THE SUBTIDAL EPIBENTHIC COMMUNITIES OFF PUERTO DEL CARMEN (LANZAROTE, CANARY ISLANDS)

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SCUBA diving down to ca 50 m depth in February 1996 allowed the recording of 150 conspicuous species (or species groups) by visual census and photography. Five main communities were identified using cluster analysis on presence / absence data. Rock in shallow water (< 10 m) was covered by a species-rich community dominated by photophilic algae. A community characterised by several fish species inhabited sandy bottom at a depth 10 to 20 m deep. Between 20 and 50 m, a volcanic reef ran almost parallel to the coastline. A community characterised chiefly by echinoderms, encrusting invertebrates and few algae thrived on the reef head, whereas a community of sessile animals (sponges, cnidarians etc.) was recognisable on the reef wall and in caves. A further community was found on rocks at the base of the reef, and was constituted mainly by bushy cnidarians. Species composition and general physiognomy of these five epibenthic communities were similar to those already described from other sites of the Canaries and showed analogies with corresponding communities in the rest of the Atlantic-Mediterranean region.

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INTRODUCTION

The lack of a comprehensive and structured classification system of the European marine habitats, such as that developed for the terrestrial habitats (COMMISSION OF THE EUROPEAN COMMUNITIES 1991), has been highlighted by CONNOR et al. (1995). Much reference work is available for the Mediterranean Sea (AUGIER 1982; BELLAN-SANTINI et al. 1994), and PÉRÈS (1982) extended to a worldwide scale his still largely employed "Nouveau manuel de bionomie benthique de la Mer Méditerranée" (PÉRÈS & PICARD 1964). Reference is also available for the northern European seas (GLÉMAREC 1973; HISCOCK & MITCHELL 1980), whereas little exists for the Eastern Atlantic.

The Canary Islands are an important part of the Eastern Atlantic, because of their geographic position and the relationships within both the "Macaronesia" puzzle (BEYHL et al. 1995) and the Atlantic-Mediterranean region (TORTONESE 1960).

The marine flora and fauna of the Canaries are sufficiently known (BACALLADO ARÁNEGA 1984; GONZÁLES HENRÍQUEZ et al. 1986) and guides to invertebrates and fish are available (BRITO 1991; PÉREZ SÁNCHEZ & MORENO BATET 1991; WIRTZ 1994, 1995), but comparatively few studies have been undertaken on the classification of marine communities. Most of these studies deal with algal vegetation (*e. g.*, LAWSON & NORTON 1971; HAROUN TABRAUE et al. 1984; BALLESTEROS 1993; MEDINA et al. 1995), but HERRERA et al. (1993) and ARÍSTEGUI et al. (1987) examined whole epibenthic communities.

The aim of this paper is to characterise the main epibenthic communities and their zonation according to bottom types off Puerto del Carmen, a small town on the SE coast of the Island of Lanzarote, the easternmost of the Canaries.

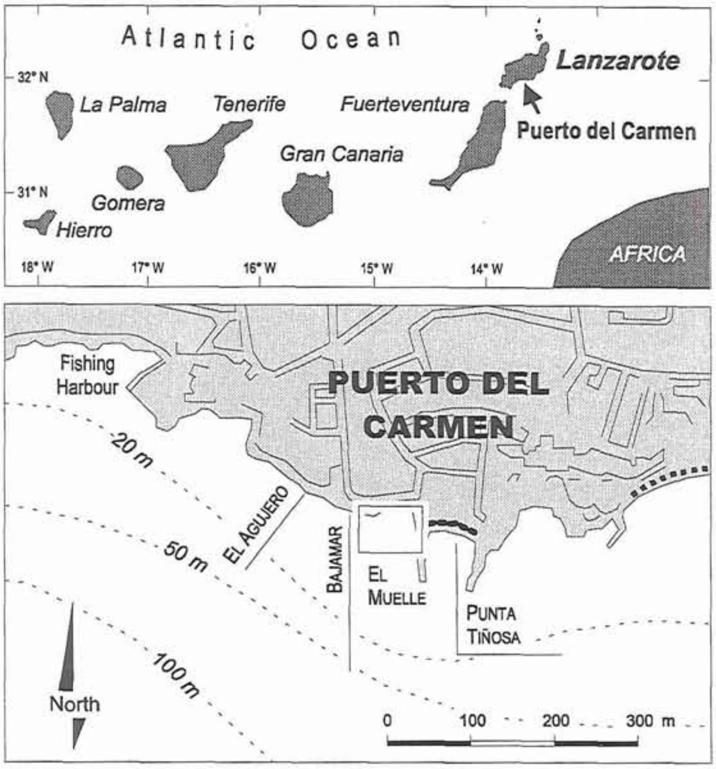

Fig. 1. Location of study area at Puerto del Carmen Lanzarote (Canary Islands), with diving sites indicated.

