MARINE ALGAE OF THE ISLAND OF FLORES, AZORES: ECOLOGY AND FLORISTICS

By IAN TITTLEY [1], ANA I. NETO [2] & WILLIAM F. FARNHAM [3]

With 6 figures and 1 table

ABSTRACT. Preliminary results of an extensive field survey of the marine algal flora of Flores are presented. Intertidal and subtidal algal zonation and community structure were investigated by sampling quadrats along transect lines. Intertidal areas were characterised by successive zones of barnacles, algal turf (*Gelidium spp.*, *Centroceras clavulatum*, *Laurencia spp.* and other algae), and *Corallina sp.*, *Pterocladia capillacea* and *Asparagopsis armata* near low water level. At subtidal levels, assemblages were characterised by crustose Corallinaceae and *A. armata* in shallow waters, and by *Stypocaulon scoparium* and *Zonaria tournefortii* at greater depths. New species recorded for the Azores and for Flores are reported; the overall flora of Flores in comparison to other islands in the archipelago is less species-rich with 125 species recorded so far.

INTRODUCTION

The Azores is an archipelago of nine islands in the mid Atlantic Ocean lying between latitude 36°59'N and 39°44'N and longitude 24°41'W and 31°16'W. There are three separate island groups within the archipelago (eastern, central, western). The eastern island of San Miguel lies 1100km due west of Portugal; the small island of Flores lies a further 600km to the west, and with Corvo forms the western group. Flores and Corvo are situated to the north of the other islands. The islands of the archipelago represent peaks of volcanoes and are separated by deep oceanic water; they are of relatively recent geological origin and situated on different tectonic plates (Flores lies in the American plate). Flores is small (16km north to south, by 10km; Fig. 1) and reaches an altitude of 812m. The coastline is mainly of high, steep cliffs with a variety of stack, arch, cave and gully formations, inaccessible other than by boat. Although sea-shores are generally steeply sloping, there are places where depths of

[1] Department of Botany, The Natural History Museum, Cromwell Road, London SW7 5BD, UK
[2] Departamento de Biologia, Universidade dos Açores, Rua de Mãe de Deus, 9500 - Ponta Delagada, Azores
[3] Institute of Marine Sciences, University of Portsmouth, Portsmouth p04 9Ly, UK

Bol. Mus. Mun. Funchal, Sup. no. 5: 463-479, 1998 ISSN 0870-3876

less than 30m extend several hundred metres offshore.

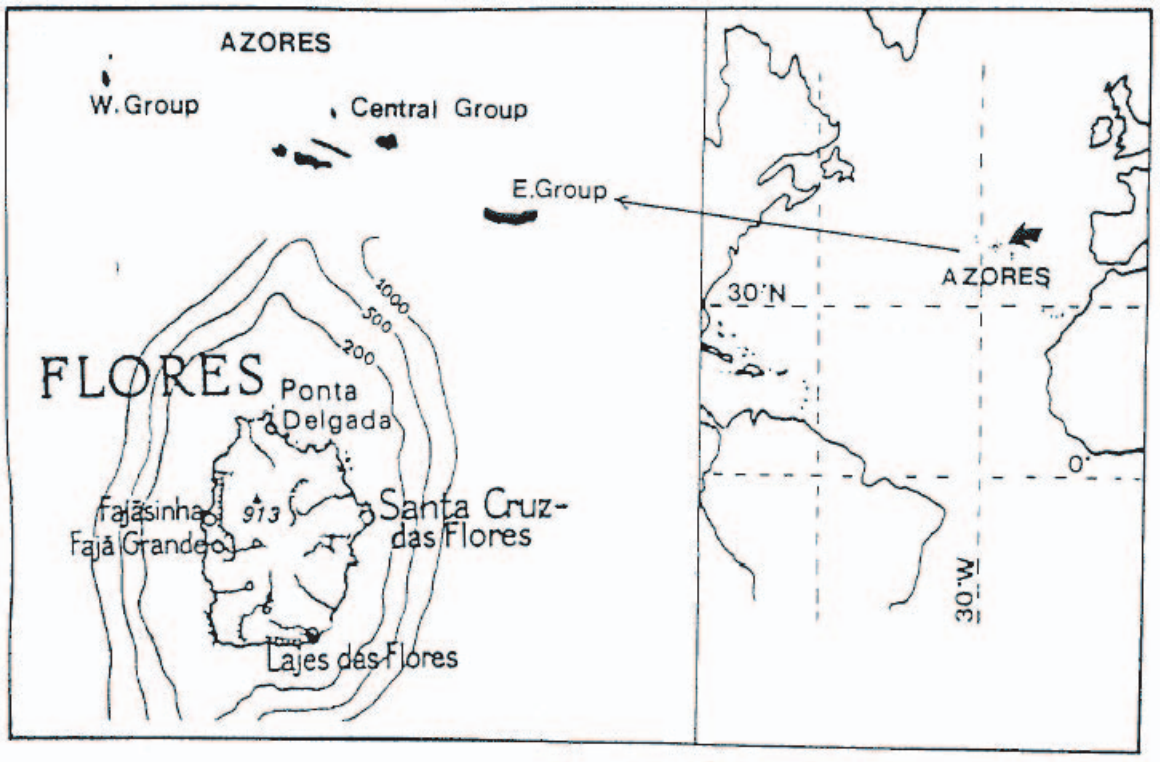

Fig. 1 - Map showing the location of the Azores, and of Flores.

The islands lie within the warm temperate region, have a high rainfall and suffer severe storms in summer and winter. Most shores are subject to swell and surge. Heavy rainfall in early summer 1995 (prior to our field investigations) resulted in several major landslides into the sea, the effects of which were still evident two months later as locally turbid sea-water containing a high suspended sediment load. Summer sea temperatures are 20 - 22°C (winter 12°C), and waters are mostly clear with 30m - 40m visibility.

Although the marine algal flora of the Azores has been sporadically investigated during the past century and a half, research since the late 1980s has yielded much new information. Field studies have focussed on the eastern and central groups of islands in the archipelago (Faial in 1989 - NETO & TITTLEY (1996), TITTLEY & NETO (1994), (1996); São Miguel from 1990, NETO (1992) 1997). A comprehensive algal checklist (NETO, 1994) brings together all exisiting published information and provides distributional information within the archipelago. Published information on the marine algal flora of Flores is given in TRELEASE (1897), GAIN (1914), SCHMIDT (1929, 1931), FRALICK & HEHRE (1990), NETO & AZEVEDO (1990) and NETO & BALDWIN (1990). Nonetheless, the marine algal flora of Flores remained relatively poorly known.

