

SUBLITTORAL EPIBENTHIC COMMUNITIES AROUND FUNCHAL (ILHA DA MADEIRA, NE ATLANTIC)

By C. NIKE BIANCHI¹, CARLA MORRI², GIANFRANCO SARTONI³ &
PETER WIRTZ⁴

With 3 figures

ABSTRACT. The main epibenthic communities and their zonation were studied down to about 25 m depth in six sites along the southern coast of the Island of Madeira. Subsequent belts of *Chthamalus stellatus*, *Corallina elongata* and *Cystoseira abies-marina* characterised the midlittoral to infralittoral transition on exposed rocks; immediately below, to about 5 m depth, there was a mixed algal belt dominated by *Sargassum filipendula*. Deeper infralittoral rocks, down to about 15-20 m depth, were inhabited by two major communities: one with a rich algal cover, dominated by species of Dictyotales (especially *Zonaria tournefortii* and *Styopodium zonale*); the other characterised by an almost bare substratum because of the grazing activity of the sea-urchin *Diadema antillarum*. Circalittoral enclaves, with animal dominance, occupied overhangs and caves. "Gardens" of the conger-eel *Heteroconger longissimus* were the most conspicuous feature of the volcanic sands at the base of the littoral rock. The physiognomy of most of the observed assemblages was reminiscent of their Mediterranean analogues; however, the dominant species were more often amphiatlantic tropical rather than Mediterranean-Atlantic elements. Comparison with information taken in 1983 showed that no dramatic change occurred in the epibenthic communities of Madeira, but two conspicuous algae with tropical affinity (*Sargassum filipendula* and *Styopodium zonale*) had not been observed in a previous study done in the same sites with similar methods: there is no clear evidence as to whether the two species were overlooked in the past or rather are cases of recent colonisation or increased abundance due to climatic change.

¹ Marine Environment Research Centre, ENEA Santa Teresa, P.O. Box 316, I-19100 LA SPEZIA (Italy)

² Istituto di Zoologia, Università, via Balbi 5, I-16126 GENOVA (Italy)

³ Dipartimento di Biologia Vegetale, Università, via La Pira 4, I-50121 FIRENZE (Italy)

⁴ Centro de Ciências Biológicas e Geológicas, Universidade da Madeira, Largo do Colégio, P-9000 FUNCHAL (Portugal)

INTRODUCTION

Madeira, roughly located around 32°45' N and 17° W, is the largest island of the archipelago bearing the same name and including also Porto Santo and the smaller Desertas (Fig. 1).

The Archipelago of Madeira is part of Macaronesia, a heterogeneous group of oceanic islands located in the mid-Atlantic (BÁEZ & SÁNCHEZ-PINTO, 1983; BEYHL *et al.*, 1995). Due to its geographic position, this group of islands has attracted the interest of marine biogeographers since the last century. Although in modern marine biogeography Macaronesia is not regarded as a biogeographic unit (PRUD'HOMME VAN REINE & VAN DEN HOEK, 1990), it does embrace the western outpost of the Mediterranean-Atlantic Region (BRIGGS, 1974).

Many scientific expeditions from several European countries have collected marine biological samples in the Arquipélago da Madeira, the most recent being those of the CANCAP series, led by Dutch scientists (VAN DER LAND, 1987). Thanks to collections from expeditions and investigation by local institutions (Museu Municipal do Funchal and Universidade da Madeira), the knowledge of the marine flora and fauna of Madeira is slowly accumulating. WIRTZ (1994a, 1995a) has recently been able to produce the first field guides to the identification of marine fish and invertebrates, although some information on submarine life of Madeira was already present in the identification guide of SALDANHA (1980, 1995).

Beside basic taxonomy, however, little has been done on bionomic aspects such as identification and description of the benthic communities of Madeira. LEDOYER (1967) described the vagile fauna assemblages of different biotopes, whereas CABIOCH (1974) studied the algal vegetation of maërl (sea-bottom dominated by free lithothamnia). CANCELA DA FONSECA *et al.* (1995) studied the macrozoobenthos of the upper level sediments of Porto Santo. AUGIER (1985, 1986) described and mapped the main marine epibenthic biocoenoses around Funchal, on the southern coast of the Island of Madeira. ANDRADE & ALBUQUERQUE (1995) reported on the benthic fish fauna of the same region.

In October 1993, we had the opportunity of carrying out a number of SCUBA diving biological surveys in the same region. This paper will present the results of this investigation, with two major aims: 1) continuing and updating the observations made by AUGIER (1985, 1986) in 1983; and 2) comparing the physiognomy and zonation of the epibenthic communities observed at Madeira with those described from the Mediterranean Sea.

METHODS

Biological surveys were conducted by SCUBA diving in six sites around Funchal (Fig. 1): **a)** Ponta Gorda, **b)** Recife do Carneiro, **c)** Ilhéu Gorgulho, **d)** Ponta do Clube Naval, **e)** Praia do Garajau, **f)** Caniço de Baixo. One of our sites (Ilhéu Gorgulho) coincided with transect R1 of AUGIER (1985), while another one (Ponta do Clube Naval) was partly in continuity with AUGIER's transect R3.

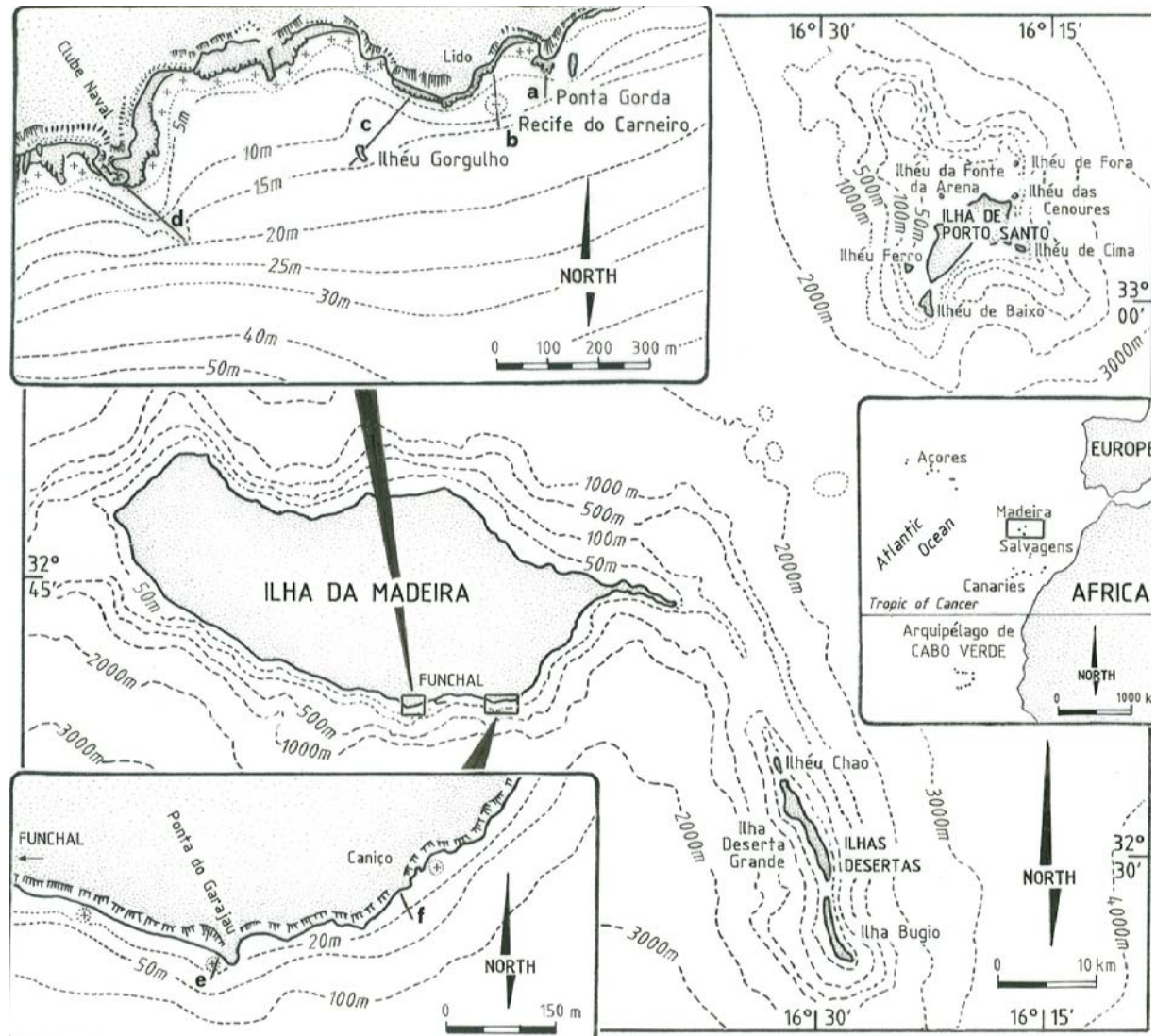


Fig. 1 - The Arquipélago da Madeira with location of study sites (insets: **a** to **f**) around Funchal on Ilha da Madeira.