METHODS

We used visual census and underwater photography by SCUBA diving down to ca 50 m depth. Four sites were investigated (Fig. 1): 1) El Agujero, 2) Bajamar, 3) Punta Tiñosa; 4) El Muelle. The first three sites were explored by SCUBA diving along depth profiles (Fig. 2). Bajamar was visited four times, to explore the deep reef in detail (Fig. 3). El Muelle (Fig. 4) is a shallow water area near the dock, and dives were conducted by simply wandering around over the bottom. Depths were measured with a diving computer, and subsequently corrected to chart datum.

In each site, 2 to 5 different stations were identified physiognomically (BIANCHI et al. 1991), *i. e.*, a "station" was a relatively large area homogenous in aspect. In each of such stations, the "conspicuous" (HISCOCK 1987) species of flora and fauna were recorded and photographed with an underwater camera equipped with a wide-angle (15 mm) lens and an electronic strobe.

A matrix "stations × species" was produced, using presence / absence data. Similarity between stations was calculated applying Sorensen coefficient (BOUDOURESQUE 1971) and stations were subsequently clustered into a dendrogram through complete linkage.

RESULTS

A total of 152 species/species groups was observed and/or photographed in the 4 diving sites: 21 macroalgae, 11 sponges, 32 cnidarians, 10 molluscs, 6 polychaetes, 7 crustaceans, 6 lophophorates, 9 echinoderms, 4 ascidians, and 46 fishes (Table 1).

Species-groups were used in the case of organisms not easily recognised underwater or on the slides, but sharing the general aspect (HISCOCK 1987). The name "algal turf" was given to a mixture of different small-sized algal thalli, as defined by NETO (1992). A similar definition applies to hydroid mat.

Encrusting coralline algae, encrusting

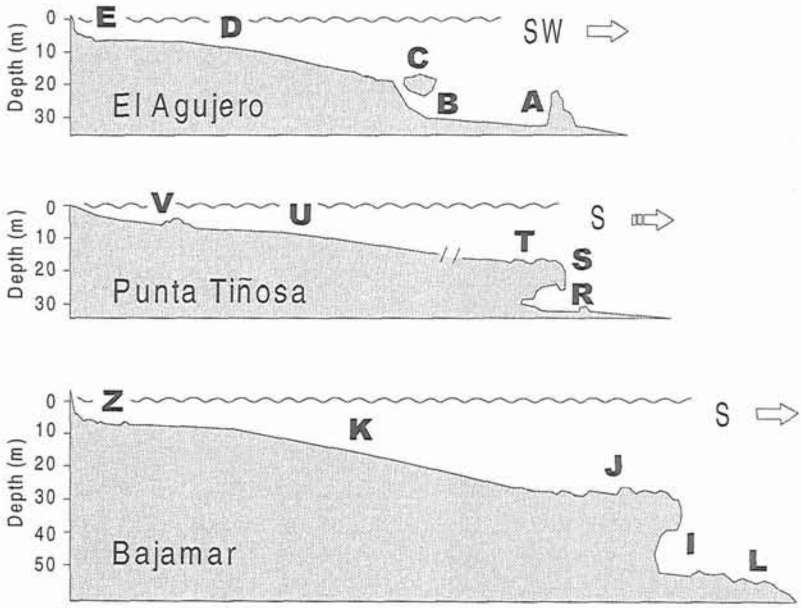

Fig. 2. Schematic sea-bottom profiles at three dive sites: El Agujero, Bajamar, Tiñosa. Horizontal distances are taken from maps and are thus simply indicative. Letters indicate stations.

bryozoans and encrusting sponges were especially abundant in sea-urchin barrens where *Baltzella inops* and *Phorbas fictitius* were the most common sponges, and *Reptadeonella violacea* and *Schizoporella longirostris* the most common bryozoans. However, similar encrusting species occurred also in other habitats, and a consistent identification down to species level was not possible.

