Zonation patterns of benthic communities in an upwelling area from the western Mediterranean (La Herradura, Alboran Sea)*

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ABSTRACT: Species composition and distribution of marine benthic communities from La Herradura (Alboran Sea, western Mediterranean) are described to characterise its rocky and sedimentary bottoms bionomically. Rocky bottoms were studied by means of several underwater transects and soft bottoms with fixed stations along a bathymetric gradient. The study of the floristic and faunistic composition of the rocky benthic communities highlights depth as the main axis of variation. Factorial Correspondence Analysis segregates deep-water communities below 25 m depth (circalittoral communities) from shallower communities (axis I), and communities thriving between 5 and 25 m depth (lower infralittoral communities) from communities thriving close to the surface (shallow infralittoral communities) (axis II). The study of the sedimentary bottoms also suggests that depth, together with physical sedimentary properties, is the main axis of variation in species distribution. Floristic and faunistic records show the particular composition of La Herradura benthic communities, compared to Mediterranean and Atlantic ones. Mixing of Mediterranean and Atlantic waters, together with deep water upwelling episodes typical of this area, probably determine the peculiar composition of the benthic communities.

Key words: zonation patterns, benthic communities, rocky and sedimentary bottoms, species distribution, Alboran Sea.

RESUMEN: PATRONES DE ZONACIÓN EN LAS COMUNIDADES BENTÓNICAS UNA ZONA DE AFLORAMIENTO DEL MEDITERRÁNEO OCCIDENTAL (LA HERRADURA, MAR DE ALBORÁN). – Se describen la composición y distribución de las comunidades bentónicas de La Herradura (Mar de Alborán, Mediterráneo Occidental) con el fin de caracterizar bionómicamente sus fondos rocosos y sedimentarios. Los fondos rocosos se estudiaron mediante transectos submarinos y los fondos sedimentarios mediante el muestreo de puntos fijos a lo largo de un gradiente batimétrico. La composición florística y faunística permite discernir la profundidad como eje de variación principal en los fondos rocosos. Tras aplicar un análisis factorial de correspondencias a los inventarios efectuados se observa que el primer eje segrega las comunidades situadas por debajo de los 25 metros (comunidades circalitorales) de las más superficiales (comunidades infralitorales), mientras que el segundo eje principal separa las comunidades situadas entre 5 y 25 metros (comunidades de la zona infralitoral inferior) de las situadas por encima de los 5 metros de profundidad (comunidades de la zona infralitoral superior). El estudio del fondo sedimentario refleja también la profundidad como factor predominante en la composición de las comunidades y, asociado a él, el tipo de sedimento encontrado. Todos los inventarios evidencian también la particular composición de los fondos estudiados, muy distinta a la del resto del Mediterráneo y diferente también a la del vecino Atlántico. La mezcla de aguas atlánticas y mediterráneas junto a los episodios de afloramiento de aguas profundas propios de esta zona son probablemente los factores determinantes de esta bionomía tan particular.

Palabras clave: patrones de zonación, comunidades bentónicas, fondos rocosos y sedimentarios, distribución de especies, Mar de Alborán.

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INTRODUCTION

The Alboran Sea is located at the westernmost part of the Mediterranean and has its own physical and biological traits (Gil, 1988). Surface Atlantic waters enter the Mediterranean through the Strait of Gibraltar and reach the Alboran Sea poorly mixed with Mediterranean waters (Cano, 1978). Furthermore, Atlantic waters usually describe an anticyclonic gyre that generates an upwelling of deep waters along the coasts of Málaga and Granada (southern Spain; Lanoix, 1974; Parrilla and Kinder, 1987; Minas *et al*., 1991; Tintoré *et al*., 1991). Deep water upwellings are enhanced by the strong western winds that usually blow in this area (Rodríguez, 1990). The combination of all these hydrological features together with the pronounced biogeographical differences between the Atlantic Ocean and the Mediterranean Sea (Conde, 1989; Pérès, 1985; González and Conde, 1993; Maldonado and Uriz, 1995; Cebrian *et al*. 2000) should affect benthic communities and their zonation patterns.

Although submerged vegetation patterns have been studied in several localities of the Alboran Sea (Giaccone, 1972; González, 1994), species composition of some circalittoral communities has been described (Templado *et al*., 1986; Templado *et al*., 1993; Maldonado, 1992, 1993), and the knowledge of the main invertebrates thriving in its waters is compiled in Ocaña *et al*. (2000), there are no available data on macroalgae and macrofauna species composition and distribution of communities along depth gradients in shallow (0-50 m) waters, with the exception of two transects described in Cebrian *et al*. (2000).

In the present study we describe the species composition and the zonation patterns of benthic communities thriving in the rocky and sedimentary bottoms of the village of La Herradura, whose coastal waters are regularly affected by deep water upwellings (Lanoix, 1974; Rodríguez, 1990; Templado *et al*., 1993), and we compare the structure of the studied communities and their spatial distribution with similar studies performed in other western Mediterranean localities.

MATERIALS AND METHODS

La Herradura (36°44'N, 3°45'W) (Fig. 1), was selected amongst other localities of the southern coast of Spain due to its geographical position in front of an upwelling area, its rather steep sea bottom slopes which are responsible for a high landscape diversity, the presence of deep rocky bottoms close to the coast, and its diving facilities. Sampling was performed with SCUBA diving techniques (Zabala *et al*., 1982) between 18 June and 6 July 1997.

Sampling stations were selected covering different substrates, ranges of wave exposure and orientation. Identification of communities was performed following a transect perpendicular to the shore at every sampling station.

Transects on rocky bottoms were performed by two divers. In the first stage (descent) the topographic and bathymetric characteristics of the transect were noted, from the surface to the deeper zone (Table 1). Different communities were distinguished

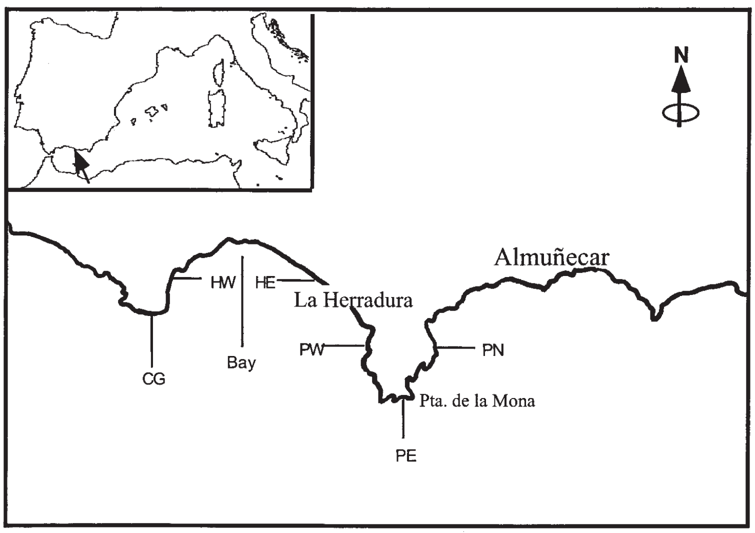

FIG. 1. – Location of the transects in La Herradura.

TABLE 1. – Code, depth, orientation and kind of substrate for each sample.