Biological observations were organised along depth-transects roughly perpendicular to the shore (Fig. 2). Horizontal distances were taken from maps (British Admiralty Charts nos. 1831 and 1689) and are thus simply indicative (no metric line was used). Depths were measured with a diving computer, and subsequently corrected with tide datum: consequently, 0 on our transects (Fig. 2) is the hydrographical zero. Maximum depth reached was 25 m.

Epibenthic communities were identified through a physiognomic approach (BIANCHI *et al.*, 1991) by visual and photographic survey techniques (ROS & GILI, 1984; BALDUZZI *et al.*, 1986). Swimming along each depth-transect, divers annotated on a diving slate the presence of conspicuous (for size and/or abundance) sessile or sedentary species. The occurrence of some of the most important associated vagile fauna was also annotated for the sake of completeness. Photographs of conspicuous species were taken through a UW camera equipped with a wide-angle (15 mm) UW lens.

RESULTS

Topography and bottom morphology (Fig. 2)

Transect a – The littoral cliff of Ponta Gorda ended with a basal notch at about 5 m depth on a terrace gradually giving place to a boulder slope. A sandy floor followed at 12-14 m. The small and sheltered bay situated between Ponta Gorda and Lido (i. e., on the west side of the transect) was also investigated: the sea floor was mainly 3 to 5 m deep, with cobble and boulders.

Transect b – Recife do Carneiro is a rocky reef situated in front of the Lido do Funchal, rising from a bottom of about 12 m and topping at nearly 3 m. On the northern side of the reef, facing the Lido, a number of small caves or notches was observed at about 9 m.

Transect c – The transect started from the western side of Lido and reached Ilhéu Gorgulho, a small islet abruptly rising from a depth of 15 m at about 150 m to the south-west. The Lido cliff was interrupted at 3 m depth by a short terrace, and at 5 m by a larger one. A boulder slope followed, ending on the sandy floor at about 10 m.

Transect d – Our dives concentrated on the outer portion of the transect off Ponta do Clube Naval, on a vertical rocky cliff (known by local divers as “the wall”) starting at 12 m depth and ending at 21 m on a sandy floor.

Transect e – Praia do Garajau is the small pebbly beach situated to the west of Ponta do Garajau, a Nature Reserve. At around 10 to 15 m depth, rocks and large boulders were present on an otherwise gravely-sandy floor.

Transect f – The dive started from in front of Hotel Rocamar (Caniço de Baixo), and reached about 25 m on a sandy bottom. A short rock terrace was observed at 5 m, and a larger one at about 10-14 m. From this latter terrace, an impressive overhanging wall reached the sandy floor below.

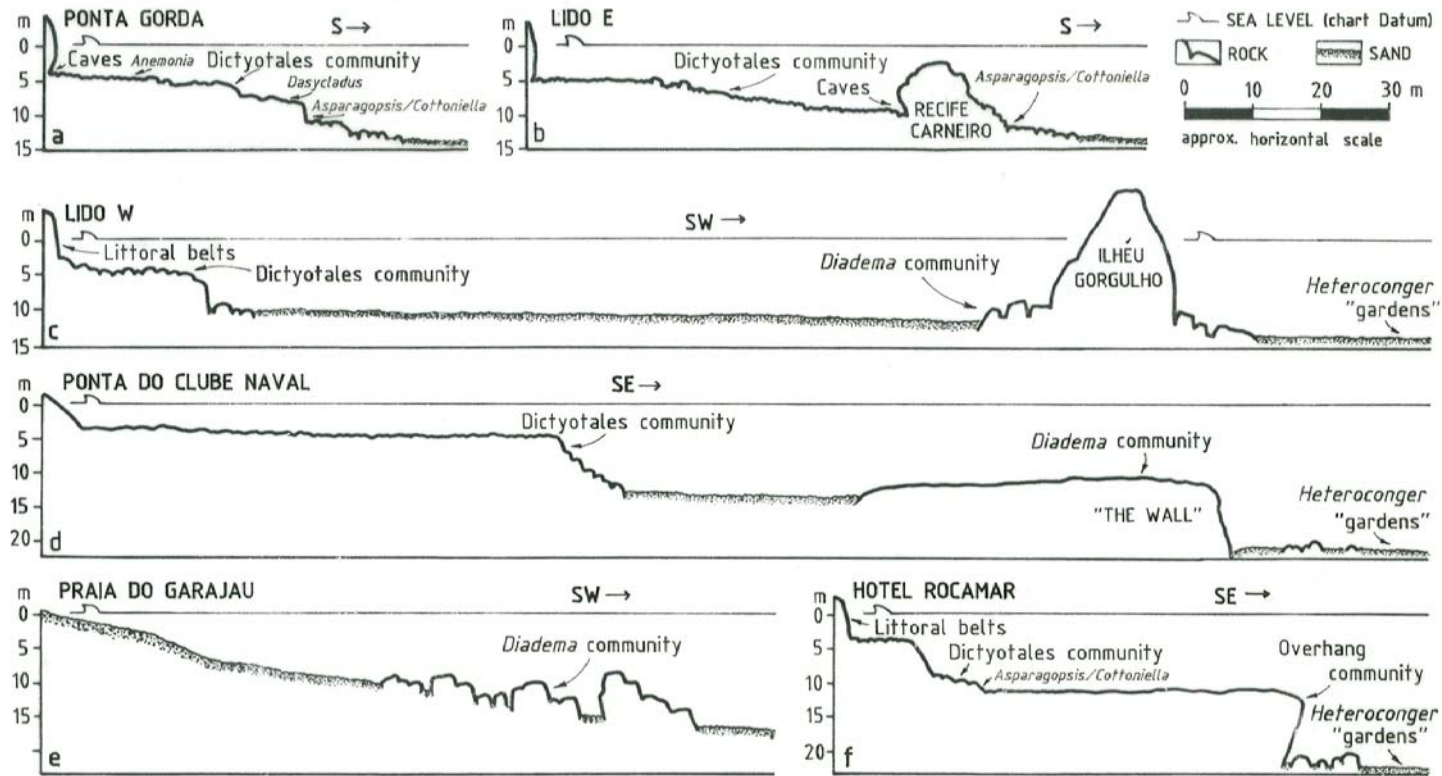


Fig. 2 - Schematic sea-bottom profiles at the six study sites; major epibenthic communities and facies are indicated (see text).

Epibenthic assemblages (Fig. 3)

Littoral belts – Although our study concentrated on the sublittoral zone, some observations on littoral assemblages were made snorkelling at Lido, in correspondence with the beginning of transect **c**. This may be considered an exposed location. Above the chart datum, three different belts were clearly recognised. The highest one was characterised by the cirriped *Chthamalus stellatus* (POLI), to which the green alga *Ulva lactuca* L. and the gastropod *Patella ulyssiponensis* GMELIN added in the lower part. The red alga *Corallina elongata* ELLIS & SOLANDER formed the second belt, and the brown alga *Cystoseira abies-marina* (GMELIN) C. AGARDH the third and lower one. (The *Cystoseira* belt was also observed at transect **f**.) Below chart datum, down to about 5 m depth, there was a multispecific algal assemblage, with a canopy of the brown alga *Sargassum filipendula* C. AGARDH and a lower storey with mixed algae such as *Codium adhaerens* (CABRERA) C. AGARDH, *Pterocladia capillacea* (GMELIN) BORNET & THURET and *Stypocaulon scoparium* (L.) KÜTZING. No conspicuous associated vagile fauna was noticed in the field. Among the fish, *Oblada melanura* (L.) and *Trachynotus ovatus* (L.) were common.