Many different species of sponges shared a massive growth-form, but species of *Acanthella*, *Aplysina*, *Axinella*, *Ircinia* and *Spongionella* were excluded from the group and consistently recognised to at least genus level. The group "large hydroids" comprised species of *Aglaophenia*, *Eudendrium* and *Halecium*, among others. Serpulidae and Vermetidae possibly included only one species each, whereas *Ircinia* sp.p. might well correspond to different massive sponges: CRUZ SIMÓ (1984) listed five *Ircinia* species for the Canaries, all occurring in habitats such as those studied here. A similar remark applies for the alga *Hypnea* sp.p., several species being known in the region (HAROUN & PRUD'HOMME VAN REINE 1993).

Cluster analysis applied to the presence / absence data matrix identified 5 major group of stations (Fig. 5).

The best defined cluster was composed by five stations (Q Y U D K), all located on the sand slope which, starting from the base of the littoral cliff at about 10 m, reached 25 m depth at a distance of about 150-180 m from the shore (Fig. 2). It was a rather steep slope of bare volcanic sand nearly deprived of visible flora and fauna. Thus, this cluster resulted defined primarily by a number of fish species (Table 1), among which the conger eel *Heteroconger longissimus* was noticeable for its characteristic "gardens". Swarms of the opossum shrimp *Paramysis arenosa* were also common (WITTMAN & WIRTZ 1998).

A second well-defined cluster included six stations (E G F Z H V) located on rock in shallow water (Fig. 5). These stations corresponded to the base of the littoral rocky cliff, ending generally within 7 m depth and leaving place to a boulder field (Fig. 4). The rocky substrate generally exhibited high biological cover, with the dominance of photophilic algae, such as *Dictyota dichotoma*, *Pterocladiella capillacea* and many others (Table 1). Small areas of bare rock were

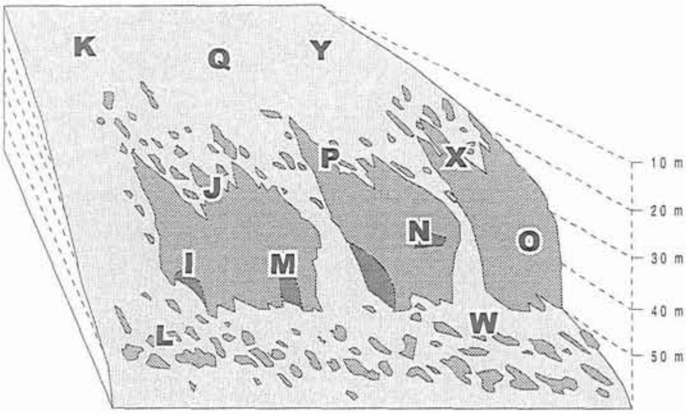

Fig. 3. A pictorial view of the submerged volcanic reef off Bajamar, running almost parallel to the coastline of Puerto del Carmen. Letters indicate stations.

nevertheless observed chiefly where sea urchins (especially *Arbacia lixula*) were abundant. The sponge *Aplysina aerophoba* and the sea anemone *Anemonia viridis* were the most important sessile invertebrates: both species are known to harbour phototrophic endosymbionts (BIANCHI et al. 1998). Many different fish species were frequent (Table 1). The boundary between rocks and sand was characterised by crowding *Arachnanthus nocturnus*, a tube anemone locally reaching the density of 200 individuals·m².

The other three clusters were less sharply separated and embraced the stations located on the impressive submerged reef that ran almost parallel to the coastline at the outer end of the sand slope, between 25 and 50 m depth (Fig. 3). The volcanic rock forming the reef was highly fissured and uneven, thus originating many different habitats, among which submarine caves and overhangs (Fig. 2).

