12,540	3,750		37,140	25,640				0,750	0,800	1,690	2,660	2,400	2,990	1,000		3,900			1,330
Corallina elongata	corelo							1,740																	
Fucus spiralis	fucspi																								
Gelidium microdon	gelmic																								2,660
Gelidium pusillum	gelpus																			9,960	1,470		1,460	2,200	1,330
Gymnogongrus crenulatus	gymcre																2,660	2,400	2,990	9,960	7,330	19,500			
Gymnogongrus griffithsiae	gymgri																						1,460	1,100	
Osmundia pinnatifida	osmpin												1,890										1,460	11,000	
Ulva rigida	ulvrig							0,550				2,200	1,890				2,660		2,990		1,470	3,900			
Total dry weight (g/m2)		102,500	71,300	132,300	303,690	170,470	97,570	33,160	92,860	64,090	49,370	46,120	41,640	11,950	12,840	27,020	47,810	40,820	53,870	35,870	32,250	85,790	26,230	30,800	25,240
Mean dry weight (g/m2)			102,033			190,577			63,370			45,710			17,270			47,500			51,303			27,423	
sd			30,503			104,521			29,857			3,881			8,455			6,531			29,921			2,966	
Number of species (S)		2	2	2	2	2	3	3	2	2	2	3	4	2	2	2	4	3	4	4	4	4	4	4	4
Mean number of species			2,000			2,333			2,333			3,000			2,000			3,667			4,000			4,000	
sd			0,000			0,577			0,577			1,000			0,000			0,577			0,000			0,000	

		95. Feb			Mar			Apr			May			Jun			Jul			Aug			Sep		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Caulacanthus ustulatus	cauust	58,950	46,480	51,980	28,540	14,490	30,610				19,140	15,580	26,220	37,520	93,770	36,680	63,740	44,580	39,240	26,420	33,670	30,920	1,550	115,240	61,920
Ceramium strictum sensu Harvey	cerstr																								
Chaetomorpha linum	chalin	3,930	3,100	3,430										5,000	12,500	2,450	4,250	2,970		1,760	2,240	2,060			4,130
Corallina elongata	corelo																								
Fucus spiralis	fucspi							15,130	7,410	30,710	15,250	26,770	20,860				4,250	3,180	42,610		6,460		35,720	15,370	4,130
Gelidium microdon	gelmic				28,540	14,490	30,610	45,400	55,590	20,470	3,830	15,580	26,220			12,230			1,070	1,760			1,550	15,370	4,130
Gelidium pusillum	gelpus				2,850												4,250	2,970			11,220	2,060			
Gymnogongrus crenulatus	gymcre	3,930	6,200	6,930																					
Gymnogongrus griffithsiae	gymgri													2,500	6,250										
Osmundia pinnatifida	osmpin					1,450		6,050	18,530	10,240	9,570	78,890	131,110			4,890			15,690	1,760	4,490		11,620	15,370	8,260
Ulva rigida	ulvrig				5,500	0,490					1,910							2,970					0,770	7,680	
Total dry weight (g/m2)		66,810	55,780	62,340	65,430	30,920	61,220	66,580	81,530	61,420	49,700	136,820	204,410	45,020	112,520	56,250	76,490	56,670	98,610	31,700	58,080	35,040	51,210	169,030	82,570
Mean dry weight (g/m2)			61,643			52,523			69,843			130,310			71,263			77,257			41,607			100,937	
sd			5,548			18,827			10,445			77,560			36,168			20,981			14,364			61,020	
Number of species (S)		3	3	3	4	4	2	3	3	3	5	4	4	3	3	4	4	5	4	4	5	3	5	5	5
Mean number of species			3,000			3,333			3,000			4,333			3,333			4,333			4,000			5,000	
sd			0,000			1,155			0,000			0,577			0,577			0,577			1,000			0,000	

A2. Quadrat scraping data (dry weight, g/m2) from the lower eulittoral of São Roque

		93.Sep			Oct			Nov			Dec			94. Jan			Feb			Mar			Apr		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Asparagopsis armata	asparm						9,090	40,360	57,860	48,710	6,030	13,760								1,500					
Botryocladia botryoides	botbot																								
Bryopsis hypnoides	bryhyp															9,790	0,010	10,620			1,400	0,100			
Callithamnion granulatum	calgra																							1,100	0,200
Callithamnion tetragonum	caltet																		0,110						
Caulacanthus ustulatus	cauust					13,460	84,460				11,680	2,510	49,030	44,910											
Centroceras clavulatum	cencla							0,300																	
Ceramium botriocarpum	cerbot													4,670	0,450										
Ceramium cimbricum	cercim																								
Ceramium deslongchampii	cerdes																								
Ceramium diafanum	cerdia																						0,400		
Ceramium pallidum	cerpal																	79,800	35,150	84,000	73,400	2,400	4,700	9,900	17,500
Chaetomorpha crassa	chacra															0,040									
Chaetomorpha linum	chalin																			8,400					
Chondracanthus acicularis	choaci							27,320	25,660		5,390			6,110	4,060			26,220	14,250					16,100	
Chondria coerulescens	chocoe																								
Chondria dasyphylla	chodas																								2,900
Colpomenia sinuosa	colsin																					3,700			
Corallina elongata	corelo	279,470	309,170	287,450	55,500	102,010		63,180	114,660	114,860	24,860	15,060	9,810	19,800	230,100	99,900	233,220		14,060	126,000		95,700	247,200	180,000	215,700
Cryptopleura ramosa	cryram																								
Dictyota dichotoma	dicdic																								
Falkenbergia rufolanosa	falruf																0,260								
Gastroclonium ovatum	gasova																3,230								
Gastroclonium reflexum	gasrel																		70,770						
Gelidium latifolium	gellat															6,380									
Gelidium pusillum	gelpus																								
Gymnogongrus griffithsiae	gymgri																								
Jania crassa	jancra				55,500	13,460	339,330	34,980	312,550	114,860	49,450	18,850	73,350	44,910							24,200				
Jania rubens	janrub									15,300						1,460		52,440	14,060	42,000					
Laurencia obtusa	lauobt														0,160										0,900
Lomentaria articulata	lomart																								
Nytophyllum punctatum	nytpun																								
Osmundia pinnatifida	osmpin				88,330	13,460		14,860		7,660	2,460			6,730		1,210	0,650	11,800	14,060		48,500	35,200	12,100	2,500	6,400
Plocamium cartilagineum	plocar																0,570			2,000					
Pterocladia capillacea	ptecap				0,260	64,800	0,480	18,800	0,010		19,590	22,270		9,650	0,470	4,440	2,210			8,200			0,600	8,200	4,900
Pterothamniun crispum	ptecri																				0,400	0,500			
Rodhymenia holmesii	rhohol																						0,400		
Stypocaulon scoparia	stysco															9,790									
Symphyocladia marchantioides	symmar																0,230	0,810				4,000			
Ulva rigida	ulvrig				3,200	0,290	4,190		24,160				1,170	0,020		0,020		0,050				0,600	0,100		
Total dry weight (g/m2)		279,470	309,170	287,450	202,790	207,480	437,550	199,800	534,900	301,390	119,460	72,450	133,360	136,800	235,240	133,030	240,380	181,740	162,460	272,100	147,900	142,200	265,500	217,800	248,500
Mean dry weight (g/m2)			292,030			282,607			345,363			108,423			168,357			194,860			187,400			243,933	
sd			15,371			134,205			171,823			31,920			57,953			40,583			73,408			24,176	
Number of species (S)		1	1	1	5	6	5	7	6	5	7	5	4	8	5	9	8	7	7	7	5	8	7	6	7
Mean number of species			1,000			5,333			6,000			5,333			7,333			7,333			6,667			6,667	
sd			0,000			0,577			1,000			1,528			2,082			0,577			1,528			0,577	

A2. (cont.)

		94. May			Jun			Jul			Aug			Sep			94. Oct			Nov			95. Jan		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Asparagopsis armata	asparm	36,100	31,200	28,000	31,310	17,720	45,420	9,220	12,030				9,360												
Botryocladia botryoides	botbot																			4,100	6,770	14,490			
Bryopsis hypnoides	bryhyp																13,710								
Callithamnion granulatum	calgra																								
Callithamnion tetragonum	caltet																								
Caulacanthus ustulatus	cauust																			20,480	6,770				
Centroceras clavulatum	cencla																			4,100		14,490			
Ceramium botriocarpum	cerbot																								
Ceramium cimbricum	cercim																								
Ceramium deslongchampii	cerdes																			4,100	6,770	14,490			
Ceramium diafanum	cerdia																								
Ceramium pallidum	cerpal							1,670		20,740			5,920												
Chaetomorpha crassa	chacra																								
Chaetomorpha linum	chalin														24,090										
Chondracanthus acicularis	choaci	1,200	1,200		6,400	22,470	17,660		6,480			66,630	5,920	21,060	60,220	44,900	6,860		12,950		16,940			0,310	
Chondria coerulescens	chocoe									10,370				10,530		8,980									
Chondria dasyphylla	chodas																								
Colpomenia sinuosa	colsin																								
Corallina elongata	corelo	9,800		5,100	102,020	136,920	52,980			10,370	76,270	93,560	88,820	157,930	180,660	134,700	102,850	183,060	194,300	20,480	50,810	108,680	41,690	146,130	28,660
Cryptopleura ramosa	cryram	0,700																							
Dictyota dichotoma	dicdic																								
Falkenbergia rufolanosa	falruf																								
Gastroclonium ovatum	gasova												5,920												
Gastroclonium reflexum	gasref																								
Gelidium latifolium	gellat																								
Gelidium pusillum	gelpus																13,710					7,250			
Gymnogongrus griffithsiae	gymgri		0,600																			14,490			
Jania crassa	jancra													105,290	24,090	89,800				61,450	13,440		62,530	97,420	19,100
Jania rubens	janrub	17,600	1,200	12,500									5,920				13,710	24,410	25,900	20,480	6,770	14,490			
Laurencia obtusa	lauobt																								
Lomentaria articulata	lomart										25,420	6,240	5,920												
Nytophyllum punctatum	nytpun														12,040										
Osmundia pinnatifida	osmpin	44,900		0,700							5,080	6,240	5,920							4,100	6,770	14,490			
Plocamium cartilagineum	plocar																								
Pterocladia capillacea	ptecap			7,600		0,450	0,700		1,370	67,320	15,400	16,000	6,550		15,490	7,160	20,480	3,520		16,480		16,800	24,170	78,320	22,050
Pterothamniun crispum	ptecri																								
Rodhymenia holmesii	rhohol																								
Stypocaulon scoparia	stysco																								
Symphyocladia marchantioides	symmar		6,000							4,150	10,170	12,480	11,840		12,040	8,980	6,860	24,410	25,900			14,490	4,170	9,740	1,910
Ulva rigida	ulvrig		1,500	4,900	0,420			5,030	7,220							8,980				4,100	6,770	0,720		0,890	
Total dry weight (g/m2)		110,300	41,700	58,800	140,150	177,560	116,760	15,920	27,100	112,950	132,340	201,150	152,090	294,810	328,630	303,500	178,180	235,400	259,050	159,870	121,810	234,880	132,560	332,810	71,720
Mean dry weight (g/m2)			70,267			144,823			51,990			161,860			308,980			224,210			172,187			179,030	
sd			35,709			30,668			53,088			35,430			17,563			41,580			57,532			136,607	
Number of species (S)		6	6	6	4	4	4	3	4	5	5	6	10	4	7	7	7	4	4	10	9	11	4	6	4
Mean number of species			6,000			4,000			4,000			7,000			6,000			5,000			10,000			4,667	
sd			0,000			0,000			1,000			2,646			1,732			1,732			1,000			1,155	

A2. (cont.)

		95. Feb			Mar			Apr			May			Jun			Jul			Aug			Sep		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Asparagopsis armata	asparm	29,370	10,850					22,970	22,920	21,880	6,980	4,130	1,420	19,080	14,130	22,840	2,310	4,260	2,630						
Botryocladia botryoides	botbot					13,570																			
Bryopsis hypnoides	bryhyp						4,890																		
Callithamnion granulatum	calgra																								
Callithamnion tetragonum	caltet																								
Caulacanthus ustulatus	cauust		10,850		2,540		9,770			10,940													15,560		
Centroceras clavulatum	cencla																								
Ceramium botriocarpum	cerbot																								
Ceramium cimbricum	cercim																								
Ceramium deslongchampii	cerdes				12,720	1,360	9,770	34,460	4,580	21,880				1,270		1,430									
Ceramium diafanum	cerdia																								
Ceramium pallidum	cerpal										68,170	86,970	33,520				2,310	8,510	2,630		11,890	4,710			
Chaetomorpha crassa	chacra																								
Chaetomorpha linum	chalin						4,890																		
Chondracanthus acicularis	choaci	11,750	10,850			2,710	9,770	11,490	11,460	4,380	9,090	5,800	6,700	2,540		2,860	2,310	8,510	2,630		11,890	4,710			
Chondria coerulescens	chocoe				5,090	2,710	24,430				9,090			6,360											
Chondria dasyphylla	chodas																								
Colpomenia sinuosa	colsin																								
Corallina elongata	corelo	29,370	27,120	23,880		6,790	48,860			4,380	22,720	11,600	6,700	2,540	1,060	2,860	4,620	21,280	13,160	65,870	59,470	47,140	116,700	91,650	28,460
Cryptopleura ramosa	cryram																								
Dictyota dichotoma	dicdic													1,270			2,310		5,260						
Falkenbergia rufolanosa	falruf																								
Gastroclonium ovatum	gasova			9,550																					
Gastroclonium reflexum	gasref							4,590																	
Gelidium latifolium	gellat																								
Gelidium pusillum	gelpus																								
Gymnogongrus griffithsiae	gymgri																				5,950		7,780		
Jania crassa	jancra	58,740	54,240	47,760		2,710	24,430		4,580	4,380				12,720	15,910	21,450	34,620	42,550	39,470	65,870	59,470	70,720	77,800	137,480	28,460
Jania rubens	janrub				12,720			4,590	4,580	4,380	9,090	11,600	16,760												
Laurencia obtusa	lauobl											5,800													
Lomentaria articulata	lomart																								
Nytophyllum punctatum	nytpun																								
Osmundia pinnatifida	osmpin	5,870	10,850	9,550	2,540				4,580	2,190				6,360		1,430							7,780		
Plocamium cartilagineum	plocar													1,270											
Pterocladia capillacea	ptecap	88,100	54,240	47,760		66,460		4,590	22,920	21,880				2,540	62,760	31,910	47,620	31,340	29,980	37,630	32,640	45,040	32,900	91,650	85,390
Pterothamniun crispum	ptecri																								
Rodhymenia holmesii	rhohol			9,550																					
Stypocaulon scoparia	stysco						4,890																		5,690
Symphyocladia marchantioides	symmar	11,750		4,780		1,360	4,890							1,270	5,300	2,860	2,310	4,260	2,630	6,590	5,950	4,710	7,780		5,690
Ulva rigida	ulvrig				2,540		0,430	2,300	2,290	2,190		0,360	1,360				2,310	4,260	2,630	6,590	0,680	4,710		9,170	
Total dry weight (g/m2)		234,950	179,000	152,830	38,150	97,670	147,020	84,990	77,910	98,480	125,140	126,260	66,460	57,220	99,160	87,640	100,720	124,970	101,020	182,550	187,940	181,740	266,300	329,950	153,690
Mean dry weight (g/m2)			188,927			94,280			87,127			105,953			81,340			108,903			184,077			249,980	
sd			41,950			54,514			10,450			34,207			21,668			13,915			3,370			89,256	
Number of species (S)		7	7	7	6	8	11	7	8	10	6	7	6	11	5	8	9	8	9	5	8	7	7	4	5
Mean number of species			7,000			8,333			8,333			6,333			8,000			8,667			6,667			5,333	
sd			0,000			2,517			1,528			0,577			3,000			0,577			1,528			1,528	

A3. Quadrat scraping data (dry weight, g/m2) from the upper eulittoral of São Vicente

		93.Sep			Oct			Nov			Dec		
Species	**Abbrev**	1	2	3	1	2	3	1	2	3	1	2	3
Caulacanthus ustulatus	cauust												
Chaetomorpha linum	chalin	0,040										0,010	
Enteromorpha intestinalis	entint												
Fucus spiralis	fucspi	27,290	92,550	71,370	66,610	55,860	40,530	39,760	29,700	36,040	52,050	28,710	13,310
Gelidium microdon	gelmic	7,780	2,710	1,880	6,620	10,520	22,490	21,110	47,580	18,660	27,560	29,120	75,700
Gelidium pusillum	gelpus											6,280	
Gymnogongrus griffithsiae	gymgri												
Ulva rigida	ulvrig	0,210						0,430					
Total dry weight (g/m2)		35,320	95,260	73,250	73,230	66,380	63,020	61,300	77,280	54,700	79,610	64,120	89,010
Mean dry weight (g/m2)			67,943			67,543			64,427			77,580	
sd			30,320			5,203			11,610			12,569	
Number of species (S)		4	2	2	2	2	2	3	2	2	2	4	2
Mean number of species			2,667			2,000			2,333			2,667	
sd			1,155			0,000			0,577			1,155	

		94. Jan			Feb			Mar			Apr			May		
Species	**Abbrev**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Caulacanthus ustulatus	cauust															
Chaetomorpha linum	chalin					0,110			1,200							
Enteromorpha intestinalis	entint															
Fucus spiralis	fucspi	20,790	31,620	51,770	13,880	8,990	4,700	28,000	28,100	79,300	33,600	25,400	38,800	76,000	32,900	7,900
Gelidium microdon	gelmic	109,190	47,180	78,230	55,160	36,180	65,010	40,900	5,500	25,000	99,100	92,700	98,500	27,400	64,400	66,100
Gelidium pusillum	gelpus								1,200							
Gymnogongrus griffithsiae	gymgri															
Ulva rigida	ulvrig					0,490										
Total dry weight (g/m2)		129,980	78,800	130,000	69,040	45,770	69,710	68,900	36,000	104,300	132,700	118,100	137,300	103,400	97,300	74,000
Mean dry weight (g/m2)			112,927			61,507			69,733			129,367			91,567	
sd			29,555			13,632			34,158			10,025			15,516	
Number of species (S)		2	2	2	2	4	2	2	4	2	2	2	2	2	2	2
Mean number of species			2,000			2,667			2,667			2,000			2,000	
sd			0,000			1,155			1,155			0,000			0,000	