Code	Depth (m)	Transect	Slope	Orientation	Substratum
1CG	>-24	Cerro Gordo	gently slope	south-east	small boulders
2CG	23 - 17		subhorizontal		rocky
3CG	10 - 17		vertical cliff		rocky
4CG	0 - 10		vertical cliff		rocky
1HW	>-15	La Herradura (west)	gently slope	east	muddy bottom
2HW	15 - 10		gently slope		large boulders
3HW	-11		gently slope		crevice
4HW	10 - 5		gently slope		large boulders
5HW	5 - 1,5		steep slope		rocky
6HW	1,5 - 0		steep slope		rocky
1HE	12 -20	La Herradura (east)	gently slope	west	small boulders
2HE	10 -12		gently slope		big boulders
3HE	8 - 10		steep slope		big boulders
4HE	2 - 8		steep slope		big boulders
5HE	0 - 2		steep slope		rocky
1PW	>-38	Punta de la Mona (west)	gently slope	south	detritic bottom
2PW	23 - 28		gently slope		large boulders
3PW	12 - 23		gently slope		large boulders
4PW	6 - 12		vertical cliff		rocky bottom
5PW	0 - 6		vertical cliff		rocky bottom
1PE	>-47	Punta de la Mona (east)	gently slope	south	detritic bottom
2PE	46 - 30		steep slope		rocky bottom
3PE	20 - 30		steep slope		rocky bottom
4PE	10 - 20		steep slope		rocky bottom
5PE	5 - 10		steep slope		rocky bottom
6PE	<-6		steep slope		rocky bottom
1PN	> -14	Punta de la Mona (north)	gently slope	north east	detritic bottom
2PN	10 - 14		very steep		rocky bottom
3PN	8 - 10		very steep		rocky bottom
4PN	4 - 8		very steep		rocky bottom
5PN	0 - 4		very steep		rocky bottom

along the transect according to the dominant species. In the second stage (ascent) each community was carefully checked for ten minutes and its species composition and abundances were recorded according to a semi-quantitative index (Braun Blanquet, 1979). Qualitative samples of each predefined community were collected for identification of the organisms in the laboratory.

On sedimentary bottoms the sampling was performed at 5 different stations located along a transect situated in the middle of the bay. Dives were performed at depths of 10, 20, 30, 40 and 50 metres and species composition and abundance were recorded for ten minutes, with collection of samples for identification of the organims. Sediment samples were collected using two cores and two dredges (van Veen) at each sampling station. Dredges were obtained by ordinary methods below 50 m depth and characterised qualitatively by their species composition. Cores were of 12.5 cm diameter and 30 cm length. Small superficial sediment subsamples were collected from the core for granulometrical analysis. They were analysed using an LS particle size analyser at the Department of Geology of the University of Barcelona. The grain size distribution of the sediment was performed following Wentworth (1972) classification.

Data obtained from the transects were used to describe them and to draw precise sketches of benthic communities.

A factorial correspondence analysis (Legendre and Legendre, 1979; Ter Braak, 1987) was performed with the samples collected on rocky bottoms to show affinities and differences between samples. Mean percent abundance values obtained from the six rocky transects were used as data entries in a species-station raw matrix. Species present in only one or two samples were not considered in the analysis. Sample 3HO collected in a crevice was also omitted from the analysis due to its very peculiar species composition. The final analysed matrix included 30 points and 84 taxa.

RESULTS

Species composition and abundances for each sample are indicated in Table 2 (rocky transects) and in Table 3 (sedimentary transect) and are diagrammatically shown in Figures 2 to 5.

TABLE 2. – Species composition and abundance in the communities distinguished along the six rocky transects, according to Braun Blanquet index. Key signs: (+) presence, (1) 1-10% abundance, (2) 10-25% abundance, (3) 25-50 % abundance, (4) 50-75% abundance. *crevice. Ordination of species in the table follows criteria of abundance.

