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STRUCTURE AND ZONATION OF ALGAL TURF COMMUNITIES ON THE AZORES: A NUMERICAL APPROACH

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With 7 figures and 3 tables

ABSTRACT. An appraisal of benthic marine algal communities of the Monte da Guia marine nature reserve (Faial) was undertaken as part of "Expedição Açores 1989". The first account of the subtidal algal communities and zonation for the Azores archipelago by direct observations using SCUBA is presented. In the field quadrats were sampled at intervals along five transects from the littoral fringe to deep sublittoral levels. Intertidal zonation varied according to wave-exposure; some shores were barnacle-dominated but at lower levels much of the vegetation was characterised by a dense algal turf externally uniform in appearance and comprising principally articulated Corallinaceae, together with filiform Chlorophyta, Phaeophyta and Rhodophyta. It extended to at least 30m depth and there was little variation in species composition and abundance with shore level and continuity into the shallow sublittoral. Numerical methods (Decorana) provided the best means of comparing samples in order to assess similarities and differences.

INTRODUCTION

Ecological investigations on the Azores that describe benthic marine algal community structure and zonation are few and very little is known of the subtidal vegetation. The earliest, and most comprehensive study is that of SCHMIDT (1931) who identified two supralittoral, 17 littoral and 5 sublittoral species associations throughout the archipelago. Subsequently PRYOR (1967) outlined algal zonation at sites on São Jorge and more recently NETO (1992) studied algal zonation at two sites on São Miguel. The present study was undertaken in the summer of 1989 on Faial as part of the international investigation "Expedição Açores 1989" Its main aim was to identify and map marine communities of the Monte da Guia marine nature reserve.

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Algal turfs are growths of either diminutive algae or diminutive forms of larger species forming dense, compact stands rarely more than 2 - 3cm high. Visually turf assemblages appear externally uniform. The formation of algal turfs may relate to local ecology and the effect of browsing by fish and invertebrates (ROGERS & SALESKY, 1981; STEWART, 1982).

STUDY SITES

Field-studies were undertaken at Monte da Guia, a steeply sloping caldeira at the southeast corner of Faial (Fig. 1). Sites around the caldeira varied in wave-exposure conditions from sheltered (in Porto Pim Bay - transect 4) to extremely exposed (Ponta das Garças - transect 3); shores in the central lagoon (Caldeira do Inferno - transect 5) are more sheltered but still subject to swell and wave-wash. Porto Pim has a gently sloping rocky shore merging into a sandy sea bed at only a few metres depth whereas other shores were steeply sloping and a sandy sea-bed was at depths below 40m.

METHODS

Of the 10 study sites outlined by Martins *et al.* (1992), five were sampled for algae (Table 1). These were in sheltered, moderately exposed and very exposed situations. A destructive sampling method was used and samples were taken between littoral fringe (the first point where marine organisms occurred) and deep sublittoral levels. Subtidal work was carried out by SCUBA diving. This involved removing all plant and animal material from 0.5x0.5m (0.25m²) quadrats; three to five replicates were taken at each shore-level sampled. Intertidal quadrats were successively sampled at linear distance intervals of 1m. Subtidal samples were taken at selected vertical depth intervals. An additional site (transect 8) was investigated at deep subtidal levels only. Material was brought back to the laboratory for identification; all species present were listed and relative abundances estimated using the DAFOR scale (Dominant, Abundant, Frequent, Occasional, Rare).

Information from sample sites was collated into a database for analysis wholly or in part. DAFOR ratings were converted to an abundance scale of 5 decreasing to 1. Since direct observations could not always discern variations in the algal turf and the data were complex, numerical multivariate analysis was considered the best means of comparing samples in order to assess similarities and differences. KENT & COKER (1992) reviewed the use of such methods, and their recommendations are followed here. We used a gradient ordination analysis (Decorana, detrended correspondence analysis, Vespan II package, MALLOCH, 1993). The output from Decorana is an ordination plot which is a scattergram of points representing sample sites.

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RESULTS

Transect 2

At Transect 2, a wave-exposed site, direct intertidal observations at high shore levels revealed algae generally to be rare or absent (except for Cyanophyta) and the biota to be animal dominated. The intertidal algal turf at low shore levels was characterised by *Corallina officinalis* (nomenclature follows SOUTH & TITTLE, 1986) with *Laurencia obtusa* frequently to occasionally associated; *Gelidium pusillum*, *Gigartina acicularis* and *Jania rubens* were less commonly present. Forty seven species were recorded in the intertidal transect (Table 2) with quadrats containing between two and fourteen species and greater species richness occurring at low shore levels. Ordination analysis (Fig. 2) of the intertidal turf data shows a single cluster of points with some outliers but with no clear separation of sample sites according to shore level.