		94.Jun			Jul			Aug			Sep		
Species	**Abbrev**	1	2	3	1	2	3	1	2	3	1	2	3
Caulacanthus ustulatus	cauust										11,200	12,040	25,330
Chaetomorpha linum	chalin										0,750	0,800	1,690
Enteromorpha intestinalis	entint												
Fucus spiralis	fucspi	7,400	1,000	46,700	27,300	104,010	17,470		8,130				
Gelidium microdon	gelmic	217,000	132,500	61,900	62,280	36,800	39,560	26,110	13,590	64,630			
Gelidium pusillum	gelpus												
Gymnogongrus griffithsiae	gymgri												
Ulva rigida	ulvrig												
Total dry weight (g/m2)		224,400	133,500	108,600	89,580	140,810	57,030	26,110	19,720	64,630	11,950	12,840	27,020
Mean dry weight (g/m2)			155,500			95,807			36,820			17,270	
sd			60,954			42,236			24,295			8,455	
Number of species (S)		2	2	2	2	2	2	1	2	1	2	2	2
Mean number of species			2,000			2,000			1,333			2,000	
sd			0,000			0,000			0,577			0,000	

		Oct			Nov			Dec			95. Jan			Feb		
Species	**Abbrev**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Caulacanthus ustulatus	cauust	39,830	36,020	44,900										7,350	4,620	3,920
Chaetomorpha linum	chalin	2,660	2,400	2,990												0,780
Enteromorpha intestinalis	entint															
Fucus spiralis	fucspi				0,200	19,630	1,260	10,080	5,700	5,720	10,650	1,930	14,420	11,281	21,940	4,270
Gelidium microdon	gelmic				37,230	32,590	40,740	50,580	61,630	40,900	33,120	44,660	27,850	50,500	34,820	76,330
Gelidium pusillum	gelpus													2,940	3,310	3,920
Gymnogongrus griffithsiae	gymgri															
Ulva rigida	ulvrig	2,660		2,990	0,080		0,080		1,090	0,620	0,250	0,010		3,440	0,460	
Total dry weight (g/m2)		45,150	38,420	50,880	37,510	52,220	42,080	60,660	68,420	47,240	44,020	46,600	42,270	75,511	65,150	89,220
Mean dry weight (g/m2)			44,817			43,937			58,773			44,297			76,627	
sd			6,237			7,529			10,715			2,178			12,074	
Number of species (S)		3	2	3	3	2	3	2	3	3	3	3	2	5	5	5
Mean number of species			2,667			2,667			2,667			2,667			5,000	
sd			0,577			0,577			0,577			0,577			0,000	

		95.Mar			Apr			May			Jun		
Species	**Abbrev**	1	2	3	1	2	3	1	2	3	1	2	3
Caulacanthus ustulatus	cauust		0,280										
Chaetomorpha linum	chalin					3,860	2,910						
Enteromorpha intestinalis	entint												
Fucus spiralis	fucspi	3,350	4,430	0,880	36,730	7,730	2,910		10,170	8,550	0,580	11,740	16,270
Gelidium microdon	gelmic	35,120	116,590	96,540	110,190	57,950	43,590	139,830	128,480	106,720	189,990	76,510	32,480
Gelidium pusillum	gelpus		0,370										
Gymnogongrus griffithsiae	gymgri												
Ulva rigida	ulvrig	0,040	0,020			7,730	2,910			0,550			
Total dry weight (g/m2)		38,510	121,690	97,420	146,920	77,270	52,320	139,830	138,650	115,820	190,570	88,250	48,750
Mean dry weight (g/m2)			85,873			92,170			131,433			109,190	
sd			42,775			49,029			13,534			73,192	
Number of species (S)		3	5	2	2	4	4	1	2	3	2	2	2
Mean number of species			3,333			3,333			2,000			2,000	
sd			1,528			1,155			1,000			0,000	

		Jul			Aug			Sep		
Species	**Abbrev**	1	2	3	1	2	3	1	2	3
Caulacanthus ustulatus	cauust									
Chaetomorpha linum	chalin					2,640	2,310			
Enteromorpha intestinalis	entint					2,640	2,310			
Fucus spiralis	fucspi	0,690	6,920	1,030					3,010	
Gelidium microdon	gelmic	48,550	47,250	57,590	45,390	39,530	34,670	10,660	22,570	18,550
Gelidium pusillum	gelpus					2,640	2,310	0,710	1,500	1,240
Gymnogongrus griffithsiae	gymgri							3,550	3,010	2,470
Ulva rigida	ulvrig	0,110			3,030		2,310		1,500	1,240
Total dry weight (g/m2)		49,350	54,170	58,620	48,420	47,450	43,910	14,920	31,590	23,500
Mean dry weight (g/m2)			54,047			46,593			23,337	
sd			4,636			2,374			8,336	
Number of species (S)		3	2	2	2	4	5	3	5	4
Mean number of species			2,333			3,667			4,000	
sd			0,577			1,528			1,000	

A4. Quadrat scraping data (dry weight, g/m2) from the lower eulittoral of São Vicente

		93. Sep			Oct			Nov			Dec			94. Jan			Feb			Mar			Apr			May		
Species	**Abbrev.**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Asparagopsis armata	asparm												2,490															
Bryopsis hypnoides	bryhyp											1,590		13,700														
Calithamnium granulatum	calgra																2,950											
Caulacanthus ustulatus	cauust																											
Centroceras clavulatum	cencla	80,610	26,390	36,250	75,660	55,230	21,090	155,730	117,190	1,740	22,720	35,330	25,010	68,550	8,540		29,570	19,370	60,130									
Ceramium ciliatum	cercil																29,570	19,370	60,130	24,400	19,400	16,700	34,400	61,100	33,000	34,100	62,700	30,700
Ceramium diaphanum	cerdia																											
Ceramium nodulosum	cernod																											
Chaetomorpha linum	chalin				0,040	0,060					0,150	0,030	2,490					3,870		1,800			4,600					
Chondracanthus acicularis	choaci		26,390	36,250								7,050	2,490		42,710	28,050	5,910		12,020	12,700	19,400	11,100	11,500	91,600	11,000	22,700	41,800	20,500
Chondria coerulescens	chocoe																											
Chondria dasyphilla	chodas																											
Cladophora coelothrix	clacoe																5,910	3,870	12,020									
Cladophora prolifera	clapro									0,340																		
Codium adhaerens	codadh																											
Colpomenia sinuosa	colsin																0,320							12,200				
Corallina elongata	corelo	53,740	26,390	36,250				51,910	39,070	26,010	15,150	35,240	24,940		21,350	14,030			6,010					12,200				
Cryptopleura ramosa	cryram													13,700														
Cystoseira abies-marina	cysabi									1,880																		
Dictyota dichotoma	dicdic																											
Enteromorpha muscoides	entmus																				1,900							
Gastroclonium ovatum	gasova																											
Gastroclonium reflexum	gasref																											
Gelidium pusillum	gelpus											7,050						3,870		16,300	19,400	11,100		30,500				
Gymnogongrus griffithsiae	gymgri																											
Hidroclathrus clathratus	hydcla																				0,800							
Hypnea musciformis	hymus									0,940																		
Jania longifurca	janlon		13,190	18,130	56,740	41,430	15,810													12,200		2,800	5,750	30,550	5,500	11,350	20,900	10,250
Jania rubens	janrub		13,190	18,130	56,740	41,430	15,810	51,910	78,130	8,660		7,050	2,490	68,550	42,710	42,070	29,570	19,370	60,130	12,200		2,800	5,750	30,550	5,500	11,350	20,900	10,250
Laurencia obtusa	lauobt		13,190	18,130	37,830	55,230	21,090					3,520		34,260	42,710	14,030					11,100		11,500			11,400	20,900	20,500
Nytophyllum punctatum	nytpun																											
Osmundia pinnatifida	osmpin	10,750	26,390	36,250		27,620		20,760	39,070	9,330	15,150	35,240	24,940		21,350		5,910	3,870	12,020				11,500	6,100	11,000			
Plocamium cartilagineul	plocar																											
Polysiphonia denudata	polden																											
Pterocladia capillacea	ptecap		2,640	3,630						34,060																		
Pterothamnion crispum	ptecri																											
Rhodymenia holmesii	rhohol												0,120															
Stypocaulon scoparia	stysco																											
Symphyocladia marchantioides	symmar																											
Ulva rigida	ulvrig	5,370	2,640	3,630					7,810	0,180		0,010			0,260	0,150	0,610	0,080		0,400	1,600	0,600						
Total dry weight (g/m2)		150,470	150,410	206,650	227,010	221,000	73,800	280,310	281,270	83,140	53,170	132,110	84,970	198,760	179,630	98,330	110,320	73,670	222,460	80,000	73,600	45,100	85,000	274,800	66,000	90,900	167,200	92,200
Mean dry weight (g/m2)			169,177			173,937			214,907			90,083			158,907			135,483			66,233			141,933			116,767	
sd			32,453			86,773			114,114			39,718			53,326			77,521			18,580			115,457			43,681	
Number of species (S)		4	9	8	5	6	4	4	5	9	4	10	8	5	7	5	9	8	7	7	7	6	7	8	5	5	5	5
Mean number of species			7,333			5,000			6,000			7,333			5,667			8,000			6,667			6,667			5,000	
sd			2,887			1,000			2,646			3,055			1,155			1,000			0,577			1,528			0,000	

A4. (cont.)

		94. Jun			Jul			Aug			Sep			94. Oct			Nov			Dec			95. Jan		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Asparagopsis armata	asparm																		2,140	11,110	14,310			6,090	
Bryopsis hypnoides	bryhyp													13,710											
Calithamnium granulatum	calgra																								
Caulacanthus ustulatus	cauust																								
Centroceras clavulatum	cencla									3,360							34,680	36,560	21,420	83,300	107,320	73,510	54,870	45,660	33,050
Ceramium ciliatum	cercil	56,700	39,300	71,600	32,970	45,290	33,300											3,660							
Ceramium diaphanum	cerdia																								
Ceramium nodulosum	cernod																								
Chaetomorpha linum	chalin											24,090									7,150			3,040	2,200
Chondracanthus acicularis	choaci	18,900	13,100	23,900					19,080	6,730	21,060	60,220	44,900	6,860		12,950	6,940	7,310	10,710			24,500	7,320	3,040	2,200
Chondria coerulescens	chocoe										10,530		8,980										3,660	6,090	2,200
Chondria dasyphilla	chodas					9,060																			
Cladophora coelothrix	clacoe																								
Cladophora prolifera	clapro																						3,660		
Codium adhaerens	codadh																								
Colpomenia sinuosa	colsin																					9,800			
Corallina elongata	corelo									33,630	157,930	180,660	134,700	102,850	183,060	194,300	34,680	18,280	10,710	11,110	7,150	4,900			
Cryptopleura ramosa	cryram																								
Cystoseira abies-marina	cysabi				127,000																		3,660		
Dictyota dichotoma	dicdic																		2,140				7,320		
Enteromorpha muscoides	entmus																								
Gastroclonium ovatum	gasova																								
Gastroclonium reflexum	gasref																3,470								
Gelidium pusillum	gelpus													13,710											
Gymnogongrus griffithsiae	gymgri																		2,140					3,040	2,200
Hidroclathrus clathratus	hydcla																								
Hypnea musciformis	hymus																								
Jania longifurca	janlon	28,350	19,650	23,850	49,450	67,930	49,950		9,540	1,680	105,290	24,090	89,800				17,340	36,560	21,420						
Jania rubens	janrub	28,350	19,650	23,850					9,540	1,680				13,710	24,410	25,900	6,940	18,280	4,280	55,540	71,550	49,010	36,580	30,440	22,030
Laurencia obtusa	lauobt				16,480		33,300		9,540	3,360							17,340	36,560	10,710	27,770	35,770	9,800			
Nytophyllum punctatum	nytpun											12,040													
Osmundia pinnatifida	osmpin		13,100														3,470	7,310	10,710	11,110	14,310	9,800	18,290	3,040	4,410
Plocamium cartilagineul	plocar																					9,800			
Polysiphonia denudata	polden																								
Pterocladia capillacea	ptecap				3,300							15,490	7,160	20,480	3,520		3,470	3,660	10,710			9,800	3,660		
Pterothamnion crispum	ptecri																								
Rhodymenia holmesii	rhohol																								
Stypocaulon scoparia	stysco																		2,140						
Symphyocladia marchantioides	symmar											12,040	8,980	6,860	24,410	25,900							3,660		
Ulva rigida	ulvrig			0,100				1,430		0,460			8,980					0,050						6,090	2,200
Total dry weight (g/m2)		132,300	104,800	143,300	229,200	122,280	116,550	1,430	47,700	50,900	294,810	328,630	303,500	178,180	235,400	259,050	128,330	168,230	109,230	199,940	257,560	200,920	142,680	106,530	70,490
Mean dry weight (g/m2)			126,800			156,010			33,343			308,980			224,210			135,263			219,473			106,567	
sd			19,831			63,449			27,684			17,563			41,580			30,105			32,988			36,095	
Number of species (S)		4	5	5	5	3	3	1	4	7	4	7	7	7	4	4	9	10	12	6	7	9	10	9	8
Mean number of species			4,667			3,667			4,000			6,000			5,000			10,333			7,333			9,000	
sd			0,577			1,155			3,000			1,732			1,732			1,528			1,528			1,000	

A4. (cont.)

		95. Feb			Mar			Apr			May			Jun			Jul			Aug			Sep		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Asparagopsis armata	asparm							5,450		10,710															
Bryopsis hypnoides	bryhyp																								
Calithamnium granulatum	calgra																								
Caulacanthus ustulatus	cauust		7,610																						
Centroceras clavulatum	cencla		7,610	51,960	74,280	155,470	74,010	27,250	18,360	26,780	41,180	44,030	19,290	30,300	18,190	20,920	3,060	2,810	2,090	8,060	13,690	8,840	10,000	13,850	10,850
Ceramium ciliatum	cercil										8,240	0,880	7,720	30,300	18,190	20,920	3,060	2,810	2,090						
Ceramium diaphanum	cerdia																						5,700	13,850	10,850
Ceramium nodulosum	cernod														6,060										
Chaetomorpha linum	chalin	2,740	0,760	3,460	4,950										1,210					4,030	13,690	8,840			
Chondracanthus acicularis	choaci			6,930	4,950			10,900	18,360	10,710	8,240	0,880	3,860	4,040	2,430		7,660	7,010	2,090	4,030		22,110	5,700	6,930	5,430
Chondria coerulescens	chocoe																								
Chondria dasyphilla	chodas																								
Cladophora coelothrix	clacoe						4,630							2,020	2,430	1,390		1,400							
Cladophora prolifera	clapro							5,450							2,430								5,700		
Codium adhaerens	codadh				49,520		46,250																		
Colpomenia sinuosa	colsin								18,360	10,710		0,880					1,530							13,850	5,430
Corallina elongata	corelo			6,930				10,900	9,180	10,710	8,240	22,020	19,290							8,060	13,690	22,110	57,040	13,850	27,140
Cryptopleura ramosa	cryram							5,450																	
Cystoseira abies-marina	cysabi							5,450	18,360																
Dictyota dichotoma	dicdic																								
Enteromorpha muscoides	entmus																								
Gastroclonium ovatum	gasova																								
Gastroclonium reflexum	gasref																								
Gelidium pusillum	gelpus	5,470	7,610	3,460																					
Gymnogongrus griffithsiae	gymgri	5,470		6,930	9,900	9,720																			
Hidroclathrus clathratus	hydcla									10,710				2,020											
Hypnea musciformis	hymus							27,250	9,180	5,360										8,060	34,210	8,840			
Jania longifurca	janlon																			4,030	13,690	8,840			
Jania rubens	janrub	5,470	1,520	34,640				54,500	45,900	26,780	41,180	44,030	38,590	20,200	12,130	13,940	22,980	21,040	15,670	40,310	68,430		28,520	103,880	54,270
Laurencia obtusa	lauobt					19,430		27,250	18,360	10,710	8,240	0,880	7,720	4,040	2,430	2,790	3,060	7,010	10,450		13,690	8,840	10,000	34,630	
Nytophyllum punctatum	nytpun																								
Osmundia pinnatifida	osmpin		1,520	6,930		9,720	4,630	10,900	18,360	10,710	20,590	22,020	38,590							8,060	13,690	8,840		13,850	54,270
Plocamium cartilagineul	plocar			3,460																					
Polysiphonia denudata	polden																			4,030	6,840	22,110	5,700	13,850	10,850
Pterocladia capillacea	ptecap																			8,060		8,840	5,700		
Pterothamnion crispum	ptecri	2,740		3,460																					
Rhodymenia holmesii	rhohol							5,450																	
Stypocaulon scoparia	stysco							54,500	91,800			0,880			2,430		3,060			40,310	68,430	66,330	28,520	6,930	10,850
Symphyocladia marchantioides	symmar							10,900	9,180	5,360							1,530	1,400		4,030	6,840	4,420			
Ulva rigida	ulvrig			3,460				5,450	9,180	5,360		4,400		2,020	1,210		15,320	2,810	1,040	8,060	13,690	8,840	10,000	6,930	5,430
Total dry weight (g/m2)		21,890	26,630	131,620	143,600	194,340	129,520	267,050	284,580	144,610	135,910	140,900	135,060	94,940	69,140	59,960	61,260	46,290	33,430	149,130	280,580	207,800	172,580	242,400	195,370
Mean dry weight (g/m2)			60,047			155,820			232,080			137,290			74,680			46,993			212,503			203,450	
sd			62,030			34,094			76,257			3,155			18,136			13,928			65,851			35,604	
Number of species (S)		5	6	11	5	4	4	15	12	12	7	10	7	8	11	5	9	8	6	13	12	13	11	11	10
Mean number of species			7,333			4,333			13,000			8,000			8,000			7,667			12,667			10,667	
sd			3,215			0,577			1,732			1,732			3,000			1,528			0,577			0,577	

A5. Quadrat scraping data (dry weight, g/m2) from the subtidal of São Roque, 5m depth

		93, Sep			Oct			Nov			Dec			94. Jan			Mar			Abr			May		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Acrosorium venulosum	acrven													3,440	0,516										
Aglaothamnion bipinnatum	aglbip													2,204	0,176		2,092		0,816						
Asparagopsis armata	asparm				2,576		3,200							17,948	59,328	11,108	22,816	22,052	38,536	225,040	143,840	197,160	172,040	109,220	52,040
Bryopsis hypnoides	bryhyp													0,048											
Ceramium echionotum	cerech																								
Chondracanthus acicularis	choaci	3,180	3,600	9,056	13,152	32,528	2,912				6,408			2,028		3,592		0,448							0,320
Chondracanthus teedii	chotee						2,624																		
Chondria dasyphylla	chodas																		0,004						
Cladophora laetevirens	clalae																								
Cladophora prolifera	clapro					0,256																			
Codium adhaerens	codadh											0,504													
Codium elisabethae	codeli										0,508						0,456								
Colpomenia sinuosa	colsin																								
Corallina elongata	corelo	305,200	287,760	222,224	80,096	646,464	94,576	771,024	143,372	407,036	1703,160	729,264	1088,620	363,092	189,312	558,192	520,852	237,120	337,880	161,800	198,040	197,160	60,200	109,220	184,780
Cryptopleura ramosa	cryram																								
Dictyota dichotoma	dicdic				0,224										3,972				0,008			0,080			
Gastroclonium reflexum	gasref						0,432																		
Gelidium latifolium	gellat						1,744								1,044				0,052						
Gymnogongrus crenulatus	gymcre						5,040																0,240		
Hypnea musciformis	hypmus																		0,080						
Jania longifurca	janlon				42,736		35,280							13,692	2,276	10,432	49,460	74,320	20,792		3,960		60,200	109,220	184,780
Jania verrucosa	janver	293,200	64,604	18,416	18,256		18,160	514,016	362,248	271,360				8,452	0,276				0,844	161,800	143,960	197,160			
Peyssonnelia cf. squamaria	peysqu													4,700											
Plocamium cartilagineum	plocar						0,080							7,156	21,048	0,524	2,864	3,316	3,892	176,160	150,680	197,160	36,360	158,180	61,520
Pterocladia capillacea	plecap		3,384	2,872	55,776	6,363	156,208	8,708			0,932			10,500	8,104	11,076	8,676		3,332	7,000	11,560		21,040	0,200	31,480
Pterothamnion crispum	ptecri														0,588	1,480	4,256	14,472		17,640	1,640	4,360		2,480	
Pterothamnion plumula	pteplu													2,204											
Rhodymenia holmesii	rhohol																					6,720			
Stypocaulon scoparia	stysco			1,120	45,600		1,488					24,524	0,740	7,480	4,376								0,960		
Symphyocladia marchanthioides	symmar			0,720											0,388				29,340		0,040	2,200			
Ulva rigida	ulvrig					0,096	0,080							0,040						0,520			2,600	0,160	0,360
Valonia utricularis	valutr				0,256																				
Zonaria tournefortii	zontou						8,064						13,776	57,672		4,644							1,800		
Total dry weight (g/m2)		601,580	359,348	254,408	258,672	685,712	329,888	1293,748	505,620	678,396	1711,008	754,292	1103,136	500,656	291,404	601,048	611,472	351,728	435,576	749,960	653,720	802,000	355,440	488,680	515,280
Mean dry weight (g/m2)			405,112			424,757			825,921			1189,479			464,369			466,259			735,227			453,133	
sd			178,053			228,781			414,257			484,167			157,979			132,562			75,230			85,644	
Number of species (S)		3	4	6	9	5	14	3	2	2	4	3	3	15	13	8	8	6	12	7	8	8	9	7	7
Mean number of species			4,333			9,333			2,333			3,333			12,000			8,667			7,667			7,667	
sd			1,528			4,509			0,577			0,577			3,606			3,055			0,577			1,155	

A5. (cont.)