Dictyotales community – Sublittoral rocks and boulders in relatively sheltered locations (e. g., transects **a** and **b**) exhibited a rich algal cover dominated by species of Dictyotales, especially between 5 and 12 m depth. *Zonaria tournefortii* (LAMOUROUX) MONTAGNE constituted dense canopies on the higher stratum, but *Styopodium zonale* (LAMOUROUX) PAPENFUSS, *Dictyota neglecta* HÖRNIG & SCHNETTER and, to a lesser extent, *Padina pavonica* (L.) LAMOUROUX were also frequent. The green alga *Dasycladus vermicularis* (SCOPOLI) KRASSER formed small mats on horizontal substrates covered by some sands, while on vertical surfaces, particularly in the deepest parts, the red algae *Asparagopsis armata* HARVEY and *Cottoniella filamentosa* (HOWE) BØRGESEN formed nearly monospecific stands. The vagile associated fauna finding shelter amidst the algal canopies was abundant and diverse, and included molluscs, such as *Haliotis tuberculata* L., *Charonia lampas lampas* (L.), *Hexaplex trunculus* (L.), *Astraea rugosa* (L.), *Erosaria spurca* (L.), *Octopus vulgaris* CUVIER; crustaceans, such as *Stenorhynchus lanceolatus* (BRULLÉ), *Maya squinado* (HERBST), *Percnon gibbesi* (H. MILNE-EDWARDS); and echinoderms, such as *Diadema antillarum* PHILIPPI, *Sphaerechinus granularis* (LAMARCK), *Ophidiaster ophidianus* (LAMARCK), *Marthasterias glacialis* (L.). Among the numerous fish, the following were recognised as abundant: *Synodus synodus* (L.), *Muraena augusti* (KAUP), *Serranus atricauda* GÜNTHER, *Diplodus vulgaris* (E. GEOFFROY SAINT-HILAIRE), *Diplodus sargus cadenati* DE LA PAZ, BAUCHOT & DAGET, *Diplodus cervinus cervinus* (LOWE), *Oblada melanura*, *Pomadasis incisus* (BOWDICH), *Chromis limbatus* (VALENCIENNES), *Abudefduf luridus* (CUVIER), *Thalassoma pavo* L., *Centrolabrus trutta* (LOWE), *Sparisoma (Euscarus) cretense* (L.), *Scorpaena maderensis* VALENCIENNES, *Canthigaster rostrata* (BLOCH), *Sphoeroides marmoratus* (LOWE). Sessile and sedentary fauna was relatively

inconspicuous within the algae, with the exception of the sheltered pebble and boulder bottom of the small bay between Ponta Gorda and Lido, around 5 m depth. Here, frondose algae were scarcer and the zooxanthellate anthozoan *Anemonia viridis* (FORSSKÅL) dominated. Other important sessile animals were the hydroid *Halocordyle disticha* (GOLDFUSS), the fan-mussel *Pinna rudis* L., and especially two sponges possessing symbiotic cyanobacteria or zoocyanellae (SARÀ, 1965): *Petrosia ficiformis* (POIRET) and *Aplysina aerophoba* SCHMIDT, the latter with the opisthobranch *Tylodina perversa* (GMELIN).

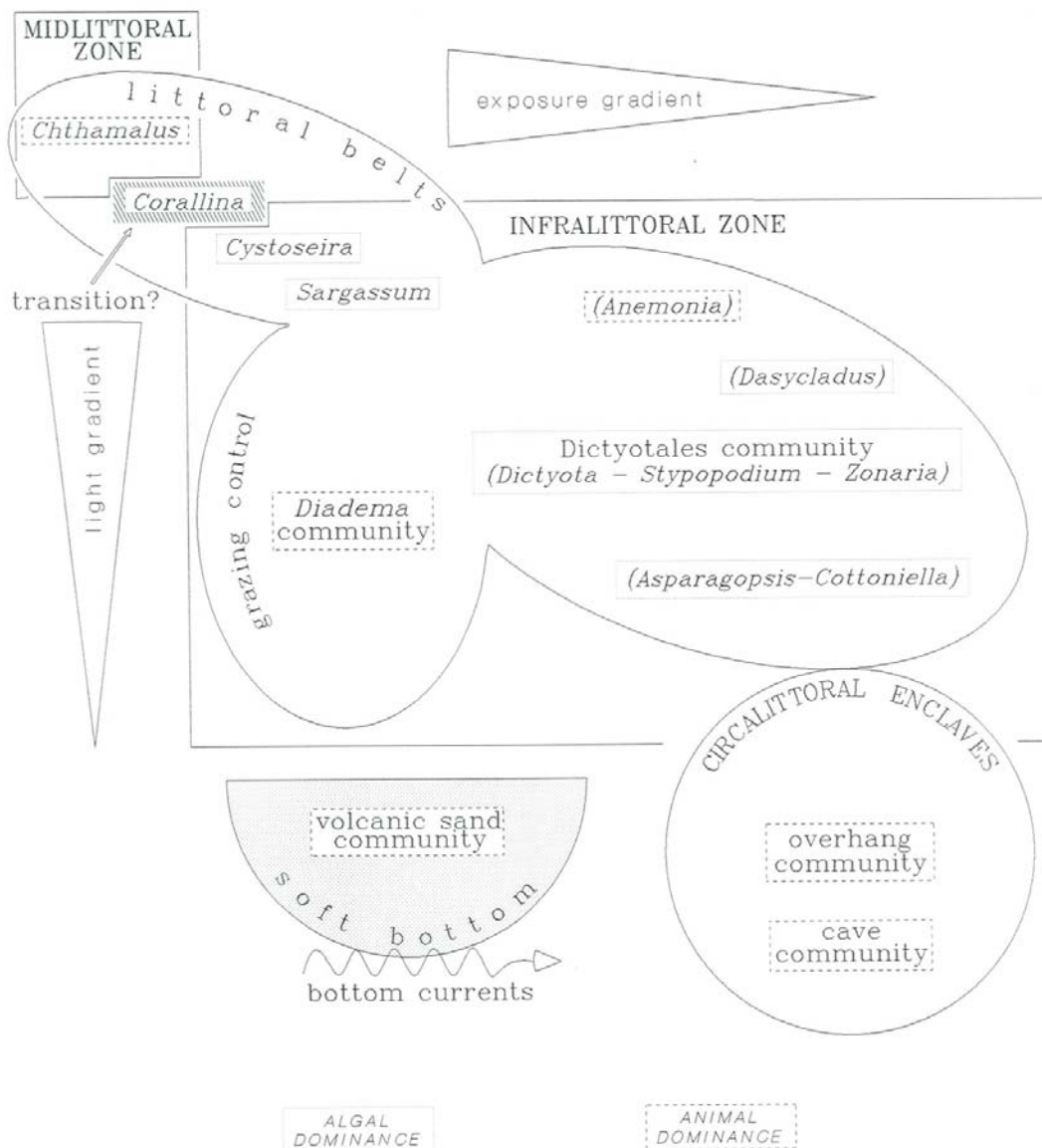


Fig. 3 - A schematic synopsis of the major marine epibenthic communities and facies observed around Funchal (see text), together with indication of the main ecological factors supposed to act upon them.