The subtidal alga turf contained 46 species (listed in Table 2) of which 5 were present in nearly all samples (*Asparagopsis armata*, *Corallina officinalis*, *Dictyota dichotoma*, *Polysiphonia* sp. 1., and rosette *Sargassum*). *Jania rubens*, *Halopteris scoparia* and *Falkenbergia*-stage were commonly recorded. No clear pattern of changes in dominance with depth was visually recognized. Ordination of subtidal data (Fig. 3) shows a single cluster of sample sites with the 30m sample sites separated from the main cluster along the first axis. The spread of points along axis 1 is two standard deviations indicating significant differences between the extremes. Corresponding ordination of species (not illustrated) reveals *Chaetomorpha pachynema*, *Cladophora prolifera*, *Codium elisabethae*, *Polysiphonia* (indetermined sp. 2), *Symphycloadia marchantioides* and *Zonaria tournefortii* to be responsible for separating the 30m sites. Ordination analysis of intertidal and subtidal data together (Fig. 4) shows separate clusters of intertidal and subtidal sampling sites, although the separation (one standard deviation) is not significant. The corresponding ordination of species (not illustrated) shows *Cladophora laetevirens*, *Gelidiella*, *Ralfsia* sp. among others to be responsible for separating intertidal sites, while *Bryopsis* sp., *Codium elisabethae* and *Padina pavonica* were among species responsible for separating subtidal sites.

Transect 4

A distinct intertidal algal zonation was recorded at this sheltered site in Porto Pim Bay. High shore levels (around HWN) were characterized by a band of green algae (comprising *Blidingia minima* and *Enteromorpha intestinalis*) and Cyanophyta. At middle shore levels plant cover comprised a mosaic also of green algae but principally *Enteromorpha* (*E. intestinalis*, *E. ramulosa*) and *Ulva rigida* mixed with patches of *Corallina officinalis*. *Corallina* is the dominant component of an algal turf at low shore levels. This intertidal site was poorer in species than Transect 2 with only nineteen recorded. The algal turf continued

into shallow subtidal levels (3m was the greatest depth investigated) and was characterised throughout by *Corallina officinalis* and *Centroceras clavulatum*. Species richness was greater at subtidal levels with 43 recorded (a full list for the site is given in Table 3).

Ordination of combined intertidal and subtidal data (Fig. 5) shows a spread of sample sites along the first axis, with subtidal sites to the left and high intertidal sites to the right. A clear gradient exists with lower intertidal sites adjacent to subtidal sites and separated from upper intertidal sites. The subtidal sites form a cluster spread also along the second axis; intertidal sites, in contrast, were spread only linearly along the first axis, and the ordination at the extremes attained almost 8 standard deviations. While the first axis is depth related, factors responsible for the spread of subtidal sites along the second axis are not apparent.

Other transects

The inner Caldeira, transect 5, lacked algal growth (apart from Cyanophyta) at high shore levels but, lower levels supported an algal turf dominated by *Corallina* with *Jania rubens* and *Laurencia obtusa* and extending to subtidal levels. More quadrats at shallow sublittoral levels (to 8m) were examined than at Transects 1 and here the algal turf comprised principally *Corallina officinalis* and *Haliptylon virgatum*; forty-five species were recorded from the quadrats. Decorana ordination of combined intertidal and subtidal data (Fig. 6) showed a single cluster of sites but with intertidal and subtidal sites positioned to each side of the cluster and slightly separating along the first axis. Transect 1 was also an inner Caldeira site where subtidal samples were not taken below 20m. Ordination of subtidal data (Fig. 7) showed only a single cluster of points. That there is no strong separation and sites of differing depths are mixed in the plot suggested a mosaic of subtly changing species assemblages. At Transect 3, upper shore levels lacked algal growth, but at middle to lower levels supported an algal turf dominated by *Corallina* with *Jania rubens*, *Gelidium microdon*, *Hypnea musciformis* and *Laurencia obtusa*. Low shore levels were characterised by a band of *Codium adhaerens* and below this a patchy mosaic of principally *Gigartina acicularis* and *Valonia utricularis*. Thirty six species were recorded in deep water (30 - 46m) at Transect 8; articulated corallinaceae (*Jania* spp., *Haliptylon virgatum*) were present in the turf together with species known from shallow waters and also *Bryopsis hypnoides*, *Carpomitra costata* and *Lobophora variegata*.

DISCUSSION & CONCLUSIONS

We concur with STEWART's (1982) comment that "turf" is a convenient term to describe mats of small algal thalli in warm temperate and tropical regions. Algal turfs have been widely recorded in the Atlantic Ocean from the Canary Islands (LAWSON & NORTON, 1971), West Africa (LAWSON & JOHN, 1977), the Caribbean (ROGERS & SALESKY, 1981) and Brazil (OLIVEIRA & MAYRAL, 1976); Keates (pers. comm.) found turf formations to be widespread on both Atlantic and Indian Ocean coasts of South Africa. In the Pacific Ocean

they have been recorded (SANTELICES & NORTON, 1982) and agree in over 50% of the formation sites. Intertidal animal interactions in California are dominated by *Haliptylon* at low shore turfs due to their being better able to tolerate subtidal provides a suitable habitat & DAHL (1982) a mixture of species. Intertidal turf communities of many of the species (1982) that are

At middle shore levels, the shores were dominated by *Corallina* described by STEWART (1982) are common assemblages. *Corallina* does not form a dominant middle shore assemblage, the dominant species is *adhaerens* at low shore levels. Lower littoral assemblages were probably changing species from shore to within 20m.