		94. Jun			Jul			Aug		94. Sep			Oct			Nov			Dec			95, Feb		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Acrosorium venulosum	acrven																							
Aglaothamnion bipinnatum	aglbip																							
Asparagopsis armata	asparm		0,520	154,828																			126,120	238,920
Bryopsis hypnoides	bryhyp																							
Ceramium echionotum	cerech																					1,424		
Chondracanthus acicularis	choaci														40,584			36,188	68,788	16,308	145,564			
Chondracanthus teedii	chotee																							
Chondria dasyphylla	chodas																							
Cladophora laetevirens	clalae																							
Cladophora prolifera	clapro																							
Codium adhaerens	codadh																							
Codium elisabethae	codeli						28,104											10,700		50,616	55,836	4,224		
Colpomenia sinuosa	colsin													23,808										
Corallina elongata	corelo	442,464	903,768	464,480	543,450	782,244	743,996	336,888	367,400	309,532	411,660	481,300	386,304	357,148	608,768	352,096	628,928	542,832	515,912	244,624	436,692	376,368	945,904	716,764
Cryptopleura ramosa	cryram																							
Dictyota dichotoma	dicdic																							
Gastroclonium reflexum	gasref																							
Gelidium latifolium	gellat																							
Gymnogongrus crenulatus	gymcre																							
Hypnea musciformis	hypmus																							95,568
Jania longifurca	janlon	294,976	602,512	309,652	362,304	521,504	495,996	224,592	244,932	206,352	274,440	320,868	257,536	238,096	405,844			72,376	343,940	163,080	145,564	50,184	126,120	477,844
Jania verrucosa	janver									103,176	137,220	160,432	257,536	238,096	405,844	234,732	41,928	72,376	343,940	163,080	145,564	125,456	315,300	238,920
Peyssonnelia cf. squamaria	peysqu																							
Plocamium cartilagineum	plocar			29,040																		54,356	63,060	
Pterocladia capillacea	ptecap	3,280	11,480	4,800					122,468	362,352		188,048	51,508	47,620	81,168		419,284		68,788	81,540	29,112	50,184	126,120	95,568
Pterothamnion crispum	ptecri																							
Pterothamnion plumula	ptepiu																							
Rhodymenia holmesii	rhohol																							
Stypocaulon scoparia	stysco															46,948								
Symphyocladia marchanthioides	symmar															46,948		72,376	34,396	16,308	29,112	54,356	63,060	47,784
Ulva rigida	ulvrig	1,240									0,212		25,752											47,784
Valonia utricularis	valutr															23,472	41,928							
Zonaria tournefortii	zontou															117,364					29,112			
Total dry weight (g/m2)		741,960	1518,280	962,800	905,760	1303,748	1268,096	561,480	734,800	981,412	823,532	1150,648	978,636	904,768	1542,208	821,560	1132,068	806,848	1375,764	735,556	1016,556	716,552	1765,684	1959,152
Mean dry weight (g/m2)			1074,347			1159,201			648,140		985,197			1141,871			920,159			1042,625			1480,463	
sd			400,000			220,209			122,556		163,591			348,664			183,666			320,899			668,601	
Number of species (S)		4	4	5	2	2	3	2	3	4	4	4	5	5	5	6	4	6	6	7	8	8	7	8
Mean number of species			4,333			2,333			2,500		4,000			5,000			5,333			7,000			7,667	
sd			0,577			0,577			0,707		0,000			0,000			1,155			1,000			0,577	

A5. (cont.)

		95. Mar			Apr			May			Jun			Jul			Aug			Sep		
Species	**Abbrev.**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Acrosorium venulosum	acrven																					
Aglaothamnion bipinnatum	aglbip																					
Asparagopsis armata	asparm	239,552	261,652	244,568	235,108	307,216	417,120	288,272	161,356	227,428	56,844	114,632	70,220	12,004	39,960	66,128						
Bryopsis hypnoides	bryhyp																					
Ceramium echionotum	cerech																					
Chondracanthus acicularis	choaci		52,332																			21,476
Chondracanthus teedii	chotee																					
Chondria dasyphylla	chodas															26,452						
Cladophora laetevirens	clalae											22,928	35,108									21,476
Cladophora prolifera	clapro																					
Codium adhaerens	codadh																					
Codium elisabethae	codeli					15,268																
Colpomenia sinuosa	colsin																					
Corallina elongata	corelo	359,332	392,476	366,848	705,324	460,824	417,120	432,412	484,072	341,144	426,328	343,892	526,648	180,084	199,800	66,128	186,772	454,088	49,300	232,708	127,816	214,768
Cryptopleura ramosa	cryram							28,828			28,060	22,928	35,108									
Dictyota dichotoma	dicdic	23,956													19,980				9,860			
Gastroclonium reflexum	gasref																					
Gelidium latifolium	gellat																					
Gymnogongrus crenulatus	gymcre																					
Hypnea musciformis	hypmus													12,004	39,960	66,128	37,356	30,272	98,600	116,356	17,044	107,384
Jania longifurca	janlon	119,776	261,652	244,568	94,044	61,444	83,424	57,656	64,544	113,716				120,056	199,800	132,256	280,156	302,724	98,600	232,708	85,212	214,768
Jania verrucosa	janver	119,776	130,824	122,284	235,108	61,444	83,424	57,656	161,356	113,716	284,220	213,260	351,100	120,056	199,800		186,772	302,724	49,300	23,272	85,212	107,384
Peyssonnelia cf. squamaria	peysqu																					
Plocamium cartilagineum	plocar		52,332	48,912				28,828	64,544	45,484	56,844	45,852	70,220									
Pterocladia capillacea	ptecap	119,776	130,824	122,284	94,044	61,444	83,424	144,136	64,544	227,428	284,220	213,260	351,100	60,028	19,980	66,128	37,356	302,724	49,300	329,064	17,044	322,152
Pterothamnion crispum	ptecri	23,956	26,164	24,456				28,828		22,744				12,004						23,272	8,520	21,476
Pterothamnion plumula	pteplu																					
Rhodymenia holmesii	rhohol																37,356	30,272	9,860			
Stypocaulon scoparia	stysco		26,164	48,912		61,444							70,220		19,980		93,384		19,720			
Symphyocladia marchanthioides	symmar			48,912	94,044	30,720	41,712	28,828	32,272	22,744			70,220	12,004	19,980	13,224	18,676		9,860			
Ulva rigida	ulvrig			24,456		30,720	41,712		32,272					12,004	19,980		18,676	30,272	9,860		8,520	
Valonia utricularis	valutr							28,828														
Zonaria tournefortii	zontou																					
Total dry weight (g/m2)		1006,124	1334,420	1296,200	1457,672	1090,524	1167,936	1124,272	1064,960	1114,404	1136,516	976,752	1579,944	540,244	779,220	436,444	896,504	1453,076	404,260	957,380	349,368	1030,884
Mean dry weight (g/m2)			1212,248			1238,711			1101,212			1231,071			585,303			917,947			779,211	
sd			179,529			193,536			31,780			312,515			175,774			524,737			374,064	
Number of species (S)		7	9	10	6	9	7	10	8	8	6	7	9	9	10	7	9	7	10	6	7	8
Mean number of species			8,667			7,333			8,667			7,333			8,667			8,667			7,000	
sd			1,528			1,528			1,155			1,528			1,528			1,528			1,000	

A6. Quadrat scraping data (dry weight, g/m2) from the subtidal of São Roque, 10m depth

		93. Sep			Oct			Nov			Dec			94. Jan			Mar			Abr			May		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Aglaothamnion bipinatum	aglbip						29,816							0,588	4,360		5,000		6,528						
Asparagopsis armata	aspam										0,384		5,304	34,200	20,436	27,568	8,536	2,592	3,788	6,840	8,320	5,880	97,880	151,120	151,720
Bryopsis hypnoides	bryhyp												0,004	6,340											
Centroceras clavulatum	cencia			5,688																					
Chondracanthus acicularis	choaci	27,573	32,315	18,488	6,688	44,566		21,181		3,176		5,900	26,080	12,680	10,100	4,896	0,068								
?Chondrymenia	chond?																		0,912					0,120	
Cladophora coelothrix	clacoe			5,684	0,224	9,048			0,020																
Cladophora laetevirens	clalae												0,012												
Cladophora prolifera	clapro		16,123		1,264														0,080						
Cladostephus spongiosus	claspo				0,528																				
Codium adhaerens	codadh										4,436														
Codium decorticatum	coddec																								
Codium elisabethae	codeli			6,528	0,032					0,300	4,772		7,168	6,216	60,636	2,628			0,680	10,000	7,560				37,960
Colpomenia sinuosa	colsin												0,024	0,092						0,520			0,040		
Corallina elongata	corelo	27,901	54,723	21,036	37,104	148,694	44,488	51,721	154,220	243,840	48,604	813,840	42,732	0,804	2,164	25,746	7,268		5,532	1,280					
Cryptopleura ramosa	cryram																								
Cystoseira abies-marina	cysabi																0,176			1,480	3,200				
Cystoseira foeniculaceus	cysfoe																								
Dasya hutchinsiae	dashut			7,020							1,816		1,632												
Dictyota dichotoma	dicdic		15,779	5,740				20,849	0,520	0,200	3,944	0,204	5,284	0,116			0,104		0,432	0,480	3,680	0,600	38,320	24,080	33,600
Falkenbergia rufolanosa	falruf													0,588	4,360		4,116		15,604		5,200	0,480			
Gastroclonium reflexum	gasref		15,687	5,808																					
Halicystis	halicy																								
Halopteris filicina	halfil					9,046	31,400																		
Hydroclathrus clathratus	hydcla																								
Hypnea musciformis	hypmus																								
Hypoglossum hypoglossoides	hyphyp									0,004															
Jania adhaerens	janadh		17,743	6,832									11,588												
Jania longifurca	janlon					10,758	35,560	23,913		119,668			11,588	34,188	26,024	51,088	2,884		0,560						
Jania verrucosa	janver	21,205	51,295	8,408	108,192	36,374	37,384	21,269		1,424				64,152	38,780	53,204	0,528	2,300	19,204				0,600		
Liagora viscida	liavis																								
Nytophyllum punctatum	nytpun								0,432																
Osmundia pinnatifida	osmpin			5,728	0,144																				
Padina pavonica	padpav																								
Plocamium cartilagineum	plocar		15,623						0,532	0,152	0,420	0,976	1,436	13,032	9,352	10,800	7,344	10,508	14,412	5,120	2,280	8,240	45,120	4,120	5,280
Polysiphonia denudata	polden																				5,200	0,480			
Pterocladia capillacea	ptecap		15,759		4,176	10,550	31,512	20,836			31,360		0,008	1,100			5,432	0,012	4,240			1,200	0,200	1,160	
Pterosiphonia pennata	ptepen																								
Pterothamnion crispum	ptecri																								
Pterothamnion plumula	pteplu																				5,200	0,480			
Rhodymenia holmesii	rhohol																					0,040	0,960		
Rosette Sargassum type hystrix	rossah																			0,600	0,880	1,680			
Sargassum vulgare	sarvul			6,032	2,496	9,126		20,840						1,432											
Stypocaulon scoparia	stysco	26,769	20,739		1,408	164,998	54,744	60,861	10,832	28,728		0,320	0,872	84,608	46,912	72,688	68,720	256,964	86,480	324,920	282,120	118,880	80,720	274,360	33,640
Stypopodium zonale	styzon																								
Symphyocladia marchanthioides	symmar										6,628	0,656	5,656	34,556	24,936	9,796	2,776	14,416	25,696		2,160			5,960	
Taonia atomaria	taoato																								
Ulva rigida	ulvrig		15,643	5,756					0,016				0,184	6,340		0,024									
Valonia utricularis	valutr						31,080								0,004										
Zonaria tournefortii	zontou	19,157	16,067	7,608	71,712	14,214		35,024			78,424		15,648	35,884	32,388	16,584	8,916	3,116	7,292		0,520	0,160	7,800	14,320	
Total dry weight, g/m2		122,604	287,492	116,356	233,968	457,378	295,984	276,496	166,572	397,492	180,788	821,896	135,220	336,916	280,452	275,024	121,868	289,908	191,440	351,240	326,320	138,120	271,640	475,240	262,200
Mean dry weight, g/m2			175,484			329,110			280,187			379,301			297,464			201,072			271,893			336,360	
sd			97,052			115,330			115,504			383,975			34,274			84,433			116,519			120,366	
Number of species (S)		5	12	14	12	10	8	9	7	9	10	6	17	18	13	11	14	7	15	9	12	11	9	8	5
Mean number of species			10,3			10			8,3			11			14			12			10,7			7,3	
sd			4,7			2			1,2			5,6			3,6			4,4			1,5			2,1	

A6. (cont.)

		94. Jun			Jul			Aug			94. Sep			Oct			Nov			Dec			95, Feb		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Aglaothamnion bipinatum	aglbip																								
Asparagopsis armata	asparm																						24,328	42,256	25,476
Bryopsis hypnoides	bryhyp																								
Centroceras clavulatum	cencia															51,708		45,104	16,120						
Chondracanthus acicularis	choaci				19,916	20,712	53,852				19,100	10,516	16,976	9,712				112,760	80,628	49,496	42,848	59,784			
?Chondrymenia	chond?																								
Cladophora coelothrix	clacoe																								
Cladophora laetevirens	clalae	10,348																							
Cladophora prolifera	clapro																		32,252						
Cladostephus spongiosus	claspo																								
Codium adhaerens	codadh																								
Codium decorticatum	coddec																								
Codium elisabethae	codeli	4,160	64,160		43,276	36,952		14,508		43,464	151,140	20,260		75,556		19,048			5,476	1,800				3,468	
Colpomenia sinuosa	colsin						0,320	0,948	3,604		5,712	2,692	2,876	1,808	1,408	4,000									25,476
Corallina elongata	corelo	20,696	9,356	17,532	49,908	20,712	53,852	8,884	46,956	200,852	47,748	52,572	42,444	145,700	193,924	25,856	298,464	225,516	161,216	49,496	214,248	298,912	364,928	310,920	382,164
Cryptopleura ramosa	cryram																								
Cystoseira abies-marina	cysabi							0,836	2,100						12,928										
Cystoseira foeniculaceus	cysfoe																								
Dasya hutchinsiae	dashut																								
Dictyota dichotoma	dicdic	103,480	10,760	87,664	99,576	75,980	163,492		93,912				42,444		12,928	5,172			16,120	9,900			24,328	20,728	50,956
Falkenbergia rufolanosa	falruf																								
Gastroclonium reflexum	gasref																								
Halicystis	halicy																								
Halopteris filicina	halfil																							20,728	
Hydroclathrus clathratus	hydcla																								
Hypnea musciformis	hypmus							1,188		40,172													24,328		127,388
Hypoglossum hypoglossoides	hyphyp																								
Jania adhaerens	janadh																								
Jania longifurca	janlon				19,916	6,300	53,852				19,100	55,372	84,884	97,132	129,284	25,856	298,464	225,516	161,216	98,992	214,248	298,912	121,644	103,640	254,776
Jania verrucosa	janver	51,740	23,392	35,064							95,496	105,140	42,444	97,132	129,284	51,708	298,464	225,516	161,216	98,992	107,124	149,456	24,328	20,728	
Liagora viscida	liavis																								
Nytophyllum punctatum	nytpun							1,652	46,956																
Osmundia pinnatifida	osmpin																								
Padina pavonica	padpav												0,164					22,552							
Plocamium cartilagineum	plocar	51,740	23,392																32,252					103,640	50,956
Polysiphonia denudata	polden																								
Pterocladia capillacea	ptecap		9,356											48,568	64,600	10,340				9,900	42,848	59,784			
Pterosiphonia pennata	ptepen																								
Pterothamnion crispum	ptecri																								
Pterothamnion plumula	pteplu																								
Rhodymenia holmesii	rhohol			35,064								9,992			12,928		29,848	22,552	16,120					42,256	
Rosette Sargassum type hystrix	rossah										19,100			9,712											
Sargassum vulgare	sarvul																								
Stypocaulon scoparia	stysco	51,740	23,392	35,064				458,384	167,632		40,492				12,928	25,856				19,800				42,256	
Stypopodium zonale	styzon																								
Symphyocladia marchanthioides	symmar			262,988			21,540		18,784	100,428					25,856		29,848	112,760	32,252	19,800	21,424	149,456	48,656	42,256	50,956
Taonia atomaria	taoato																								
Ulva rigida	ulvrig		0,960		9,952		10,772				9,548		8,488					22,552		9,900					
Valonia utricularis	valutr			35,064											12,928										
Zonaria tournefortii	zontou	20,696	9,356		1,516	14,992	33,552	0,504	50,528	92,428	68,816	46,812	6,240	14,772	6,316	85,760			16,120		21,424		24,328		25,476
Total dry weight, g/m2		314,600	174,124	508,440	244,060	177,648	391,232	486,904	430,472	477,344	476,252	303,356	246,960	500,092	615,312	305,304	955,088	1014,828	730,988	368,076	664,164	1016,304	656,868	752,876	993,624
Mean dry weight, g/m2			332,388			270,980			464,907			342,189			473,569			900,301			682,848			801,123	
sd			167,866			109,307			30,202			119,477			156,697			149,641			324,518			173,485	
Number of species (S)		8	9	7	7	6	8	8	8	5	10	8	9	9	12	10	5	9	12	10	7	6	8	11	9
Mean number of species			8			7			7			9			10,3			8,7			7,7			9,3	
sd			1			1			1,7			1			1,5			3,5			2,1			1,5	

A6. (cont.)