		Cerro Gordo				La Herradura (west)						La Herradura (east)				
		1CG	2CG	3CG	4CG	1HW	2HW	3HW*	4HW	5HW	6HW	1HE	2HE	3HE	4HE	5HE
1	*Cliona viridis*	2	2	1	1	2	1	-	1	1	-	2	2	2	2	-
2	*Mesophyllum alternans*	-	2	3	1	2	2	-	2	1	2	3	2	+	2	2
3	*Astroides calycularis*	+	+	1	1	-	-	-	1	2	+	-	-	-	1	-
4	*Schizobrachiella sanguinea*	-	1	2	1	-	-	-	2	2	-	2	3	+	1	-
5	*Crambe crambe*	-	2	+	1	-	1	1	1	1	-	2	3	3	1	-
6	*Lithophyllum incrustans*	-	-	+	2	-	1	-	2	5	1	3	3	4	3	-
7	*Aiptasia mutabilis*	-	-	1	+	-	1	-	2	-	-	+	1	1	1	-
8	*Asparagopsis armata*	+	1	2	2	-	-	-	2	-	2	-	-	-	2	2
9	*Halopteris filicina*	1	2	-	-	2	2	-	-	-	-	-	+	-	-	-
10	*Aglaophenia* sp.	1	2	-	-	2	2	-	2	2	2	-	-	-	2	-
11	*Arbacia lixula*	-	-	2	1	-	-	-	1	3	+	+	1	2	1	-
12	*Peyssonnelia rosa-marina*	-	-	2	3	-	1	-	1	+	-	3	4	3	4	-
13	*Aglaozonia* sp.	-	-	-	1	-	-	-	1	2	1	-	2	+	+	-
14	*Paracentrotus lividus*	-	-	-	2	-	-	-	1	2	+	1	1	2	2	-
15	*Plocamium cartilagineum*	1	1	1	1	-	-	-	-	-	-	-	-	-	2	-
16	*Sphaerechinus granularis*	-	-	+	1	-	-	-	1	1	-	1	1	1	1	-
17	*Aphanocladia stichidiosa*	1	2	1	2	-	-	-	-	-	-	+	-	-	+	-
18	*Holothuria sanctori*	-	2	2	1	-	-	-	1	+	-	2	+	-	-	-
19	*Myriapora truncata*	+	+	+	-	1	1	-	1	-	-	1	-	-	-	-
20	*Serpula vermicularis*	-	+	-	-	-	-	-	+	-	+	1	1	+	1	-
21	*Chondrosia reniformis*	-	1	-	-	-	1	1	-	-	-	-	+	-	+	-
22	*Dictyota dichotoma*	+	+	-	-	1	1	-	1	-	+	-	-	-	1	-
23	*Salmacina dysteri*	1	1	+	+	-	-	2	-	-	-	-	-	-	-	-
24	*Clathrina cerebrum*	-	1	-	-	-	-	-	+	+	-	-	-	-	1	-
25	*Actinothoe sphyrodeta*	-	-	-	2	-	-	-	+	2	2	-	-	-	1	-
26	*Dysidea avara*	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
27	*Ircinia fasciculata*	-	2	-	-	-	1	-	2	1	-	+	-	-	1	-
28	*Cliona celata*	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-
	Holothuria forskali	-	+	-	-	-	+	+	+	-	-	1	+	-	-	-
	Protula sp.	-	-	-	-	-	+	+	-	-	-	-	+	1	+	-
29	*Pseudodistoma crucigaster*	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
30	*Alcyonium acaule*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	*Clavelina dellavallei*	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-
32	*Codium bursa*	-	-	-	-	-	-	-	+	-	-	+	-	+	-	-
33	*Corynactis viridis*	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-
34	*Holothuria tubulosa*	1	-	-	-	2	2	-	+	-	-	2	-	-	-	-
	Marthasterias glacialis	-	-	-	+	-	-	-	+	+	-	-	-	-	-	-
35	*Rhodymenia ardissonei*	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
36	*Corallina elongata*	-	-	-	-	-	-	-	-	-	3	-	-	-	-	2
37	*Hemimycale columella*	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-
38	*Peyssonnelia sp.*	-	-	-	+	-	1	-	-	-	-	-	-	-	1	-
39	*Phorbas fictitius*	-	1	-	-	-	-	+	-	-	-	-	-	-	-	-
	Schizomavella discoidea	-	1	-	-	1	1	+	-	-	-	-	-	-	-	-
40	*Amphiroa beauvoisii*	-	-	-	-	-	-	-	-	-	3	-	-	-	+	2
41	*Axinella damicornis*	-	+	-	-	-	-	2	-	-	-	-	-	-	-	-
	Bryopsis plumosa	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-
42	*Cerianthus membranaceus*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Chartella tenella	-	-	-	-	-	+	3	-	-	-	-	-	-	-	-
	Clavularia crassa	-	-	+	-	-	-	-	1	-	-	-	-	-	-	-
43	*Falkenbergia rufolanosa*	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
	Ophidiaster ophidianus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	*Pentapora fascialis*	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peyssonnelia coriacea	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
	Sarcotragus spinosula	-	+	-	-	-	-	-	-	-	-	-	+	-	+	-
	Acrosorium venulosum	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	Adeonella calveti	-	-	-	-	-	+	2	-	-	-	-	-	-	-	-
	Bonnemaisonia asparagoides	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
	Clavelina nana	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	Colpomenia sinuosa	-	-	-	-	-	-	-	1	+	-	-	-	-	1	-
45	*Didemnum maculosum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Gelidium pusillum	-	-	-	-	-	-	-	-	-	-	-	-	+	2	-
	Haliclona mediterranea	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
	Oscarella lobularis	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-
46	*Parazoanthus axinellae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Rynchozoon neapolitanum	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
47	*Actinia* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Bonellia viridis	-	-	-	-	+	+	-	-	+	-	-	-	-	-	-
	Cliona smithii	-	-	-	-	-	-	-	-	-	-	-	+	1	1	-
	Codium vermilara	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
48	*Dendrophyllia ramea*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Diplosoma spongiforme	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Echinaster sepositus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Eudendrium sp.	-	-	-	-	-	-	2	-	-	-	-	+	-	-	-
	Hexadella racovitzai	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
49	*Ircinia variabilis*	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
50	*Leptogorgia sarmentosa*	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Padina pavonica	-	-	+	1	-	-	-	1	-	-	-	-	-	-	-
	Paraerythropodium coralloides	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
	Petrosia ficiformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peyssonnelia bornetii	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-
	Phallusia fumigata	-	-	-	-	-	-	-	1	+	-	-	+	-	-	-
	Phyllangia mouchezii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51	*Rynchozoon* sp.	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-
	Sabella spallanzani	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-
	Turbicellepora avicularis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	Cerro Gordo				La Herradura (west)						La Herradura (east)				
	1CG	2CG	3CG	4CG	1HW	2HW	3HW*	4HW	5HW	6HW	1HE	2HE	3HE	4HE	5HE
Aglaophenia pluma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Axinella polypoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Balanophyllia regia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Balanus perforatus	-	-	-	-	-	-	-	-	1	+	-	-	-	-	-
Balliella cladoderma	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Botryocladia sp.	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Celleporina sp.	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceramium flaccidum	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Clathrina clathrus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clavelina lepadiformis	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
Codium effusum	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-
Algal complex	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Contarinia squamariae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dictyonella incisa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Didemnum pseudofulgens	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Didemnum sp.	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Erythroglossum sandrianum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eunicella verrucosa	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eurypon sp.	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-
Ircinia oros	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Jania corniculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jania rubens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptopsammia pruvotii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lissoclinum perforatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lomentaria ercegovicii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Obelia bidentata	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Pleraplysilla spinifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polysyncraton sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Porella cervicornis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reptadeonella violacea	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-
Rynchozoon sp II.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Savygniella lafontii	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbicellepora magnicostata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Valonia macrophysa	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Acanthella acuta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aglaophenia acacia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aglaophenia kincherpaueri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aglaothamnion tripinnatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alicia mirabilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphiroa cryptarthrodia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aplysina cavernicola	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aplysilla sulphurea	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Bolma rugosa	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caberea boryi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calliostoma zizyphinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Celleporina caminata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Centrostephanus longispinus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cereus pedunculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corallina granifera	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Cornularia cornucopiae	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Crella elegans	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Cutleria adspersa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cutleria monoica	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Dardanus callidus	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Dentiporella sardonica	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Dictyonella pelligera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Didemnum cf. commune	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Didemnum coriaceum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Epizoanthus arenaceus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eupolymnia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Gelidium latifolium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hacelia attenuata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haraldia lenormandii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Holothuria sp.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Cacospongia scalaris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kallymenia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oscarella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paramuricea clavata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parasmittina tropica	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Peyssonnelia magna	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Peyssonnelia rubra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phorbas tenacior	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Platoma cyclocolpa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified Polychaeta	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
Polycyathus muellerae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polysiphonia scopulorum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polysiphonia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pterothamnion plumula	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Reniera sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Schizomavella cuspidata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scinaia sp.	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Serpulorbis arenarius	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Stephanoscyphus mirabilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbicellepora plana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ulosa stuposa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Veretillum cynomorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Walkeria uva	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 2 (Cont.). – Species composition and abundance in the communities distinguished along the six rocky transects, according to Braun Blanquet index. Key signs: (+) presence, (1) 1-10% abundance, (2) 10-25% abundance, (3) 25-50 % abundance, (4) 50-75% abundance. Ordination of species in the table follows criteria of abundance.

