

STRUCTURE AND ZONATION OF ALGAL COMMUNITIES IN THE BAY OF SÃO VICENTE (SÃO MIGUEL, AZORES)

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An appraisal of the benthic marine algal communities of the bay of São Vicente (São Miguel island, Azores) was undertaken in July 1996 and July 1997 as part of the project "Biodiversity of the archipelago of the Azores". A permanent transect was laid down across the subtidal zone. Quadrates were sampled at pre-determined intervals along the transect from the low water level, down to 30m depth. Qualitative collections were made along the transect. The relative importance of each species was determined using a semi-quantitative scale. The transect revealed the occurrence of relatively large and frondose algae establishing the transition between the intertidal and the subtidal zones. *Pterocladia capillacea* was the dominant species in this transition zone and extended its presence down to 12m depth. A depth-related change in the algal flora was present in both years. *Pterocladia*, *Ulva* spp., *Stypocaulon scoparia*, *Hypnea musciformis* and *Asparagopsis armata* dominated the shallow levels; *Zonaria tournefortii*, together with *Sphaerococcus coronopifolius* and *Dictyota dichotoma* dominated the deep ones.

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INTRODUCTION

The island of São Miguel (Fig. 1), with approximately 750 km², is the largest of the archipelago of the Azores. 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 difficult to access by land. Although seashores are generally steeply sloping, there are places where depths of less than 30m extend several hundred meters offshore. The wave action is known to be stronger on north coast and responsible for the higher erosion that occurs there (BORGES 1995). Tides are semi-diurnal and tidal range is less than 2 m, even at extreme neap tides (INSTITUTO HIDROGRÁFICO 1981).

Although the marine algal flora of the Azores has been sporadically investigated during the past century and a half (see NETO 1997 for revision), research since the late 1980s has yielded much new information. A comprehensive algal checklist (NETO 1994) brings together all existing published information and provides distributional information within the archipelago. Nonetheless, ecological investigations describing the structure and zonation of benthic marine algal communities were only recently initiated in the Azores. In São Miguel, CASTRO & VIEGAS (1987), HAWKINS et al. (1990) and NETO (1991, 1992a) studied the zonation patterns of littoral organisms at different locations around the island. NETO & AZEVEDO (1990) and more recently TITTLE et al. (1998) studied the zonation patterns and the community structures at several sites on the island of Flores.