		95. Mar			Apr			May			Jun			Jul			Aug			Sep		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Aglaothamnion bipinatum	aglbip																					
Asparagopsis armata	asparm	85,408	140,592	79,660	26,144	119,540	105,812	160,124	215,268	73,616	59,780	24,540	27,272	22,392			13,680					
Bryopsis hypnoides	bryhyp																					
Centroceras clavulatum	cencla																					
Chondracanthus acicularis	choaci	17,080	28,120	7,968	5,228	11,956	7,056															
?Chondrymenia	chond?																					
Cladophora coelothrix	clacoe																					
Cladophora laetevirens	clalae									14,724				4,480	10,264		13,680		4,760			
Cladophora prolifera	clapro													4,480								
Cladostephus spongiosus	claspo																					
Codium adhaerens	codadh																					
Codium decorticatum	coddec																			6,296		
Codium elisabethae	codeli		22,852								33,924	46,848	1,852	6,292		12,160				1,344		
Colpomenia sinuosa	colsin									14,724	59,780	49,052	54,556	4,480	10,264	2,856	13,680	36,436	4,760	12,592	26,704	9,084
Corallina elongata	corelo	17,080	28,120	39,832	5,228	59,772	14,108	294,188	322,904	147,232	298,868	245,264	136,364	8,956	20,528	2,856	68,392	91,092	9,520	31,480	26,704	45,420
Cryptopleura ramosa	cryram										59,780	49,052	54,556		20,528							
Cystoseira abies-marina	cysabi		28,120	15,932							29,900	24,540	54,556	4,480		2,856	27,356	18,220	4,760	12,592		
Cystoseira foeniculaceus	cysfoe																13,680					
Dasya hutchinsiae	dashut																					
Dictyota dichotoma	dicdic	8,540	14,060	7,968	13,072	23,908	14,108		21,528	14,724	149,396	49,052	54,556	44,788	51,316	2,856	27,356	36,436	9,520	6,296	13,352	9,084
Falkenbergia rufolanosa	falruf																					
Gastroclonium reflexum	gasref																					
Halicystis	halicy																13,680					
Halopteris filicina	halfil																13,680	18,220	4,760			
Hydroclathrus clathratus	hydcla													4,480								
Hypnea musciformis	hypmus		28,120	39,832				19,612	43,052	73,616	59,780	245,264	272,724	67,180	51,316	28,552	68,392	36,436	23,804	62,960	200,272	136,260
Hypoglossum hypoglossoides	hyphyp																					
Jania adhaerens	janadh					23,908	7,056	39,224	43,052	29,448	149,396	122,632	54,556									
Jania longifurca	janlon	17,080	28,120	39,832										8,956	51,316	5,712	136,788	182,184	23,804	12,592	26,704	18,168
Jania verrucosa	janver				5,228	23,908	14,108	98,064	107,636	29,448		122,632	272,724				136,788	182,184	47,604	62,960	66,756	45,420
Liagora viscida	liavis															2,856						
Nytophyllum punctatum	nytpun																					
Osmundia pinnatifida	osmpin																					
Padina pavonica	padpav															28,552					26,704	
Plocamium cartilagineum	plocar	42,704	70,296	15,932	5,228		14,108	19,612		29,448		49,052	136,364	4,480	10,264							
Polysiphonia denudata	polden																					
Pterocladia capillacea	ptecap			39,832	5,228	23,908	14,108			29,448		49,052	54,556	4,480					4,760	6,296	13,352	45,420
Pterosiphonia pennata	ptepen	8,540	14,060	7,968																		
Pterothamnion crispum	ptecri							39,224	21,528	29,448		49,052	54,556	4,480		2,856			4,760			
Pterothamnion plumula	pteplu																					
Rhodymenia holmesii	rhohol		28,120								59,780	24,540	54,556		51,316							
Rosette Sargassum type hystrix	rossah		28,120													5,712	27,356					
Sargassum vulgare	sarvul																					
Stypocaulon scoparia	stysco	17,080		15,932		23,908					59,780	122,632	54,556	8,956	153,952	14,276	27,356	36,436	9.520		133,516	18,168
Stypopodium zonale	styzon									14,724												
Symphyocladia marchanthioides	symmar	42,704	70,296	39,832	26,144	59,772	35,272	39,224	43,052	29,448	59,780	49,052	136,364	4,480	51,316	5,712	13,680	18,220	9,520	6,296	13,352	9,084
Taonia atomaria	taoato										42,104											
Ulva rigida	ulvrig				2,616			19,612	21,528			24,540		4,480		2,856						
Valonia utricularis	valutr																			6,296		9,084
Zonaria tournefortii	zontou	8,540	28,120	7,968								24,540		8,956		28,552	13,680	36,436		31,480		
Total dry weight, g/m2		264,756	557,116	358,488	94,116	370,580	225,736	728,884	839,548	530,048	1122,048	1371,336	1474,668	221,276	482,380	149,220	629,224	692,300	161,852	259,480	547,416	345,192
Mean dry weight, g/m2			393,453			230,144			699,493			1322,684			284,292			494,459			384,029	
sd			149,283			138,285			156,829			181,275			175,292			289,767			147,845	
Number of species (S)		10	14	13	9	9	9	9	9	13	13	18	16	18	11	15	16	11	13	13	10	10
Mean number of species			12,3			9			10,3			15,7			14,7			13,3			11	
sd			2,1			0			2,3			2,5			3,5			2,5			1,7	

A7. Quadrat scraping data (dry weight, g/m2) from the subtidal of São Roque, 15m depth

		93, Sep			Oct			Nov			Dec			94. Jan			Mar			Abr			May		
Species	**Abbrev**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Acrosorium venulosum	acrven																								
Aglaothamnion bipinnatum	aglbip										13,776	11,232	16,184				7,384			91,560	58,240	41,120			
Aglaothamnion hookeri	aglhoo													2,080	8,672	0,412									
Asparagopsis armata	asparm	2,344	7,608	5,724	0,576			22,380				0,840	0,024	0,912	0,236	3,392	2,992	1,340		23,400	1,680	67,040	141,312	225,756	178,556
Bornetia secundiflora	borsec																								
Bryopsis hypnoides	bryhyp							22,448		29,940	0,012	0,040	0,176	0,172	0,052										
Callithamnion corymbosum	calcor	1,632																		91,560	58,240	41,120			
Carpomitra costata	carcos																								
Centroceras clavulatum	cencla			5,400																					
Chondracanthus acicularis	choaci	6,712	18,612	14,288	1,312	7,856	1,440	25,028	0,888	27,657	34,484	22,072	16,304			0,684		0,020							
Chondria dasyphylla	chodas	1,652		5,400																					
?Chondrymenia	chond?																								
Cladophora coelothrix	clacoe	1,740	7,808																						
Cladophora laetevirens	clalae									27,597															
Cladophora prolifera	clapro										0,012														
Cladostaphus spongiosus	claspo							22,384		27,617															
Codium decorticatum	coddec																								
Codium elisabethae	codeli		8,108	15,804		35,408					0,604		2,416			0,488				0,000	18,960	3,360	2,040		3,480
Colpomenia sinuosa	colsin											0,144					0,184				0,040	0,560			
Corallina elongata	corelo	2,420	11,716	7,416		4,400	6,112	22,292		27,769		2,848	0,492	0,392	3,728	0,652			5,116	0,440	2,120	6,200			
Cryptopleura ramosa	cryram									27,669															
Cystoseira abies-marina	cysabi																	0,636			0,560				
Cystoseira foeniculaceus	cysfoe																								
Dasya hutchinsiae	dashut										13,776	11,232	16,184												
Dictyopteris membranacea	dicmem																								
Dictyota dichotoma	dicdic	4,712	6,912	5,468	4,464	0,304	3,632	25,716	0,848	28,893	3,424	3,424	5,012	3,164	0,064	1,248				5,360	11,440	7,440	141,312	150,504	119,036
Erythrodermis traillii	erytra		6,744	5,448																					
Falkenbergia rufolanosa	falruf		6,228														7,384			91,560	58,240	41,120			
Gastroclonium reflexum	gasref	1,676	6,216	5,464																					
Gelidium latifolium	gellat			5,452				22,292																	
Griffithsia flosculosa	griflo			5,400																					
Halopteris filicina	halfil	1,924	6,956	12,352																					
Hypnea musciformis	hypmus																								
Hypoglossum hypoglossoides	hyphyp									27,597															
Jania longifurca	janlon	5,164	23,696	6,208		8,528	20,144							0,972	1,176	0,496		0,080	0,784	1,720	1,360	8,960			
Jania rubens	janver	2,808		7,544			0,480	23,492			0,036	0,496	2,292		4,364	1,188		0,224	0,080		1,840				
Lophosiphonia subadunca	lopsub	1,624																							
Mastocarpus stellatus	masste		6,336																						
Menia n.d. (1)	menia1	1,624	6,216	5,400																					
Nytophyllum punctatum	nytpun									27,857															
Osmundia pinnatifida	osmpin		6,420																						
Padina pavonica	padpav																								
Phyllophora crispa	phycri																								
Plocamium cartilagineum	plocar	1,952	6,652	6,020	0,048		0,000	22,268		27,893	0,152	5,892	16,184	1,220	0,572	0,804	0,280	0,348	2,692	2,360		9,480	70,656	30,100	23,808
Pterocladia capillacea	plecap	3,312	12,716	12,096	7,440	1,920	1,712	44,528	0,460	27,741	35,496	11,636	27,836	3,388	0,080	2,140	0,176	0,120	0,280	0,000	0,640	0,040			
Pterosiphonia pennata	plepen																								
Pterothamnion crispum	ptecri													2,080	8,672	0,520	7,384								
Rhodymenia holmesii	rhohol															1,680			4,396						
Sargassum cf. vulgare	sarvul				32,464								0,584												
Rosette Sargassum type hystrix	rossah																	1,416	0,000						
Spermothamnion cf. repens	sperep		6,216	5,412																					
Sphaerococcus coronopifolius	spacor																								
Stypocaulon scoparia	stysco				125,168	28,976	147,984	46,612	13,092	35,985	13,852	15,876	21,324	10,236	200,280	3,424	90,772	275,280	214,652	9,720		25,840			
Symphyocladia marchanthioides	symmar					0,368		26,588			34,436	57,320	43,712	7,456	30,368	2,604	11,828	4,168	2,744	0,000	8,760	2,120			
Taonia atomaria	taoato																								
Ulva rigida	ulvrig	1,656	6,516	5,488			0,240	22,272			0,020	0,016	0,012												
Valonia utricularis	valutr						0,144						0,008		0,020			1,132	0,024						
Zonaria tournefortii	zontou			9,980			40,176								0,048	4,328			2,852	1,640		0,480			
Total dry weight (g/m2)		42,952	161,676	151,764	171,472	87,760	222,064	348,300	15,288	344,211	150,080	143,068	168,744	32,072	258,332	24,060	128,384	284,764	233,620	319,320	222,120	254,880	355,320	406,360	324,880
Mean dry weight (g/m2)			118,797			160,432			235,933			153,964			104,821			215,589			265,440			362,187	
sd			65,871			67,829			191,095			13,271			133,004			79,734			49,453			41,172	
Number of species (S)		16	18	20	7	8	11	13	4	12	13	14	16	11	14	15	9	11	11	13	13	14	4	3	4
Mean number of species			18,000			8,667			9,667			14,333			13,333			10,333			13,333			3,667	
sd			2,000			2,082			4,933			1,528			2,082			1,155			0,577			0,577	

A7. (cont.)

		94. Jun			Jul			Aug			94. Sep			Oct			Nov			Dec			95, Feb		
Species	**Abbrev**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Acrosorium venulosum	acrven																								
Aglaothamnion bipinnatum	aglbip																								
Aglaothamnion hookeri	aglhoo																								
Asparagopsis armata	asparm			3,812	1,348	5,276	0,852																	6,520	
Bornetia secundiflora	borsec																							6,520	
Bryopsis hypnoides	bryhyp																							6,520	7,928
Callithamnion corymbosum	calcor																								
Carpomitra costata	carcos																								
Centroceras clavulatum	cencla																								
Chondracanthus acicularis	choaci					0,036									9,340	11,148	6,200	5,828	6,452						7,928
Chondria dasyphylla	chodas																								
?Chondrymenia	chond?																					18,312			
Cladophora coelothrix	clacoe																								
Cladophora laetevirens	clalae																								
Cladophora prolifera	clapro							14,156										5,828							
Cladostephus spongiosus	claspo																								
Codium decorticatum	coddec																							6,520	
Codium elisabethae	codeli	12,040		18,240	4,856			25,908		6,200	1,528	4,032		5,592	8,064	56,260	4,496		9,160	10,304	15,532	32,884	133,128	5,916	2,260
Colpomenia sinuosa	colsin	8,008							4,324		22,800	6,276	24,460	10,824	9,340	5,572									7,928
Corallina elongata	corelo					22,200	12,156											58,296		14,656		18,312			7,928
Cryptopleura ramosa	cryram																						20,676		7,928
Cystoseira abies-marina	cysabi								46,804	10,036		12,552	24,460	108,220	18,676	27,868				29,312	4,676			13,040	7,928
Cystoseira foeniculaceus	cysfoe																								
Dasya hutchinsiae	dashut																								
Dictyopteris membranacea	dicmem																								
Dictyota dicholoma	dicdic	120,108	5,068	18,572	7,908	63,976	36,620	36,716	107,928	11,848		31,384	122,296					11,660	6,452		4,676	9,156	20,676	32,596	15,856
Erythrodermis traillii	erytra																								
Falkenbergia rufolanosa	falruf				0,164	2,248																			
Gastroclonium reflexum	gasref																								
Gelidium latifolium	gellat																								
Griffithsia floscullosa	griflo																								
Halopteris filicina	halfil																						20,676	6,520	15,856
Hypnea musciformis	hypmus																							13,040	
Hypoglossum hypoglossoides	hyphyp																								
Jania longifurca	janlon																			14,656	0,000	45,780		13,040	0,000
Jania rubens	janver				0,244	22,200	4,864	35,392	21,584											14,656	9,352				
Lophosiphonia subadunca	lopsub																								
Mastocarpus stellatus	masste																								
Menia n.d. (1)	menia1																								
Nytophyllum punctatum	nytpun																			14,656		9,156			
Osmundia pinnatifida	osmpin																								
Padina pavonica	padpav																								
Phyllophora crispa	phycri																								
Plocamium cartilagineum	plocar	40,036	25,332	19,060															12,904	14,656	4,676		51,692	13,040	39,644
Pterocladia capillacea	ptecap	40,036	12,668	19,060	6,228		3,304	2,336	21,584		22,800		12,228	21,644	9,340	11,148	31,000	11,660	54,252	29,312		18,312			
Pterosiphonia pennata	ptepen																						51,692	32,596	39,644
Pterothamnion crispum	ptecri																6,200	11,660							
Rhodymenia holmesii	rhohol			9,528				40,052			57,000	62,768	61,148							29,312				13,040	
Sargassum cf. vulgare	sarvul																	5,828			4,676	18,312		6,520	7,928
Rosette Sargassum type hystrix	rossah																								
Spermothamnion cf. repens	sperep																								
Sphaerococcus coronopifolius	spacor																								
Stypocaulon scoparia	stysco	40,036	25,332	251,528	0,604	0,864	12,156	70,788	107,928	578,968	113,996	94,148	183,444	162,332	140,072	55,736	31,000	5,828	96,768	73,284	70,152	91,560	155,080	97,792	118,932
Symphyocladia marchanthioides	symmar																15,500	58,296	12,904	73,284	46,768	137,336	51,692	13,040	15,856
Taonia atomaria	taoato																								
Ulva rigida	ulvrig								0,096																
Valonia utricularis	valutr																				4,676				
Zonaria tournefortii	zontou						3,584	12,192		11,728									4,228		4,676	18,312			
Total dry weight (g/m2)		260,264	68,400	339,800	21,352	116,800	73,536	237,540	310,248	618,780	218,124	211,160	428,036	308,612	194,832	167,732	94,396	174,884	203,120	318,088	169,860	417,432	505,312	286,260	303,544
Mean dry weight (g/m2)			222,821			70,563			388,856			285,773			223,725			157,467			301,793			365,039	
sd			139,520			47,793			202,411			123,252			74,752			56,416			124,588			121,787	
Number of species (S)		6	4	7	7	7	7	8	7	5	5	6	6	5	6	6	6	9	8	11	11	11	8	16	15
Mean number of species			5,667			7,000			6,667			5,667			5,667			7,667			11,000			13,000	
sd			1,528			0,000			1,528			0,577			0,577			1,528			0,000			4,359	

A7. (cont.)