Corallina and also from the Pacific Ocean. *Corallina*, *Jania* and *Gelidium* support epiphytic algae. The term 'assemblage' is used to describe epiphytic organisms. *Centroceras*

they have been described from California and Mexico (STEWART, 1982, 1989) and Chile (SANTELICES & ABBOT, 1978). Algal turfs on the Azores (cf. PRYOR, 1967; NETO, 1992) agree in overall physiognomy with those described elsewhere. 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 fish or invertebrates. Turfs on the Azores are, as in California and elsewhere, often coralline dominated with *Corallina*, *Jania*, *Amphiroa* or *Haliptylon* attached directly to the rocks. *Corallina* often persists as the dominant species in turfs due to its ability to regenerate from a perennial basal crust; calcified thalli are also better able to resist abrasion than can softer algae. The compact mat retains water and provides a suitable habitat including surfaces for attachment for admixed algae. NEUSCHUL & DAHL (1967) defined turfs on the California coast as being a taxonomically complex mixture of small algae and developmental forms of large algae; our observations on Azores turf communities agree with this and we had considerable difficulties with the identification of many of the constituent species. Our observations also concur with those of STEWART (1982) that algal thalli in the intertidal turf intertwine and reattach to one another.

At most intertidal sites there were distinct animal and algal zones; wave-exposed shores were often animal (barnacle) dominated while sheltered, shaded sites were plant dominated; and the overall patterns of zonation at Monte de Guia were similar to those described by NETO (1992) for the island of São Miguel. Zones of Cyanophyta and barnacles are common on wave-exposed shores in the North Atlantic. A *Corallina*-dominated algal assemblage also occurs widely on northern North Atlantic shores (TITTLEBY *et al.*, 1989) but does not form a turf. At Monte de Guia a coralline-dominated algal turf occurred from middle shore to deep subtidal levels (30m). Some turfs were characterised by *Laurencia* as the dominant species. Sometimes the coralline turf was divided by a band of *Codium adhaerens* near low water level. Our numerical studies confirmed uniform stands of corallines at low shore levels showing little variation with depth; they also suggested continuity between lower littoral and sublittoral assemblages. The discontinuity evident on some transect analyses was probably due to a gap in sampling at shallow sublittoral levels, a difficult part of the sea-shore to work in wave-washed situations. Numerical analyses also suggested a gradually changing species composition in the turf down to 20m, and a more pronounced change below 20m.

Comparison with turf constituents identified by STEWART (1982) from California and also from turf communities elsewhere, revealed common elements at the genus level; *Corallina*, *Pterocladia* (common on the Azores but less often in the turf), *Hypnea*, *Jania* and *Gelidium* were defined as "anchor taxa" (those that attach to the rock substrate and support epiphytic or binding species). Another category comprised "epiphytes" (we suggest the term 'associated species' as it is not always clear for Azores turfs whether species were epiphytic or entwined) and common genera to both Azores and California were *Ceramium*, *Centroceras*, *Laurencia*, *Chondria*, *Gelidium*, *Gigartina*, *Polysiphonia* and *Sphacelaria*.

Stewart also recorded about 50 taxa as "infrequently occurring" and many of the genera are also present in the Azores turf (*Acrosorium*, *Chaetomorpha*, *Cladophora*, *Colpomenia*, *Dictyota*, *Enteromorpha*, *Herposiphonia*, *Plocamium*, *Polysiphonia* and *Sargassum*). A turf assemblage was described from Mexico in which *Laurencia* was the dominant, we too observed this at Monte de Guia. In West Africa, LAWSON & JOHN (1977) and LAWSON, JOHN & PRICE (1975) list species of *Centroceras*, *Champia*, *Corallina*, *Gelidium*, *Hypnea*, *Polysiphonia*, and *Ulva* as major components of intertidal turfs, while LAWSON & NORTON (1971) listed *Centroceras*, *Gelidium*, *Laurencia* and articulated Corallinaceae as the main components of turfs on the Canary Islands. A similar turf assemblage to that on the Azores was reported by OLIVEIRA & MAYRAL (1976) from Brazil; it contained *Amphiroa beauvoisii*, *Centroceras clavulatum*, *Jania adhaerens* and *Colpomenia sinuosa*, and *Ceramium*, *Chaetomorpha*, *Cladophora*, *Sphacelaria* and *Ulva*.

Our transect studies revealed species assemblages which resembled some of the ecological groupings described by SCHMIDT (1931); at intertidal levels these included the following associations: *Enteromorpha*; *Gelidium microdon*; *Laurencia obtusa*; *Haliptylon squamatum*; *Caulacanthus-Gigartina-Ceramiaceae*; *Gelidium pusillum-Codium adhaerens*; *Laurencia pinnatifida*, *Haliptylon squamatum* and crustose corallinaceae. At subtidal levels we recognised the following: *Corallina officinalis*, *Halopteris-Dictyota*, *Asparagopsis armata*, *Sargassum-Cladostephus-Nitophyllum-Plocamium*, *Zonaria* and *Halopteris*. Large growth forms of algae were not detected on Monte de Guia; *Fucus spiralis* occurs sporadically elsewhere on Faial, as do *Cystoseira* and *Sargassum*. Laminarians were absent from Monte de Guia; they are rare on the Azores and restricted to deep water (ARDRÉ *et al.*, 1973). The only large brown algae detected in the transects were small rosette-like plants of *Sargassum* in the turf; they grew to reproductive maturity with receptacles formed on centrally arising stalks. We are not sure certain whether this represents a distinct species or a turf ecotype.

Turf algal assemblages still remain incompletely described for the Azores; in order to understand the factors controlling the formation of algal turfs, experimental studies involving clearance, recolonisation and exclusion may yield important clues. Excluding the main browsers and grazers from areas might allow some of the taxonomically difficult entities to attain maturity and allow more precise identification.