The aim of our study and the focus of the present paper is to describe and inventory the island's marine flora and to define ecologically the main marine plant communities. Improved floristic data will allow us to test biogeographical relationships both within the archipelago (see TITTLEY & NETO (1996)) and with the east and west coasts of the Atlantic Ocean and with the Mediterranean and Caribbean Seas (see PRUD'HOMME VAN REINE (1988), PRUD'HOMME VAN REINE & VAN DEN HOEK (1988, 1990), TITTLEY *et al.* (1990), TITTLEY & NETO (1996)). Improved ecological information will contribute to the classification of benthic marine biotopes currently being undertaken for the north-east Atlantic (HISCOCK, 1995).

METHODS

A reconnaissance field survey was undertaken in August 1994. Four main sites around the island were evaluated (in sheltered, wave-exposed and anthropogenically disturbed situations); they allowed good access to the sea-shore, and were safe and practical for undertaking intertidal and subtidal fieldwork.

Extensive investigations were undertaken in July and August 1995. The field study method involved studying the vegetation along transect lines laid from high tide level to a subtidal depth of 30m or to a predetermined distance offshore (usually 100 or 200m); subtidal investigations were undertaken by SCUBA diving. Four intertidal and two subtidal transects were investigated at Ponta Delgada in the north, sixteen intertidal and subtidal transects in the Santa Cruz area on the east coast, two intertidal and three subtidal transects at Lajes das Flores in the south, and six intertidal and subtidal transects at Fajã Grande on the west coast. Transect lines were levelled by surveying for intertidal shores and by using calibrated depth gauges for subtidal shores; from these data shore profiles were constructed and the main habitat features correlated with the profile. Subtidal transects were additionally photographed using an underwater video-camera.

Study quadrats were located at intervals along the transect line. The distance apart of quadrats along the line varied according to the slope of the seashore (closer together or continuous on steep shores); at subtidal levels quadrats they were at 5, 10 or 20m intervals. Dominant species and relative abundances were recorded at intertidal sites from 25 x 25cm quadrats, and at subtidal sites from 50 x 50cm quadrats; a sample of vegetation was cleared from 10 x 10cm and 25 x 25cm quadrats within each of the larger quadrats respectively and brought back to the laboratory for preliminary analysis. All species present were listed and abundances in a sample noted using the DAFOR scale. Data sheets were completed for each quadrat and a database for each transect was constructed on computer. Material sampled was provisionally identified and taxonomically difficult material was preserved in 4% formalin for further checking; a comprehensive set of herbarium specimens was also prepared.

RESULTS

Zonation and community structure

Algal occurrence was distinctly zoned at both intertidal and subtidal levels. These zones were characterised by Cyanophyta, *Caulacanthus ustulatus* [see Table 1 for full nomenclatural citations], *Gelidium* spp. and *Corallina* sp. turfs, and stands of *Asparagopsis armata* at intertidal levels, and by subtidal assemblages dominated by crustose Corallinaceae, *Stypocaulon scoparium* and *Zonaria tournefortii* dominated assemblages at subtidal levels. For a complete species list see Table 1.

TABLE 1 - List of species recorded from Flores (past and present)

* = New record for Flores

Chlorophyta

Anadyomene stellata (Wulfen) C.Agardh *
Blidingia minima (Kütz.) Kylin *
Bryopsis hypnoides J.V. Lamour.
Bryopsis plumosa (Huds.) C. Agardh
Chaetomorpha aerea (Dillwyn) Kütz.
Chaetomorpha linum (O.F. Müll.) Kütz.
Chaetomorpha pachynema Mont. *
Cladophora albida (Nees.) Kütz.
Cladophora coelothrix Kütz.
Cladophora laetivirens (Dillwyn) Kütz.
Cladophora prolifera (Roth) Kütz.
Cladophoropsis membranacea (C. Agardh) Børgesen *
Codium adhaerens C. Agardh
Codium decorticatum (Woodw.) Howe.
Codium fragile (Suringar) Hariot * [Requires further investigation as to subspecies]
Codium tomentosum Stackh. *
Derbesia marina (Lyngb.) Solier * (Including Halicystis stage *)
Enteromorpha intestinalis (L.) Nees
Enteromorpha muscoides (Clemente y Rubio) Cremades
Enteromorpha prolifera (O.F. Müll.) J. Agardh *
Halimeda tuna (J. Ellis et Sol.) J.V. Lamour.
Microdicyton calodictyon (Mont.) Dcne *
Pedobesia lamourouxii (J. Agardh) Feldmann, Loreau, Codomier et Couté *
Ulva lactuca L.
Ulva rigida C. Agardh
Urococcus hookerianus Kütz.

Valonia utricularis (Roth) C. Agardh

Fucophyta (Phaeophyta)

Ascophyllum nodosum (L.) Le Jol. [Drift] *
Bachelotia antillarum (Gruno) Gerloff *
Carpomitra costata (Stackh.) Batters *
Cladostephus spongiosus (Huds.) C. Agardh
Colpomenia sinuosa (Roth) Derbès et Solier
Cutleria multifida (Sm.) Grev. (Aglaozonia stage *)
Cystoseira foeniculaceus (L.) Grev. *
Cystoseira humilis Kütz.
Dictyota adnata Zanardini
Dictyota dichotoma (Huds.) J.V. Lamour.
Fucus spiralis L.
Halopteris filicina (Gratel.) Kütz.
Leathesia difformis (L.) Aresch. *
Liebmannia leveillei J. Agardh
Myrionema strangulans Grev. *
Padina pavonica (L.) Thivy
Sargassum cymosum C. Agardh *
Sargassum vulgare C. Agardh
Stypocaulon scoparia (L.) Kütz.
Zonaria tournefortii (J.V. Lamour.) Mont.