		95. Mar			Apr			May			Jun			Jul			Aug			Sep		
Species	**Abbrev**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Acrosorium venulosum	acrven											34,28	11,39								5,06	9,48
Aglaothamnion bipinnatum	aglbip																					
Aglaothamnion hookeri	aglhoo																					
Asparagopsis armata	asparm	211,20	50,86	122,73	51,92	96,42	20,78	16,20	6,22	23,88	4,85											
Bornetia secundiflora	borsec																					
Bryopsis hypnoides	bryhyp																				5,06	
Callithamnion corymbosum	calcor																					
Carpomitra costata	carcos																15,42					
Centroceras clavulatum	cencla																15,42					
Chondracanthus acicularis	choaci	105,60									9,70									7,60		18,97
Chondria dasyphylla	chodas																					
?Chondrymenia	chond?																					
Cladophora coelothrix	clacoe												22,78								5,06	
Cladophora laetevirens	clalae														6,76		15,42	25,44	6,45			
Cladophora prolifera	clapro																				5,06	9,48
Cladostephus spongiosus	claspo																					
Codium decorticatum	coddec																					
Codium elisabethae	codeli	29,12		31,47							1,42		95,37	38,42	13,17				29,75	15,72	76,58	
Colpomenia sinuosa	colsin			24,54	10,38		10,39	63,88	1,40					22,01		26,62	30,84	50,89	12,90	18,99	10,12	18,97
Corallina elongata	corelo			49,09	20,77												30,84			3,80		9,48
Cryptopleura ramosa	cryram								6,22					22,01	6,76	26,62						
Cystoseira abies-marina	cysabi							8,10						55,02	33,83	66,56						
Cystoseira foeniculaceus	cysfoe																		6,45		5,06	
Dasya hutchinsiae	dashut																	25,44				
Dictyopteris membranacea	dicmem						10,39															
Dictyota dichotoma	dicdic		25,43	24,54	51,92	96,42	20,78	16,20	31,11	59,70	72,74	17,16	56,95		33,83	26,62	77,09	50,89	32,24	7,60	10,12	18,97
Erythrodermis traillii	erytra																					
Falkenbergia rufolanosa	falruf									11,94												
Gastroclonium reflexum	gasref																					
Gelidium latifolium	gellat																					
Griffithsia flosculosa	grifio																			3,80		9,48
Halopteris filicina	halfil	21,12		49,09	10,38	19,28											15,42	25,44	6,45			
Hypnea musciformis	hypmus				51,92			81,00	31,11	23,88			56,95	55,02	13,53	26,62			64,47	37,99	25,31	
Hypoglossum hypoglossoides	hyphyp									11,94												
Jania longifurca	janlon	21,12	50,86											9,00	13,53				12,90	3,80		9,48
Jania rubens	janver		50,86	49,09								34,28	11,39									
Lophosiphonia subadunca	lopsub																					
Mastocarpus stellatus	masste																					
Menia n.d. (1)	menia1																					
Nytophyllum punctatum	nytpun		25,43																			
Osmundia pinnatifida	osmpin																					
Padina pavonica	padpav																				5,06	
Phyllophora crispa	phycri																					
Plocamium cartilagineum	plocar		50,86			38,57	10,39	16,20	12,44			17,16		9,00				25,44				9,48
Pterocladia capillacea	ptecap				10,38				31,11	11,94	4,85	34,28	22,78	22,01	13,53	26,62	15,42	25,44	6,45	7,60	10,12	
Pterosiphonia pennata	ptepen	21,12	25,43	24,54																		
Pterothamnion crispum	ptecri																					9,48
Rhodymenia holmesii	rhohol					38,57			6,22		4,85	34,28				13,31						
Sargassum cf. vulgare	sarvul				20,77			16,20			9,70				13,53	26,62						
Rosette Sargassum type hystrix	rossah																			7,60	25,31	
Spermothamnion cf. repens	sperep																					
Sphaerococcus coronopifolius	spacor				10,38	19,28																
Stypocaulon scoparia	stysco	105,60	254,31		51,92	38,57	155,89	81,00	31,11	119,40	24,24	257,35	113,90	165,06	101,44	199,69	77,09	381,68	12,90	18,99	75,92	142,25
Symphyocladia marchanthioides	symmar	42,24	126,86	49,09	20,77	38,57	20,78	16,20	31,11	119,40	9,70	34,28	22,78	22,01	13,53	66,56	15,42	25,44	6,45	7,60	10,12	18,97
Taonia atomaria	taoato										72,74	0,00	22,78									
Ulva rigida	ulvrig	21,12		24,54				8,10		11,94				9,00					6,45			
Valonia utricularis	valutr		25,43			18,08		8,10						9,00								
Zonaria tournefortii	zontou				20,77		10,39	8,10	6,22	11,94		17,16										
Total dry weight (g/m2)		578,24	686,36	448,74	332,29	403,76	259,81	339,28	194,30	405,97	214,78	480,24	437,08	437,58	263,46	505,87	308,38	636,12	203,83	141,08	273,97	284,51
Mean dry weight (g/m2)			571,11			331,95			313,18			377,37			402,30			382,78			233,19	
sd			118,97			71,98			108,22			142,44			125,00			225,55			79,94	
Number of species (S)		9	10	10	12	9	8	12	11	10	10	10	10	12	11	10	10	9	12	12	14	12
Mean number of species			9,67			9,67			11,00			10,00			11,00			10,33			12,67	
sd			0,58			2,08			1,00			0,00			1,00			1,53			1,15	

A8. Quadrat scraping data (dry weight, g/m2) from the subtidal of São Vicente, 5m depth

Species	Abbrev.	93. Sep			Oct			Nov			Dec			94. Jan			Mar			Apr			May		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Asparagopsis armata	asparm	52,128	25,740	38,260	1,088	0,580		8,836	32,236	18,192	124,596	135,840	51,512	408,520	492,712	396,344	268,924	93,396	635,300	172,000	280,200	111,400	148,212	100,696	103,988
Bryopsis hypnoides	bryhyp		25,444																						
Callithamnion sp.	callsp			37,336																					
Centroceras clavulatum	cencla			39,520		0,476		18,216	80,588	45,484															
Chaetomorpha linum	chalin	52,108	25,416	37,340																					
Chondracanthus acicularis	choaci	53,732	26,028	44,116	73,840	60,708		45,536	80,588	19,472	246,384	250,924	100,796												
?Chondrymenia	chond?																	3,760							
Cladophora coelothrix	clacoe	52,388	25,472																						
Cladophora laetevirens	clalae																								
Cladophora prolifera	clapro		25,524	37,348																					
Cladostephus spongiosus	claspo						20,599																		
Codium elisabethae	codeli																								
Colpomenia sinuosa	colsin																								
Corallina officinalis	coroff	65,012	59,096	108,020	77,008	66,592	53,459	45,536	80,588	57,456	179,020	248,760	94,268		60,168	13,688			8,304	15,600	138,080	53,440	139,732	35,348	135,404
Cryptopleura ramosa	cryram																			0,080				0,920	
Cystoseira abies-marina	cysabi				0,040	19,276	20,443																		
Dasya sp.	dasysp																								
Dictyota cervicornis	diccer																								
Dictyota dichotoma	dicdic										20,392	24,984	10,756									0,320	147,852	35,788	13,200
Enteromorpha intestinalis	entint																								
Gastroclonium ovatum	gasova																								
Gastroclonium reflexum	gasref																								
Halopteris filicina	halfil	117,568																							
Hydroclathrus clathratus	hydcla																								
Hypnea musciformis	hypmus	63,528	32,908	68,592													0,088			0,800					
Hypoglossum hypoglossoides	hyphyp																								
Jania longifurca	janlon	53,716	27,472	39,300		6,004			32,216		8,184		5,264		60,168	13,688			6,580						
Jania rubens	janrub	52,844	34,964	37,388	73,968	52,816		18,216	32,236	18,192	82,936	124,380	41,940										126,548	35,348	42,540
Kallymenia reniformis	katren						20,180																		
Laurencia obtusa	lauobt																								
Nytophyllum punctatum	nytpun						20,180																		
Osmundia pinnatifida	osmpin																								
Padina pavonica	padpav																								
Peyssonelia squamaria	peysqu					0,448							4,428												
Plocamium cartilagineum	plocar	53,456		41,356	1,072	9,260	36,999	54,856	179,404	18,192	150,188	176,208	112,952	101,608	20,044	29,632	62,704	250,716	34,796	212,280	40,120	123,080	131,532	321,976	156,560
Pterocladia capillacea	ptecap	72,692	28,944	63,764	73,840	50,304	32,247	29,516	56,388	75,896	135,004	159,424	96,556			0,744		1,200		41,000	2,200	6,280	126,548	102,136	17,360
Pterothamnion crispum	ptecri																								
Rhodymenia holmesii	rhohol																							0,840	
Rosette Sargassum type hystrix	rossah										4,940		7,384							0,960		46,440			
Sphaerococcus coronopifolius	sphcor						56,723																		
Stypocaulon scoparia	stysco	85,480	96,828	108,332		8,196	48,055	346,872	250,340	196,748	18,216		39,328	1,096		19,872	25,592	8,772	6,160	6,680		9,560		4,840	7,200
Symphyocladia marchanthioides	symmar	52,784	27,532		74,840	51,272	20,180	45,536	32,236	18,192	195,372	248,760	89,716								3,120	5,840	139,852		140,864
Taonia atomaria	taoato																								
Ulva rigida	ulvrig			37,348									0,040										1,200	0,720	1,160
Valonia utricularis	valutr																								
Zonaria tournefortii	zontou		26,928		6,360	0,120	25,335			18,192	16,588	24,876	14,588				24,680					4,840			
Total dry weight (g/m2)		827,436	488,296	738,020	382,056	326,052	354,396	613,120	856,820	486,016	1181,820	1394,156	669,528	511,224	633,092	473,968	381,988	357,844	691,140	449,400	463,720	361,200	961,476	636,612	618,276
Mean dry weight (g/m2)			684,584			354,168			651,985			1081,835			539,428			476,991			424,773			739,455	
sd			175,771			28,003			188,432			372,517			83,227			185,851			55,520			192,545	
Number of species (S)		13	14	14	9	13	11	9	10	10	12	9	14	3	4	6	5	5	5	8	5	9	8	10	9
Mean number of species			13,667			11,000			9,667			11,667			4,333			5,000			7,333			9,000	
sd			0,577			2,000			0,577			2,517			1,528			0,000			2,082			1,000	

A8. (cont.)

Species	Abbrev.	Jun			Jul			Aug			Sep			94. Oct			Nov			Dec			95. Jan		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Asparagopsis armata	asparm			105,748	16,676	33,352	39,580	2,744	35,440	26,776								18,328		236,412	93,084	126,432	247,684	219,216	241,956
Bryopsis hypnoides	bryhyp																								
Callithamnion sp.	calisp																								
Centroceras clavulatum	cencla														52,604	100,972		36,656	52,256	47,284	37,072	50,572			
Chaetomorpha linum	chalin																								
Chondracanthus acicularis	choaci									22,288			34,224	34,328	52,604	40,388	107,616	91,636	130,640	354,616	185,368	253,264	82,560	43,844	241,956
?Chondrymenia	chond?			72,120					9,156														16,512		
Cladophora coelothrix	clacoe																								
Cladophora laetevirens	clalae								0,360																
Cladophora prolifera	clapro														26,300										
Cladostephus spongiosus	claspo																								
Codium elisabethae	codeli										97,748														
Colpomenia sinuosa	colsin		32,548	0,280		4,136	3,720																		
Corallina officinalis	corofl	58,332	32,548	42,300		66,704	19,792		6,080	192,596	528,400	74,608	85,560	34,328	263,016		107,616	182,872	261,276	23,640	37,072	50,572	82,560	109,608	120,976
Cryptopleura ramosa	cryram																								
Cystoseira abies-marina	cysabi	0,880					2,068		4,592																
Dasya sp.	dasysp																								
Dictyota cervicornis	diccer				10,116	45,620	39,276																		
Dictyota dichotoma	dicdic	8,920	27,120	8,920	3,268	149,096	28,232			3,692				0,212			21,524	36,656	26,128	23,640		25,328			
Enteromorpha intestinalis	entint																							21,920	
Gastroclonium ovatum	gasova															20,196									
Gastroclonium reflexum	gasref																								
Halopteris filicina	halfil																								
Hydroclathrus clathratus	hydcla													0,100											
Hypnea musciformis	hypmus	175,000	244,104	109,748	91,304	246,940	98,952	554,476	62,184	556,308	105,680	149,220	256,684	171,636	131,508	100,972	43,048	18,328	52,256	47,284	37,072	50,572			
Hypoglossum hypoglossoides	hyphyp																								
Jania longifurca	janlon					66,704			49,036					34,328	131,508	100,972				118,204	93,084	126,432	82,560	109,608	120,976
Jania rubens	janrub			42,300										34,328	263,016	201,948				118,204	37,072	50,572			
Kallymenia reniformis	kairen																								
Laurencia obtusa	lauobt																								
Nytophyllum punctatum	nytpun																								
Osmundia pinnatifida	osmpin								0,184																
Padina pavonica	padpav				0,600	4,972	19,780			0,824			1,368												
Peyssonelia squamaria	peysqu		7,120		41,688				7,372			2,040													
Plocamium cartilagineum	plocar	116,668	162,736	211,496					5,616					85,820	52,604	40,388				118,204	37,072	50,572			48,392
Pterocladia capillacea	plecap	116,668	81,368	211,496	49,480	333,528	197,904		46,656	8,916	528,400	102,128	85,560	171,636	131,508	201,948	215,236	183,272	261,276	236,412	185,368	126,432	82,560	109,608	241,956
Pterothamnion crispum	ptecri																						16,512	43,844	48,392
Rhodymenia holmesii	rhohol		0,560						0,356											47,284		126,432		43,844	48,392
Rosette Sargassum type hystrix	rossah		2,320	7,240	1,372		0,300		4,220					0,696				1,868							
Sphaerococcus coronopifolius	sphcor										2,448	116,988					21,524								
Stypocaulon scoparia	stysco	152,692	146,808	109,748	500,548	198,656	158,484	786,352	208,812		264,200	235,280	203,576	184,496	52,604	24,948	13,504	9,680	15,972	47,284	278,048	50,572	165,124	219,216	48,392
Symphyocladia marchanthioides	symmar		162,736		16,676	166,764			76,676					34,328	131,508	100,972	43,048	91,636	52,256	47,284	37,072	50,572	16,512	43,844	
Taonia atomaria	taoato																								
Ulva rigida	ulvrig	2,080	0,920	0,080	18,832	30,168	106,624	0,408	3,148	6,796					52,604						18,536				
Valonia utricularis	valutr																	18,328							
Zonaria tournefortii	zontou		51,600		105,564	1,328	84,008		1,296		0,624	50,500	97,092			4,968	21,524	18,328	26,128	23,640					
Total dry weight (g/m2)		631,240	952,488	921,476	856,124	1347,968	798,720	1343,980	523,184	818,196	1527,500	730,764	764,064	786,236	1341,384	938,672	594,640	707,588	878,188	1489,392	1075,920	1138,324	792,584	964,552	1161,388
Mean dry weight (g/m2)			835,068			1000,937			895,120			1007,443			1022,097			726,805			1234,545			972,841	
sd			177,200			301,905			415,770			450,691			286,823			142,747			222,898			184,542	
Number of species (S)		8	13	12	12	13	13	4	17	8	7	7	7	12	12	11	9	12	9	14	12	13	9	10	9
Mean number of species			11,000			12,667			9,667			7,000			11,667			10,000			13,000			9,333	
sd			2,646			0,577			6,658			0,000			0,577			1,732			1,000			0,577	

A8. (cont.)

Species	Abbrev.	Feb			Mar			Apr			May			Jun			Jul			Aug			Sep		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Asparagopsis armata	asparm	163,832	201,920	130,208	93,432	78,216	72,464	325,252	289,924	289,336	173,964	229,024	123,696	161,840	49,852	88,224	60,084								
Bryopsis hypnoides	bryhyp																								
Callithamnion sp.	callsp																								
Centroceras clavulatum	cencla																						15,256	24,428	
Chaetomorpha linum	chalin																								21,880
Chondracanthus acicularis	choaci				33,812	26,072	36,232	43,368	38,656	38,580	23,196	30,536	16,492	323,676	49,852	88,224									
?Chondrymenia	chond?																								
Cladophora coelothrix	clacoe																60,084						15,256		
Cladophora laetevirens	clalae															17,644				30,456		27,336	15,256	12,212	
Cladophora prolifera	clapro																				13,780			12,212	
Cladostephus spongiosus	claspo																								
Codium elisabethae	codeli																				1,868				
Colpomenia sinuosa	colsin													32,368			60,084			30,456		27,336			
Corallina officinalis	coroff	54,612	67,308	17,360		10,428	14,492	108,404	38,656	38,580	23,196	30,536	16,492			35,288	150,212			60,912	27,560	54,672	30,508	24,428	43,760
Cryptopleura ramosa	cryram		13,460	8,680	6,764	5,216	7,248										30,044						15,256	12,212	
Cystoseira abies-marina	cysabi	21,844															30,044				27,560		15,256		
Dasya sp	dasysp		13,460																				30,508		
Dictyota cervicornis	diccer																								
Dictyota dichotoma	dicdic	10,924		8,136	13,524		14,492	21,684	19,328	19,288	115,976	76,340	16,492	161,840	24,924					60,912		54,672	15,256	24,428	43,760
Enteromorpha intestinalis	entint																								
Gastroclonium ovatum	gasova																								
Gastroclonium reflexum	gasref																								21,880
Halopteris filicina	halfil																						15,256	12,212	21,880
Hydroclathrus clathratus	hydcla																								
Hypnea musciformis	hypmus	54,612	26,924	43,404	13,524	10,428		43,368	38,656	38,580	57,988	30,536	16,492	323,676	49,852	88,224	300,424			456,832	206,688	410,040	152,692	122,132	218,796
Hypoglossum hypoglossoides	hyphyp	10,924		17,360																					
Jania longifurca	janlon	10,924	13,460	17,360													150,212				13,780		30,508	24,428	43,760
Jania rubens	janrub				67,620	10,428	14,492			38,580	57,988	76,340	82,464	64,736	24,924	35,288	150,212			152,276	68,896	136,680	30,508	61,064	109,400
Kallymenia reniformis	kalren																								
Laurencia obtusa	lauobt															35,288									
Nytophyllum punctatum	nytpun									19,288			8,248												
Osmundia pinnatifida	osmpin																								
Padina pavonica	padpav																60,084			30,456	13,780				
Peyssonelia squamaria	peysqu	2,776																							
Plocamium cartilagineum	plocar	109,220	67,308	43,404	13,524	52,144	72,464	108,404	96,640	192,892	23,196	76,340	41,232	64,736	24,924	35,288	30,044						30,508	24,428	43,760
Pterocladia capillacea	ptecap	54,612	26,924	43,404		10,428	14,492	21,684	96,640	38,580	23,196	30,536	41,232	64,736	24,924	88,224				60,912	68,896	136,680	76,272		109,400
Pterothamnion crispum	ptecri		13,460	8,680				21,684			23,196	15,268	16,492									27,336		12,212	21,880
Rhodymenia holmesii	rhohol	21,844	26,924	17,360	6,764	10,428	14,492					15,268													
Rosette Sargassum type hystrix	rossah									38,580						17,644	60,084			30,456	68,896		15,256	12,212	
Sphaerococcus coronopifolius	sphcor									19,288													15,256		
Stypocaulon scoparia	stysco	9,432	23,944		33,812	26,072	14,492	108,404	38,656	19,288	57,988	76,340	41,232	161,840	373,876	176,448	450,636			60,912	27,560		76,272	24,428	109,400
Symphyocladia marchanthioides	symmar	109,220	134,612	86,808	33,812	10,428	14,492	43,368	193,280	96,444	57,988	76,340	41,232	64,736	49,852	88,224	60,084			60,912	27,560	54,672	30,508	24,428	43,760
Taonia atomaria	taoato											15,268													
Ulva rigida	ulvrig						14,492		19,328		23,196	15,268	8,248	32,368		17,644	30,044			30,456			15,256		21,880
Valonia utricularis	valutr																								
Zonaria tournefortii	zontou	19,164								19,288		30,536			127,048	35,288							15,256	61,064	21,880
Total dry weight (g/m2)		653,940	629,704	442,164	316,588	250,288	304,344	845,620	869,764	906,592	661,068	824,476	470,044	1456,552	800,028	846,940	1682,376	0,000	0,000	1065,948	566,824	929,424	656,100	488,528	897,076
Mean dry weight (g/m2)			575,269			290,407			873,992			651,863			1034,507			560,792			854,065			680,568	
sd			115,908			35,279			30,705			177,395			366,254			971,320			257,954			205,370	
Number of species (S)		14	12	12	10	11	12	10	10	14	12	15	13	11	10	14	15	0	0	12	12	9	20	16	15
Mean number of species			12,667			11,000			11,333			13,333			11,667			5,000			11,000			17,000	
sd			1,155			1,000			2,309			1,528			2,082			8,660			1,732			2,646	