Three stations (P J C) located on the reef head and two (X O) located on the (upper) reef wall clustered together (Fig. 5). This cluster was characterised by few algae and several sessile or sedentary animals, among which different echinoderms occurred (Table 1). Rocks at the reef head exhibited low biological cover probably because of the intense grazing by the sea-urchin *Diadema antillarum*; other common organisms were the sea-star *Narcissia canariensis*, the algae *Lobophora variegata*, *Lophocladia trichoclados* and *Cottoniella filamentosa*, and the ascidian *Pycnoclavella* sp., together with encrusting sponges and bryozoans.

Another cluster was formed by height stations, five of which (B R N I M) corresponded to caves or overhangs, two (S A) to the reef wall, and only one (T) to atract of reef head near a cave (Fig. 2). A diverse sessile fauna was characteristic of this cluster (sponges, cnidarians, polychaetes etc.), whereas fish were less important (Table 1). Hydroids were abundant on the reef wall. Stations I and M, corresponding to deep overhangs characterised by the tree coral *Dendrophyllia ramea*, formed a slightly distinct subcluster (Fig. 5).

Finally, the last cluster was made up by only two stations (L W), located on the deep rocks at the base of the reef. This cluster was defined especially by its exclusive sessile biota, with the black coral *Anthipathes wollastoni* forming extensive "forests". Different gorgonian species and the epizoic zoanthid *Gerardia savaglia* were also common (Table 1).

DISCUSSION

The five station clusters may easily be interpreted as different benthic habitats, each one having its peculiar biotic community (in the sense of HISCOCK & MITCHELL 1980).

These communities fit well within the general scheme outlined for the Canaries by BACALLADO ARÁNEGA (1984) and GONZÁLES HENRÍQUEZ et al. (1986). Analogies can be found with those described by HERRERA et al. (1993) at Playa del Cabrón, Gran Canaria, and by BALLESTEROS (1993) in some stations off Fuerteventura and Lanzarote.

The main difference between the latter study and the present one, is the relatively limited extension of photophilic algal assemblages at

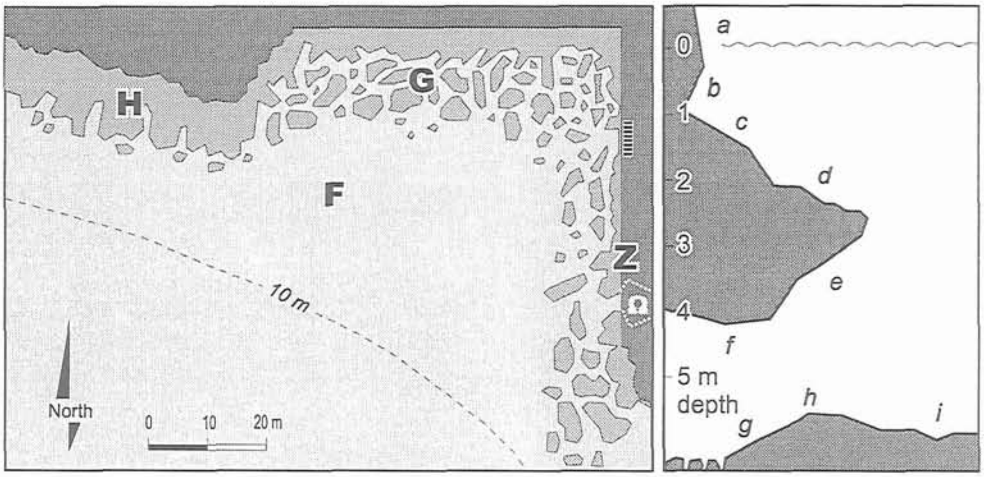

Fig. 4. Schematic map of the sea-bottom in the dive site called "El Muelle". Letters indicate stations (left). Vertical profile and zonation at station Z (right): a) *Ulva rigida* and *Actinia equina*; b) *Corynactis viridis*; c) *Corallina elongata*; d) *Arbacia lixula* and encrusting corallines; e) *Parazoanthus* sp.; f) cave with encrusting and massive sponges; g) encrusting corallines; h) *Dictyota dichotoma* and other algae.