	Pta. la Mona (west)					Pta. la Mona (east)						Pta.la Mona (north)				
	1PW	2PW	3PW	4PW	5PW	1PE	2PE	3PE	4PE	5PE	6PE	1PN	2PN	3PN	4PN	5PN
Cliona viridis	2	3	1	1	1	2	2	1	1	1	+	3	1	1	1	1
Mesophyllum alternans	1	2	2	1	2	-	-	-	3	2	1	3	2	3	2	4
Astroides calycularis	-	1	2	1	1	-	-	1	1	3	3	+	+	3	1	3
Schizobrachiella sanguinea	-	1	1	1	2	+	-	-	2	+	2	-	2	2	1	2
Crambe crambe	-	1	-	-	-	-	-	1	1	+	1	1	+	1	+	-
Lithophyllum incrustans	-	-	+	3	2	-	-	-	1	2	+	3	1	3	4	-
Aiptasia mutabilis	-	-	1	1	1	-	-	-	1	+	1	1	+	1	1	-
Asparagopsis armata	-	-	1	2	2	-	-	-	2	2	+	-	1	1	+	2
Halopteris filicina	-	1	2	+	-	-	+	2	2	+	+	3	1	2	-	+
Aglaophenia sp.	2	2	-	-	-	2	2	2	-	-		1	+	1	-	-
Arbacia lixula	-	-	-	1	1	-	-	-	-	1	1	-	+	1	2	-
Peyssonnelia rosa-marina	-	-	-	-	2	-	-	-	-	1	+	3	3	3	3	-
Aglaozonia sp.	-	-	-	-	1	-	-	-	-	1	1	2	1	3	2	+
Paracentrotus lividus	-	-	1	2	1	-	-	-	-	1	1	-	-	1	3	-
Plocamium cartilagineum	-	-	-	-	1	-	-	1	1	+	+	-	1	2	+	+
Sphaerechinus granularis	-	-	1	1	-	-	-	-	1	-	-	-	+	1	1	-
Aphanocladia stichidiosa	-	-	2	2	2	-	+	1	-	+	-	-	-	-	+	-
Holothuria sanctori	-	-	1	-	-	-	-	1	1	1	-	-	-	1	-	-
Myriapora truncata	-	-	1	-	-	-	-	1	+	-	-	-	1	1	-	-
Serpula vermicularis	-	-	-	-	-	-	+	+	-	-	+	-	1	+	-	-
Chondrosia reniformis	-	+	-	-	-	-	1	1	-	-	1	-	2	1	-	-
Dictyota dichotoma	-	-	-	-	-	-	-	-	-	-	-	2	+	1	+	-
Salmacina dysteri	1	3	-	-	-	+	2	1	-	-	-	-	-	-	-	1
Clathrina cerebrum	-	-	-	+	1	-	-	-	-	-	+	-	1	1	-	2
Actinothoe sphyrodeta	-	-	+	1	3	-	-	-	-	1	-	-	-	-	-	-
Dysidea avara	-	+	-	-	-	+	1	1	+	+	1	-	2	-	-	-
Ircinia fasciculata	-	-	-	-	-	-	-	-	-	-	-	-	2	+	+	-
Cliona celata	-	-	-	2	+	-	-	-	1	1	+	-	-	-	-	1
Holothuria forskali	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-
Protula sp.	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	-
Pseudodistoma crucigaster	-	-	2	1	+	-	-	1	1	-	-	-	-	1	1	-
Alcyonium acaule	-	2	1	+	-	-	2	1	-	-	-	-	1	+	-	-
Clavelina dellavallei	1	2	-	-	-	-	2	1	2	-	-	-	-	-	-	-
Codium bursa	-	-	-	1	1	-	-	-	1	-	+	-	-	-	-	-
Corynactis viridis	-	-	-	-	-	-	-	-	-	+	+	-	-	1	+	+
Holothuria tubulosa	-	-	-	-	-	-	-	2	-	-	-	2	-	-	-	-
Marthasterias glacialis	+	+	-	-	-	-	-	-	+	-	+	-	-	-	-	-
Rhodymenia ardissonei	-	-	-	-	-	-	+	-	-	+	-	-	+	2	-	+
Corallina elongata	-	-	-	+	1	-	-	-	-	-	-	-	-	1	-	3
Hemimycale columella	+	+	-	-	-	-	1	1	-	-	-	-	-	-	-	-
Peyssonnelia sp.	-	-	-	-	-	-	-	-	-	-	-	1	2	1	-	-
Phorbas fictitius	-	+	-	-	-	-	-	-	-	-	1	-	-	1	1	-
Schizomavella discoidea	-	-	-	-	-	+	-	-	1	-	-	1	-	-	-	-
Amphiroa beauvoisii	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	3
Axinella damicornis	-	-	-	-	-	-	2	1	-	-	-	-	+	-	-	-
Bryopsis plumosa	-	-	-	-	-	-	-	-	-	-	1	-	+	1	-	-
Cerianthus membranaceus	1	2	-	-	-	-	2	1	-	-	-	-	-	-	-	-
Chartella tenella	-	-	-	-	-	-	-	+	+	-	-	-	-	-	+	-
Clavularia crassa	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	+
Falkenbergia rufolanosa	-	-	-	-	1	-	+	-	-	-	-	-	-	-	+	+
Ophidiaster ophidianus	-	-	+	+	-	-	-	-	-	-	+	-	-	+	+	-
Pentapora fascialis	-	2,3	-	-	-	-	2	2	1	-	-	-	-	-	-	-
Peyssonnelia coriacea	-	-	-	-	-	-	+	-	+	+	1	-	-	-	-	-
Sarcotragus spinosula	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-
Acrosorium venulosum	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-
Adeonella calveti	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-
Bonnemaisonia asparagoides	-	-	-	-	-	-	+	+	-	-	-	+	-	-	-	-
Clavelina nana	-	-	-	-	-	-	-	1	1	-	+	-	-	-	-	-
Colpomenia sinuosa	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Didemnum maculosum	1	2	-	-	-	1	-	-	-	-	1	-	-	-	-	-
Gelidium pusillum	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+
Haliclona mediterranea	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	-
Oscarella lobularis	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-
Parazoanthus axinellae	-	+	-	-	-	-	2	1	-	-	-	-	2	-	-	-
Rynchozoon neapolitanum	-	-	-	-	-	-	-	-	-	+	-	+	1	-	-	-
Actinia sp.	-	-	-	2	2	-	-	-	-	2	-	-	-	-	-	-
Bonellia viridis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cliona smithii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Codium vermilara	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-
Dendrophyllia ramea	-	1	-	-	-	1	2	-	-	-	-	-	-	-	-	-
Diplosoma spongiforme	-	-	-	-	-	-	-	-	+	-	+	-	1	-	-	-
Echinaster sepositus	-	-	-	-	-	-	-	+	+	-	+	-	-	-	-	-
Eudendrium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Hexadella racovitzai	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
Ircinia variabilis	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-
Leptogorgia sarmentosa	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Padina pavonica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paraerythropodium coralloides	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
Petrosia ficiformis	-	+	-	-	-	-	1	1	-	-	-	-	-	-	-	-
Peyssonnelia bornetii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Phallusia fumigata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phyllangia mouchezii	+	1	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Rynchozoon sp.	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Sabella spallanzani	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbicellepora avicularis	1	1	-	-	-	+	-	-	-	-	-	-	-	-	-	-

	Pta. la Mona (west)					Pta. la Mona (east)						Pta. la Mona (north)				
	1PW	2PW	3PW	4PW	5PW	1PE	2PE	3PE	4PE	5PE	6PE	1PN	2PN	3PN	4PN	5PN
Aglaophenia pluma	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Axinella polypoides	-	+	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Balanophyllia regia	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-
Balanus perforatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Balliella cladoderma	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Botryocladia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Celleporina sp.	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceramium flaccidum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Clathrina clathrus	-	-	-	-	-	-	-	-	-	-	+	-	1	-	-	-
Clavelina lepadiformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Codium effusum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Algal complex	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-
Contarinia squamariae	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-
Dictyonella incisa	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-
Didemnum pseudofulgens	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Didemnum sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Erythroglossum sandrianum	-	1	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Eunicella verrucosa	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Eurypon sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ircinia oros	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Jania corniculata	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	+
Jania rubens	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-
Leptopsammia pruvotii	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Lissoclinum perforatum	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-
Lomentaria ercegovicii	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-
Obelia bidentata	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Pleraplysilla spinifera	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-
Polysyncraton sp.	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-
Porella cervicornis	-	1	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Reptadeonella violacea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rynchozoon sp II.	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Savygniella lafontii	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbicellepora magnicostata	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+
Valonia macrophysa	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Acanthella acuta	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Aglaophenia acacia	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Aglaophenia kincherpaueri	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Aglaothamnion tripinnatum	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Alicia mirabilis	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphiroa cryptarthrodia	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Aplysina cavernicola	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Aplysilla sulphurea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bolma rugosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caberea boryi	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Calliostoma zizyphinum	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Celleporina caminata	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Centrostephanus longispinus	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Cereus pedunculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Corallina granifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cornularia cornucopiae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crella elegans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cutleria adspersa	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Cutleria monoica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dardanus callidus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dentiporella sardonica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dictyonella pelligera	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Didemnum cf. commune	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Didemnum coriaceum	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Epizoanthus arenaceus	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eupolymnia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gelidium latifolium	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Hacelia attenuata	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Haraldia lenormandii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Holothuria sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cacospongia scalaris	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Kallymenia sp.	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Oscarella sp.	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Paramuricea clavata	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Parasmittina tropica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peyssonnelia magna	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peyssonnelia rubra	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Phorbas tenacior	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Platoma cyclocolpa	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Unidentified Polychaeta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycyathus muellerae	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Polysiphonia scopulorum	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Polysiphonia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Pterothamnion plumula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reniera sp.	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Schizomavella cuspidata	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Scinaia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Serpulorbis arenarius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stephanoscyphus mirabilis	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Turbicellepora plana	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Ulosa stuposa	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Veretillum cynomorium	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Walkeria uva	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