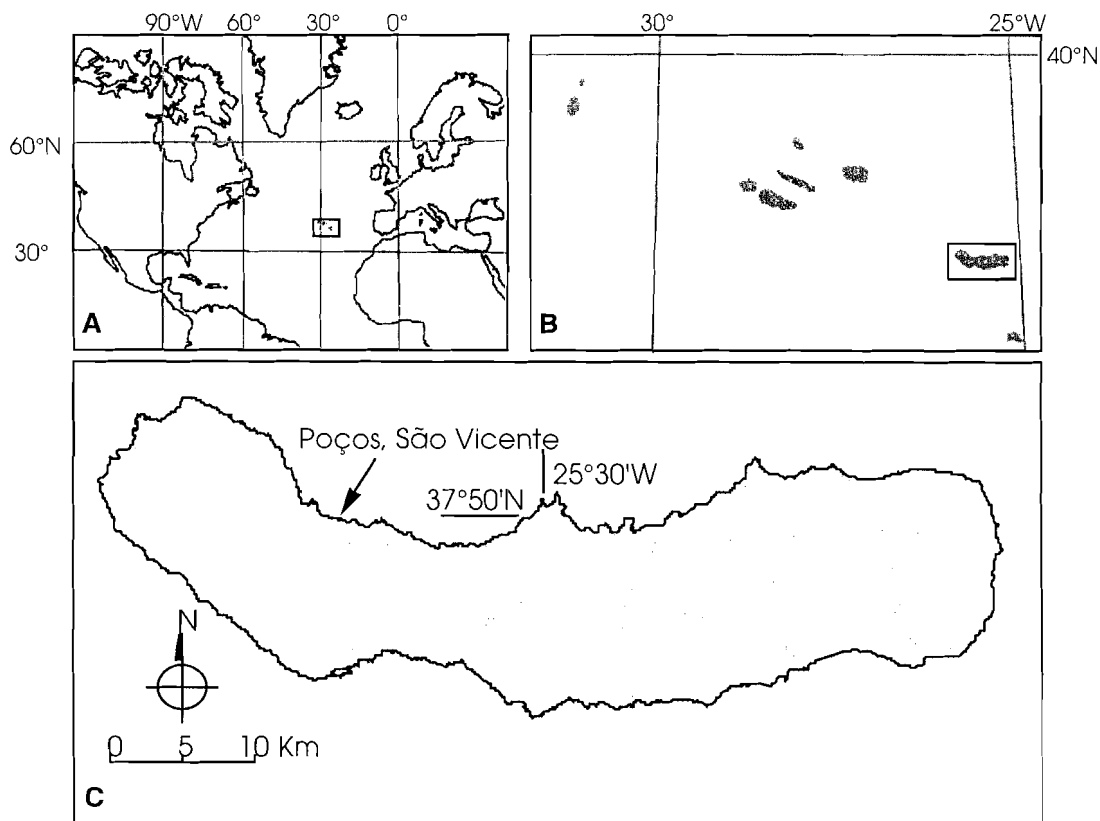


Fig. 1. The Azores (B) and its location on the North Atlantic (A). Location of the study site on the island of São Miguel (C).

TITTLE & NETO (1994, 1995), and NETO & TITTLE (1995) studied the algal flora and the zonation of the Monte da Guia Nature Reserve in Faial. NETO (1997), reports the results of the first detailed investigation into the marine algal communities of São Miguel, carried out over a continuous two year period, in contrast to the previous one-off expeditions discussed above.

The aim of this paper is to describe the structure of a macroalgal community on the island of São Miguel, thus contributing to the knowledge of the littoral communities of the Azores.

MATERIAL AND METHODS

Work was undertaken in São Vicente bay, in the north coast of the island of São Miguel (Fig. 1) in

July 1996 and July 1997. A permanent transect was laid down across the subtidal zone from 0 m down to 30 m depth. The bottom topography was determined by divers swimming along the transect and recording at each meter the depth and type of substrate. Depth was determined with a diving computer. The transect profile was drawn. Quantitative collections were made at pre-determined intervals along the transect (3, 8, 10, 12, 15, 20, 25, 30 meters, Fig. 2). For each level, three samples of 2500 cm² were collected, a sample consisting of the material obtained by carefully scraping with a chisel all the attached algae inside the quadrat into a fine mesh net bag. Qualitative collections were made by swimming around the area and collecting representative specimens into previously labelled bags. Habitat details for each species (depth, substrate, orientation and aspect of the rock, gully, crevice,

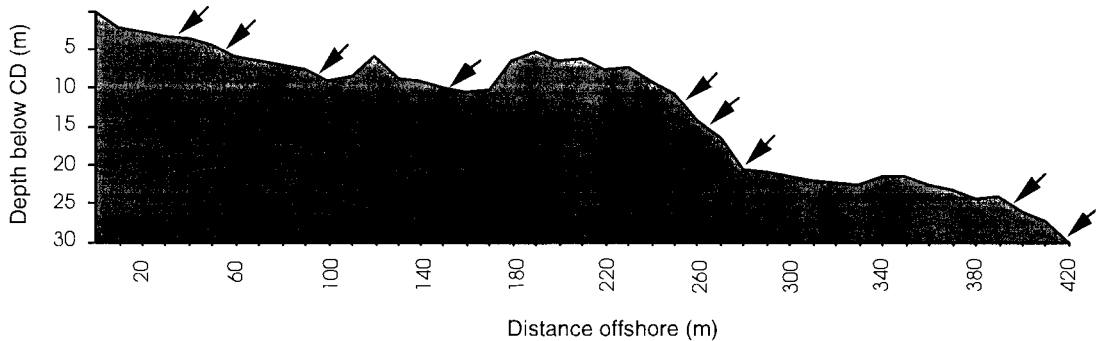


Fig. 2. Profile of the transect with indication of the collecting sites (arrows).

cave, etc.) were noted on underwater writing boards.

In the laboratory, the algae from both qualitative and quantitative collections were sorted into species. Samples that could not be examined alive were preserved in 5% buffered formaldehyde-sea water solution (NEZELOF et al., 1972). All plants were examined microscopically, using stereo and compound microscopes. Cells and other structures were measured, using a calibrated micrometer eye piece. For the identification of some species, histological work was necessary. Transverse sections were made using a freezing microtome. The relative importance of each species was determined using a semi-quantitative scale (D: dominant; A: abundant; F: frequent; O: occasional; R: rare).

Two types of reference collections were established, one in liquid, the other on paper. 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 & COSSON (1986). Both collections are deposited at the University of the Azores.

RESULTS

A total of 201 species was identified (25 Chlorophyta, 23 Phaeophyta, 153 Rhodophyta).