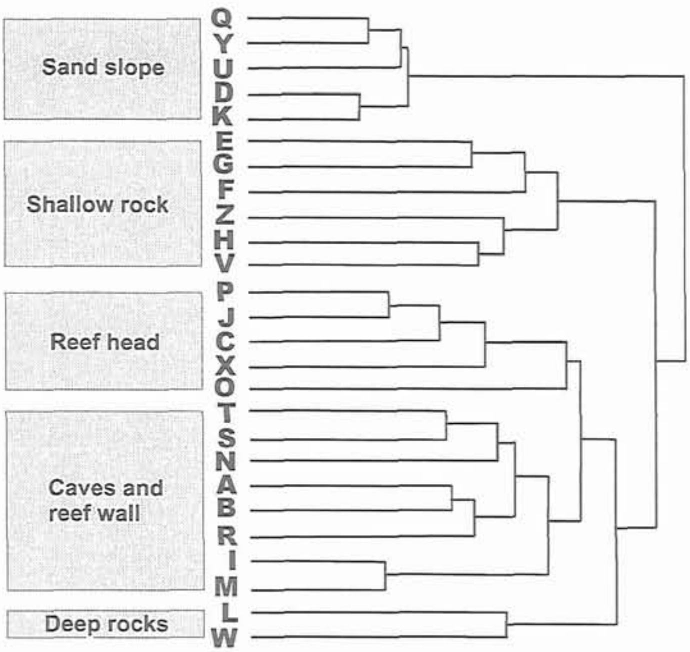

Fig. 5. Dendrogram resulting from cluster analysis (Sorensen coefficient, complete linkage). Letters indicate stations (*see text for explanation*).

Anyway, the general dominance by Dictyotales (here especially *Dictyota dichotoma*) is a common feature of such algal assemblages in the whole Atlantic-Mediterranean region (BIANCHI et al. 1998).

At Playa del Cabrón, HERRERA et al. (1993) limited their study to a depth of 30 m, whereas at Puerto del Carmen we extended investigation down to about 50 m. The community we observed in deep water is similar to that found by BALLESTEROS (1993) at 53 m depth off Punta Tiñosa and by ARÍSTEGUI et al. (1987) when dredging from 40 to 200 m depth off Tenerife. Diving allowed us to allocate *Dendrophyllia ramea* and the other bushy anthozoa (gorgonians and antipatharians) to different "sub-habitats": the former was found under overhangs, the latter on sub-horizontal rocks. Gorgonians characterise a similar depth zone on hard bottoms also in the Mediterranean Sea, but antipatharians and *Dendrophyllia ramea* live deeper (PÉRÈS & PICARD 1964). A gorgonian-

Puerto del Carmen, but this may be explained by the fact that the shallow water area investigated was rather sciophilous, under steep cliffs.

Table 1

List of the species observed or photographed during the dives at Puerto del Carmen, February 1996, 0 to 54 m depth, and their presence in the five major habitats recognised through cluster analysis and ranked according to increasing depth. Notes: [1] confused within "encrusting sponges"; [2] on shells occupied by the hermit crab *Pagurus prideaux*; [3] confused within "large hydroids"; [4] inside sponges, in very high densities (WIRTZ 1996); [5] the rich crustacean fauna associated with this species has been described by WIRTZ (1997); [6] associated with the sea-star *Astropecten aranciacus* and visible at night; [7] associated with the black coral *Antipathes wollastoni* (FRANSEN & WIRTZ 1998); [8] confused within "encrusting bryozoans".