A9. Quadrat scraping data (dry weight, g/m2) from the subtidal of São Vicente, 10m depth

			93. Sep			Oct			Nov			Dec			94. Jan			Mar	
Species	**Abbrev.**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Antithamnion crispum	antcri	9,212																	
Asparagopsis armata	asparm	14,636	8,892	37,736		0,364		37,858	55,461	46,570	203,460	2,580	10,036	76,628	249,756	440,140	65,992	168,800	69,568
Bryopsis hypnoides	bryhyp												0,080	0,192					
Centroceras clavulatum	cencl	19,140	4,584																
Chondracanthus acicularis	choaci	11,816	4,952	31,632	34,672	71,840	82,332			36,248			116,444						
Chondracanthus teedii	chotee				0,080			36,834	52,180										
?Chondrymenia	chond?					37,340								1,268			104,260		
Cladophora coelotrhix	clacoe																		
Cladophora laetevirens	clalae																		
Cladophora prolifera	clapro									36,334									
Codium elisabethae	codeli	66,348	97,560								204,840	0,020							66,012
Colpomenia sinuosa	colsin																		
Corallina elongata	corelo	9,948	14,924	46,656		1,884	5,244	42,774	68,485	80,658		1,096	2,164		4,504	4,336		1,148	
Cryptopleura ramosa	cryram	9,604	5,420																
Cystoseira abies-marina	cysabi																		
Dasya cf. ocellata	dasoce																		
Dictyopteris membranacea	dicmem																		
Dictyota cervicornis	diccer																		
Dictyota dichotoma	dicdic							35,714				0,768				1,624	0,404	0,652	
Gastroclonium reflexum	gasref																		
Halopteris filicina	halfil	22,772																	
Halopteris scoparia	halsco	10,268	90,540		21 924	13,216			62,000			8,144	228,808	10,688			0,328	8,944	20,472
Hypnea musciformis	hypmus	75,908	39,936	108,576		71,840	66,992	47,694	53,725						0,044	8,528			
Jania capillacea	jancap	9,616	7,884																
Jania longifurca	janlon					6,908		36,908								4,336			
Jania rubens	janrub	10,556	10,020	40,284			12,124			38,560									
Mastocarpus stelatus	masste	17,960	4,528																
Nytophyllum punctatum	nytpun																		
Osmundia pinnatifida	osmpin	9,504																	
Padina pavonica	padpav																		
Peyssonnelia squamaria	peysqu	11,716									203,032	2,376		184,932					
Plocamium cartilagineum	plocar	26,432	14,508	28,116	1,332	0,144		36,368	63,533	56,274	217,356	14,376	4,300	138,236	71,008	20,808	62,148	8,940	22,796
Pterocladia capillacea	ptecap	47,172	26,760	28,800	2,840	71,840	66,992	37,482	61,429	119,206		8,888	16,864	3,952	0,208		0,756		
Pterothamnium crispum	ptecri																		
Rhodymenia holmesii	rhohol																	6,740	
Rosette Sargassum type hystrix	rossah																		
Sphaeroccocus coronopifolius	sphcor	37,400	79,956		174,872														342,616
Symphyocladia marchanthioides	symmar	138,832	11,652	28,720	22,148		1,608	43,762	90,993	55,158		19,400		6,880	10,596	23,888	30,776	0,892	
Taonia atomaria	taoato	20,476	35,668		23,612						204,248								
Ulva rigida	ulvrig		7,800	28,060								0,108							
Zonaria tournefortii	zontou	49,644	28,440		123,896	65,952						274,784	17,008		31,740	7,628	66,980	101,908	12,104
Total dry weight (g/m2)		628,960	494,024	378,580	405,376	341,328	235,292	355,392	507,806	469,008	1032,936	332,540	395,704	422,776	367,856	511,288	331,644	298,024	533,568
Mean dry weight (g/m2)			500,521			327,332			444,069			587,060			433,973			387,745	
sd			125,316			85,901			79,208			387,429			72,369			127,400	
Number of species (S)		21	18	9	9	10	6	9	8	8	5	11	8	8	7	8	8	8	6
Mean number of species			16			8,3			8,3			8			7,7			7,3	
sd			6,2			2,1			0,6			3			0,6			1,2	

A9. (cont.)

Species	**Abbrev.**	**94. Apr**			**May**			**94. Jun**			**Jul**			**Aug**			**Sep**		
		1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Antithamnion crispum	antcri																		
Asparagopsis armata	asparm	83,520	137,320	46,080	122,696	145,840	74,140				26,548	4,320						2,124	
Bryopsis hypnoides	bryhyp																		
Centroceras clavulatum	cencl																		
Chondracanthus acicularis	choaci										16,440								
Chondracanthus teedii	chotee																		
?Chondrymenia	chond?			5,280			1,240	54,340	421,312	19,380									
Cladophora coelotrhix	clacoe																		
Cladophora laetevirens	clalae													0,372					
Cladophora prolifera	clapro																		
Codium elisabethae	codeli																		
Colpomenia sinuosa	colsin														0,272				
Corallina elongata	corelo								140,436	19,380	6,356	71,620	68,196	41,368	157,432	1,188	21,512	20,076	17,600
Cryptopleura ramosa	cryram				19,480														
Cystoseira abies-marina	cysabi										0,248								
Dasya cf. ocellata	dasoce																		
Dictyopteris membranacea	dicmem											0,104							
Dictyota cervicornis	diccer										14,360	17,276							
Dictyota dichotoma	dicdic	0,200	0,560	0,240	15,120	16,400	4,440			12,480	24,720	97,536	192,808	22,524	30,508	8,296			
Gastroclonium reflexum	gasref																		
Halopteris filicina	halfil																		
Halopteris scoparia	halsco	16,640	7,480	17,800	23,680	27,280	38,300	135,852	140,436	27,320	19,164			7,848		22,436	53,780	121,528	35,200
Hypnea musciformis	hypmus									48,448	17,120	76,596	340,972	124,100	472,300	30,532	107,564	150,564	263,996
Jania capillacea	jancap																		
Jania longifurca	janlon										6,356	28,648		41,368	157,432			20,076	17,600
Jania rubens	janrub			0,360	7,792	5,152													
Mastocarpus stelatus	masste																		
Nytophyllum punctatum	nytpun										0,152					0,216			
Osmundia pinnatifida	osmpin																		
Padina pavonica	padpav											0,164				0,672			
Peyssonnelia squamaria	peysqu							1,880	56,176										
Plocamium cartilagineum	plocar	151,360	4,120	11,440	27,752	38,256		271,700	140,436	99,852	5,740						21,512		
Pterocladia capillacea	ptecap	1,240		1,160	0,240	18,632				96,932	6,356	143,240				2,916			175,996
Pterothamnium crispum	ptecri																		
Rhodymenia holmesii	rhohol										1,584							20,076	
Rosette Sargassum type hystrix	rossah										0,236		170,488						
Sphaeroccocus coronopifolius	sphcor						228,880	85,120						101,416	233,592	302,956	1007,832		192,516
Symphyocladia marchanthioides	symmar	4,880	0,600		98,840	107,000	13,500	407,552		96,932	31,772	143,240	340,972	31,868	4,532		10,756		35,200
Taonia atomaria	taoato																		
Ulva rigida	ulvrig					1,240			0,440	0,840	1,864	88,708	4,308	0,220	0,944	0,356			
Zonaria tournefortii	zontou	7,000	21,880	78,000	6,080	78,400	63,460			13,400	256,836	16,372		36,924		312,924		75,972	
Total dry weight (g/m2)		264,840	171,960	160,360	321,680	438,200	423,960	956,444	899,236	434,964	435,852	687,824	1117,744	408,008	1057,012	682,492	1222,956	410,416	738,108
Mean dry weight (g/m2)			199,053			394,613			763,548			747,140			715,837			790,493	
sd			57,267			63,562			285,996			344,794			325,784			408,795	
Number of species (S)		7	6	8	9	9	7	6	6	10	17	12	6	10	8	10	6	7	7
Mean number of species			7			8,3			7,3			11,7			9,3			6,7	
sd			1			1,2			2,3			5,5			1,2			0,6	

A9. (cont.)

		94. Oct			Nov			Dec			95. Jan			95. Feb			Mar		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Antithamnion crispum	antcri																		
Asparagopsis armata	asparm		5,504		55,552	11,780	60,764	0,912	23,876	1,036	131,360	33,696	45,324	103,704	71,380	117,248	51,520	90,940	67,452
Bryopsis hypnoides	bryhyp																		
Centroceras clavulatum	cencl					11,780			23,876	22,516									
Chondracanthus acicularis	choaci	70,628	11,008	8,864	111,108	29,444	60,764		179,068	67,544							6,868	12,124	
Chondracanthus teedii	chotee																		
?Chondrymenia	chond?			8,172				8,348			131,360	151,976					17,172		8,992
Cladophora coelotrhix	clacoe	14,124																	
Cladophora laetevirens	clalae																		
Cladophora prolifera	clapro																		
Codium elisabethae	codeli					26,764					0,952				90,104	58,624			
Colpomenia sinuosa	colsin			4,432															
Corallina elongata	corelo		27,524	4,432	55,552		121,532	10,080	119,380		131,360	13,480	45,324	51,852	14,276	23,448		12,124	4,496
Cryptopleura ramosa	cryram													10,372	7,140	11,724			
Cystoseira abies-marina	cysabi							7,076											
Dasya cf. ocellata	dasoce													10,372	7,140	11,724			
Dictyopteris membranacea	dicmem																		
Dictyota cervicornis	diccer																		
Dictyota dichotoma	dicdic	28,252	11,008	4,432	22,220	11,780	24,308				52,544	6,740	18,128	27,716	18,780		17,172	12,124	22,484
Gastroclonium reflexum	gasref																		
Halopteris filicina	halfil																		
Halopteris scoparia	halsco	28,252	11,008	4,432		41,128		68,352	23,876	36,624	262,740	101,088	90,644	1,092		11,612	17,172	30,312	8,992
Hypnea musciformis	hypmus	141,256	11,008	22,164	55,552		24,308		23,876	11,432			18,128	51,852	35,688	58,624		12,124	
Jania capillacea	jancap																		
Jania longifurca	janlon	70,628	5,504	4,432			24,308	16,036	59,688	22,516	262,740	13,480	45,324	20,740	14,276	58,624			
Jania rubens	janrub			8,864					23,876	11,432									
Mastocarpus stelatus	masste																		
Nytophyllum punctatum	nytpun		5,504																
Osmundia pinnatifida	osmpin								11,936										
Padina pavonica	padpav																		
Peyssonnelia squamaria	peysqu							26,424											
Plocamium cartilagineum	plocar	28,252		4,432		11,780				13,764				51,852	35,688	23,448	34,348	30,312	22,484
Pterocladia capillacea	ptecap	70,628	189,060	66,492		58,892	121,532	1,908	59,688	25,192	52,544	6,740		51,852	35,688	58,624	6,868	12,124	4,496
Pterothamnium crispum	ptecri																		
Rhodymenia holmesii	rhohol																		
Rosette Sargassum type hystrix	rossah	28,252		4,432															
Sphaeroccocus coronopifolius	sphcor	14,124				26,300		106,032	48,876						101,952				
Symphyocladia marchanthioides	symmar	70,628	11,008	8,864			60,764	6,784	23,876	0,484	52,544	6,740	90,644	155,560	107,076	117,248	17,172	12,124	8,992
Taonia atomaria	taoato																		
Ulva rigida	ulvrig	14,124			11,112	11,780			11,936				9,064				3,436		
Zonaria tournefortii	zontou		109,632	414,728	2,948	41,284	6,640	0,760		15,176		76,252		11,892	3,940	31,876		60,628	44,968
Total dry weight (g/m2)		579,148	397,768	569,172	314,044	282,712	504,920	252,712	633,828	227,716	1078,144	410,192	362,580	548,856	543,128	582,824	171,728	284,936	193,356
Mean dry weight (g/m2)			515,363			367,225			371,419			616,972			558,269			216,673	
sd			101,962			120,272			227,597			400,096			21,457			60,098	
Number of species (S)		12	11	14	7	11	9	11	13	11	9	9	8	12	13	12	9	10	9
Mean number of species			12,3			9			11,7			8,7			12,3			9,3	
sd			1,5			2			1,2			0,6			0,6			0,6	

A9. (cont.)

		94. Apr			May			Jun			Jul			Aug			Sep		
Species	**Abbrev.**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Antithamnion crispum	antcri																		
Asparagopsis armata	asparm	164,636	280,176	186,128	144,320	318,576	211,128				8,796								
Bryopsis hypnoides	bryhyp																		
Centroceras clavulatum	cencl																		
Chondracanthus acicularis	choaci				14,432		28,152								11,864		15,432	11,004	12,056
Chondracanthus teedii	chotee																		
?Chondrymenia	chond?							211,268											
Cladophora coelotrhix	clacoe																15,432		
Cladophora laetevirens	clalae									15,796									
Cladophora prolifera	clapro																		
Codium elisabethae	codeli			36,752			14,076	41,664					41,884						
Colpomenia sinuosa	colsin							42,256					21,680	8,652		9,912			
Corallina elongata	corelo	10,976	37,356	24,816	14,432	42,476	28,152	42,256	16,172	15,796	17,592	23,944		17,304	23,728	19,820	30,864	11,004	24,116
Cryptopleura ramosa	cryram					21,240	14,076				8,796								
Cystoseira abies-marina	cysabi							84,508	80,856					8,652			15,432	11,004	12,056
Dasya cf. ocellata	dasoce																	11,004	
Dictyopteris membranacea	dicmem											59,856							
Dictyota cervicornis	diccer																		
Dictyota dichotoma	dicdic	54,880	37,356		14,432	42,476	28,152	211,268	32,344	31,592				8,652	23,728	9,912	30,864	11,004	12,056
Gastroclonium reflexum	gasref														11,864				
Halopteris filicina	halfil										17,592								
Halopteris scoparia	halsco	54,880		62,044	14,432	42,476	28,152		32,344	116,936	17,592	23,944	162,584	17,304	59,316	49,552	30,864	110,036	60,288
Hypnea musciformis	hypmus			24,816	14,432			422,544	161,712	78,980	131,932	119,712	54,196	129,792	177,948	148,660	154,316	110,036	120,576
Jania capillacea	jancap						28,152	84,508											
Jania longifurca	janlon																30,864	22,008	24,116
Jania rubens	janrub		37,356		14,432	42,476	28,152				17,592	23,944		17,304	23,728	19,820	30,864	11,004	12,056
Mastocarpus stelatus	masste																		
Nytophyllum punctatum	nytpun																		
Osmundia pinnatifida	osmpin																		
Padina pavonica	padpav												21,680		23,728	9,912	15,432	11,004	12,056
Peyssonnelia squamaria	peysqu									31,596									
Plocamium cartilagineum	plocar	54,880	93,392	62,044	72,160	212,384	70,376	84,508	80,856	78,980	43,976		21,680	8,652	11,864		15,432	11,004	12,056
Pterocladia capillacea	ptecap				72,160			32,344	78,980			11,972	21,680	86,528	59,316	49,552			
Pterothamnium crispum	ptecri				14,432	21,240	14,076	84,508	16,172					8,652	11,864	9,912	15,432		12,056
Rhodymenia holmesii	rhohol							84,508											
Rosette Sargassum type hystrix	rossah								32,344				10,840			9,912	15,432	11,004	
Sphaeroccocus coronopifolius	sphcor			62,044							17,592		54,196	17,304	23,728	261,208			
Symphyocladia marchanthioides	symmar	54,880	93,392	62,044	144,320	106,192	140,752	84,508	16,172	31,592	43,976	59,856	108,392	17,304	23,728	19,820	30,864	22,008	24,116
Taonia atomaria	taoato								161,712		87,956	23,944							
Ulva rigida	ulvrig											11,972	10,840	8,652			15,432	11,004	
Zonaria tournefortii	zontou	54,880	18,680	24,816	144,320				80,856	15,796	43,976	119,712	108,392	43,264	23,728	49,552			120,576
Total dry weight (g/m2)		450,012	597,708	545,504	678,304	849,536	633,396	1510,648	790,520	417,064	457,368	478,856	638,044	398,016	510,132	667,544	462,956	374,128	458,180
Mean dry weight (g/m2)			531,075			720,412			906,077			524,756			525,231			431,755	
sd			74,898			114,057			555,875			98,697			135,397			49,963	
Number of species (S)		7	7	9	12	9	12	13	12	9	12	10	12	14	14	13	15	14	13
Mean number of species			7,7			11			11,3			11,3			13,7			14	
sd			1,2			1,7			2,1			1,2			0,6			1	

A10. Quadrat scraping data (dry weight, g/m2) from the subtidal of São Vicente, 15m depth