Rhodophyta

Acrosorium venulosum (Zanardini) Kylin *
Aglaothamnion bipinnatum (P. Crouan et H. Crouan) Feldm.-Maz. *
Aglaothamnion byssoides (Harvey) L' Hardy-Halos et Rueness *
Amphiroa beauvoisii J.V. Lamour. *
Amphiroa rigida J.V. Lamour. *
Asparagopsis armata Harvey
Audoniela purporea (Lightf.) Woelk.
Boergeseninella fruticolosa (Wulfen) Kylin.
Bornetia secundiflora (J. Agardh) Thur.
Callithamnion corymbosum (Sm.) Lyngb.
Caulacanthus ustulatus (Turner) Kütz. *
Centroceras clavulatum (C. Agardh) Mont. *
Ceramium ciliatum (J. Ellis) Ducluz.
Ceramium cimbricum H. Petersen. *
Ceramium derbesii Kütz.
Ceramium fastigiatum Eroth Harvey
Ceramium gaditanum Clemente y Rubio) Cremades.
Ceramium nodulosum (Lightf.) Ducluz.
Champia parvula (C. Agardh) Harvey *
Chondracanthus acicularis (Roth) Fredericq

Chondria capillaris Huds.
Chondria dasyphylla (Woodw.) C. Agardh
Coccotylus truncatus (Pallas) M. Wynne et J. Heine [previous uncertain record]
Corallina elongata J.Ellis et Sol. *
Corallina officinalis L.
Cruoria pellita (Lyngb.) Fr.
Erythrodermis traillii (Batters) Guiry et Garbary
Erythrotrichia carnea (Dillwyn) J. Agardh *
Gelidium latifolium (Grev.) Bornet *
Gelidium microdon Kütz.
Gelidium pusillum (Stackh.) Le Jol.
Gelidium sesquipedale (Clemente y Rubio) Thur.
Gigartina pistillata (S.G. Gmelin) Stackh.
Gracilaria verrucosa (Huds.) Papenf. [previous record requiring investigation]
Grateloupia filicina (J.V. Lamour.) C. Agardh
Griffithisia corallinoides (L.) Trevisan
? Griffithsia devoniensis Harvey *
Gymnogongrus crenulatus (Turner) J. Agardh
Gymnogongrus griffithsiae (Turner) Martins
Gymnothamnion elegans (C. Agardh) J. Agardh *
Haliptylon virgatum (Zanardini) Garbary et H.W. Johans. *
Halurus flosculosa (J. Ellis) Maggs et Hommergand
Hildenbrandia sp. * [only sterile material found]
Hypnea cervicornis J. Agardh
Hypnea musciformis (Wulfen) J.V. Lamour.
Jania adhaerens J.V. Lamour.
Jania longifurca Zanardini
Jania rubens (L.) J.V. Lamour
Kallymenia reniformis (Turner) J. Agardh
Laurencia obtusa (Huds.) J.V. Lamour.
Liagora divaricata C.K. Tseng *
Lomentaria articulata (Huds.) Lyngb.
Melobesia membranacea (Esper) J.V. Lamour.
Nemalion helminthoides (Velley) Batters
Osmundea (Laurencia) hybrida (DC) K.W. Nam
Osmundea (Laurencia) pinnatifida (Huds.) Stackh.
Peyssonnelia squamaria (S.G. Gmel.) Dcne *
Phyllophora crispa (Huds.) P.S. Dixon
Plocamium cartilagineum (L.) P.S. Dixon
Polysiphonia atlantica Kapraun et J.N. Norris
Polysiphonia brodiei (Dillwyn) Spreng. *
Polysiphonia denudata (Dillwyn) Harvey *
Polysiphonia fucoides (Huds.) Grev.
Polysiphonia havanensis Mont.
Polysiphonia opaca (C. Agardh) Moris et De Not.
Polysiphonia spinulosa Grev.

Polysiphonia stricta (Dillwyn) Grev. *
Pterocladia capillacea (S.G. Gmel.) Bornet.
? Pterothamnion crispum (Ducluz.) Nägeli *
Rhodophyllis divaricata (Stackh.) Papenf.
Rhodymenia holmesii Ardiss.
Schimmelmannia ornata Schousb. *
Schizymenia dubyi (Duby) J. Agardh
Schottera nicaeensis (Duby) Guiry et Hollenb.
Sphaerococcus coronopifolius Stackh.
Spyridia filamentosa (Wulfen) Harvey *
Stenogramme interupta (C. Agardh) Harvey
Symphyocladia marchantioides (Harvey) Falkenb. *
Tenarea tortuosa (Esper) Me Lemoine

At Ponta Delgada (Fig. 2), the moderately exposed intertidal shore was characterised by a band of *Littorina* spp. which extended from high water level to lower littoral levels, and by an extensive band of barnacles from below high water level to just above low water level. The intertidal vegetation was characterised by patches of the crustose coralline alga *Tenarea tortuosa* together with filamentous green and brown algae, and *Corallina* spp. A zone of dense algal turf occurred below the barnacle zone (in the surge zone at infralittoral fringe levels) and assemblages were characterised by *Stypocaulon scoparium* and *Centroceras clavulatum* (with *Chondracanthus acicularis*, *Caulacanthus ustulatus*, *Griffithisia* sp., and *Jania* spp.). Heavy swell and surge prevented investigation between low water level and 6m depth. Between 6m and 16m depth (to 200m offshore) the vegetation was mainly of extensive stands of the brown alga *Zonaria tournefortii* which grew 0.3m high, and occasional stands of the feathery brown alga *Stypocaulon scoparium*. Associated underflora species included *Dictyota* spp., *Jania* spp., *Haliptylon virgatum, Cladophora prolifera, Sargassum* sp. and *Acrosorium venulosum* (often as an epiphyte). A generally uniform subtidal vegetation was recorded.