Diadema community – At relatively more exposed sites, subtidal rocks appeared nearly bare and showed an extreme abundance of the sea-urchin *Diadema antillarum*. This was especially the situation observed at Ilhéu Gorgulho (transect **c**) and Garajau (transect **e**) at 10-15 m, and along the “wall” off Ponta do Clube Naval (transect **d**), 12 to 20 m depth. Algal cover was extremely poor, almost completely restricted to encrusting corallines. Sessile animals were similarly represented mostly by encrusting sponges, such as *Batzella inops* (TOPSENT), and bryozoans, such as *Reptadeonella violacea* (JOHNSTON), together with barnacles, serpulids and vermetids. The sedentary hermit crab *Calcinus tubularis* (L.) was observed inhabiting many of the vermetid tubes. The sponge *Aplysina aerophoba* was locally abundant, forming patches up to 0.5 m² wide (Ilhéu Gorgulho). Also abundant locally were the hydroids *Aglaophenia pluma* (L.) and *Macrorhynchia philippina* KIRCHENPAUER, the latter on deep boulders (below 15 m). The colonial coral *Madracis asperula* MILNE-EDWARDS & HAIME was observed around 18 m depth on the “wall” of transect **d**. Vagile fauna other than *Diadema* was scarce: the most common species were the fire-worm *Hermodice carunculata* (PALLAS), the gastropod *Astraea rugosa*, and the crustaceans *Stenorhynchus lanceolatus* and *Leptomysis* aff. *heterophila* WITTMAN. On the contrary, fish were extremely abundant: *Synodus synodus*, *Mycteroperca fusca* (LOWE), *Serranus atricauda*, *Diplodus vulgaris*, *Diplodus sargus cadenati*, *Diplodus cervinus cervinus*, *SpondylIOSOMA cantharus* (L.), *Boops boops* (L.), *Oblada melanura*, *Chromis limbatus*, *Abudefduf luridus*, *Pseudolepidaplois scrofa* (VALENCIENNES), *Coris julis* (L.), *Thalassoma pavo*, *Sparisoma cretense*, *Scorpaena maderensis*, *Balistes carolinensis* GMELIN, *Canthigaster rostrata*. Big individuals of the grouper *Epinephelus marginatus* (LOWE) were seen in the Nature Reserve of Garajau.

Circalittoral enclaves – The term “enclave” is here intended to mean the presence, due to microclimatic factors, of one organismic assemblage within a different one (PÉRÈS, 1982). Owing to local reduction in light intensity, two communities showed circalittoral affinities even if observed at infralittoral depths. The overhanging cliff of transect **f**, at depths between 12 and 23 m, harboured a community dominated by relatively large sessile animals, especially sponges, such as *Callyspongia simplex* BURTON, *Axinella damicornis* (ESPER), *Acanthella acuta* SCHMIDT, and cnidarians, such as *Telmatactis cricoides* (DUCHASSAING), *Parazoanthus* sp., *Phyllangia mouchezi* MILNE-EDWARDS & HAIME, *Madracis pharensis* (HELLER). Algae were represented almost exclusively by encrusting corallines. Similarly, the small caves and notches observed at 5 m in transect **a** and at 9 m in transect **b** were dominated by animals, algae being restricted to the outer part. A number of generalist sciaphilic animals, such as the sponge *Chondrosia reniformis* NARDO, the tube-anemone *Pachycerianthus* sp., and the sea-cucumber *Holothuria forskali* DELLE CHIAJE, abounded at the cave entrance, while the scleractinians *Caryophyllia inornata* (DUNCAN) and *Madracis pharensis*, serpulids, and the brachiopod *Megathiris detruncata* (GMELIN) were common in the inner parts. The cardinal fish *Apogon imberbis* (L.) was

commonly seen in the caves.

Volcanic sand community – Sandy floors at the base of rocky cliffs or boulder slopes, at depths ranging from 13 to 25 m according to specific sites, usually appeared bare. Although we frequently saw debris of *Cymodocea nodosa* (UCRIA) ASCHERSON leaves on the sea floor, we never encountered *Cymodocea* meadows, which, however, occur at other places along the shores of Madeira (WIRTZ, 1995b). The most conspicuous feature we observed on sands were the ‘gardens’ of the conger-eel *Heteroconger longissimus* GÜNTHER a fish adopting a sedentary planctotrophic way of life thanks to the presence of bottom currents. Its distribution and ecology at Madeira have been studied by SALDANHA (1982), and ANDRADE & ALBUQUERQUE (1995) found it extremely abundant (up to 3 individuals·m⁻²) between Ilhéu Gorgulho and Ponta do Clube Naval. Other fish species frequenting sandy bottoms were *Synodus saurus* (L.), *Mullus surmuletus* L., *Pseudocaranx dentex* (BLOCH & SCHNEIDER) (young animals), *Xyrichtys novacula* (L.), *Bothus podas maderensis* (LOWE). Large schools of the small goby *Pomatoschistus pictus* (MALM) were seen swimming very close to the bottom. The most conspicuous invertebrates on sands were the polychaetes *Myxicola infundibulum* (RENIER), *Ditrupa arietina* (O. F. MÜLLER) and *Lygdamis* sp. (the last at the borderline of rocks to sand, in areas apparently enriched with organic matter), the crab *Cryptosoma cristata* (BRULLÉ), and the cuttlefish *Sepia officinalis* L.

DISCUSSION

Observations made along depth-transects allowed us to recognise recurrent morphologies on the sea floor around Funchal. Rocky terraces were observed at about 3 m, 5 m and 10-14 m depth, the deepest two being best developed. Series of small caves were observed at 5 m and 9 m. These recurrent morphologies may be indicators of sea-level lowstands of late Quaternary age: terraces might represent abrasion surfaces, caves might derive from old intertidal notches. Interpretation, however, will remain speculative until absolute dates are available.

Bottom morphologies influenced, at least in part, the distribution of the biotic assemblages we observed during our dives: terraces harboured strictly infralittoral assemblages, whereas those of overhangs and caves showed circalittoral affinities.

The littoral and infralittoral assemblages have been described by AUGIER (1985, 1986), who named them according to the phytosociological usage. Nearly all have their analogous counterparts in the rest of the Mediterranean-Atlantic Region, and particularly in the Mediterranean Sea proper, where the zonation of benthic communities has been more thoroughly studied (PÉRÈS, 1967; AUGIER, 1982). LEDOYER (1967) also compared the vagile fauna assemblages of Madeira with their Mediterranean analogues. The biogeographical relationship of Madeira to the Mediterranean has already been stressed by BRIGGS (1974).

Among the littoral belts we observed at Madeira, that of *Chthamalus* (*Chthamaletum*

stellati in AUGIER's terms) was the best characterised. The same community is found midlittorally throughout the Mediterranean, on most western European coasts, in the Canaries (LAWSON & JOHN, 1971; HAROUN TABRAUE *et al.*, 1984) and in the Azores (HAWKINS *et al.*, 1990).

Belts of *Corallina elongata* are common along all European coasts: they are midlittoral in the Azores (NETO, 1992) and on the Spanish Atlantic coast (SIERRA & FERNÁNDEZ, 1984) but typically infralittoral in the Mediterranean (BOUDOURESQUE & CINELLI, 1976; BOUDOURESQUE, 1984), although they may also occur midlittorally (BALLESTEROS, 1982). Generalisations are thus difficult, and inconsistencies may also be expected due to the great differences in the tidal regimes between the Mediterranean and the Atlantic. At Madeira, *Corallina elongata* has been considered midlittoral by LEVRING (1974) and infralittoral by AUGIER (1985); both authors identified the species as *Corallina officinalis* L. A midlittoral belt of *Corallina elongata* similar to that we saw around Funchal is described in the Canaries by ELEJABEITA *et al.* (1992), but the species is known to occur also infralittorally in the same region (HAROUN TABRAUE *et al.*, 1984; PINEDO *et al.*, 1992; REYES *et al.*, 1994). All this seems to indicate the “transitional” character, between midlittoral and infralittoral zones, of the *Corallina* belt.