In both years, variations were observed in the algal composition and abundance following the depth gradient (Fig. 3). In 1996, *Pterocliadiella capillacea*, *Ulva* spp., *Stypocaulon scoparia*,

Taonia atomaria and *Asparagopsis armata* dominated and were only present at the shallow depths. *Sphaerococcus coronopifolius* was only present below 12 m, where it was the dominant species together with *Zonaria tournefortii*. The latter and *Plocamium cartilagineum* were only present below 10-12 m. *Plocamium*, together with *Sphaerococcus*, were the abundant species at 20-25 m. *Dictyota dichotoma* and *Acrosorium* spp. were present from shallow to deep levels, with no distinct pattern. *Halopteris filicina* was a frequent species between 10 and 20 m.

In 1997 this depth-related change in the algal flora was also observed, with *Pterocliadiella capillacea*, *Ulva* spp., *Stypocaulon scoparia*, *Asparagopsis armata* and *Hypnea musciformis* dominating the shallow levels and *Plocamium cartilagineum* occurring exclusively below 15 m (Fig. 3). *Pterocliadiella*, *Ulva* spp. and *Hypnea* were not found below 12 m and *Stypocaulon* was not present below 15 m. *Asparagopsis*, *Halopteris* and *Dictyota* were present at all levels, the first gradually decreasing in abundance with depth, whereas *Halopteris* was more abundant below 12 m and *Dictyota dichotoma* was more abundant between 3-8 m and 15-25 m. *Zonaria tournefortii* and its epiphytes *Acrosorium* spp. were abundant species below 12 m, being the dominant ones at 25-30 m. *Sphaerococcus* was only found between 12 and 20 m.

Differences were observed on the transect between the two successive years. The major ones included, in the second year, the increased abundance of *Pterocliadiella*, *Ulva* spp., *Asparagopsis* and *Halopteris*, the lack of *Taonia atomaria* and the lower abundance of *Plocamium*