		93. Sep			Oct			Nov			Dec			94. Jan			Mar			Apr			May		
Species	**Abbrev.**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Acrosonum venulosum	acrven																								
Anadyomena stellata	anaste																								
Anotrichium barbatum	anobar																								
Antithamnionella sp	antisp									4,432															
Asparagopsis armata	asparm		0,776	2,956	0,036			0,556	8,333	10,144		0,820	0,104	165,992		37,220	54,000	85,672	70,532	138,120	174,960	189,640	36,680	39,240	95,144
Bryospis hypnoides	bryhyp														0,116										
Centroceras clavulatum	cencl																								
Chaetomorpha linum	chalin																								
Chondracanthus acicularis	choaci			20,040											1,220					0,160					
?Chondrymenia	chond?	4,028			24,900	4,520	13,148																		
Cladophora coelothrix	clacoe		0,016																						
Cladophora laetevirens	clalae																								
Cladophra prolifera	clapro			8,128							0,768														
Codium elisabethae	codeli				0,880				10,713		28,744	5,096											16,080	26,560	
Colpomenia sinuosa	colsin																								
Corallina elongata	corelo		5,908	35,244				0,168		42,644		26,300	63,784			1,224									
Cryptopleura ramosa	cryram		41,340	10,020																					
Cystoseira abies-marina	cysabi										0,228														
Dasya hutchinsiae	dashut																								
Dictyota cervicornis	diccer																								
Dictyota dichotoma	dicdic			0,280							2,376	4,136	1,320	8,532	26,344	3,248	18,708	30,156				1,280	6,600	23,880	6,760
Halopteris filicina	halfil	9,968					3,044																		
Hypnea musciformis	hypmus	46,788	19,452	183,272						24,160		21,632	48,580				2,948	1,160		0,080					
Hypoglossum hypoglossoides	hyphyp																								
Jania capillacea	jancap		0,212	31,700																					
Jania longifurca	janlon						0,744			28,900															
Jania rubens	janrub		2,540	28,760					8,281	9,516															4,992
Kallymenia reniformis	kalren																								
Padina pavonica	padpav											0,036													
Peyssonnelia squamaria	peysqu		11,008		61,900	114,104									20,464			13,476							
Plocamium cartilagineum	plocar	3,572	69,524	65,032	1,968	14,744	16,048	18,720		55,188	15,616	21,640	66,572	117,380	32,932	33,636	117,836	83,588	37,140	44,280	82,960	42,960	80,280	287,840	9,984
Polysiphonia atlantica	polatl									4,432															
Polysiphonia denudata	polden			10,020																					
Polysiphonia foetidissima	polfoe										28,036														
Pterocladia capillacea	ptecap		0,360	3,188	0,160	0,320	0,076				5,012	21,228	81,124	11,168	91,288	3,168			0,048	0,200		0,520			9,984
Pterothamnion crispum	ptecri									4,432	14,756														
Pterothamnion plumula	pteplu										28,036														
Ptilothamnion pluma	ptiplu									4,432															
Rhodymenia holmesii	rhohol																								
Rosette Sargassum type hystrix	rossah														0,152										
Sphaeroccocus coronopifolius	sphcor		12,248																						
Sphondilothamnion multifidum	sphmul									4,432															
Stypocaulon scoparia	stysco		49,368		4,348	52,828	13,320	3,816	24,637	9,284	31,932	1,364	9,144		19,080	35,328	6,636	30,892	39,296	73,960	2,120	48,560	87,440	46,720	76,600
Symphyocladia marchanthioides	symmar	19,444		50,104			46,692		7,997		84,104	36,520	48,580	154,444	101,808	55,384	47,184	36,944	21,952			4,280	2,640	2,480	83,188
Taonia atomaria	taoato	0,816	26,708		6,412	13,428		21,360																	
Ulva rigida	ulvrig																								
Valonia utricularis	valutr																								
Zonaria tournefortii	zontou	354,344	280,908		118,168	16,948		314,516	190,033	165,144	9,832	91,084	48,580		26,704	227,672	22,540	3,732	187,924	295,600	4,000	8,120	9,080	147,280	349,072
Total dry weight (g/m2)		438,960	520,388	448,744	218,772	216,892	93,072	359,136	249,992	367,140	249,440	229,856	367,788	457,516	320,108	396,880	269,852	285,620	356,892	552,400	264,040	295,360	238,800	574,000	635,724
Mean dry weight (g/m2)			469,364			176,245			325,423			282,361			391,501			304,121			370,600			482,841	
sd			44,458			72,036			65,447			74,627			68,862			46,376			158,220			213,587	
Number of species (S)		7	14	13	9	7	7	6	6	13	12	11	9	5	10	8	7	8	6	7	4	7	7	7	8
Mean number of species			11,3			7,7			8,3			10,7			7,7			7			6			7,3	
sd			3,8			1,2			4,0			1,5			2,5			1			1,7			0,6	

A10. (cont.)

Species	Abbrev.	94. Jun			Jul			Aug			Sep			94. Oct			Nov			Dec			95. Jan		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Acrosonum venulosum	acrven																								13,152
Anadyomene stellata	anaste																								
Anotrichium barbatum	anobar															12,892									
Antithamnionella sp.	antisp																								
Asparagopsis armata	asparm		14,112	37,136	75,728		70,584	0,508	0,404			4,136	10,720						10,476				16,148		
Bryospis hypnoides	bryhyp																								
Centroceras clavulatum	cencl													59,112											
Chaetomorpha linum	chalin																								
Chondracanthus acicularis	choaci															12,892		18,492					16,148		
?Chondrymenia	chond?																			1,000				9,912	
Cladophora coelothrix	clacoe																	3,700							
Cladophora laetevirens	clalae								0,056																
Cladophra prolifera	clapro												0,484					7,396							
Codium elisabethae	codeli	0,280					7,948								38,460									34,028	
Colpomenia sinuosa	colsin				2,852							2,236													
Corallina elongata	corelo								113,052				21,440							1,368				11,808	26,308
Cryptopleura ramosa	cryram																								
Cystoseira abies-marina	cysabi													59,112	38,460			7,396							
Dasya hutchinsiae	dashut																								
Dictyota cervicornis	diccer				2,712	10,364																			
Dictyota dichotoma	dicdic	2,760	10,520		46,920	60,188	352,928	3,376	4,272			7,592		23,644		25,784	5,588		10,476				40,728	5,904	26,308
Halopteris filicina	halfil																								
Hypnea musciformis	hypmus	101,600	42,924	14,856	41,616	2,104	141,172	131,584	27,868	62,136	112,476	62,064	160,796	59,112	96,148	25,784				0,044					
Hypoglossum hypoglossoides	hyphyp																								
Jania capillacea	jancap																								
Jania longifurca	janlon								0,520										10,476					11,808	26,308
Jania rubens	janrub																	18,492	10,476						
Kallymenia reniformis	kalren																								
Padina pavonica	padpav																								
Peyssonnelia squamaria	peysqu															25,784							1,044		
Plocamium cartilagineum	plocar	132,400	143,604	74,272	5,744	7,836	70,584		109,116								5,588			0,836	3,908	1,316	16,292	29,516	26,308
Polysiphonia atlantica	polatl																								
Polysiphonia denudata	polden																								
Polysiphonia foetidissima	polfoe																								
Pterocladia capillacea	ptecap	50,800	14,112	37,136	75,728			131,584						118,224	38,460	25,784	5,588		26,188	0,432	7,816		16,292	29,516	131,532
Pterothamnion crispum	ptecri																						8,144	11,808	26,308
Pterothamnion plumula	pteplu																								
Ptilothamnion pluma	ptiplu																								
Rhodymenia holmesii	rhohol																								
Rosette Sargassum type hystrix	rossah						28,236			1,268	12,652			11,824										5,904	
Sphaeroccocus coronopifolius	sphcor			125,320		434,484		3,604		36,148						12,892		18,492	26,188						
Sphondilothamnion multifidum	sphmul																								
Stypocaulon scoparia	stysco	6,160	50,764	37,136	45,064	79,504	70,584		5,860	193,608	194,304	20,364	106,924	59,112	96,148	64,464	27,712	21,224	10,476	27,032	27,276	26,780	81,452	88,552	
Symphyocladia marchanthioides	symmar	101,600	105,852	74,272	227,188	159,260	70,584	21,052	109,116	267,620	63,260	41,376	107,196	23,644	192,300	128,928	5,588	36,984	52,376	45,036	42,848	29,312	8,144	5,904	13,152
Taonia atomaria	taoato																								
Ulva rigida	ulvrig	0,320											1,280					7,396					8,144		
Valonia utricularis	valutr																								
Zonaria tournefortii	zontou	113,600	38,432		66,020	79,996	141,172	210,076	499,756	159,976	125,676	410,744	99,896		96,148	217,528	368,852	400,420	122,836	337,764	262,732	233,972	122,180	59,036	197,296
Total dry weight (g/m2)		509,520	420,320	400,128	589,572	833,736	953,792	501,784	870,020	720,756	508,368	548,512	508,736	413,784	596,124	552,732	418,916	539,992	279,968	413,512	344,580	291,380	334,716	303,696	486,672
Mean dry weight (g/m2)			443,323			792,367			697,520			521,872			520,880			412,959			349,824			375,028	
sd			58,211			185,601			185,214			23,072			95,252			130,114			61,235			97,923	
Number of species (S)		9	8	7	10	8	9	7	10	6	5	7	8	8	7	10	6	10	9	8	5	4	11	12	9
Mean number of species			8			9			7,7			6,7			8,3			8,3			5,7			10,7	
sd			1			1			2,1			1,5			1,5			2,1			2,1			1,5	

A10. (cont.)

		95. Feb			Mar			Apr			May			Jun			Jul			Aug			Sep		
Species	**Abbrev.**	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Acrosorium venulosum	acrven																								
Anadyomene stellata	anaste									14,352							20,720	16,800							
Anotrichium barbatum	anobar																								
Antithamnionella sp.	antisp																								
Asparagopsis armata	asparm	71,412	4,172	38,796	121,568	77,044	69,288	464,736	179,376	143,536	281,368	198,256	239,876				20,720								
Bryospis hypnoides	bryhyp			6,560																					
Centroceras clavulatum	cencl																								
Chaetomorpha linum	chalin																						12,536		13,052
Chondracanthus acicularis	choaci				60,784	30,820	27,716				37,516	19,824													
?Chondrymenia	chond?																41,440	16,800		11,016	11,800				
Cladophora coelothrix	clacoe													14,816											
Cladophora laetevirens	clalae																	16,800		5,508		13,012			
Cladophra prolifera	clapro																								
Codium elisabethae	codeli	7,140	0,488							6,040	18,756	19,824							3,968			18,976			
Colpomenia sinuosa	colsin																	33,596	27,976	5,508					
Corallina elongata	corelo				12,156		13,856			28,668	18,756	19,824	15,992	14,816		25,620	20,720	33,596	13,988		11,800	13,012	12,536	15,132	26,104
Cryptopleura ramosa	cryram				12,156	15,408									39,000		20,720	33,596	13,988						
Cystoseira abies-marina	cysabi							61,964		14,352		19,824					20,720								
Dasya hutchinsiae	dashut																					26,020	12,536	30,264	
Dictyota cervicornis	diccer																						25,072	15,132	13,052
Dictyota dichotoma	dicdic	14,284	8,384	7,760	24,312	30,820	27,716	61,964	35,876	28,668	93,788	39,652	79,960	74,084	97,504	128,108		33,596		5,508	11,800	13,012	12,536	15,132	13,052
Halopteris filicina	halfil	7,140																		5,508	11,800	13,012	12,536	15,132	13,052
Hypnea musciformis	hypmus	35,708	45,828	19,396	24,312		27,716	30,984		28,668				74,084	39,000	128,108	41,440	83,992	69,940	82,632	59,000	195,156	125,364	151,312	195,780
Hypoglossum hypoglossoides	hyphyp	14,284																							
Jania capillacea	jancap								35,876	14,352		19,824													
Jania longifurca	janlon																	16,800	13,988						
Jania rubens	janrub							30,984	35,876	28,668		19,824	15,992			51,204		33,596	13,988	11,016	23,600	13,012	25,072	15,132	26,104
Kallymenia reniformis	kalren																								
Padina pavonica	padpav																								
Peyssonnelia squamaria	peysqu		1,140																		11,800				
Plocamium cartilagineum	plocar	35,708	18,836	19,396	60,784	77,044	69,288	61,964	35,876	71,768	187,560	198,256	79,960	29,632	39,000	51,204	20,720	33,596	27,976	5,508	23,600	13,012	25,072	30,264	13,052
Polysiphonia atlantica	polati																								
Polysiphonia denudata	polden																			5,508	11,800	13,012			
Polysiphonia foetidissima	polfoe																								
Pterocladia capillacea	ptecap				60,784		13,856						159,916	74,084	39,000	51,204	103,600	33,596	69,940		59,000	130,104	25,072	15,132	13,052
Pterothamnion crispum	plecri	7,140		3,880							18,756	19,824	15,992				20,720								
Pterothamnion plumula	pteplu																								
Ptilothamnion pluma	ptiplu																								
Rhodymenia holmesii	rhohol																				11,800				
Rosette Sargassum type hystrix	rossah							61,964											27,976	11,016		13,012	25,072		
Sphaerococcus coronopifolius	sphcor														195,008		41,440	33,596		149,216		13,012			
Sphondilothamnion multifidum	sphmul																								
Stypocaulon scoparia	stysco		37,880	29,104					89,688	71,768	93,788	198,256		148,164	39,000	256,212	41,440	33,596		27,544	59,000	26,020	77,528	75,656	26,104
Symphyocladia marchanthioides	symmar	107,120	229,132	58,192	60,784	77,044	69,288	154,912	89,688	28,668	93,788	99,128	79,960	29,632	39,000	51,204	41,440	33,596	139,964	5,508	23,600	13,012	25,072	15,132	26,104
Taonia atomaria	taoato													74,084		256,212			27,976						
Ulva rigida	ulvrig											19,824	15,992					16,800							
Valonia utricularis	valutr		22,912																			13,012			
Zonaria tournefortii	zontou		343,696	149,252	182,348	231,152	207,864	154,912	179,376	143,536	37,516	198,256	31,984	148,164	195,008		310,804	251,980		11,016	177,004	26,020	188,044	30,264	26,104
Total dry weight (g/m2)		299,936	712,468	332,336	619,988	539,332	526,588	1084,384	681,632	623,044	881,612	1090,396	735,624	681,560	721,520	999,076	766,644	755,932	451,668	342,012	507,404	565,428	604,048	423,684	404,612
Mean dry weight (g/m2)			448,247			561,969			796,353			902,544			800,719			658,081			471,615			477,448	
sd			229,395			50,648			251,156			178,310			172,941			178,839			115,928			110,053	
Number of species (S)		9	10	9	10	7	9	9	8	13	10	14	10	10	9	9	14	17	12	14	14	17	14	12	12
Mean number of species			9,3			8,7			10			11,3			9,3			14,3			15			12,7	
sd			0,6			1,5			2,8			2,3			0,6			2.5			1,7			1,2	

A11. Qualitative data from the intertidal level of São Roque

		93				94												95								
Species	Abbrev.	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Acrosorium venulosum	acrven											1														
Aglaothamnion byssoides	aglbys						1					1														
Aglaothamnion gallicum	aglgal														1						1					
Asparagopsis armata	asparm			1	1	1	1		1	1	1	1			1				1	1	1	1	1	1	1	
Botryocladia botryoides	botbot							1																		
Bryopsis hypnoides	bryhyp	1			2	1	1	1	1	2		1				1	1		1	1	1	1	1	1		
Callithamnion granulatum	calgra						1	1		1	1	1							1	1		1	1			
Callithamnion tetragonum	caltet						1																1			
Caulacanthus ustulatus	cauust	1		1	1		1		1		1			1		1	1		2		1	2	1		1	1
Centroceras clavulatum	cencla							1				2		1	1				1	1		1	1	1	1	1
Ceramium botryocarpum	cerbot								1	1	1	1								1	1					
Ceramium ciliatum	cercil																			1						
Ceramium cimbricum	cercim						1				1	1														
Ceramium circinatum	cercir							1													1					
Ceramium deslongchampii	cerdes								1			2														
Ceramium flaccidum	cerfla											1								1			1	1		
Ceramium nodulosum	cernod					1																				
Ceramium pallidum	cerpal							2	1	1		3	1		1		1				1	1	1			
Ceramium secundatum	cersec						1					1											1			2
Ceramium strictum sensu Harv.	cerstr								1																	
Chaetomorpha linum	chalin					1						2			1					1		1	1	1	1	1
Chaetomorpha mediterranea	chamed																		1							
Chondracanthus acicularis	choaci				1		1		1	1		1	1	1		1		1			1	1	1	1	1	
Chondracanthus teedii	chotee											1	1													
Chondria coerulescens	chocoe											1			1		1				1		1		1	
Chondria dasyphylla	chodas							1																		
Cladophora coelothrix	clacoe												1													
Cladophora laetevirens	clalae										1															
Codium adhaerens	codadh													1												
Colpomenia sinuosa	colsin			1	1						1	1	1	1						1		1	1		1	
Corallina elongata	corelo	1		1	1	1	1	1	1	1		1	1		1	1	2		1	1	1	1	1	1	1	1
Cystoseira foeniculaceus	cysfoe	1										1								1						
Dasya corymbifera	dascor														1											
Dasya ocellata	dasoce																					1				
Dictyota dichotoma	dicdic											1								1			1			
Dilsea carnosa	dilcar									1		1														
Drachiella heterocarpa	drahet											1														

A11. (cont.)