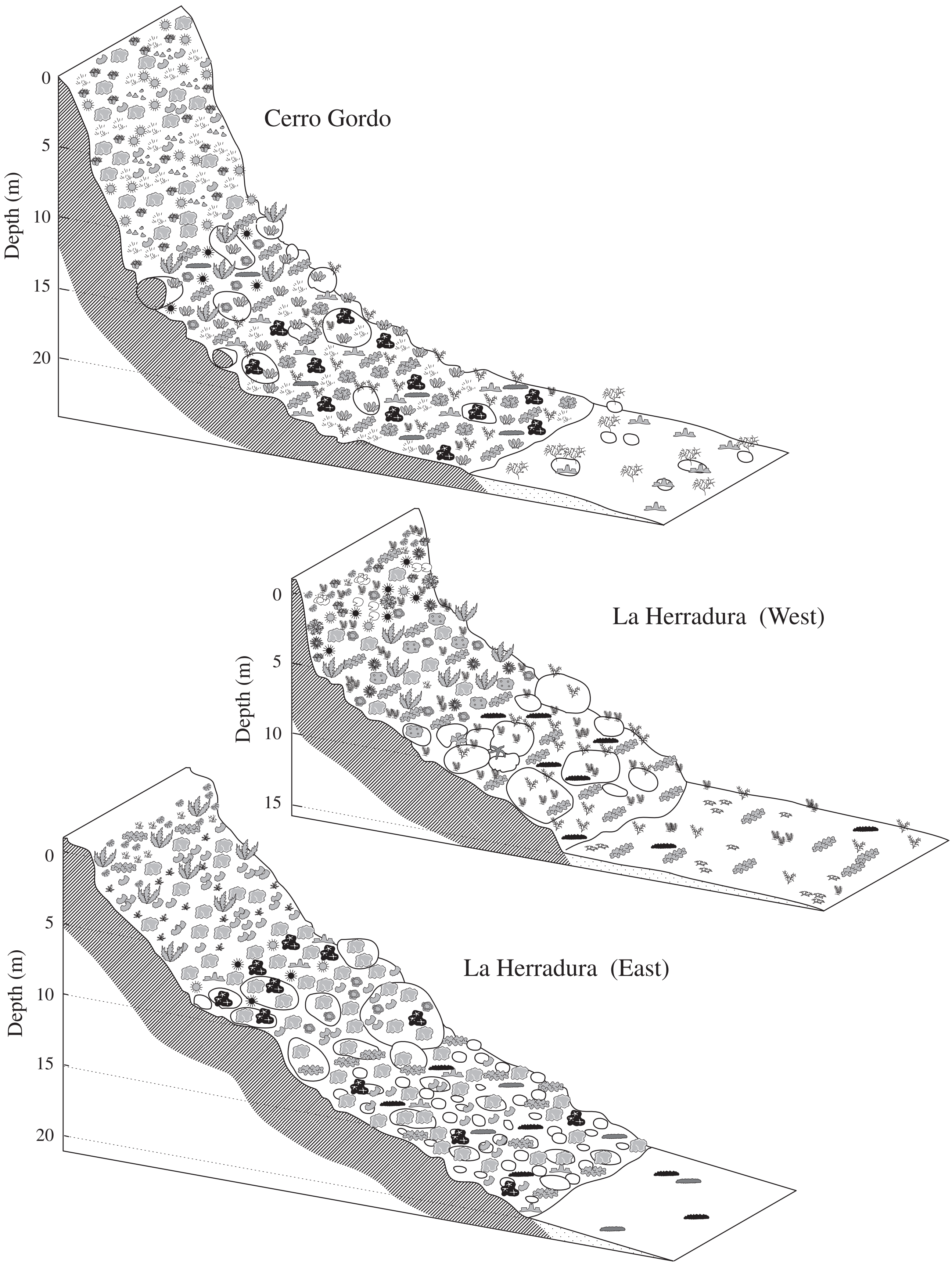

FIG. 2. – Diagrammatic representation of rocky bottom transects: Cerro Gordo (CG), La Herradura-East (HE), La Herradura-West (HW).