	Shallow rock (< 10 m)	**Sand slope** (10-20 m)	**Reef head** (~ 25 m)	**Caves and reef wall** (30-40 m)	**Deep rocks** (~ 50 m)
ALGAE					
algal turf	+	.	+	+	+
Asparagopsis taxiformis	+	.	+	.	.
Carpomitra costata	.	.	.	.	+
Caulerpa racemosa	+	.	.	.	.
Caulerpa webbiana	+	.	+	+	+
Cottoniella filamentosa	.	+	+	.	+
Dictyota bartayresii	+	.	.	.	.
Dictyota dichotoma	+	.	+	+	.
encrusting corallines	+	.	+	+	+
Falkenbergia rufolanosa	+	+	+	.	+
Halopteris filicina	+	.	+	.	+
Hypnea sp. p.	+	+	+	.	.
Lobophora variegata	+	+	+	.	.
Lophocladia trichoclados	+	+	+	.	+
Mycrodictyon tenuis	.	.	.	.	+
Padina pavonica	+	+	+	.	.
Palmophyllum crassum	+	.	+	+	+
Pterocladiella capillacea	+	.	.	.	.
Stypocaulon scoparium	+	.	+	.	.
Stypopodium zonale	+	+	+	.	.
Ulva rigida	+	.	.	.	.
PORIFERA					
Acanthella acuta	.	.	.	+	.
Aplysina aerophoba	+	.	+	.	.
Axinella damicornis	.	.	+	+	+
Axinella polypoides	.	.	.	+	.
Baltzella inops [1]	+	.	+	.	.
encrusting sponges	+	.	+	+	+
Ircinia sp. p.	+	.	.	+	.
massive sponges	+	.	+	+	+
Phorbas fictitius [1]	+	.	+	.	.
Plakortis simplex	.	.	+	+	.
Spongionella pulchella	+	.	+	+	.
CNIDARIA					
Actinia equina	+	.	.	.	.
Adamsia palliata [2]	.	+	.	.	.
Aglaophenia pluma [3]	.	.	+	.	.
Aiptasia mutabilis	+	.	.	.	.
Alicia mirabilis	+	.	.	.	.
Anemonia melanaster	+	.	.	.	.

(Table 1 continued)

Anemonia viridis	+	.	.	.	.
Antipathes wollastoni	.	.	.	+	+
Arachnanthus nocturnus	+	+	.	.	.
Balanophyllia regia	+	.	+	.	.
Caryophyllia inornata	.	.	+	+	.
Corynactis viridis	+	.	.	.	.
Dendrophyllia ramea	.	.	.	+	.
Ellisella paraplexauroides	.	.	.	.	+
Eudendrium sp. [3]	.	.	.	+	.
Eunicella verrucosa	.	.	.	.	+
Gerardia savaglia	.	.	.	.	+
Halecium sp. [3]	.	.	.	+	
Hoplangia durotrix	.	.	.	+	.
hydroid mat	+	.	.	+	.
large hydroids	.	.	+	+	+
Leptopsammia pruvoti	.	.	+	+	+
Lophogorgia ruberrima	.	.	.	.	+
Lophogorgia viminalis	.	.	.	.	+
Madracis asperula	.	.	.	+	.
Madracis pharensis	.	.	.	+	.
Nausithoe punctata [4]	.	.	.	+	.
Pachycerianthus sp.	.	.	+	+	.
Paracyathus pulchellus	.	.	+	.	.
Parazoanthus sp.	+	.	.	+	+
Phyllangia mouchezii	.	.	+	+	.
Telmatactis cricoides [5]	+	.	+	.	.
MOLLUSCA					
Chama gryphoides	.	.	+	.	.
Coryphella pedata	.	.	+	.	.
Discodoris atromaculata	+	.	.	.	.
Hypselodoris fontandraui	+	.	.	.	.
Hypselodoris picta	.	.	.	+	.
Neopycnodonte cochlear	.	.	.	+	.
Pinna rudis	+	.	.	.	.
Spurilla neapolitana	+	.	.	.	.
Umbraculum umbraculum	+	.	.	.	.
Vermetidae gen. sp.	.	.	.	+	.
POLYCHAETA					
Acholoe squamosa [6]	.	+	.	.	.
Bispira viola	.	.	.	+	.
Hermodice carunculata	.	.	.	+	+
Protula tubularia	.	.	+	+	.
Serpulidae gen. sp.	.	.	+	+	.
Vermiliopsis sp.	.	.	.	+	.
CRUSTACEA	.	.	.	.	.
Balanus trigonus	.	.	+	+	.
Eualus occultus	.	+	.	.	.
Pagurus prideaux	.	+	.	.	.
Paramysis arenosa	.	+	.	.	.
Percnon gibbesi	+	.	.	.	.
Periclimenes wirtzi [7]	.	.	.	.	+
Stenorhynchus lanceolatus	+	.	+	+	.