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Transect 1
Transect 2
Transect 3
Transect 4
Transect 5
Transect 8

Key to abbreviat

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TABLE 1 - Transect sampling sites

	Intertidal	Subtidal	Depths (m)	Exposure	Slope	Aspect
Transect 1	+	+	5, 10, 15, 19	me	s	sw
Transect 2	+	+	5, 10, 15, 20, 30	ve	s	w
Transect 3	+	-		ve	s	w
Transect 4	+	+	1, 1, 2, 2, 3	sh	g	n
Transect 5	+	+	3, 5, 8	me	s	se
Transect 8	-	!	30, 41, 46	-	-	-

Key to abbreviations

!	samples in deep water only
me	medium wave exposure
ve	very exposed
sh	sheltered
s	steeply sloping
g	gently sloping

n	north
se	southeast
sw	southwest
w	west

TABLE 2 - Species recorded from Transect 2 (+7 to +0 to indicates linear distance in metres above low water neap tides; other figures indicate depth below low water). Species are listed in depth order. (+ = present, 0 = absent, . = not recorded)

Species	+7	+6	+5	+4	+3	+2	+1	+0	5	10	15	20	30
<i>Gelidium pusillum</i> (Stackh.) Le Jol.	+	.	+	0	0	.	+	+	0	0	0	0	0
<i>Laurencia obtusa</i> (Huds.) Lamouroux	+	.	0	+	+	.	+	+	0	0	0	0	0
<i>Ceramium diaphanum</i> (Lightf.) Roth	0	.	+	0	0	.	0	+	0	0	0	0	0
<i>Ceramium rubrum</i> (Huds.) Agardh	0	.	+	0	0	.	+	+	0	0	0	0	0
<i>Chaetomorpha aerea</i> (Dillwyn) Kütz.	0	.	+	0	0	.	0	0	0	0	0	0	0
<i>Cladophora</i> sp.	0	.	+	0	0	.	0	0	0	0	0	0	0
<i>Corallina officinalis</i> L.	0	.	+	+	+	.	+	+	+	+	+	+	0
Crustose corallinaceae	0	.	+	+	+	.	+	+	+	+	+	+	0
<i>Enteromorpha linza</i> (L.) J. Agardh	0	.	+	0	0	.	0	0	0	0	0	0	0
<i>Enteromorpha prolifera</i> (O.F. Müll.) J. Agardh	0	.	+	0	0	.	0	0	0	0	0	0	0
<i>Leathesia difformis</i> (L.) Aresch.	0	.	+	0	0	.	0	0	0	0	0	0	0
<i>Polysiphonia brodiaei</i> (Dillwyn) Sprengel	0	.	+	0	0	.	0	0	0	0	0	0	0
<i>Polysiphonia</i> sp. 1	0	.	+	0	0	.	0	0	0	0	0	0	0
<i>Polysiphonia urceolata</i> (Gillwyn) Grev.	0	.	+	0	0	.	+	0	+	+	+	+	+
<i>Valonia utricularis</i> (Roth) Agardh	0	.	+	0	0	.	0	0	0	0	0	0	0
<i>Jania rubens</i> (L.) Lamouroux	0	.	+	0	0	.	+	0	+	0	+	0	0
<i>Cladophora laetivirens</i> (Dillwyn) Kütz.	0	.	+	+	+	.	+	+	+	+	+	0	+
<i>Gelidiella</i> sp.	0	.	0	+	0	.	+	0	0	0	0	0	0
<i>Gigartina acicularis</i> (Roth) Lamouroux	0	.	0	+	0	.	+	+	0	0	0	0	0
<i>Nemalion helminthoides</i> (Velley) Batters	0	.	0	+	0	.	+	+	0	0	0	0	0
<i>Chaetomorpha pachynema</i> Mont.	0	.	0	+	0	.	0	0	0	0	0	0	0
<i>Cladophora sericea</i> (Hudson) Kütz.	0	.	0	0	+	.	0	0	0	0	0	0	+
<i>Corallina elongata</i> Ellis et Sol.	0	.	0	0	+	.	0	0	0	0	0	0	0
<i>Dictyota dichotoma</i> (Hudson) Lamouroux	0	.	0	0	+	.	0	0	0	0	0	0	0
<i>Halopteris scoparia</i> (Hudson) Lamouroux	0	.	0	0	+	.	0	0	+	+	+	+	+
<i>Laurencia pinnatifida</i> (Hudson) Lamouroux	0	.	0	0	+	.	+	0	0	0	0	0	0
<i>Lobophora variegata</i> (Lamouroux) Womers	0	.	0	0	+	.	0	0	+	0	+	0	0
<i>Ralfsia</i> sp.	0	.	0	0	+	.	0	0	0	0	0	0	0
<i>Antithamnion</i> sp.	0	.	0	0	+	.	+	0	0	0	0	+	0
<i>Callithamnion corymbosum</i> (Sm.) Lyngbye	0	.	0	0	+	.	+	+	0	0	0	0	0
<i>Catenella caespitosa</i> (With.) L. Irvine	0	.	0	0	+	.	+	+	0	0	0	0	0
<i>Ceramium ciliatum</i> (Ellis) Ducluz.	0	.	0	0	+	.	+	+	0	0	0	0	0
<i>Ceramium echionotum</i> J. Agardh	0	.	0	0	+	.	+	+	0	0	0	0	0
<i>Gastroclonium ovatum</i> (Hudson) Papenf.	0	.	0	0	0	.	+	0	0	0	0	0	0
<i>Herposiphonia secunda</i> (Agardh) Falkenb.	0	.	0	0	0	.	+	+	0	0	0	0	0
<i>Laurencia hybrida</i> (DC) Duby	0	.	0	0	0	.	+	+	+	+	+	0	0
<i>Pterocladia capillacea</i> (S. Gmelin) Bornet et Thuret	0	.	0	0	0	.	+	0	0	0	0	0	0
<i>Sphacelaria fusca</i> (Hudson) S.F. Gray	0	.	0	0	0	.	+	+	0	0	0	0	0
<i>Sphacelaria rigidula</i> (Kütz.)	0	.	0	0	0	.	+	0	0	0	0	0	0
<i>Aglaothamnion hookeri</i> (Dillwyn) Maggs et L'Hardy-Halos	0	.	0	0	0	.	+	0	0	0	0	0	0
<i>Callithamnion</i> sp.	0	.	0	0	0	.	0	+	0	0	0	0	0
<i>Chondria dasyphylla</i> (Woodw.) Agardh	0	.	0	0	0	.	0	+	0	0	0	0	0