Immediately below, the belt of *Cystoseira abies-marina* (denominated *Cystoseiretum abies-marinae* by AUGIER, 1985) indicated the beginning of the infralittoral zone proper (GONZÁLES & AFONSO CARRILLO, 1990), i. e., the “biological zero” (BOUDOURESQUE & CINELLI, 1976; ABBIATI *et al.*, 1991): the species of *Cystoseira* are known to be very intolerant of desiccation (EDWARDS *et al.*, 1985). Belts of *C. abies-marina* occur in the infralittoral fringe on exposed shores of the Canary Islands (GIL-RODRIGUEZ, 1980) and can be considered analogous to those formed by the Mediterranean species of *Cystoseira* typical of wave-swept biotopes (GIACCONE & BRUNI, 1973; GARCIA CARRASCOSA, 1987).

Sargassum filipendula formed a sparse belt at a few meters' depth in the infralittoral zone as in most rocky shores on both sides of the tropical Atlantic (GIL RODRIGUEZ *et al.*, 1984; LAWSON & JOHN, 1987). It may occur in both sheltered and semi-exposed sites (DE PAULA, 1988). Among the macroalgae we saw in the lower-storey of the *Sargassum* belt, *Pterocladia capillacea* is a species thriving on shaded and wave-beaten rocks (BOUDOURESQUE, 1984) and considered as characterising a separate community (*Pterocladietum capillaceae*) by AUGIER (1985).

Below the above-discussed belts, the rest of the sublittoral rocks was occupied by two major communities, one in relatively exposed sites (*Diadema* community), the other in more sheltered sites (Dictyotales community).

The *Diadema* community, called *Lithophyllo-Diademetum antillarum* by AUGIER (1985), was apparently identical to that known in the Canaries as “blanquizal” (HERRERA *et al.*, 1993). Grazing by *Diadema antillarum* is known to have a dramatic effect on algal biomass and abundance (SAMMARCO, 1982), and similar situations are known from many

tropical and temperate sites all around the world (LAWRENCE & SAMMARCO, 1982). The analogous community in the Mediterranean Sea is characterised by the grazing of *Arbacia lixula* (L.) (hence its phytosociological name *Lithophyllo-Arbacietum lixulae*: AUGIER, 1982) and by encrusting invertebrates perfectly corresponding to those seen at Madeira (BALDUZZI *et al.*, 1996).

The Dictyotales community was characterised by a luxuriant and diverse algal growth, with a rather general dominance by *Zonaria tournefortii* and, to a lesser extent, *Stypopodium zonale*. A similar community is known from the Mediterranean (BALLESTEROS *et al.*, 1984; GARCIA CARRASCOSA, 1987). There, the dominant species is often *Dictyopteris membranacea* (STACKHOUSE) BATTERS (BOISSET & GARCIA CARRASCOSA, 1987; MORRI *et al.*, 1988; BALDUZZI *et al.*, 1994); *Zonaria tournefortii* may also be abundant (GARCIA CARRASCOSA, 1987), while *Stypopodium zonale* is absent from the Mediterranean Sea (RIBERA *et al.*, 1992). In the Canaries, MEDINA *et al.* (1995) included *Stypopodium zonale* in one phytosociological association (*Stypopodio-Cystoseiretum abietis-marinae*) together with *Cystoseira abies-marina*, a species that we considered as characteristic of the infralittoral fringe at Madeira (see above). A *Zonaria* dominated community was recently described by TITTLE & NETO (1996) for the Azores.

Within the Dictyotales community of Madeira we observed different aspects or "facies" (*sensu* PÉRÈS, 1982), characterised by the local dominance of one (or two) different species: *Dasycladus vermicularis*; *Asparagopsis armata* (plus *Cottoniella filamentosa*); *Anemonia viridis* (plus sponges). All have their close analogues in the Mediterranean Sea (GIACCONE, 1972; BIANCHI & MORRI, 1983; BALLESTEROS *et al.*, 1984; GILI & ROS, 1985; COLL & MORENO, 1993; BALDUZZI *et al.*, 1994).

Similarly, the "circalittoral enclaves" consisted of communities resembling those to be found under overhangs and in caves of the Mediterranean (LABOREL, 1960). The reduced biotic cover we observed in the Madeiran caves, even within short distances from the entrance, agrees with the "confinement model" of zonation proposed by BIANCHI & MORRI (1994) chiefly for Mediterranean caves.

Finally, the volcanic sand community, characterised in our transects by the presence of *Heteroconger longissimus*, is rather original (AUGIER, 1985) and cannot be directly compared to any Mediterranean assemblage. Similar "conger-eel gardens", however, occur in most tropical seas thorough the world.

With this last exception, the epibenthic assemblages we observed at Madeira showed physiognomies and zonation patterns paralleling their Mediterranean analogues. However, the dominant species often indicated contrasting biogeographic affinities. Three cases should be distinguished.

First case: the dominant species is a Mediterranean-Atlantic species. *Chthamalus stellatus* and *Corallina elongata* are good examples of this situation.

Second case: the dominant species is a Macaronesian endemic. This is especially

the case of *Cystoseira abies-marina*, probably the best known marine example of a strict Macaronesian distribution (GONZÁLES & AFONSO CARRILLO, 1990).

Third case: the dominant species is amphi-atlantic, with either warm-temperate (e. g., *Zonaria tournefortii*) or tropical (e. g., *Diadema antillarum*, *Heteroconger longissimus*, *Sargassum filipendula*, *Styopodium zonale*) affinity.

This last is apparently the most common situation and gives Madeira marine benthos a peculiar trait. WIRTZ (1994b, 1995b) noted a decidedly tropical character of the coastal marine fauna of Madeira and gave examples of several species with tropical affinities, apparently reaching the northern limit of their range at Madeira.

The importance of communities dominated by tropical species indicates that, contrary to common opinion, Madeira represents the northern limit for southern communities within the Mediterranean-Atlantic Region, rather than the southern limit for northern communities.

As a whole, the epibenthic communities we identified around Funchal corresponded to those pionieerly identified by AUGIER (1985, 1986), and their ecological distribution was the same. AUGIER (1985) described littoral and infralittoral biocoenoses in detail, but did not treat the circalittoral zone: our observations on circalittoral enclaves may be considered a first approach. Hard-bottom circalittoral communities of the whole Macaronesia are poorly known, with the partial exception of the CANARIES (BRITO *et al.*, 1984), and call for further study.

The observations we made at transect **c** (Lido – Ilhéu Gorgulho), exactly coinciding with one of the sites of AUGIER (1985), indicated that no dramatic change has occurred in the last decade.

However, the two brown algae *Sargassum filipendula* and *Styopodium zonale* were not mentioned by AUGIER (1985) nor in previous studies on Madeira's algae (e. g., PICCONE, 1884; GAIN, 1914; MENEZES, 1926; LEVRING, 1974; see also PRUD'HOMME VAN REINE *et al.*, 1994. A checklist of the marine plants of Madeira, with some new records, is in prep. by NETO & CRAVO). Both algae were abundant at transect **c** (and *S. zonale* also in other sites) in October 1993, although we did not take quantitative data during our dives. The fact that these two species had never been recorded before may have two explanations.

The first considers that they were present but were overlooked by earlier authors, due to confusion with other algae. Species distinction within the genus *Sargassum*, for instance, is difficult (DE PAULA, 1988), and *S. filipendula* may have been misidentified as *Sargassum vulgare* C. AGARDH, often reported for Madeira. *Styopodium zonale* may have been confused with the coexisting and more common *Zonaria tournefortii*, which is superficially similar; the two species are already known to form mixed stands in the Canaries (ELEJABEITA *et al.*, 1992; REYES *et al.*, 1994). Of course, earlier phycologists did not collect their algal samples by diving, but rather by hand in shallow waters or by dredging in the depths: *S. zonale*, which we mainly saw at 5-15 m, might thus have escaped collection. This, however, is not tenable in the case of *S. filipendula*, which we found in very shallow water.