		93				94												95								
Species	**Abbrev.**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Endarachne binghamiae	endbin											1								1						
Fucus spiralis	fucspi							1	1			1		1		1	1		1	1	1	1	1	1	1	1
Gastroclonium ovatum	gasova					1		1					1				1			1		1			1	
Gastroclonium reflexum	gasref							1	1								1		1	1			1	1		
Gelidium latifolium	gellat				1			1		1	1	1					1			1		1			1	1
Gelidium microdon	gelmic											1			1	1	1		1	1	1	1	1	1	1	1
Gelidium pusillum	gelpus						1									1	1									
Grateloupia dichotoma	gradic						1			1		1										1	1	1	1	
Gymnogongrus crenulatus	gymcre									1		1										1		1		
Gymnogongrus griffithsiae	gymgri											1								1			1	1	1	1
Haliptilon virgatum	halvir																					1				
Haraldiophyllum bonnemaisonii	harbon																						1			
Hydroclathrus clathratus	hydcla																			1						
Hypnea musciformis	hypmus	1																		1						
Hypoglossum hypoglossoides	hyphyp						1																			
Jania adhaerens	janadh																				1					
Jania crassa	jancra				1												1					1				
Jania longifurca	janlon																			1				1		
Jania rubens	janrub				1					1	1		1						1	1				1		1
Jania verrucosa	janver							1								1	1						1		1	1
Laurencia hybrida	lauhyb											1			2		1									
Laurencia obtusa	lauobt	1					1			1											1	1		1		
Lomentaria articulata	lomart									1		1			1					1		1	1	1	1	
Nemalion helminthoides	nemhel									1	1	1														
Osmundia pinnatifida	osmpin	1		1		1	1	1	1	1		2				1			1	2	1	2	1	1	1	2
Phyllophora crispa	phycri											1														
Plocamium cartilagineum	plocar											1								1						
Polysiphonia denudata	polden																			1						
Pterocladia capillacea	ptecap	1			1	1		1	1	1	1	1	1	1	1	2	1		1	1	1	1	1	1	1	2
Pterothamnion crispum	ptecri											2														
Radicilingua thysanorhizans	radthy						1	1		1																
Schizymenia dubyi	schdub									1		1										1		1		
Sphaerotrichia divaricata	sphdiv										1															
Stypocaulon scoparia	stysco								1	1		1			1		1			1				1	1	1
Symphyocladia marchantioides	symmar											1									1	1	1			1
Taonia atomaria	taoato									1																
Ulva rigida	ulvrig			2	1	1	1	1	1	1	1	1	1		1	1	1			1	1	1	1	1		2

A12. Qualitative data from the intertidal level of São Vicente

		93				94												95								
Species	Abbrev.	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Acrosorium venulosum	acrven										1				1			1						1		
Aglaothamnion byssoides	aglbys						1														1	1			1	
Aglaothamnion gallicum	aglgal																				1	1				
Aglaothamnion hookeri	aglhoo															1					2	1				
Aglaothamnion pseudobyssoides	aglpse																			1						
Anotrichium furcellatum	anofur																			1	1	1				
Antithamnion diminuatum	antdim															1										
Asparagopsis armata	asparm				1	1	1	1	1	1	1		1		1	1	1	1		1	1	1	1	1		
Bornetia secundiflora	borsec	1																			1					
Bryopsis hypnoides	bryhyp				1													1								
Callithamnion corymbosum	calcor																				1	1				
Callithamnion granulatum	calgra				1		2	2	1	1						1		1				1				
Callithamnion tetragonum	caltet						1																			
Caulacanthus ustulatus	cauust	1							1							1	1			1		1				
Centroceras clavulatum	cencla	2				1	1		1	1		1			1	2	3	1	1	1	3	2		1	1	1
Ceramium botryocarpum	cerbot					1	1		1																	
Ceramium ciliatum	cercil				1		1		1	1	1				1		2		1	1	1	2				
Ceramium cimbricum	cercim														1						2		1			1
Ceramium deslongchampii	cerdes							1		1																
Ceramium diaphanum	cerdia	1																								
Ceramium echionotum	cerech											1														
Ceramium nodulosum	cernod																				1					
Ceramium pallidum	cerpal							2	1		1										4	1				
Ceramium strictum sensu Harv.	cerstr																					1				
Chaetomorpha linum	chalin	1			1			1								1		1							1	1
Chondracanthus acicularis	choaci	1			1		1		1	1	1	1			1	1	1	1		1	1	1	1	1		1
Chondracanthus teedii	chotee	1																								
Chondria coerulescens	chocoe																1					1				
Chondria dasyphylla	chodas																	1			3					1
Cladophora coelothrix	clacoe							1				1		1		1										
Cladophora hutchinsiae	clahut							1								1										
Cladophora laetevirens	clalae									1																1
Cladophora lehmanniana	claleh													1												
Cladophora prolifera	clapro				2	2					1	1		1	1	1		1	1		1	1				
Coccotyus truncatus	coctru	1																								
Codium adhaerens	codadh										1	2	1		1	1	1		1	1		1	1		1	1
Colpomenia sinuosa	colsin				1	1	1	1	1		1	1			1			1	1	1	1	1	1			2
Corallina elongata	corelo				1			1			1															
Cystoseira abies-marina	cysabi	1					1	1		1	1	1	1	1	1	1	1	1	1	1		1	1		1	2
Cystoseira foeniculaceus	cysfoe					1										1						1				2
Cystoseira humilis	cyshum																						1			
Dasya hutchinsiae	dashut	1																		1		1				
Dasya ocellata	dasoce																					1				
Dictyota dichotoma	dicdic			1		1	1	2	1		2	1				1	1	1		1	2	1				2
Drachiella heterocarpa	drahet						1		1		1		1													
Ectocarpus siliculosus	ectsil									1																
Endarachne binghamiae	endbin	2														1		1								
Enteromorpha intestinalis	entint								1			1										1	1	1		
Enteromorpha muscoides	entmus						1	1	1	1							1	1	1			1				
Fucus spiralis	fucspi	1				1		1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gastroclonium ovatum	gasova														1			1								

A12. (cont.)

		93				94												95								
Species	Abbrev.	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Gastroclonium reflexum	gasref																1									1
Gelidium latifolium	gellat	1												1												
Gelidium microdon	gelmic	1					1	1		1		1	1	1	1	1	1	1		1	1	1	1	1	1	1
Gelidium pusillum	gelpus															1		1		1	1					
Grateloupia dichotoma	gradic	1									1	1														
Griffithsia corallinoides	gricor															1										
Gymnogongrus griffithsiae	gymgri	1														1						1		1		1
Haliptilon virgatum	halvir																1					1				
Haraldiophyllum bonnemaisonii	harbon										1							1				1				
Hincksia mitchelliae	hinmit																								1	1
Hydroclathrus clathratus	hydcla					1			1		1				1	1			1		1	1	1			
Hypnea musciformis	hypmus	1						1		1	1	1	1		1	1	1	1		1	1	1	1	1	1	1
Hypoglossum hypoglossoides	hyphyp						1	1			1										1					
Jania adhaerens	janadh														1	1										
Jania longifurca	janlon			1								1					1		1							
Jania rubens	janrub				1			1										1	1	1	1	1		1		1
Jania verrucosa	janver						1						1													1
Kallymenia reniformis	kalren										1															
Laurencia hybrida	lauhyb				1	1			1	1								1	1	1	1					1
Laurencia obtusa	lauobt									2	1	2			2	1			1	1	2	1	1	1		3
Lomentaria articulata	lomart																	1				1				
Lophosiphonia reptabunda	loprep								1																	
Nitophyllum punctatum	nitpun			1																						
Osmundia pinnatifida	osmpin																						1			
Padina pavonica	padpav	1						1	1	1	1	1	1		1	1		1	1	1	1	1	1	1	1	1
Peyssonnelia squamaria	peysqu										1					1										
Phyllophora crispa	phycri											1														
Plocamium cartilagineum	plocar				1						1	1	1			1		1			1	1				
Polysiphonia brodiaei	polbro																				1					
Polysiphonia denudata	polden														1	1	1		1	1	1	1				
Polysiphonia furcellata	polfur							1																		
Pterocladia capillacea	ptecap	1			1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	2	1	1	1	2
Rhodymenia holmesii	rhohol										2									1						
Rhodymenia pseudopalmata	rhopse										1															
Rosette Sargassum type hystrix	rossah					1	1		1										1							
Sargassum cymosum	sarcym																	1								
Sargassum filipendula	sarfil										1	1			1							1	1	1		
Sargassum vulgare	sarvul														1					1		1			1	
Scagelia pylaisaei	scapyl																				1	1				1
Scageliopsis patens	scapat																			1						
Schizymenia dubyi	schdub																			1						
Scytosiphon lomentaria	scylom																			1	1					
Sphaerotrichia divaricata	sphdiv						1													1	1	1				
Stypocaulon scoparia	stysco						1		1		1		1	1	1	1	1	1	1	1	1		1		1	1
Symphyocladia marchantioides	symmar										2						1		1	2	2	1	1			
Taenioma nanum	taenan						1															1				
Taonia atomaria	taoato																						1			
Ulva rigida	ulvrig	1			1	2	1	1	1	1	2	3	2	2	1	1	2		1	1	1	1		1		2
Zanardinia prototypus	zanpro									1																
Zonaria tournefortii	zontou				1											1								1		

A13. Qualitative data from the subtidal level of São Roque

		93				94												95								
Species	**Abbrev.**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Acrosorium venulosum	acrven					1						1			1	2	1		1	1	2	3	2	1	1	1
Aglaothamnion bipinnatum	aglbip				1	1		3	1			2				1										
Aglaothamnion byssoides	aglbys				1	1	1	1							2											
Aglaothamnion gallicum	aglgal							2																		
Aglaothamnion pseudobyssoides	aglpse																					1				1
Amphiroa beauvoisii	ampbea																									1
Anotrichium barbatum	anobar					1		1																		
Anotrichium furcellatum	anofur																									1
Apoglossum ruscifolium	aporus											1										1				
Asparagopsis armata	asparm	1		1	3	3		3	3	3		1			1				2	2	3	3	3	3		
Bornetia secundiflora	borsec															2					1					
Bryopsis hypnoides	bryhyp			1		2			1										2							
Callithamnion corymbosum	calcor																		1							
?Callophyllis sp.	?callo									1	1															
Centroceras clavulatum	cencla														1											
Ceramium echionotum	cerech											2							1				1			
Champia parvula	chapar					1																				
Chondracanthus acicularis	choaci					1									1	1			1					1		1
?Chondrymenia	?chond									1			1			1										
Cladophora lehmanniana	claleh											1												1		
Codium adhaerens	codadh													1		1										1
Codium decorticatum	coddec											1														1
Codium elisabethae	codeli	1		1	1	2	1	2	1	2	2	3	2	2	2	3	1		2	1	1		3	1	2	2
Codium fragile	codfra												1													
Codium vermilara	codver														1											
Colpomenia sinuosa	colsin										2	1		2	2								2		2	3
Compsothamnion decompositum	comdec																									1
Corallina elongata	corelo	1		2	2	2		2	2	1	2	1		1	2	3	2		2	1	2	2	2	1		2
Cystoseira abies-marina	cysabi											1	1	2	2								1	1	1	1
Dasya hutchinsiae	dashut														1		1			1						
Dictyota dichotoma	dicdic			2	2	3		2	3	2	2	1	1		2	1	1		1	1	3	3	3	1	2	1
Gastroclonium reflexum	gasref																									1
Gelidium latifolium	gellat				1	1							1													
Haliptilon virgatum	halvir				1	2						1					1							1		1
Halopteris filicina	halfil			2	2	1		3	2	2	2	2	2	1	2	1	2		2	2	2	3	1		1	1
Haraldiophyllum bonnemaisonii	harbon																						1			

A13. (cont.)

Species	Abbrev.	93 Sep	Oct	Nov	Dec	94 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	95 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Hydroclathrus clathratus	hydcla										1															
Hypnea musciformis	hypmus			1											2	1				2	1	3	2	2	2	3
Hypoglossum hypoglossoides	hyphyp		1																1			2				1
Jania adhaerens	janadh				1							1														
Jania capillacea	jancap																				1	1				
Jania crassa	jancra														1											
Jania longifurca	janlon	1				1		1							1	1	1		2	1						
Jania verrucosa	janver	1		1		2		2											1							
Kallymenia reniformis	kalren												1	1												
Liagora viscida	liavis												2	1									1			
"Menia" nd (1)	menia1							1																		
"Menia" nd (2)	menia2								1	1		1														
Padina pavonica	padpav											1	1	1	2								1			2
Peyssonnelia squamaria	peysqu	1										1														
Phyllophora crispa	phycri	1																								
Plocamium cartilagineum	plocar	1		2	3	4		3	3	3	1	1					1		3	3	3	2	2			
Polysiphonia denudata	polden																			1						
?Predaea/Nemastoma	?prene	1																								
?Predaea/Platoma/Nemastoma	?prpln											1														
Pterocladia capillacea	ptecap	1		2	2	2		1	1	1	1	1		1	3	2	2		2	1	2	1	3	3	1	3
Pterothamnion crispum	ptecri	2				2		4							1				1	1	2	4	2	1		1
Pterothamnion plumula	pteplu					1														1	1					
Radicilingua thysanorhizans	radthy	2																			1	1				
Rosette Sargassum type acinariun	rossaa											3	1													
Rosette Sargassum type hystrix	rossah																							1		
Scagelia pylaisaei	scapyl																			1						
Schizymenia dubyi	schdub											1										1				
Spermothamnion repens	sperep																1				1					
Stypocaulon scoparia	stysco					1				1									2			2		1	1	
Symphyocladia marchantioides	symmar					1				1				1		2	1				2	2	1		2	
Taonia atomaria	taoato										1	1		1		1					1	2	2			
Ulva rigida	ulvrig									1	1	2			1							2	1	1		
Valonia utricularis	valutr											2	1													
Wrangelia penicillata	wrapen																								2	
Zonaria tournefortii	zontou	2			2			2	1		3	2	1	2	2	2	1		2			1	1	2	1	1

A14. Qualitative data from the subtidal level of São Vicente

		93				94												95								
Species	Abbrev.	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Acrosorium venulosum	acrven	1		1		1					1	1			3	2	1	2	1	1	2		3	2	2	2
Aglaothamnion bipinnatum	aglbip											1				3										
Aglaothamnion byssoides	aglbys																		1							1
Aglaothamnion hookeri	aglhoo	2																								
Aglaothamnion pseudobyssoides	aglpse																					1				
Anotrichium furcellatum	anofur	3								1								1	1		1					1
Asparagopsis armata	asparm			3	3	3		3	1	2	2		1			3	3	2	2	2	3	3	1	2	2	
Bornetia secundiflora	borsec																1		1		1	1				
Brongniartella byssoides	brobys	3																								
Bryopsis hypnoides	bryhyp					2		1									1								1	1
Centroceras clavulatum	cencla	2													2	3	3									
Ceramium echionotum	cerech										1				1											
Chondracanthus acicularis	choaci								1						2	1			1						1	
Chondracanthus teedii	chotee	1										1														
?Chondrymenia	?chond	1		1		1		1		1	1	3				3		1		1		1	1	1	2	
Codium decorticatum	coddec			1																						
Codium elisabethae	codeli				1	2		1					1	1		2	1		1							
Colpomenia sinuosa	colsin											1	1		1									1	2	
Compsothamnion decompositum	comdec	1																								
Corallina elongata	corelo			3	2	1		1		1				2	3	1	1							1	2	2
Cryptopleura ramosa	cryram	1																								
Cystoseira abies-marina	cysabi											1			1	1								1	2	1
Dasya hutchinsiae	dashut														1	1										
Dasya ocellata	dasoce															1										
Dictyopteris membranacea	dicmem									1	2									1						
Dictyota dichotoma	dicdic	1		3	2	2		3	1	3	3	2			1	2	2	2	2	2	2	1	2	1		2
Drachiella heterocarpa	drahet					1																				
Dudresnaya verticillata	dudver	1																								
Gastroclonium reflexum	gasref																							1		
Haliptilon virgatum	halvir																					1		1		1
Halopteris filicina	halfil			2	2	3		3		2	3		2	3	2	3	2	2	2	1		2	2	2		2
Haraldiophyllum bonnemaisonii	harbon																1									
Hydroclathrus clathratus	hydcla											1														
Hypnea musciformis	hypmus	3		2		1					2	2	2	3	3	3	2	2	2	1	3	2	4	2	3	3
Hypoglossum hypoglossoides	hyphyp	1										1					1		1		1					
Jania capillacea	jancap														1							1				
Jania crassa	jancra														1											

A14. (cont.)

Species	Abbrev.	93 Sep	Oct	Nov	Dec	94 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	95 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Jania longifurca	janlon													1	2	3										
Jania rubens	janrub			1											1	1								1	1	1
Jania verrucosa	janver														1											
Kallymenia reniformis	kalren		1			2																				
Liagora distenta	liadis										1	1	1													
Liagora viscida	liavis									1		2														
"Menia" nd (1)	menia1	1				1																				
"Menia" nd (2)	menia2	1	1								1		2													
Nitophyllum punctatum	nitpun	1										2														
Padina pavonica	padpav									1		1	2	1	3										2	2
Peyssonnelia squamaria	peysqu	3		1	2	3		1			1				1	4	1					3			2	1
Phyllophora crispa	phycri	1																								
Plocamium cartilagineum	plocar			3	3	3		3	1	1	2				1	3	3	2	3	1	2	2	2			1
Polysiphonia atlantica	polatl			1																						
Polysiphonia denudata	polden														1											1
Polysiphonia elongata	polelo															1										
Polysiphonia foetidissima	polfoe				1																					
Polysiphonia fucoides	polfuc																	1				2				
?Predaea/Platoma/Nemastoma	?prpln	1												1									1			
Pterocladia capillacea	ptecap			1	3	2		1		1		1	1	3	3	3	3		1		2		1		1	3
Pterothamnion crispum	ptecri	3													3	2		1	1		1	1			1	1
Pterothamnion plumula	pteplu				1																	1				
Radicilingua thysanorhizans	radthy																2					2				
Rosette Sargassum type hystrix	rossah	1										1														
Scagelia pylaisaei	scapyl														1	2		1								
Schimmelmannia schousboei	schsch											1														
Schizymenia dubyi	schdub											1														
Sebdenia prox.	sebde?												1			1								2		
Spermothamnion repens	sperep														2	1						1				
Sphaerococcus coronopifolius	sphcor	1		2	1	2		2		1	2	2	3	2	3	3	2	1	1	1	3		1	1	3	3
Sphondylothamnion multifidum	sphmul			1																						
Stypocaulon scoparia	stysco			1					3	1	2	2	1		1				1		1		1		1	1
Symphyocladia marchantioides	symmar	1	1	2							1	1			3	1	1	1	1	1	1	3	1		1	1
Taonia atomaria	taoato								1	1	4	2										1	2	1		
Ulva rigida	ulvrig								1	1	2	2	2	1								1			1	
Wrangelia penicillata	wrapen																1									
Zonaria tournefortii	zontou	1		3	3	3		3	2	2	1	2	3	2	2	3	2	1	3	1	1	1	2	2	2	3

A15. PRELIMINARY WORKING KEY FOR *JANIA* SPECIES, BASED ON PERSONAL OBSERVATIONS AND ON THE DESCRIPTIONS OF TAYLOR (1967) AND LAWSON & JOHN (1982)

1. Large plant, segments larger than 200µm in diameter 2

1. Small plant, segments never reaching 200µm in diameter 3

2. Erect plant, segments with rounded apices, 1.3-2.5mm long, 270-500µm in diameter .... ***J. longifurca***

2. Plant growing in small clumps, segments with acute to conical apices, 1-3mm long, 200-450µm in diameter .... ***J. crassa***

3. Branching at wide angles (> 45°) 4

3. Branching at narrow angles (< 45°) 5

4. Segments 100-200µ in diameter at bottom, 30-60µm at the top, 2-8 times as long as broad .... ***J. adhaerens***

4. Segments 40-100µm in diameter throughout, 4-10 times as long as broad .... ***J. capillacea***

5. Plants growing in dense clumps and mats. Segments less than 1mm long, with rounded or cube shaped apices .... ***J. verrucosa***

5. Corymbose plants. Segments with acute apices, 1-1.5mm long, 60-200µm in diameter .... ***J. rubens***