Species (cont.)
Chondria tenuissima
Falkenbergia stage
Gigartina teedii (Ro
Sphacelaria cirrosa
Ulva lactuca L.
Anotrichium tenue (A
Asparagopsis armata
Colpomenia sp.
Erythrotrichia carne
Sargassum sp. (rosett
Stylonema alsidii (Za
Aglaozonia stage
Amphiroa beauvoisii
Cryptopleura ramosa
Dasya sp.
Cystoseira abies-mari
Halopteris filicina (Gr
Halimnion virgatum (L
Jania adhaerens Lam
Plocamium cartilagine
Oscillatoria sp.
Trailliella stage
Cladophora prolifera (L
Padina pavonica (L.) L
Zonaria tournefortii (L
Bryopsis plumosa (Hud
Callithamnion sp.
Centroceras clavulatum
Cladophoropsis membra
Enteromorpha ramulosa
Feldmannia irregularis
Hypoglossum hypogloss
Microdictyon colacodict
Spermothamnion sp.
Codium elizabethae O.C
Symphyclocladia marchan
Polysiphonia sp. 2

TABLE 3 - Species recorded from Transect 4 (-1 to -6 indicates linear distance below high water mean tide level; other figures (7m to 11m) continue the sequence but below low water level *). Species are listed in depth order. (+ = present, 0 = absent, . = not recorded).

Species	-1	-2	-3	-4	-5	-6	7m	8m	9m	10m	11m	#
<i>Blidingia minima</i> (Kütz.) Kylin	+	+	.	0	0	0	0	0	0	0	0	0
Cyanophyta sp.1	+	0	.	0	0	0	0	0	0	0	0	0
<i>Enteromorpha intestinalis</i> (L.) Link	+	+	.	+	+	0	0	0	0	0	0	0
Cyanophyta sp. 2	0	+	.	0	0	0	0	0	0	0	0	0
<i>Cladophora</i> sp.	0	+	.	0	0	0	0	0	0	0	0	0
<i>Enteromorpha ramulosa</i> (Sm.) Hook.	0	+	.	+	0	+	0	+	+	0	0	0
<i>Gelidium pusillum</i> (Stackh.) Le Joliso	0	+	.	0	+	0	0	0	0	0	0	0
<i>Polysiphonia</i> sp.	0	0	.	+	+	+	+	+	+	+	+	+
<i>Corallina officinalis</i> L.	0	0	.	+	0	+	+	+	+	+	+	0
<i>Ulva rigida</i> Agardh	0	0	.	+	0	+	+	+	+	+	+	+
<i>Ceramium diaphanum</i> (Lightf.) Rothoo	0	0	.	0	+	+	+	+	+	+	+	0
<i>Laurencia obtusa</i> (Hudson) Lamouroux	0	0	.	0	+	0	0	+	+	+	+	0
<i>Polysiphonia</i> sp.1	0	0	.	0	+	+	0	0	0	0	0	0
<i>Polysiphonia</i> sp.2	0	0	.	0	+	+	+	+	+	+	+	+
<i>Centroceras clavulatum</i> (Agardh) Mont.	0	0	.	0	0	+	0	+	0	0	0	0
<i>Codium adhaerens</i> (Cabr.) Agardh	0	0	.	0	0	+	0	+	0	0	0	0
<i>Gigartina acicularis</i> (Roth) Lamouroux	0	0	.	0	0	+	0	+	+	+	+	+
<i>Jania rubens</i> (L.) Lamouroux	0	0	.	0	0	+	0	+	0	0	0	0
<i>Leathesia difformis</i> (L.) Aresch.	0	0	.	0	0	0	+	+	0	+	0	+
<i>Amphiroa rigida</i> Lamouroux	0	0	.	0	0	0	+	+	0	0	0	0
<i>Colpomenia sinuosa</i> (Roth) Derb. et Sol.	0	0	.	0	0	0	0	+	0	+	0	0
<i>Ceramium echionotum</i> J. Agardh	0	0	.	0	0	0	0	+	0	0	0	0
<i>Chondria dasyphylla</i> (Woodw.) Agardh	0	0	.	0	0	0	0	+	0	0	0	0
<i>Erythrotrichia carnea</i> (Dillwyn) Agardh	0	0	.	0	0	0	0	+	+	+	+	0
<i>Griffithsia phyllamphora</i> J. Agardh	0	0	.	0	0	0	0	+	0	+	0	0
<i>Halopteris filicina</i> (Grat.) Kütz.	0	0	.	0	0	0	0	+	0	0	0	0
<i>Laurencia hybrida</i> (DC) Duby	0	0	.	0	0	0	0	+	0	0	0	0
<i>Laurencia pinnatifida</i> (Hudson) Lamouroux	0	0	.	0	0	0	0	+	0	+	+	+
<i>Sphacelaria cirrosa</i> (Roth) Agardh	0	0	.	0	0	0	0	+	0	0	0	0
<i>Stylonema alsidii</i> (Zanard.) Drew	0	0	.	0	0	0	0	+	0	0	0	+
<i>Bryopsis</i> sp.	0	0	.	0	0	0	0	0	+	0	0	0
<i>Asparagopsis armata</i> Harvey	0	0	.	0	0	0	0	0	+	0	0	0
<i>Cryptopleura ramosa</i> (Hudson) Newton	0	0	.	0	0	0	0	0	+	0	0	+
<i>Dictyota dichotoma</i> (Hudson) Lamouroux	0	0	.	0	0	0	0	0	+	0	+	0
<i>Gelidiella</i> sp.	0	0	.	0	0	0	0	0	0	+	+	0
<i>Amphiroa beauvoisii</i> Lamouroux	0	0	.	0	0	0	0	0	+	0	0	0
<i>Chaetomorpha pachynema</i> Mont.	0	0	.	0	0	0	0	0	+	0	0	0
<i>Halitplyton virgatulum</i> (Zanard.) Garbary et Johanson	0	0	.	0	0	0	0	0	+	0	0	0
<i>Halopteris scoparia</i> (L.) Sauvageau	0	0	.	0	0	0	0	0	0	+	+	+