At Porto Baleia, near Santa Cruz, a moderately wave-exposed shore was investigated. Upper littoral levels were characterised (Fig. 3) by successive zones of littorinids, barnacles (at middle shore levels), and at lower shore levels by an algal turf. Tufts of *Gelidium microdon* occurred at midlittoral levels. At lower littoral levels a dense turf comprised principally *Corallina* spp., but also with *Caulacanthus ustulatus, Centroceras clavulatum, Chondracanthus acicularis* and *Osmundea pinnatifida. Pterocladia capillacea* and *Asparagopsis armata* were co-dominant at infralittoral fringe levels. The shallow subtidal shore sloped steeply down to 20m depth; that between 0m and 7m was not investigated in detail due to heavy wave-action but was characterised by an extensive zone of crustose Corallinaceae. *Padina pavonica* and *A. armata* were dominant species at 11m and 15m depth; between 22m and 30m depth (200m along the line) a relatively uniform vegetation was characterised by extensive stands of *Zonaria tournefortii* overlaying crustose Corallinaceae, *Peyssonnelia* spp., *Dictyota* spp. and *A. armata*.

The transect in the sheltered Santa Cruz Bay (Fig. 4) provided an opportunity to investigate shallow subtidal shores of only a few metres depth. A steeply sloping cliff supported yellow lichen and *Verrucaria* zones at supralittoral and littoral fringe levels, a barnacle and *Verrucaria* sp. zone at lower levels, and at the base of the cliff (just above low water level), a species-rich algal turf comprising the genera *Cladophora, Cladophoropsis, Caulacanthus, Hypnea, Gelidium, Centroceras, Valonia, Ulva* and *Corallina*. The vegetation over rocks at shallow subtidal levels (1m depth, 50m along the line) comprised a turf of *Corallina* spp. and *Amphiroa* spp. At a greater distance offshore but still in shallow water (1 -3m), *Stypocaulon scoparium* was the dominant species. Crustose algae (*Peyssonnelia* spp., *Aglaozonia* and Corallinaceae) formed a mosaic of underflora; at 4m depth the filamentous *Trailliella* life-history stage of *Bonnemaisonia hamifera* was locally dominant.

At Lajes, the transect (Fig. 5) traversed *Littorina* spp. and barnacle zones at upper littoral levels, a compact algal turf at upper midlittoral levels, and, at successively lower levels species-rich assemblages characterised by *Corallina* spp., *Osmundea pinnatifida* and *Ulva rigida*. The subtidal vegetation to 12m depth was a mosaic of *Stypocaulon scoparium* and *Asparagopsis armata* which formed a turf with other algae, and stands of *Corallina* spp. with *Zonaria tournefortii, Dictyota* spp. and *Asparagopsis armata*.

At Fajã Grande (Fig. 6), the extensive intertidal area supported a mosaic of algal turf assemblages characterised by different genera such as *Gelidium, Pterocladia, Stypocaulon, Jania, Laurencia obtusa*, and at infralittoral fringe levels, *Corallina*. The intertidal turf was often species-rich and not characterised by any one species. The subtidal vegetation between low water level and 200m offshore (0 - 12m depth) comprised extensive stands of *Zonaria tournefortii* overlying an underflora of crustose Corallinaceae, *Peyssonnelia* spp. and other small algae.

The flora

New species records of green, brown and red algae for the island of Flores and for the Azores as a whole were found during the field study; a provisional species checklist for Flores is given in Table 1. Examples of new records of brown algae include the diminutive, filamentous *Bachelotia antillarum* found for the first time on the Azores. The alga formed small growths a few mm long over upper littoral rocks and boulders near the harbour at Santa Cruz. The characteristic feature of this species is the stellate grouping of chloroplasts in each cell. *Bachelotia* is widespread in warm temperate and tropical seas and is known in the North Atlantic only from Portugal, Spain and France. The larger brown alga *Carpomitra cabrerae* with its characteristic sporangial structure was detected in a rock-pool also at Santa Cruz; the species is otherwise known from Terceira and Formigas in the Azores. The *Aglaozonia* (sporophyte) stage of *Cutleria multifida, Cystoseira foeniculaceus, Leathesia difformis, Myrionema strangulans* and *Sargassum cymosum* were all recorded on the island for the first time, and are known from other islands in the archipelago. Knotted Wrack (*Ascophyllum nodosum*) was

commonly found as driftweed, and *Fucus* was only found as germlings in the harbour at Lajes.

New records of green algae for the Azores and found on Flores include the diminutive filamentous *Derbesia marina* and its pea-like *Halicystis* (gametophyte) stage, and *Pedobesia lamourouxii* which occurred in shallow waters near Santa Cruz; both species are known from the warmer seas of southern Europe and the Mediterranean, but the former also occurs in cooler northern seas. *Codium fragile* was also found for the first time on the Azores; it grew in shallow standing water at Santa Cruz. Our material had utricles measuring 140µ - 300µ in diameter towards the apex, and 610µ - 740µ long; utricles were occasionally mucronate, mucrons measuring approximately 10µ in length. Hair scars were not seen. Our material therefore was not subspecies *tomentosoides*, but close to ssp. *atlanticum*, *scandinavicum* or *nova-zeelandicum*. Subspecies *atlanticum* and *scandinavicum* are known from France and Spain. Other new species records for Flores, but known elsewhere in the archipelago, include *Anadyomene stellata*, *Blidingia minima*, *Chaetomorpha pachynema*, *Cladophoropsis membranacea*, *Codium decorticatum*, *C. tomentosum*, *Enteromorpha prolifera* and *Microdictyon calodictyon*. The membranous net-like *M. calodictyon* grew as only very small growths in the Santa Cruz area at subtidal levels to 30m depth and sometimes as an epiphyte on larger algae such as *Zonaria*.

Red algae grew abundantly around the island; although no new records for the Azores have so far been recorded, much material remains to be examined. New records for the island include *Acrosorium venulosum* (a common subtidal epiphyte), *Aglaothamnion byssoides*, *Amphiroa beauvoisii, A. rigida*, *Caulacanthus ustulatus*, *Champia parvula*, *Corallina elongata*, *Erythrotrichia carnea*, *Gelidium latifolium*, *Haliptylon virgatum*, *Gymnothamnion elegans*, *Liagora divaricata*, *Schimmelmannia ornata* and *Spyridia filamentosa*. The small, creeping, flat, *Symphyocladia marchantioides*, an alien species originally from New Zealand and now common on the islands of Faial and Pico, was detected in the harbour at Santa Cruz. *Chondrus crispus* does not occur on the island, and material has been redetermined as *Gymnogongrus crenulatus*.