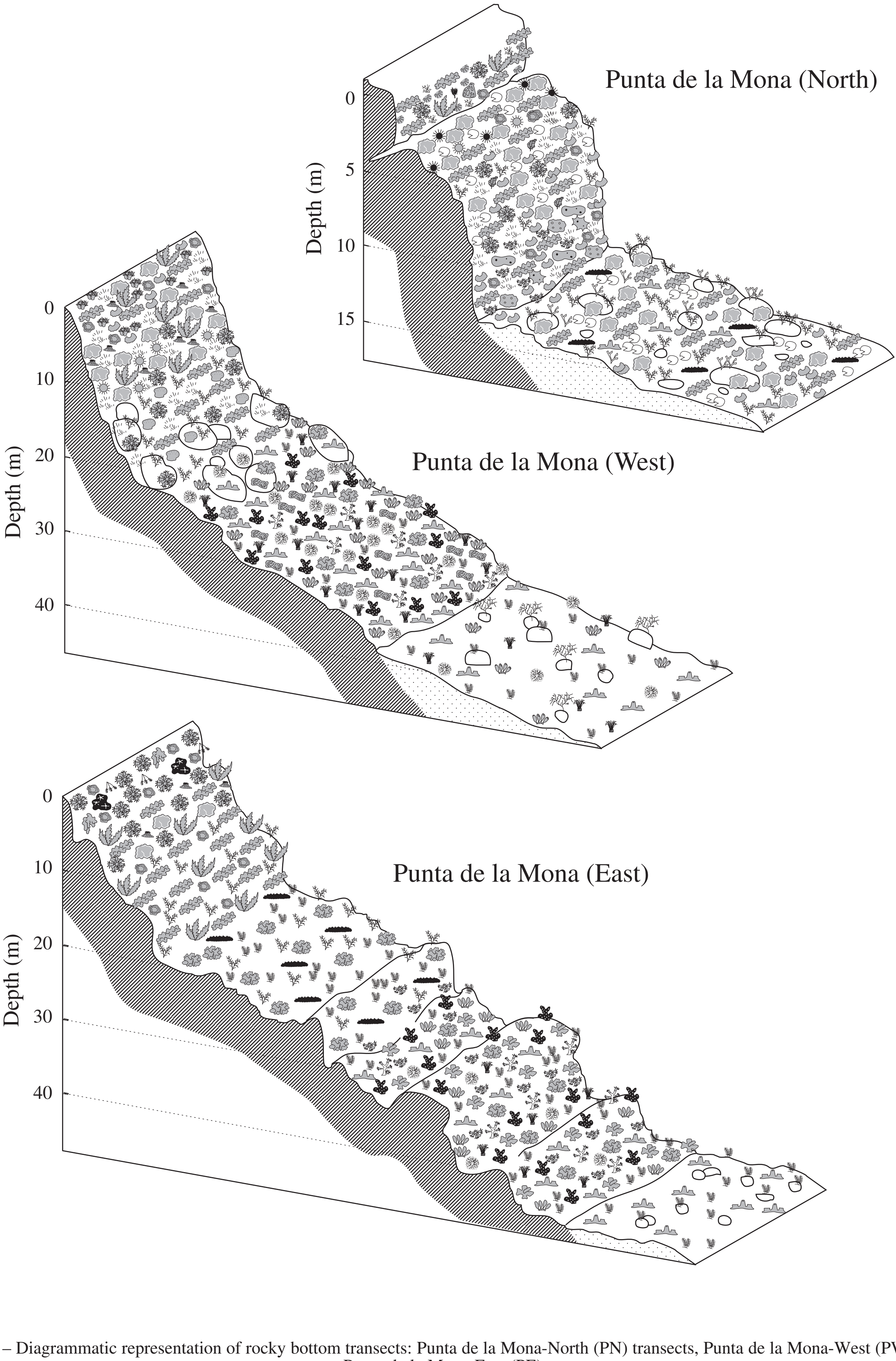

FIG. 3. – Diagrammatic representation of rocky bottom transects: Punta de la Mona-North (PN) transects, Punta de la Mona-West (PW) and Punta de la Mona-East (PE) .

FIG. 4. – Legend for species-diagrams shown in Figure 3 and 4.

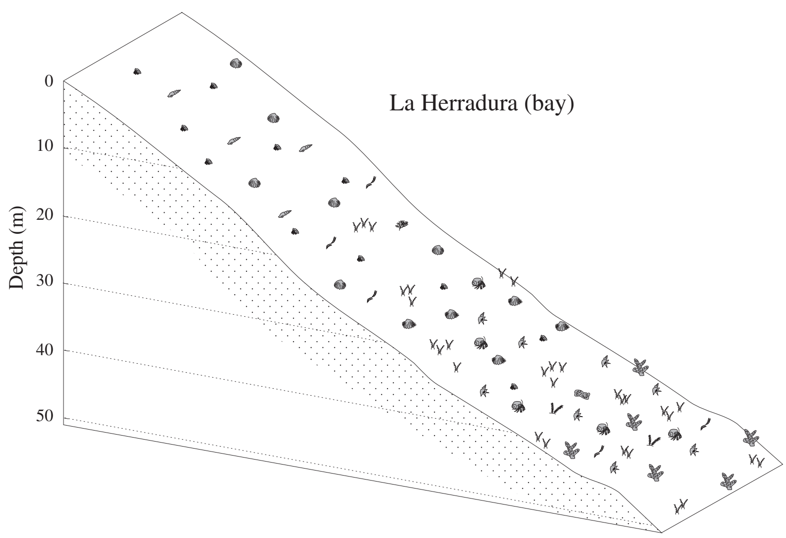

FIG. 5. – Zonation pattern of soft bottom benthic communities at La Herradura bay.

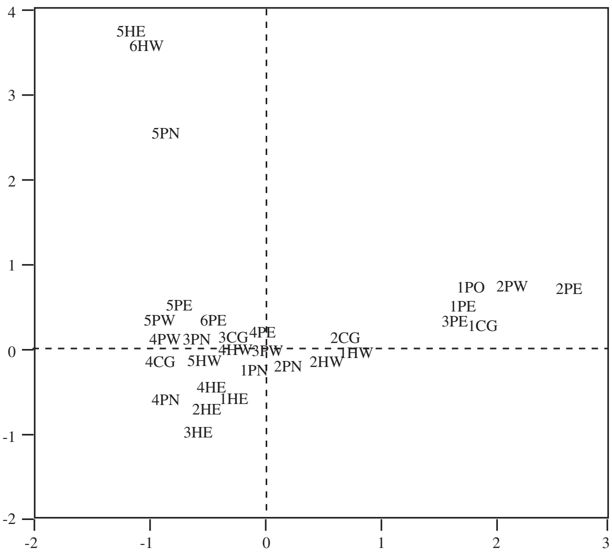

FIG. 6. – Sample representation in the two first axes derived from a factorial correspondence analysis. Sample codes correspond to those appearing in Table 1.

Rocky bottoms (Figs. 2, 3)

Ordination of samples along the two first axes discriminated by the factorial correspondence analysis shows the presence of three clusters (Fig. 6). The first axis discriminates between samples collected below 25 meters depth and those collected above, whilst the second axis segregates the samples collected above 5 m depth from all the rest. Samples collected between 5 and 25 m depth are in the same big cluster near the origin, but within this group the deepest communities are situated at positive values of axis I, whilst the shallowest samples are situated at negative values of axis I. The cumulative percentage of variance explained by the species data for the first two axes was only 28.2% (15.7% axis I and 12.5% axis II), as it corresponds to a highly variable data set.

Shallow water samples are characterised by two geniculate coralline algae which are very common above 5 m depth (*Amphiroa beauvoisii* and *Corallina elongata*), and also by the corallimorph *Corynactis viridis* (Fig. 7). The encrusting coralline algae, *Mesophyllum alternans* and *Lithophyllum incrustans*, although not restricted to these depths, are the most abundant species for all transects, whilst *Peyssonnelia rosa marina* is especially found in sheltered conditions. Red algal turfs are regularly present. *Asparagopsis armata* is the most abundant soft erect alga. Suspension feeders are also present and even abundant in very shallow waters; besides the scleractinian *Astroides calycularis*, other common species include the sponge *Clathrina cerebrum*, the sea anemone *Actinothoe sphyrodeta*, and the bryozoan *Schizobrachiella sanguinea*. Sea urchins *Paracentrotus lividus* and *Arbacia lixula* are sometimes abundant but they are absent in the surf zone (Figs. 2, 3).

Samples thriving at intermediate depths (5 to 25 m) are characterised by most of the recorded algae and sea urchins (Fig. 7). There are species that are more abundant in shallow waters (algae: *Asparagopsis armata*, both in the gametophytic and the tetrasporophytic phase of *Falkenbergia rufolanosa*, *Lithophyllum incrustans*, *Codium bursa*, *Aglaozonia* sp.; sponges: *Cliona celata*, *Clathrina cerebrum*; cnidarians: *Actinia* sp., *Actinothoe sphyrodeta*, *Astroides calycularis*; sea urchins: *Arbacia lixula*, *Paracentrotus lividus*, *Sphaerechinus granularis*) that are situated at negative values of the axis I (Fig. 7), and species that prefer deeper waters (algae: *Rhodymenia ardissonei*, *Halopteris filicina*, *Peyssonnelia* spp.; sponges: *Dysidea avara*, *Ircinia fasciculata*, *Axinella damicornis*, *Chondrosia reniformis*; cnidarians: *Parazoanthus axinellae*, *Aglaophenia* spp.; bryozoans: *Myriapora truncata* and *Pentapora fascialis*; sea cucumbers: *Holothuria tubulosa*) that are mostly situated at positive values of the axis I (Fig. 7). Other species are common everywhere, like the sponges *Crambe crambe* and *Cliona viridis*, and the bryozoan *Schizobrachiella sanguinea*. Relative abundances of suspension feeders increase with depth and they are more abundant

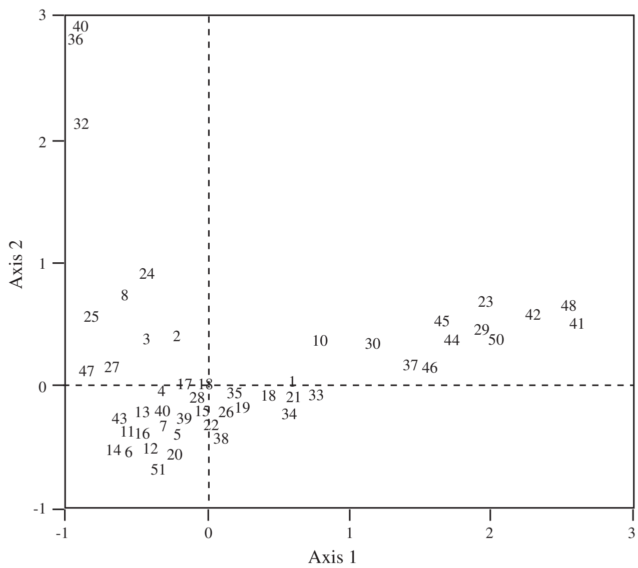

FIG. 7. – Species representation in the two first axes derived from a factorial correspondence analysis. Numbers correspond to species as indicated in Table 2.