*; # indicates sample taken beyond end of transect line at 2-3m depth

Species (cont.)

- Hypnea cervicornis* J. Agardh
- Plocamium cartilagineum* (L.) P
- Polysiphonia fruticulosa* (Wulf.)
- Valonia utricularis* (Roth) Agar
- Aglaozonia* stage
- Symphycladia marchantioides*
- Champia parvula* (Agardh) Har
- Cladophora prolifera* (Roth) K
- Cladostephus spongiosus* (Hud)
- Crouania attenuata* (Agardh) J.
- Derbesia* sp.

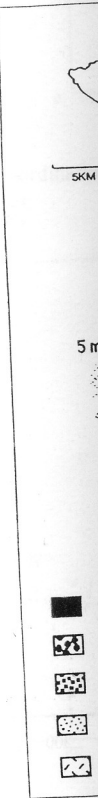


Figure 1 - The island of Faial

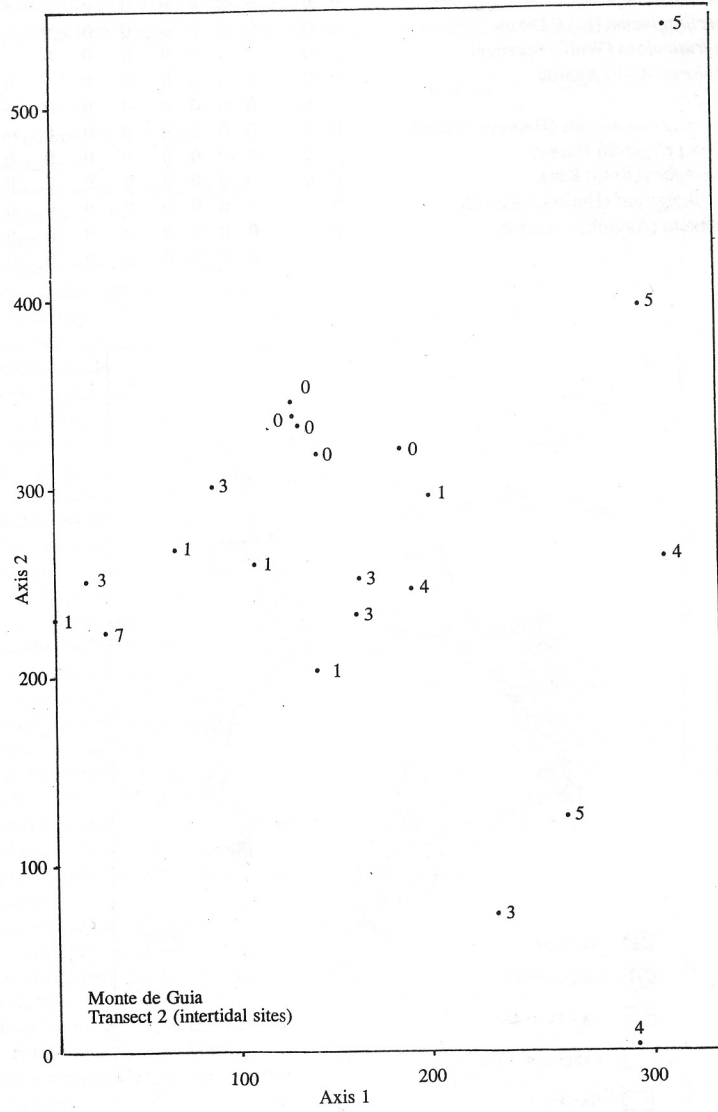


Figure 2 - Decorana ordination of Transect 2 intertidal quadrats; 0 = low water level, 1-7 = linear distance above low water (+0 - +7 in Table 2).