Species from the following genera remain to be identified: *Aglaothamnion*, *Crouania*, *Chondria*, *Gelidiella*, *Giffordia*, *Griffithsia*, *Herposiphonia*, *Lobophora*, *Lophosiphonia*, *Peyssonnelia*, *Polysiphonia*, *Pterosiphonia*, *Rhodymenia* and *Sphacelaria*; most of these are common throughout the Azores. Other material presenting difficulty in identification are the soft, gelatinous, foliose plants superficially resembling *Schizymenia* or *Platoma*, or *Nemastoma* or *Predaea*; we suspect that some of our material may be of the last genus. Crustose Corallinaceae, widespread and common on Flores at all shore levels, are also awaiting precise determination.

DISCUSSION AND CONCLUSION

The results we present here are preliminary and much remains to be done with our

collections. Most of the species assemblages described from the transect and quadrat observations occur elsewhere in the Azores, but not very commonly in the North Atlantic. The subtidal algal vegetation at many sites was characterised by stands of *Zonaria tournefortii* which were only found in deeper waters on the island of Faial; the extensive Corallinaceae-dominated turfs found down to 30m depth on Faial (NETO & TITTLEY, 1996) were nowhere as extensive on Flores .

We have provisionally identified some intertidal biotopes which appear similar to those in HISCOCK'S (1995) "Classification of benthic marine biotopes of the north-east Atlantic"; subtidal biotopes were quite different from those on northern Atlantic shores as the large kelps are mostly absent on Flores and in the Azores generally. At intertidal (upper littoral fringe) levels we detected biotopes which corresponded to "*Verrucaria* with sparse barnacles" (VER.B) (see HISCOCK, 1995 for explanation of classification and abbreviations) or "*Verrucaria maura*" (VER.VER); at lower littoral fringe levels in areas of freshwater run-off or unstable surfaces we recorded the "*Enteromorpha*" (ENT) biotope. At upper eulittoral levels in exposed situations we recorded biotopes corresponding to the "Barnacles & *Patella vulgata*" (BP) although a different limpet species is present on the Azores. In shallow pools we detected the "Coralline crusts & *Corallina officinalis*" (COR). Although *Fucus spiralis* occurs on the Azores and is recorded for Flores it does not form the distinct biotope (FSP) common on shores in the North Atlantic. At lower eulittoral levels the "*Corallina*" (RED.COR) and "Red algal turf" (RED) biotopes were common together with COR. The sublittoral fringe on Flores supports biotopes characterised by either *Corallina spp.*, *Pterocladia capillacea* or *Asparagopsis armata*.

SCHMIDT (1931) recorded 19 species associations at littoral levels; those we commonly found on Flores included his '*Enteromorpha*', '*Gelidium microdon*', '*Laurencia obtusa*', '*Caulacanthus ustulatus-Chondracanthus acicularis*-Ceramiaceae', '*Corallina elongata*', and '*Gelidium pusillum-Codium adhaerens*'associations. We will describe the intertidal and subtidal algal assemblages in more detail following determiniation of our samples and numerical analysis of the quadrat data.

The diversity of algae on Flores is lower than elsewhere on the Azores with only approximately one-half of the total algal flora so far recorded. We have added considerably to the 83 species listed by NETO (1994) and the total currently stands at 126. We expect this total to increase considerably after further work on our collections. Species recorded by others and missed by us include the green alga *Halimeda tuna* found by FRALICK & HEHRE (1990), known from the Mediterranean and Caribbean Seas, Canary Islands and Senegal, the Flores record representing its northern limit of distribution in the Atlantic. The mucilaginous brown alga *Liebmannia leveillei* and the larger brown alga *Fucus spiralis* are old records but both are known from the warm temperate region of the Atlantic Ocean. Red algae missed include *Gracilaria gracilariopsis*, *Nemalion helminthoides*, *Rhodyophyllis divaricata* and *Schottera nicaeensis*; all are known from elsewhere in the Azores archipelago, and our missing them probably indicates fluctuations in populations.