(Table 1 continued)

LOPHOPHORATA					
Bugula plumosa	.	.	.	+	.
encrusting bryozoans	+	.	+	+	+
Phoronis hippocrepia	.	.	.	+	.
Reptadeonella violacea [8]					
Schizoporella longirostris [8]					
Smittina cervicornis	.	.	.	+	.
ECHINODERMATA					
Arbacia lixula	+	.	.	.	.
Astropecten aranciacus	.	+	.	.	.
Diadema antillarum	+	.	+	+	.
Hacelia attenuata	.	.	.	.	+
Holothuria cf. *forskali*	+	.	.	.	.
Holothuria sp.	+	+	+	.	.
Martasterias glacialis	.	.	+	.	.
Narcissa canariensis	.	.	+	+	.
Sphaerechinus granularis	+	.	+	.	.
TUNICATA					
Ascidia mentula	.	.	.	.	+
Clavelina lepadiformis	.	.	.	+	.
Didemnum sp.	+	.	.	+	+
Pycnoclavella sp.	.	.	+	+	+
PISCES					
Abudefduf luridus	+	.	+	+	.
Anthias anthias	.	.	+	.	+
Apogon imberbis	+	.	+	+	.
Bodianus scrofa	.	.	.	+	.
Boops boops	+	+	.	.	.
Bothus podas madeirensis	.	+	.	.	.
Canthigaster rostrata	+	+	+	+	.
Centrolabrus trutta	+	.	.	.	.
Chelon labrosus	+	+	.	.	.
Chromis limbata	+	.	+	.	+
Diplodus cervinus	+	.	.	.	.
Diplodus sargus cadenati	+	.	+	+	.
Diplodus vulgaris	+	.	.	.	.
Epinephelus marginatus	+	.	+	+	.
Gobius niger	.	+	.	.	.
Heteroconger longissimus	.	+	.	.	.
Lithognathus mormyrus	+	+	.	.	.
Liza aurata	+	+	.	.	.
Mullus surmuletus	+	+	.	.	.
Muraena augusti	.	.	+	.	.
Mycteroperca fusca	.	.	.	.	+
Oblada melanura	+	.	.	.	.
Ophioblennius atlanticus	+	.	.	.	.
Pagellus erythrinus	.	+	.	.	.
Parablennius parvicornis	+	.	.	.	.
Parablennius pilicornis	+	.	.	.	.
Pseudocaranx dentex juv.	.	+	.	.	.
Sardinella maderensis	+	+	.	.	.
Sarpa salpa	+	.	.	.	.
Scartella cristata	+	.	.	.	.
Scorpaena maderensis	+	.	+	+	.

(Table 1 continued)

Serranus atricauda	.	.	.	+	.
Sparisoma cretense	+	.	+	+	.
Sphoeroides marmoratus	.	.	+	.	.
Sphyraena viridensis	.	+	+	+	.
Spondyliosoma cantharus	+	.	.	.	.
Squatina squatina	.	+	.	.	.
Stephanolepis hispidus	+	.	.	.	.
Synodus saurus	+	+	.	.	.
Synodus synodus	+	.	.	.	.
Taeniura grabata	.	.	.	.	+
Thalassoma pavo	+	.	+	+	+
Trachinotus ovatus	+	.	.	.	.
Trachinus draco	.	+	.	.	.
Uranoscopus scaber	.	+	.	.	.
Xyrichthys novacula	.	+	.	.	.

antipatharian community similar to that observed at Puerto del Carmen, although composed by different species, was described from the Archipelago of Cape Verde by MORRI & BIANCHI (1995).

The discussion above suggests that an economic and "low-tech" approach, mostly based on visual census and photography, may be sufficient for the description of main epibenthic communities. Recording 150 species in a limited area with such a low "sampling" effort stands for the high marine biodiversity of the Canaries.

Clearly, a major problem is that not everything can be recognised underwater or on the photographs to the species level. This was especially true for encrusting organisms, which might well be represented by different species in the different habitats we studied, and could in some cases have dampened habitat discrimination (for example, poor sorting of reef-head and reef-wall stations in cluster analysis).

Another limit is that small species were not easily seen underwater, but might be characteristic too. In some cases, these small species lived strictly associated with other, larger organisms (see notes in Table 1). Being prevalently linked to their host rather than to the physical environment, they are species-specific not really biotope-specific (BIANCHI et al. 1989; MORRI et al. 1991). Large organisms, which monopolise or dominate the substratum on which they live, are better "indicators" (KÖNNECKER 1977) of the environmental conditions or factors to which they are adapted and should be preferred for the description and classification of epibenthic communities.

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