One may say that, even without diving, most of the conspicuous algae of Madeira had already been collected in the past, and that it is difficult to believe that so many experienced phycologists failed to recognise *Sargassum filipendula* and *Stypopodium zonale*. Thus, the second explanation takes into account a recent colonisation or dramatic increase in abundance of the two species. *Sargassum filipendula* has been known for long time on the coast of tropical West Africa (LAWSON & JOHN, 1987), but has been discovered in relatively recent times in the Canaries (AFONSO-CARRILLO *et al.*, 1984). The only records of *S. zonale* in the Arquipélago da Madeira (Porto Santo, Deserta Grande) come from recent collections (OOSTERBAAN, 1984; AUDIFFRED & PRUD'HOMME VAN REINE, 1985). At Ilha da Madeira, *S. zonale* was collected during CANCAP III expedition (1978): around Porto Moniz, in shallow water, and off Caniçal, by dredging at 65-100 m; but not in shallow water near Funchal (W. F. PRUD'HOMME VAN REINE, *in litteris*, 29 April 1996). *S. zonale* is known to be toxic to sea-urchins (GERWICK *et al.*, 1985; LITTLER *et al.*, 1986) and, in the Canaries, MEDINA & HAROUN (1994) observed it was the only species surviving a strong demographic increase of *Diadema antillarum* in 1990-91. At Madeira, however, *Diadema* was already seen as abundant by AUGIER (1985) who did not notice *Stypopodium*.

The first hypothesis could perhaps be tested by checking the herbarium specimens of early workers on Madeiran marine plants. The collection of LEVRING is at the Funchal Natural History Museum. *Stypopodium zonale* is absent from this collection, but for the present publication we were not able to check if it contains *Sargassum filipendula*. The herbarium material left by PICCONE and GRUNOW has been recently revised by PRUD'HOMME VAN REINE *et al.* (1994), who found no *S. filipendula* nor *S. zonale*.

The absence of these species from old collections would be in favour of the second explanation. If it were true, the increased occurrence of tropical species such as *Sargassum filipendula* and *Stypopodium zonale* at Madeira (which represents the present northern limit for "southern communities" in the E Atlantic, as mentioned above) might be an effect of climatic change. Climatic fluctuations are said to shift biogeographic boundaries (BARRY *et al.*, 1995) and an increased occurrence of "southern species" has already been noticed in recent years in both the NE Atlantic (SOUTHWARD & BOALCH, 1994; SOUTHWARD *et al.*, 1995) and the NW Mediterranean (FRANCOUR *et al.*, 1994; ASTRALDI *et al.*, 1995). The tropical pufferfish *Canthigaster rostrata*, which used to reach at Madeira the northern limit of its east-atlantic range, has been recently reported from the Azores (AZEVEDO & HEEMSTRA, 1995). SOUTHWARD *et al.* (1995) believe that the communities in the Atlantic have not yet stabilised (on a geological time-scale), and are thus more likely to be affected by change of climate. Both *Sargassum filipendula* and *Stypopodium zonale* are conspicuous species, able to shape the physiognomy of the communities in which they thrive. Their increased abundance would thus represent a major change in the marine biota of Madeira, and we suggest that their distribution should be monitored in the future.

ACKNOWLEDGEMENTS

Skorpio diving (Lido do Funchal) and Atalaya diving (Caniço de Baixo) provided logistic support to our dives at Madeira. RICARDO HAROUN and ROGELIO HERRERA (Las Palmas de G.C.) participated in some of the dives, and R. HAROUN first identified many of the algal species: we are particularly grateful to him for drawing our attention to the presence of *Sargassum filipendula* at Madeira. Great help to improve our paper came from correspondence and discussion with HENRI AUGIER (Marseille), RICARDO HAROUN (Las Palmas de G.C.), ANA NETO (Ponta Delgada) and WILLEM F. PRUD'HOMME VAN REINE (Leiden), all of whom also read and commented upon the manuscript. PAOLO COLANTONI (Urbino) gave geomorphologic advice. LUIZ SALDANHA (Cascais) and ROBERTO POGGI (Genova) provided references. This work was done within the frame of the Research Project "MACMED" (comparing marine benthic communities and zonation in MACaronesia and the MEDiterranean) of the Marine Environment Research Centre of La Spezia.

REFERENCES

- ABBIATI, M., C.N. BIANCHI, A. CASTELLI, A. GIANGRANDE & C. LARDICCI:
1991. Distribution of Polychaetes on hard substrates of the midlittoral-infralittoral transition zone, western Mediterranean. *Ophelia*, suppl. **5**: 421-432.
- AFONSO-CARRILLO, J., M.C. GIL-RODRÍGUEZ, R. HAROUN TABRAUE, M. VILLENA BALSÀ & W. WILDPRET DE LA TORRE:
1984. Adiciones y correcciones al catálogo de algas marinas bentónicas para el Archipiélago Canario. *Vieraea*, **13**, 1983 (1-2): 27-49.
- ANDRADE, C.A.P. & F.M.M. ALBUQUERQUE:
1995. Fish assemblages associated with bottom habitats on the south coast of Madeira. *Boletim do Museu municipal do Funchal (História Natural)*, Suppl. **4 A**: 9-20.
- ASTRALDI, M., C.N. BIANCHI, G.P. GASPARINI & C. MORRI:
1995. Climatic fluctuations, current variability and marine species distribution: a case study in the Ligurian Sea (north-west Mediterranean). *Oceanologica Acta*, **18**(2): 139-149.
- AUDIFFRED, P.A.J. & W.F. PRUD'HOMME VAN REINE:
1985. Marine algae of Ilha do Porto Santo and Deserta Grande (Madeira Archipelago). *Boletim do Museu Municipal do Funchal*, **37**(166): 20-51.

AUGIER, H.:

1982. *Inventory and classification of marine benthic biocenoses of the Mediterranean*. Council of Europe, Strasbourg, Nature and environment series, **25**: 1-57.
1985. Première contribution à l'étude et à la cartographie des biocénoses marines benthiques de l'île de Madère. *Boletim do Museu Municipal do Funchal*, **37**(168): 86-129.
1986. Applicazione metodologica della pianificazione ambientale in ambiente costiero: l'isola di Madera. *Nuova Rassegna*, **4**: 513-542.

AZEVEDO, J.M.N. & P.C. HEEMSTRA:

1995. New records of fishes from the Azores. *Arquipelago*, **13** A: 1-10.

BÁEZ, M. & L. SÁNCHEZ-PINTO:

1983. *Islas de fuego y agua. Canarias, Azores, Madeira, Salvajes, Cabo Verde. Macaronesia*. Edirca, Las Palmas de G.C.: 1-184.

BALDUZZI, A., C.N. BIANCHI, F. BOERO, B. BURLANDO, R. CATTANEO-VIETTI, R. MANCONI, C. MORRI, M. PANSINI, R. PRONZATO & U. SALGHETTI DRIOLI:

1986. Premières observations sur la distribution des biocénoses littorales de substrat dur de l'île de Capraia (Archipel Toscan) par deux méthodes de relevé en plongée. *Rapports et Procès-Verbaux de la Commission internationale pour l'exploitation scientifique de la Mer Méditerranée*, **30**(2): 263.

BALDUZZI, A., C.N. BIANCHI, B. BURLANDO, R. CATTANEO-VIETTI, R. MANCONI, C. MORRI, M. PANSINI, R. PRONZATO & M. SARÀ:

1996. Zoobenthos di substrato duro delle isole di Capraia e del Giglio (Arcipelago Toscano). *Atti della Società Toscana di Scienze Naturali, Memorie*, ser. A, **102** suppl. (1995): 124-135.

BALDUZZI, A., C.N. BIANCHI, R. CATTANEO-VIETTI, C. CERRANO, S. COCITO, S. COTTA, F. DEGL'INNOCENTI, G. DIVIACCO, M. MORGIGNI, C. MORRI, M. PANSINI, L. SALVATORI, L. SENES, S. SGORBINI & L. TUNESI:

1994. Primi lineamenti di bionomia bentica dell'isola Gallinaria (mar Ligure). In: G. ALBERTELLI, R. CATTANEO-VIETTI & M. PICCAZZO (Eds.), *Atti del 10° Congresso della Associazione italiana di Oceanologia e Limnologia*. AIOL, Genova: 603-617.

BALLESTEROS, E.:

1982. Primer intento de tipificación de la vegetación marina y litoral sobre sustrato rocoso de la Costa Brava. *Oecologia aquatica*, **6**: 163-173.