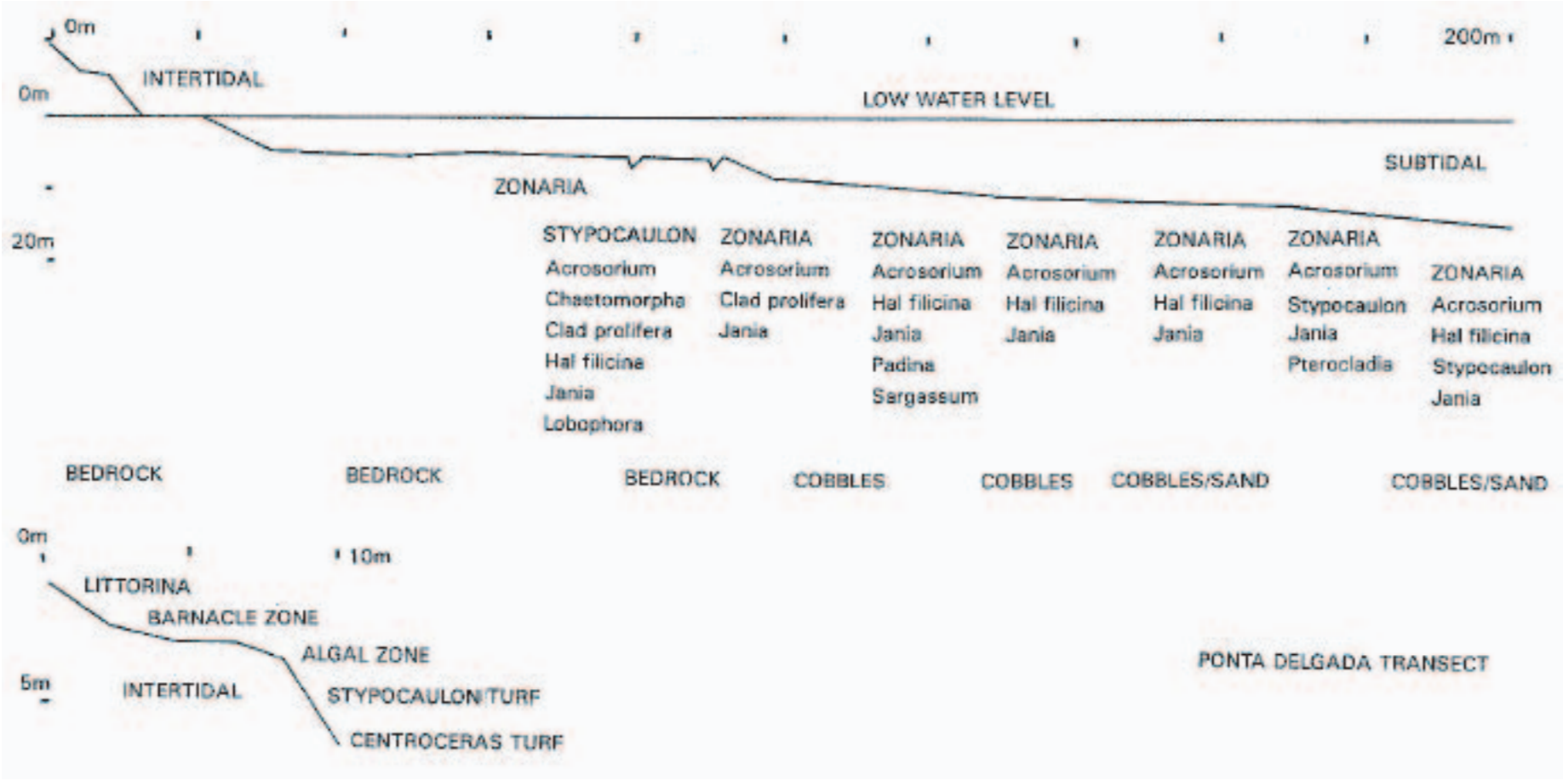

Fig. 2 - Ponta Delgada transect.

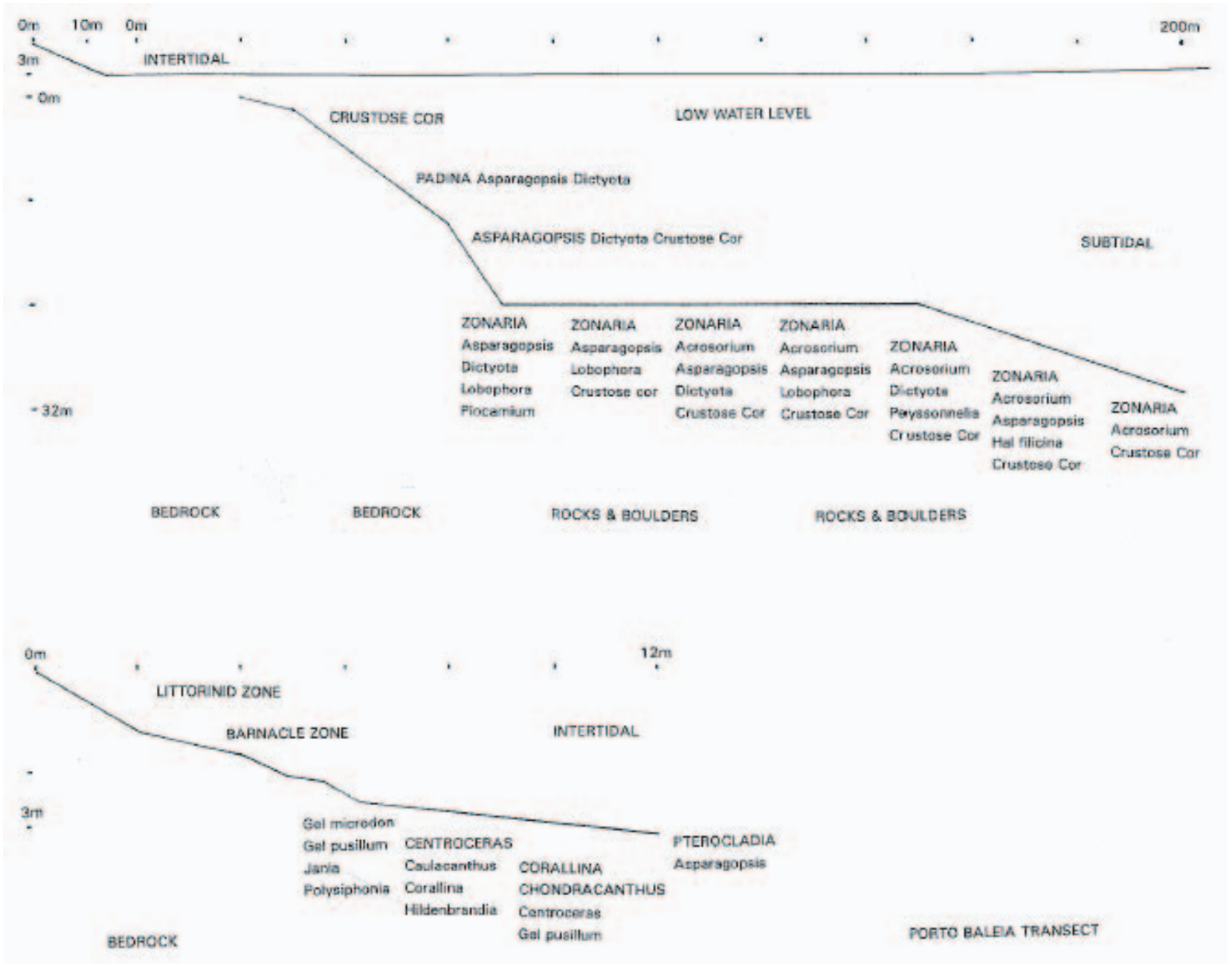

Fig. 3 - Porto Baleia transect.