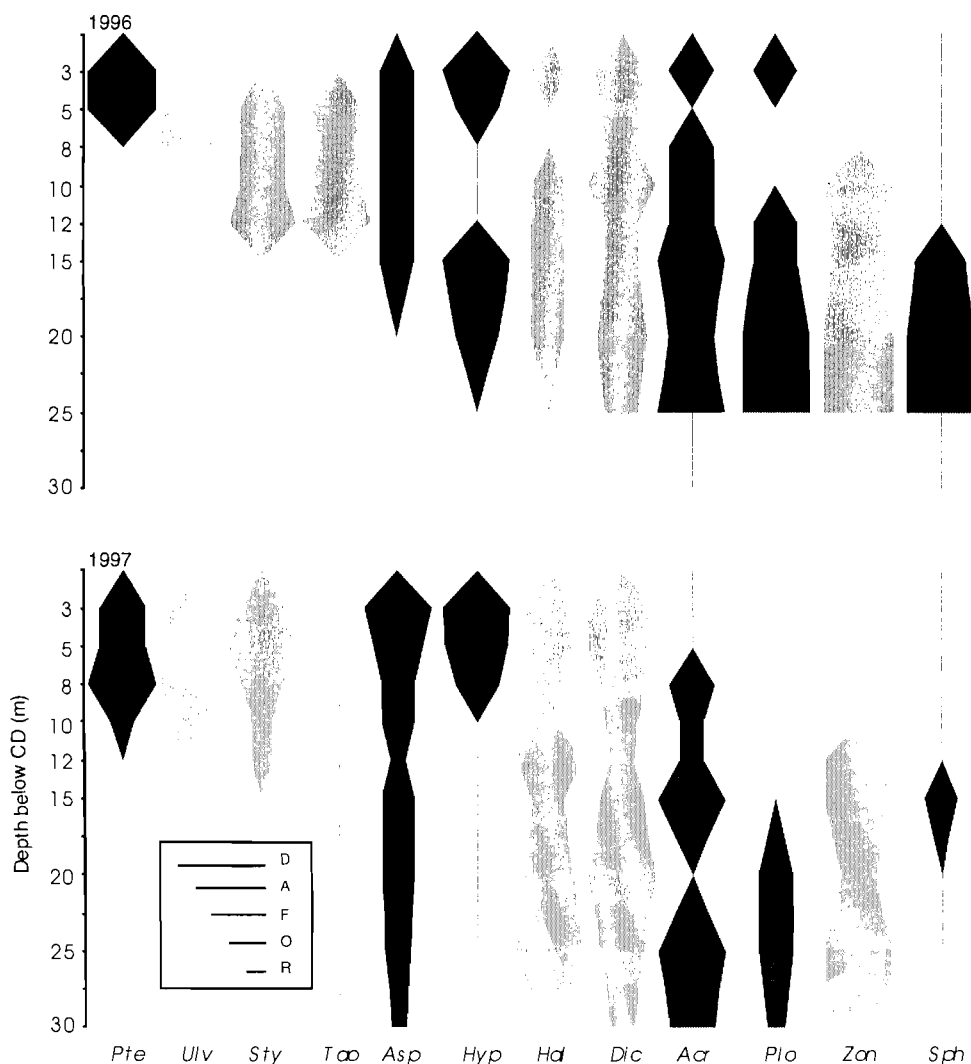


Fig. 3. Relative abundance of the more common species at each depth level in 1996 and 1997. Light grey: Chlorophyta; Medium grey: Phaeophyta; Dark grey: Rhodophyta. Pte: *Pterocladia capillacea*; Ulv: *Ulva* spp.; Sty: *Stypocaulon scoparia*; Tao: *Taonia atomaria*; Asp: *Asparagopsis armata*; Hyp: *Hypnea musciformis*; Hal: *Halopteria filicina*; Dic: *Dictyota dichotoma*; Acr: *Acrosorium* spp.; Plo: *Plocamium cartilagineum*; Zon: *Zonaria tournefortii*; Sph: *Sphaerococcus coronopifolius*.

and *Sphaerococcus*. *Dictyota dichotoma*, *Acrosorium* spp. and *Zonaria tournefortii* had a similar depth distribution in both years. The species depth distribution was nevertheless not very different between the two years. In fact, the shallower levels were dominated in both years by *Pterocladia*, *Ulva* spp., *Stypocaulon*, *Asparagopsis*, and *Hypnea*, while the lower levels were dominated by *Dictyota*, *Acrosorium* spp.

and *Zonaria*. The major differences were the abundance of *Plocamium* and *Sphaerococcus* at the lower depths in 1996 and the presence of *Asparagopsis* at all levels in 1997.

DISCUSSION

Studying the algae of the same bay in previous

years, NETO (1997) found similar results: *Pterocladia*, *Stypocaulon*, *Asparagopsis* and *Hypnea* were the more abundant species at the shallowest level studied (5 m); *Zonaria* and *Sphaerococcus* were the dominant species at 15 m, the deepest level surveyed. A depth-related gradient in community structure was also observed. There was a gradual transition between the shallow and the deep levels. These differences between the algal associations at different depths suggests that there is a real difference in community organization as related to depth. 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. These authors also concluded that, of all the factors analysed in their study, depth was the predominant environmental factor conditioning algal distribution.

The restriction to shallow water of certain species is probably related to changes in the quantity and quality of light, associated with increased depth (SMITH 1967; KAIN 1987). 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 macroalgae.

In the present study, the shallow levels were dominated by red algae, but below 8 m depth both brown and red algae were equally important. NETO (1997) had slightly different results but her work didn't include depths below 15 m. She found a different distribution of red and brown algae, with the first group dominating the shallower levels and the latter dominating the deeper ones. Luxuriant subtidal communities of brown algae have been found elsewhere. In Madeira, BIANCHI et al. (in press) record the dominance of *Z. tournefortii* in relatively sheltered locations, from 5 to 15 m. 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).

Zonaria and *Sphaerococcus* were the only species restricted to deep levels. NETO & TITTLE (1995) mention *Zonaria tournefortii* as restricted to deep water (30 m) on the island of Faial. However, only the nature reserve of Monte da Guia was studied, so it is not known if this is a valid statement for all the island. On the other hand, TITTLE et al. (1998) found this species dominating the subtidal communities of Flores Island, from shallow to deep water levels (5 to 30 m).

It is worth noting the higher abundance of *Plocamium* at the deeper levels, confirming the status of "shade lover" given by BOUDOURESQUE (1969, 1970) merely from the evidence of its habitat. This was confirmed 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 water deeper than 20 m (KAIN 1961; NORTON 1968; NORTON et al. 1969). NETO (1997) only found *P. cartilagineum* occasionally in the intertidal level, being more abundant subtidally at the deepest level surveyed at São Vicente (15 m), where it was most of the time growing in the shade of *Zonaria tournefortii*.

NETO (1997) observed stability in the communities studied. They did not exhibit major differences in species composition and abundance over the two years of investigation. The present results also suggest that, with small variations, a well established and relatively stable ecosystem is present in São Vicente bay. 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 site studied on São Miguel Island, rather more variation in mosaic structure was detected (HARTNOLL & HAWKINS 1985). It would be interesting to continue the present study so as to be able to evaluate long-term fluctuations. This

should be complemented by monitoring the major environmental parameters. With the threat of a global change in climate and subsequent variations in the environmental factors, it is at present not possible to predict how the algal communities will be in the next decades.

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