BALLESTEROS, E., J. ROMERO, J.M. GILI & J.D. ROS:

1984. L'estatge infralitoral de les illes Medes: les algues fotòfiles. *In*: J. ROS, I. OLIVELLA & J.M. GILI (Eds.), *Els sistemes naturals de les illes Medes*. Institut d'Estudis Catalans, Barcelona, Arxius de la Secció de Ciències, **73**: 661-675.

BARRY, J.P., C. H. BAXTER, R.D. SAGARIN & S.E. GILMAN:

1995. Climate-related, long-term faunal changes in a California rocky intertidal community. *Science*, **267**: 672-675.

BEYHL, F.E., B. MIES & P. OHM:

1995. Macaronesia: a biogeographical puzzle. *Boletim do Museu municipal do Funchal (História Natural)*, Suppl. **4 A**: 107-113.

BIANCHI, C.N., S. COCITO, C. MORRI & S. SGORBINI:

1991. Rilevamento bionomico subacqueo. *In*: M. ABBIATI (Ed.), *Lezioni del corso formativo per ricercatore scientifico subacqueo*. International School for Scientific Diving, Pisa: 67-83.

BIANCHI, C.N. & C. MORRI:

1983. Note sul benthos marino costiero dell'isola di Kos (Egeo sud-orientale). *Natura*, Milano, **74**(1-2): 96-114.
1994. Studio bionomico comparativo di alcune grotte marine sommerse: definizione di una scala di confinamento. *Memorie dell'Istituto italiano di Speleologia*, ser. II, **6**: 107-123.

BOISSET, F. & A.M. GARCIA CARRASCOSA:

1987. El fitobentos de las islas Columbretes: flora y comunidades vegetales. *In*: M.L.A. ALONSO, J.L. CARRETERO & A.M. GARCÍA CARRASCOSA (Eds.), *Islas Columbretes. Contribución al estudio de su medio natural*. Generalitat Valenciana, Valencia: 269-302.

BOUDOURESQUE, C.F.:

1984. Groupes écologiques d'algues marines et phytocénoses benthiques en Méditerranée nord-occidentale: une revue. *Giornale botanico italiano*, **118** (1-2) suppl. 2: 7-42.

BOUDOURESQUE, C.F. & F. CINELLI:

1976. Le peuplement algal des biotopes sciaphiles superficiels de mode battu en Méditerranée occidentale. *Pubblicazioni della Stazione Zoologica di Napoli*, **40**: 433-459.

BRIGGS, E.C.:

1974. *Marine zoogeography*. McGraw-Hill Series in Population Biology, New York: 1-475.

BRITO, A., T. CRUZ, E. MORENO & J.M. PÉREZ:

1984. Fauna marina de las Islas Canarias. In: J.J. BACALLADO (Ed.), *Fauna marina y terrestre del Archipiélago Canario*. Edirca, Las Palmas de G.C.: 42-65.

CABIOCH, J.:

1974. Un fond de maërl de l'archipel de Madère et son peuplement végétal. *Bulletin de la Société phycologique de France*, **19**: 74-82.

COLL, J. & I. MORENO:

1993. Contribución al conocimiento de la bionomía bentónica de la isla Dragonera (Mallorca, Mediterráneo occidental). *Publicaciones especiales del Instituto español de Oceanografía*, **11**: 313-324.

CANCELA DA FONSECA, L., J. GUERREIRO & J. GIL:

1995. Note on the macrozoobenthos of the upper level sediments of Porto Santo Island (Madeira, Portugal). *Boletim do Museu municipal do Funchal (História Natural)*, Suppl. **4 A**: 233-252.

DE PAULA, É.J.:

1988. O gênero *Sargassum* C. Ag. (Phaeophyta - Fucales) no litoral do estado de São Paulo, Brasil. *Boletim de Botânica, Universidade de São Paulo*, **10**: 65-118.

EDWARDS, P., E. BIRD, A. COSSINS, B. COTGREAVE, B. FOWLER, D. HERDSON & J. HUDSON:

1985. Marine phytobenthos of the Castellabate natural park. In: Regione Campania, Assessorato per il Turismo (Ed.), *I parchi costieri mediterranei*. Ente Provinciale per il Turismo, Salerno: 101-133.

ELEJABEITA, Y., J. REYES & J. AFONSO-CARRILLO:

1992. Algas marinas bentónicas de Punta del Hidalgo, Tenerife (Islas Canarias). *Vieraea*, **21**: 1-28.

FRANCOUR, P., C.F. BOUDOURESQUE, J.G. HARMELIN, M.L. HARMELIN-VIVIEN & J.P. QUIGNARD:

1994. Are the Mediterranean waters becoming warmer? Information from biological indicators. *Marine Pollution Bulletin*, **28**(9): 523-526.

GAIN, L.:

1914. Algues provenant des campagnes de l'Hirondelle II (1911-12). *Bulletin de l'Institut océanographique*, Monaco, 279: 1-23.

GARCIA CARRASCOSA, A.M.:

1987. El bentos de los alrededores de las islas Columbretes. Elementos para su cartografía bionómica. *In*: M.L.A. ALONSO, J.L. CARRETERO & A.M. GARCÍA CARRASCOSA (Eds.), *Islas Columbretes. Contribución al estudio de su medio natural*. Generalitat Valenciana, Valencia: 477-507.

GERWICK, W.H., W. FENICAL & J.N. NORRIS:

1985. Chemical variation in the tropical seaweed *Styopodium zonale* (Dictyotaceae). *Phytochemistry*, **24**: 1279-1283.

GIACCONE, G.:

1972. Struttura, ecologia e corologia dei popolamenti a laminarie dello stretto di Messina e del Mare di Alboran. *Memorie di Biologia marina e Oceanografia*, **2**(2): 37-59.

GIACCONE, G. & A. BRUNI:

1973. Le cistoseire e la vegetazione sommersa del Mediterraneo. *Atti Istituto veneto di Scienze Lettere ed Arti, Classe di Scienze matematiche e naturali*, **131**(1972-73): 59-103.

GIL-RODRIGUEZ, M.C.:

1980. Revisión taxonómica-ecológica del género *Cystoseira* C. Ag. en el Archipiélago Canario. *Vieraea*, **9** (1979) (1-2): 115-148.

GIL-RODRIGUEZ, M.C., J. AFONSO-CARRILLO, R. HAROUN TABRAUE & W. WILPRET DE LA TORRE:

1984. Iniciación al estudio taxonómico-ecológico del género *Sargassum* C. Agardh (Phaeophyta) en las Islas Canarias. *Actas do IV Simposio iberico de Estudos do Bentos marinho*, Lisboa, **3**: 83-92.

GILI, J.M. & J.D. ROS:

1985. Study and cartography of the benthic communities of Medes Islands (NE Spain). *PSZNI: Marine Ecology*, **6**(3): 219-238.

GONZÁLES, R.M. & J. AFONSO-CARRILLO:

1990. Estudio fenológico de cuatro especies de *Cystoseria* C. Agardh (Phaeophyta, Fucales) en Punta del Hidalgo, Tenerife (Islas Canarias). *Vieraea*, **18**: 205-234.

HAROUN TABRAUE, R.J., M.C. GIL-RODRÍGUEZ, J. AFONSO-CARRILLO & W. WILDPRET DE LA TORRE:

1984. Vegetación bentónica del Roque de los Organos (Gomera). *Anales de Biología*, **2** (sección especial, 2): 107-117.

HAWKINS, S.J., L.P. BURNAY, A.I. NETO, R. TRISTÃO DA CUNHA & A.M. FRIAS MARTINS:

1990. A description of the zonation patterns of molluscs and other important biota on the South coast of São Miguel, Azores. In: A. F. MARTINS (Ed.), *The marine fauna and flora of the Azores*. Supplement to *Açoreana*: 21-38.

HERRERA, R., D. MONTERO & R. HAROUN:

1993. Bionomía bentónica del litoral de la playa del Cabrón (Gran Canaria). *Publicaciones especiales del Instituto español de Oceanografía*, **11**: 291-298.