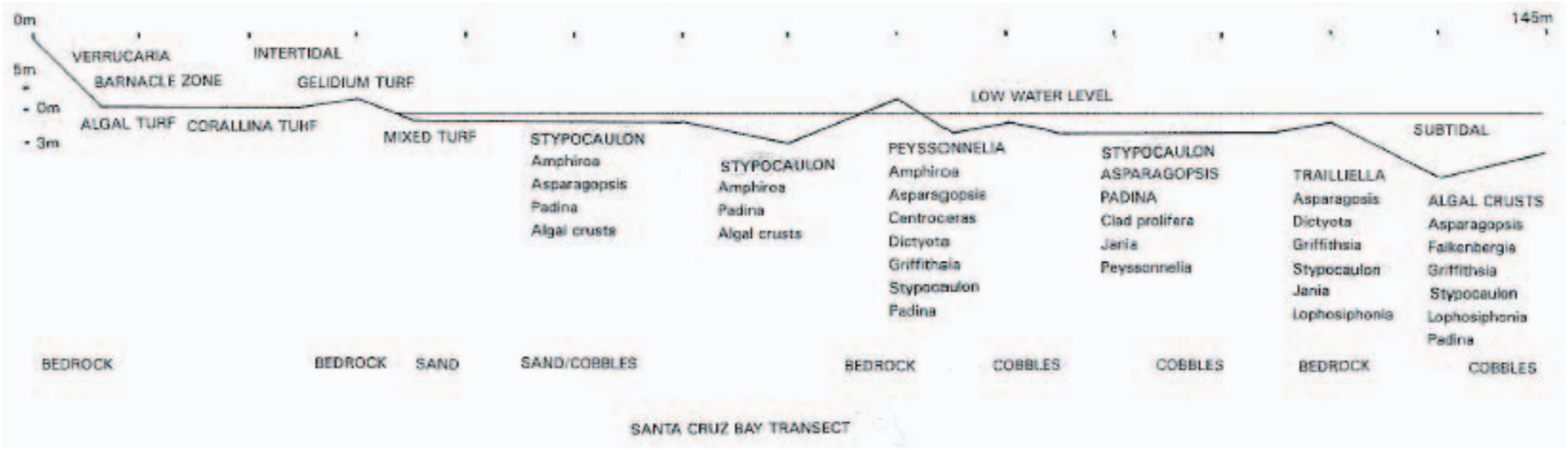

Fig. 4 - Santa Cruz Bay transect.

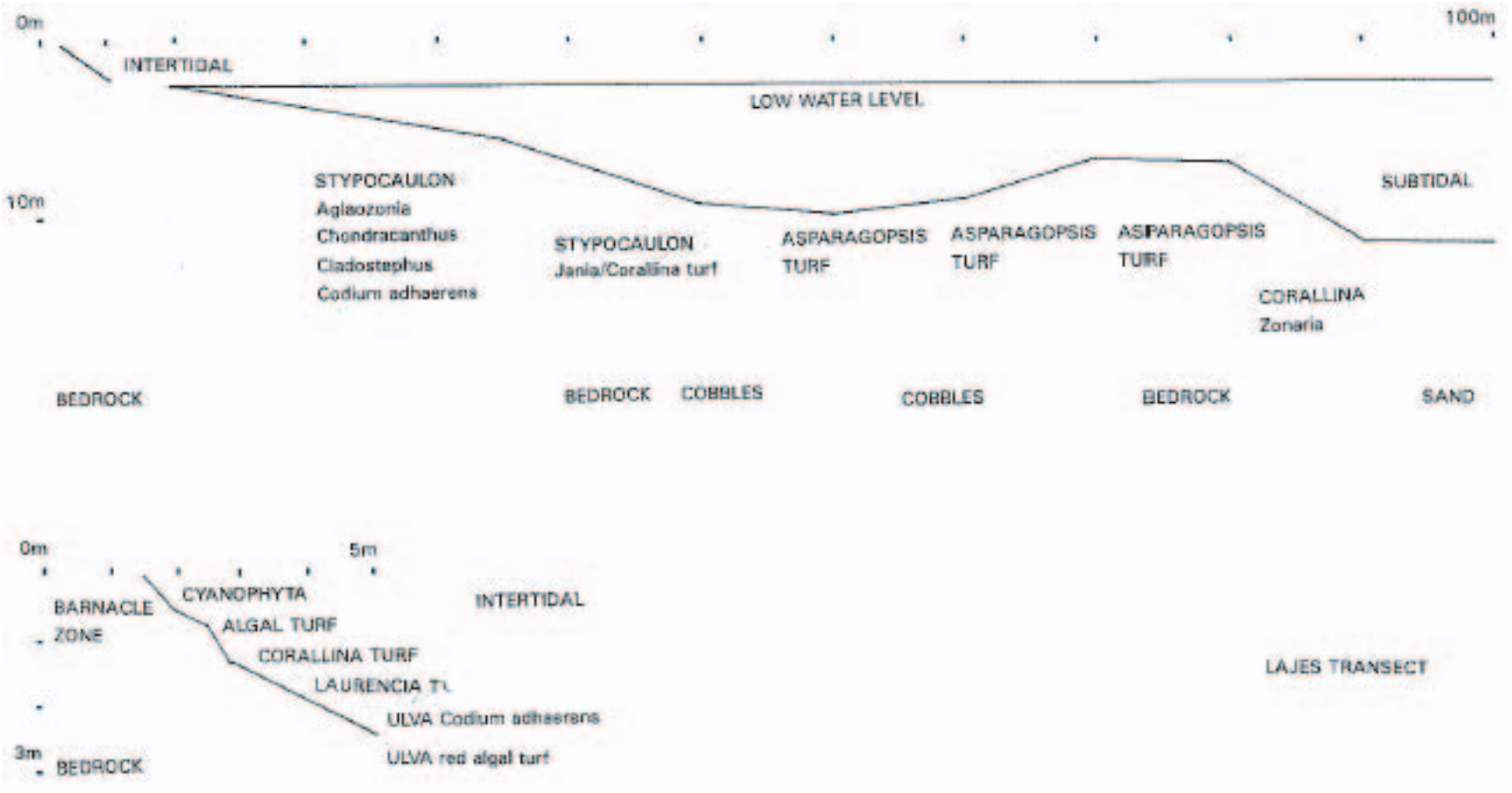

Fig. 5 - Lajes das Flores transect.