Figure 3 - Decorana ordination of sites below low water level.

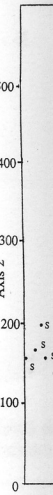
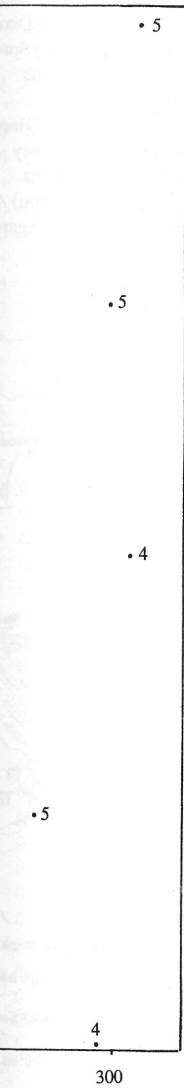


Figure 4 - Decorana ordination of sites at middle level, I = middle level.



; 0 = low water level, 1-7 = linear

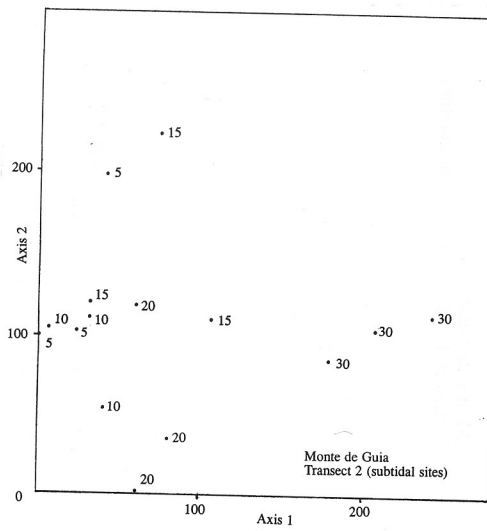


Figure 3 - Decorana ordination of Transect 2 subtidal quadrats; numbers by points indicate depths below low water level.

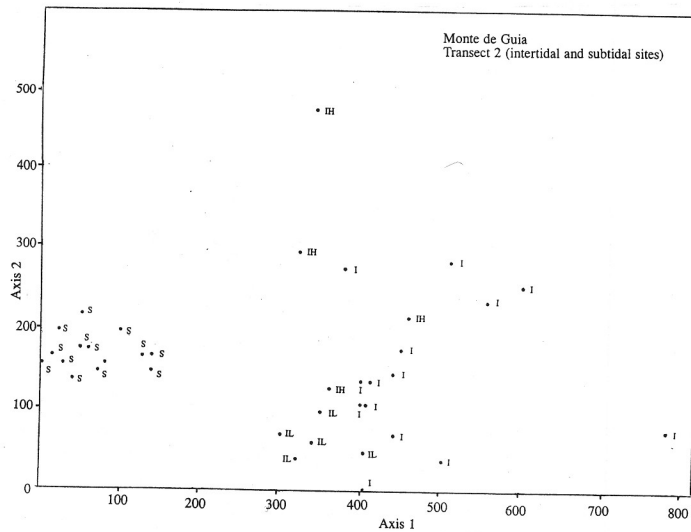


Figure 4 - Decorana ordination of Transect 2 intertidal and subtidal quadrats; IH = high intertidal level, I = middle intertidal, IL = low intertidal, S = subtidal.

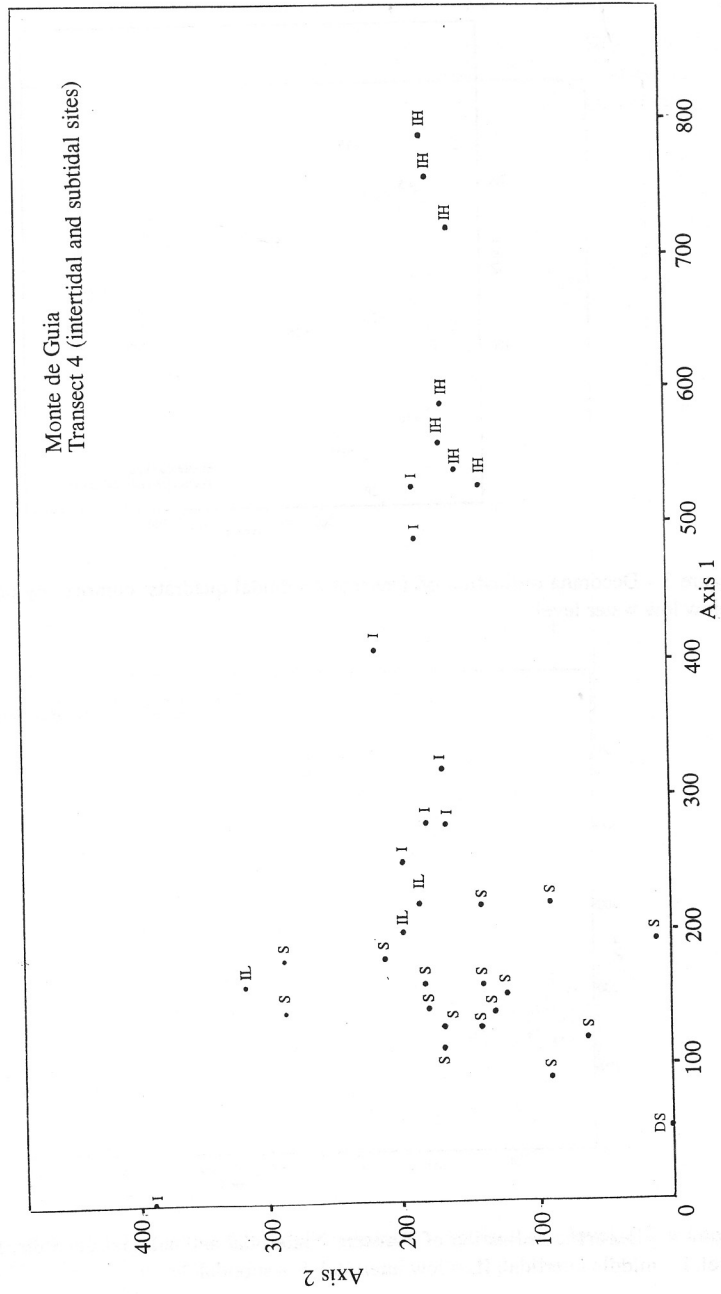
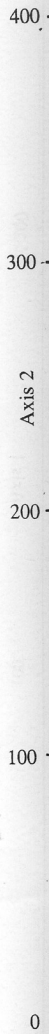