LABOREL, J.:

1960. Contribution à l'étude directe des peuplements benthiques sciaphiles sur substrat rocheux en Méditerranée. *Recueil des Travaux de la Station marine d'Endoume*, **20**(30): 117-173.

LAWRENCE, J.M. & P.W. SAMMARCO:

1982. Effects of feeding on the environment: Echinoidea. In: M. JANGOUX & J.M. LAWRENCE (Eds.), *Echinoderm nutrition*. A.A. Balkema, Rotterdam: 499-519.

LAWSON, G.W. & D.M. JOHN:

1987. *The marine algae and coastal environment of tropical West Africa*. J. Cramer, Berlin. Nova Hedwigia, **93** (Second Edition): 1-414.

LAWSON, G.W. & T.A. NORTON:

1971. Some observations on littoral and sublittoral zonation at Teneriffe (Canary Isles). *Botanica marina*, **14**: 116-120.

LEDOYER, M.:

1967. Aperçu sur la faune vagile de quelques biotopes de l'archipel de Madère. Comparaison avec les biotopes méditerranéens homologues. *Arquivos do Museu Bocage*, **1**(19): 415-424.

LEVRING, T.:

1974. The marine algae of the Archipelago of Madeira. *Boletim do Museu Municipal do Funchal*, **28**(125): 5-111.

LITTLER, M.M., P.R. TAYLOR & D.S. LITTLER:

1986. Plant defense associations in the marine environment. *Coral Reefs*, **5**: 63-71.

MEDINA, M. & R. HAROUN:

1994. Dinámica regresiva de una pradera submareal de *Cystoseira abies-marina* (Cystoseiraceae, Phaeophyta) en la isla de Tenerife. *Vieraea*, **23**: 65-71.

MEDINA, M., R.J. HAROUN & W. WILDPRET:

1995. Phytosociological study of the *Cystoseira abies-marina* (Gmelin) C. Agardh (Cystoseiraceae, Phaeophyceae) community in the Canarian Archipelago. *Boletim do Museu municipal do Funchal (História Natural)*, Suppl. 4 B: 433-440.

MENEZES, C.A.:

1926. Contribuição para o estudo das algas da Madeira. *Brotéria*, ser. bot., 22(2): 71-78.

MORRI, C., C.N. BIANCHI, V. DAMIANI, A. PEIRANO, G. ROMEO & L. TUNESI:

1988. L'ambiente marino tra punta della Chiappa e Sestri Levante (Mar Ligure): profilo ecotipologico e proposta di carta bionomica. *Bollettino dei Musei e degli Istituti biologici dell'Università di Genova*, 52 suppl. (1986): 213-231.

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.

OOSTERBAAN, A.F.F.:

1984. *Dictyotales of Macaronesia*. Rijksherbarium, Leiden: 1-60 (+ 11 plates).

PÉRÈS, J.M.:

1967. The Mediterranean benthos. *Oceanography and marine Biology annual Review*, 5: 449-533.
1982. General features of organismic assemblages in pelagial and benthal. In: O. KINNE (Ed.), *Marine ecology*. Volume V: *Ocean management*. Part 1: *Zonations and organismic assemblages*. John Wiley & Sons, Chichester, 5(1): 47-66.

PICCONE, A.:

1884. *Crociera del Corsaro alle Isola Madera e Canarie, del Capitano Enrico d'Albertis. Alghe*. Tipografia R. Istituto Sordo muti, Genova: 1-60.

PINEDO, S., M. SANSÓN & J. AFONSO-CARRILLO:

1992. Algas marinas bentónicas de Puerto de la Cruz (antes Puerto Orotava), Tenerife (Islas Canarias). *Vieraea*, 21: 29-60.

PRUD'HOMME VAN REINE, W.F., R.J. HAROUN & P.A.J. AUDIFFRED:

1994. A reinvestigation of Macaronesian seaweeds as studied by A. Piccone. With remarks on those studied by A. Grunow. *Nova Hedwigia*, 58(1-2): 67-121.

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

1990. Biogeography of Macaronesian seaweeds. *Courier Forschungsinstitut Senckenberg*, **129**: 55-73.

REYES, J., M. SANSÓN & J. AFONSO-CARRILLO:

1994. Algas marinas bentónicas de El Médano, S Tenerife (Islas Canarias). *Vieraea*, **23**: 15-42.

RIBERA, M.A., A. GOMEZ GARRETA, T. GALLARDO, M. CORMACI, G. FURNARI & G. GIACCONE:

1992. Check-list of Mediterranean seaweeds. I. Fucophyceae. *Botanica marina*, **35**: 109-130.

ROS, J.D. & J.M. GILI:

1984. L'estudi de les comunitats bentòniques de les illes Medes: metodologia i relació de mostres. In: J. ROS, I. OLIVELLA & J.M. GILI (Eds.), *Els sistemes naturals de les illes Medes*. Institut d'Estudis Catalans, Barcelona, Arxiu de la Secció de Ciències, **73**: 619-636.

SALDANHA, L.:

1980. *Fauna submarina atlântica. Portugal continental, Açores, Madeira*. Publicações Europa-América, Lisboa: 1-179.
1982. Remarques sur *Taenioconger longissimus* et *Paraconger macrops* à Madère (Pisces Congridae). *Cybium*, **6**(4): 3-14.
1995. *Fauna submarina atlântica: Portugal continental, Açores, Madeira*. Ed. revista e aumentada. Publicações Europa-América, Lisboa: 1-364.

SAMMARCO, P.W.:

1982. Effects of grazing by *Diadema antillarum* Philippi (Echinodermata, Echinoidea) on algal diversity and community structure. *Journal of experimental marine Biology and Ecology*, **65**: 83-105.

SARÀ, M.:

1965. Associations entre éponges et algues unicellulaires dans la Méditerranée. *Rapports et Procès-Verbaux de la Commission internationale pour l'exploitation scientifique de la Mer Méditerranée*, **18**(2): 125-127.

SIERRA, F. & C. FERNÁNDEZ:

1984. El horizonte de *Corallina elongata* Ellis et Soland. en la costa central de Asturias (N. de España). II: Dinamica de un ciclo anual. *Revista de Biología de la Universidad de Oviedo*, **2**: 131-141.

SOUTHWARD, A.J. & G.T. BOALCH:

1994. The effect of changing climate on marine life: past events and future predictions. *In*: S. FISHER (Ed.), *Man and the maritime environment*. University of Exeter Press (Exeter maritime Studies no. 9), Exeter: 101-143.

SOUTHWARD, A.J., S.J. HAWKINS & M.T. BURROWS:

1995. Seventy years' observations of changes in distribution and abundance of zooplankton and intertidal organisms in the western English Channel in relation to rising sea temperature. *Journal of thermal Biology*, **20**(1/2): 127-155.

TITTLE, I. & A.I. NETO:

1996. Marine algae of Flores, Azores: floristics and ecology. II Symposium «Fauna and Flora of the Atlantic Islands». Universidad de Las Palmas de Gran Canaria, Departamento de Biología. Abstracts: 77.

VAN DER LAND, J.:

1987. Report on the CANCAP-project for marine biological research in the Canarian. Cap Verdean region of the North Atlantic Ocean (1976-1986). Part I. List of stations. *Zoologische Verhandelingen*, Leiden, **243**: 1-94.

WIRTZ, P.:

- 1994a. *Unterwasserführer Madeira, Kanaren, Azoren: Fische / Underwater guide Madeira, Canary Islands, Azores: Fish*. Verlag Stephanie Naglschmid, Stuttgart: 1-159.
- 1994b. Three shrimps, five nudibranchs, and two tunicates new for the fauna of Madeira. *Boletim do Museu Municipal do Funchal*, **46**(257): 157-172.
- 1995a. *Unterwasserführer Madeira, Kanaren, Azoren: Niedere Tiere / Underwater guide Madeira, Canary Islands, Azores: Invertebrates*. Verlag Stephanie Naglschmid, Stuttgart: 1-247.
- 1995b. A vascular plant and ten invertebrate species new for the marine flora and fauna of Madeira. *Arquipelago*, **13** A: 119-124.