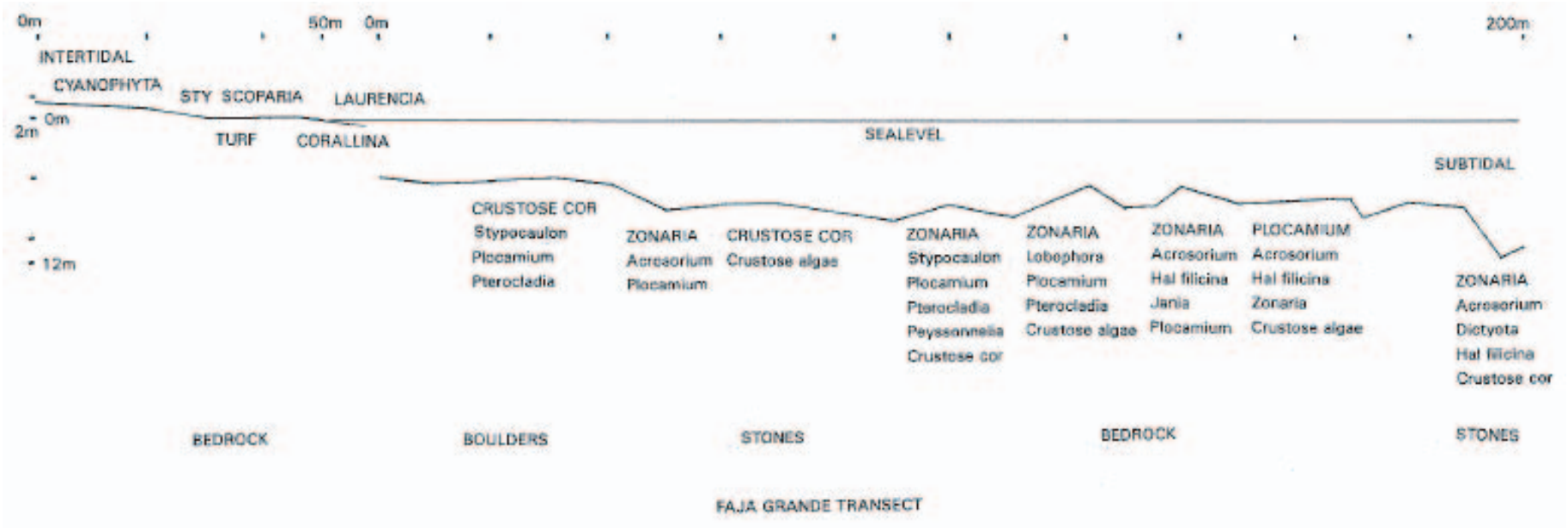

Fig. 6 - Fajã Grande transect.

ACKNOWLEDGEMENTS

The field expedition was financially supported by Earthwatch, with man-power from Earthwatch Volunteers and students and colleagues from the Universities of the Azores, Porto, Algarve and Portsmouth. We are grateful to the following organisations for their support and help, Air Azores (SATA), British Council Lisbon, Azores Regional Ministry of Education and Staff of the Escola Preparatoria de Santa Cruz das Flores, Presidents of the Municipalities of Corvo, Santa Cruz das Flores, Lajes das Flores, Ministerio da Defesa Nacional: Navy of the Republic of Portugal, Capitania do Porto de Santa Cruz, Forestry Department, Agriculture Department, and Rescue Service (Bombeiros) of Santa Cruz.

REFERENCES

FRALICK, R.A. & E.J. HEHRE:

1990. Observations on the marine algal flora of the Azores II. A check list of the Chlorophyta from the Azores. *Arquipélago* **8**: 11-17.

GAIN, L.:

1914. Algues provenant des campagnes de "l'Hirondelle" II (1911-1912). *Bulletin de l'Institute Océanografique* **279**: 1-23.

HISCOCK, K.:

1995. *Classification of benthic marine biotopes of the north-east Atlantic. Proceedings of a BioMar-Life workshop held in Cambridge 16-18 November 1994*. Joint Nature Conservation Committee, Peterborough.

NETO, A.I.:

1992. Contribution to the taxonomy and ecology of the Azorean benthic marine algae. *Biological Journal of the Linnean Society* **46**: 163-176.

1994. Checklist of the benthic marine macroalgae of the Azores. *Arquipélago*, **12A**: 15-34.

1997. Studies on algal communities of São Miguel, Azores. Tese de Doutoramento, Universidade dos Açores, Ponta Delgada, x + 309 pp.

NETO, A.I. & J.N. AZEVEDO:

1990. Contribuição para o estudo dos padrões de zonação litoral da ilha das Flores. *Flores/89, Relatório Preliminar, Relatórios e Communicações do Departamento de Biologia* **18**: 89-102.

NETO, A.I. & H.P. BALDWIN:

1990. Algas marinhas do litoral das ilhas do Corvo e Flores. *Flores/89, Relatório Preliminar, Relatórios e Communicações do Departamento de Biologia* **18**: 103-111.

NETO, A.I. & I. TITTLEY:

1996. Structure and zonation of algal turf communities on the Azores: a numerical approach. *Boletim do Museum Municipal do Funchal,* **Supl. n°4**: 487-504. PRUD'HOMME VAN REINE W.F. 1988. Phytogeography of seaweeds of the Azores. *Helgoländer Meeresuntersuchungen* **42**: 165-185.

PRUD'HOMME VAN REINE, W.F. & C.VAN DEN HOEK:

1988. Biogeography of Capeverdean seaweeds. *Courier Forschungs-Institut Senckenberg* **105**: 35-49.

1990. Biogeography of Macaronesian seaweeds. *Courier Forschungs-Institut Senckenberg* **129**: 55-73.

SCHMIDT, O.C.:

1929. Beiträge zur Kenntnis der Meeresalgen der Azoren I. *Hedwigia* **69**: 95-113.

1931. Die marine vegetation der Azoren in ihren Grundzügen dargestellt. *Bibliotheca Botanica* **24**: 1-116.

TITTLEY, I. & A.I. NETO:

1994. "Expedition Azores 1989": Benthic marine algae (seaweeds) recorded from Faial and Pico. *Arquipélago* **12A**: 1-13.

1996 The marine algal flora of the Azores and its biogeographical affinities. *Boletim do Museu Municipal do Funchal.* **Supl. n° 4**: 747-766.

TITTLEY, I., G.L.J. PATERSON, P.J.D. LAMBSHEAD & G.R. SOUTH:

1990. Algal provinces in the North Atlantic- do they exist? In: *Evolutionary Biogeography of the North Atlantic* (Eds. Garbary D.J. & G.R. South). NATO ASI Series Vol. **G 22**, pp.291-322. Springer Verlag, Berlin.

TRELEASE, W.:

1897. Botanical observations on the Azores. *Eighth Annual Report of the Michigan Botanical Garden*: 77-220.