TABLE 3. – Species composition and abundance in the communities distinguished along the sedimentary transect, according to Braun Blanquet index. Key signs as in Table 2.

	-10 m	-20 m	-30 m	-40 m	-50 m
Acanthocardia aculeata	-	2	3	+	-
Aglaophenia sp.	-	-	-	1	-
Aglaothamnion sp.	-	+	-	-	-
Alcyonium palmatum	-	+	-	2	2
Amathia semiconvoluta	+	2	2	2	-
Unidentified Actinaria	-	-	1	-	-
Anomia ephippium	-	1	2	-	-
Antedon mediterranea	-	+	-	-	-
Aphanocladia stichidiosa	-	+	-	-	-
Aporrhais pespelecani	-	+	2	2	-
Balanus sp.	-	-	-	1	1
Bothus podas	+	-	-	-	-
Botryllus sp.	-	1	-	-	-
Buccinulum corneum	-	+	+	-	-
Bugula neritina	-	2	1	1	-
Callista chione	1	1	1	-	-
Cancellaria cancellata	+	+	+	-	-
Ceramium diaphanum	-	+	-	-	-
Cerithium vulgatum	+	-	-	-	-
Cladophora sp.	-	+	-	-	-
Clibanarius erythropus	3	1	2	-	-
Chamelea gallina	3	1	+	-	-
Dardanus arrossor	-	1	+	1	-
Didemnum maculosum	-	+	-	2	-
Donacilla cornea	+	-	-	-	-
Donax sp.	2	1	-	-	-
Epizoanthus arenaceus	-	1	2	1	-
Eunicella verrucosa	-	-	-	+	-
Falkenbergia rufolanosa	-	+	-	-	-
Glycymeris sp.	-	1	+	-	-
Gracilaria sp.	-	+	-	-	-
Griffithsia sp.	-	+	-	-	-
Nassarius denticulata	-	+	+	-	-
Nassarius reticulata	+	-	+	-	-
Laevicardium oblongum	-	-	+	-	-
Lepas sp.	-	-	-	+	-
Liocarcinus vernalis	-	+	-	-	-
Lithophyllum incrustans	-	+	-	-	-
Lomentaria ercegovicii	-	+	-	-	-
Lunatia sp.	-	+	-	-	-
Mesophyllum alternans	-	1	1	-	-
Myxicola infundibulum	-	1	+	-	-
Nemertesia antennina	-	-	-	2	-
Anotrichium furcellatum	-	+	-	-	-
Obelia bidentata	-	-	-	-	1
Pagurus anachoretus	-	+	-	-	-
Paraerythropodium coralloides	-	+	-	+	-
Phyllochaetopterus socialis	2	2	-	3	2
Phymanthus pulcher	-	-	+	-	-
Pterothamnion crispum	-	+	-	-	-
Rhodophyllis divaricata	-	-	+	-	-
Rudicardium tuberculatum	3	2	+	-	-
Rynchozoon sp.	-	-	+	-	-
Salmacina dysteri	-	-	-	1	-
Scalpellum scalpellum	-	-	-	+	-
Scorpaena notata	-	-	-	1	-
Scrupocellaria sp.	-	+	-	-	-
Schizobrachiella sanguinea	-	1	1	-	-
Sepia officinalis	+	-	-	-	-
Serpulidae	-	+	+	+	-
Sertularella polyzonias	-	-	-	+	1
Solenidae	-	1	-	-	-
Sphaeronassa mutabilis	+	-	-	-	-
Sabella spallanzani	-	-	-	-	1
Synthecium evansi	-	-	-	1	-
Tellina pulchella	-	-	+	-	-
Trachinus draco	+	-	-	-	-
Unidentified tunicate	-	1	-	1	-
Turritella communis	-	-	1	+	-
Venus verrucosa	-	+	-	+	+
Veretillum cynomorium	-	-	-	1	-

in crevices, boulder zones, and north-facing slopes (e.g. Punta de la Mona-North transect) (Fig. 3).

The group of samples collected in deep waters is characterised by large suspension feeders that are more or less restricted to these areas (Fig. 7): the cnidarians *Dendrophyllia ramea*, *Leptogorgia sarmentosa*, *Parazoanthus axinellae*, *Cerianthus membranaceus* and *Alcyonium acaule*; the sponges *Axinella damicornis* and *Hemimycale columella*; the tunicates *Didemnum maculosum* and *Clavelina dellavallei*; the bryozoan *Pentapora fascialis*; and the colonial worm *Salmacina dysteri*. Other more ubiquitous species also very common at these depths include the sponge *Cliona viridis*, hydroids of the genus *Aglaophenia*, and bryozoans such as *Rynchozoon* sp. and *Savygniella lafontii*. The detritic muddy bottoms of these deepest sites are colonised by the same suspension feeders but with a highly scattered distribution and growing on the detritic cobbles. Communities dominated by these organisms are restricted to transects of Punta de la Mona East and West (see Fig. 3).

Sedimentary bottoms (Fig. 5)

The medium grain size decreases all along the transect, with a discontinuity between 20 and 30 m depth, where fine sand is replaced by very fine sand and mud. (Fig. 8)

The bivalve *Acanthocardia tuberculata*, the gastropod *Cerithium vulgatum* and the hermit crab *Clibanarius erythropus* are abundant at 10 m depth. At 20 m, the worm *Phyllochaetopterus socialis* is abundant inside the sediment and *Acanthocardia tuberculata* is also common. The bryozoans *Amathia semiconvoluta* and *Bugula neritina* colonise dead mollusc shells and small detritic stones (Fig. 5).

Between 30 and 40 m depth, *Phyllochaetopterus socialis* and *Acanthocardia aculeata* are the main infaunal species. Epibenthic macrofauna include the hermit crab *Dardanus arrossor* and the gastropod *Aporrhais pespelecani*. Dead mollusc shells provide a substratum for the hydroids *Nemertesia antennina* and *Synthecium evansii* and the bryozoan *Amathia semiconvoluta*. The soft coral *Alcyonium palmatum* is particularly abundant at 40 m depth (Fig. 5).

There is an impoverishment of the macrofauna at 50 m depth, where only *Phyllochaetopterus socialis* and *Alcyonium palmatum* are abundant. Below 50 m depth, samples collected by dredging at 60, 70, 80, 90 and 100 m depth show an assemblage dominated by the sea-pen *Pennatula phosphorea*.