Figure 5 - Decorana ordination of Transect 4 intertidal and subtidal quadrats; abbreviations as in Figure 4.

Figure 6 -
Figure 4, D



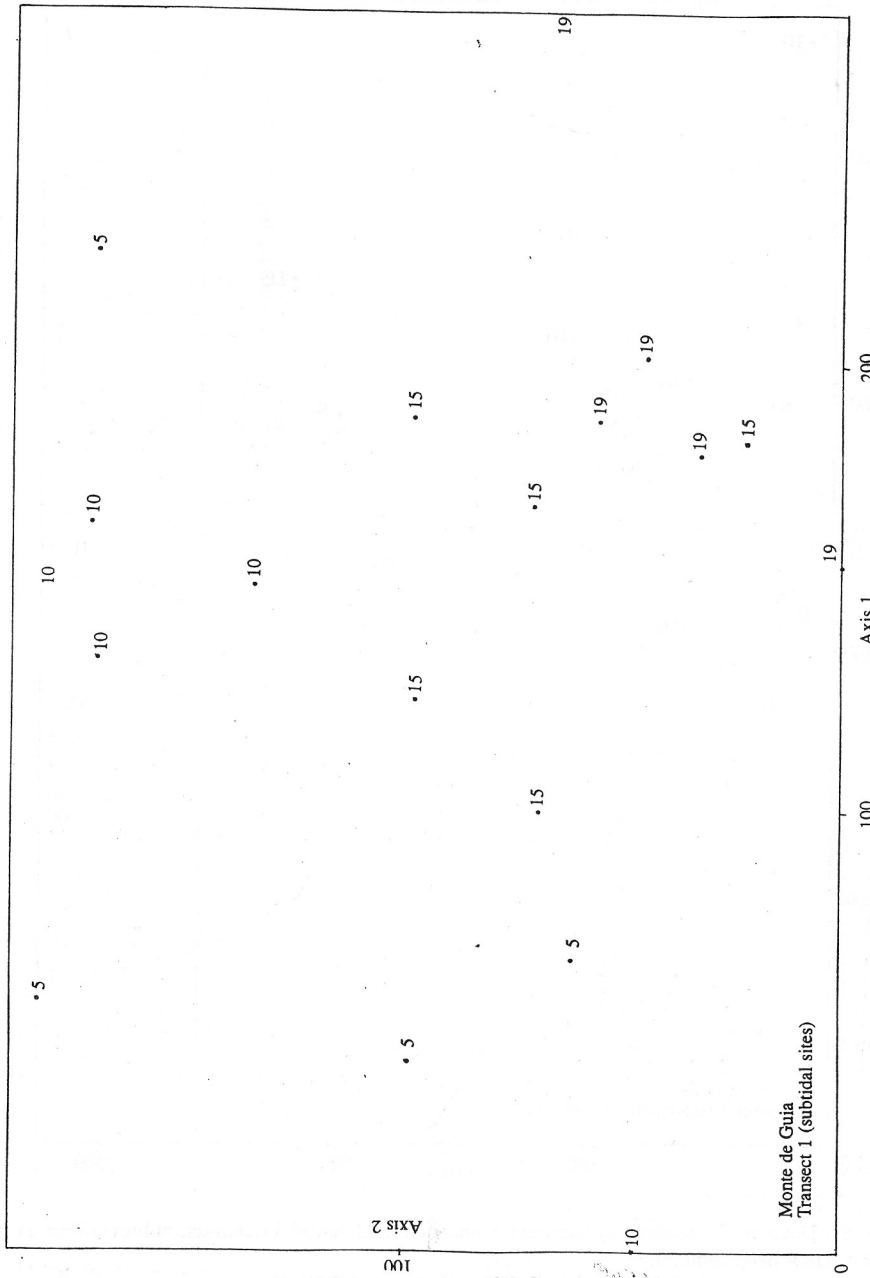


Figure 7 - Decorana ordination of Transect 1 subtidal quadrats; numbers by points indicate depths below low water level.