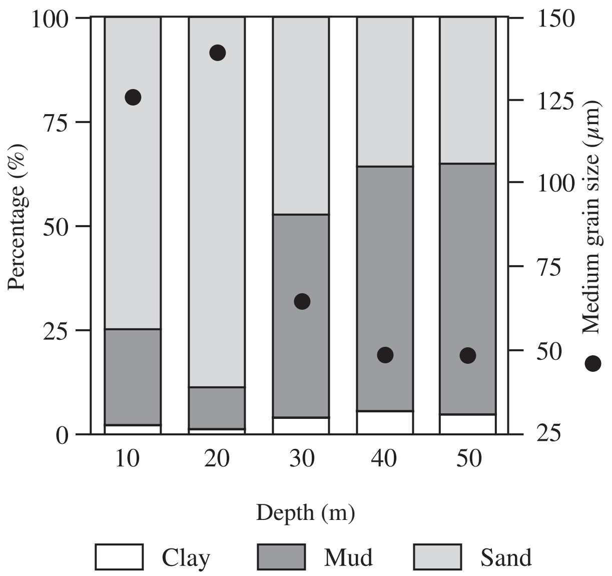

FIG. 8. – Bathymetric distribution of the different sort of sediment along the sedimentary transect.

DISCUSSION

Most of the species found in this study have a wide distribution and are common for temperate Mediterranean and Atlantic waters. According to the literature (Conde, 1989; González, 1994) most of the algal species of tropical affinities inhabiting the Mediterranean have their westernmost distribution limit at about 3°W longitude, and this is also the case for several Mediterranean endemisms (although other typical Mediterranean species such as *Posidonia oceanica* have western limits that may include La Herradura inside their distribution area; Fig. 9). Conversely, no or very few genuine Atlantic species of macrophytes are found east of about 4°30'W longitude in southern Spain (Fig. 9), so its absence in La Herradura was not unexpected. Therefore, La Herradura is situated east from the expected distribution of Atlantic species and west from most of the Mediterranean species with tropical affinities, but not from other Mediterranean species. Nevertheless, none of these last species have been found (e.g. *Posidonia oceanica*, *Cystoseira spinosa*), with the exception of *Rissoella verruculosa*, a mediolittoral species that does not appear in our sublittoral samples, but which is present in La Herradura (Flores-Moya *et al*., 1998).

It is also interesting to note that the segregation pattern between Atlantic and Mediterranean, and subtropical to tropical species of algae is not the same on the North African coasts, where Tres Forcas Cape (3°W) acts as an eastern limit for a large number of Atlantic species and a western limit for species of tropical affinities. Tres Forcas Cape (Fig. 9) is also the western limit for several Mediterranean species (González, 1994).

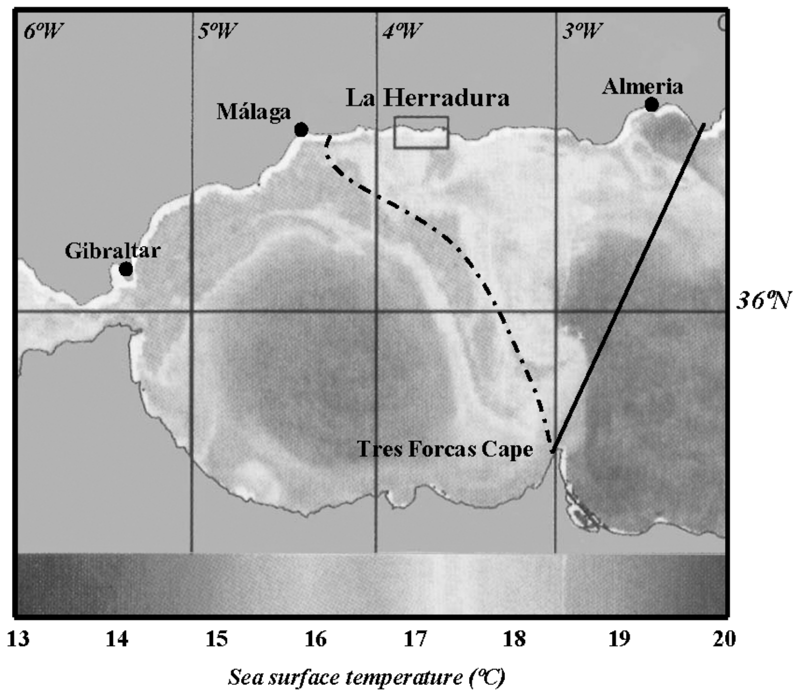

FIG. 9. – Westernmost distribution limits of most of the shallow Mediterranean sublittoral endemic algal species (e.g. *Cystoseira mediterranea*, *C. crinita*, *C. ercegovicii*) and tropical to subtropical algal species present in the Mediterranean (e.g. *Caulerpa prolifera*, *Halimeda tuna*, *Dasycladus vermicularis*, *Acetabularia acetabulum*) (solid line), and easternmost limit of most eu-atlantic algal species (e.g. *Gelidium sesquipedale*, *Gigartina pistillata*, *Fucus spiralis*) (broken line) according to data compiled by González (1994).

The zonation pattern of La Herradura rocky bottoms greatly differs from that described for other localities in the western Mediterranean (e.g. Feldmann, 1937; Molinier, 1960; Pérès and Picard, 1964; Giaccone and Bruni, 1973; Gili and Ros, 1985; Boudouresque *et al*., 1986; Soto and Conde, 1989; Ballesteros and Ros, 1989; Ballesteros, 1992; García-Raso *et al*., 1992; Ballesteros *et al*., 1993; Giaccone *et al*., 1994; Canals and Ballesteros, 1997; Calvín, 2003). Shallow benthic communities in Mediterranean waters are usually dominated by erect macroalgae belonging to the Fucophyceae (genera *Cystoseira*, *Padina*, *Halopteris*, *Cladostephus*, *Dictyota*), Rhodophyceae (*Liagora*, *Laurencia*, *Corallina*, *Amphiroa*) or Chlorophyceae (*Acetabularia*, *Dasycladus*, *Caulerpa*), with some scattered suspension feeders (mainly sponges: genera *Crambe*, *Ircinia*, *Sarcotragus*) and sea-urchins (*Paracentrotus lividus*, *Arbacia lixula*). Shallow water benthic communities in nearby Atlantic areas are characterised by belts of large erect algae (genera *Cystoseira*, *Sargassum*, *Saccorhiza*, *Halopteris*, *Corallina*, *Pterocladia*, *Gelidium*, *Halopitys* and *Sphaerococcus*) (Seoane-Camba, 1965; Otero-Schmitt and Pérez-Cirera, 2002) different to those described from the Mediterranean and different also to those described in this paper for La Herradura. La Herradura infralittoral bottoms also differ from bottoms situated near the Alboran island which are biogeographically Atlantic (Giaccone, 1972; Conde, 1989) although they are situated more than two hundred kilometers inside the Mediterranean.

Deep (20-50 m depth) Mediterranean rocky bottom communities are characterised by the dominance of algae specially adapted to dim light conditions such as the encrusting corallines *Mesophyllum alternans* and *Lithophyllum stictaeforme*, and *Peyssonnelia* spp., with erect algae *Cystoseira zosteroides*, *Halopteris filicina*, *Flabellia petiolata* and *Halimeda tuna*, amongst others (Feldmann, 1937; Boudouresque, 1973; Boudouresque *et al*., 1986; Ballesteros, 1990, 1991; Ballesteros *et al*., 1993). The growth, death and accretion of encrusting corallines builds-up a biogenic structure called coralligenous that is typical of Mediterranean circalittoral rocky bottoms (Ros *et al*., 1985). Many species of suspension feeders grow over the coralligenous banks (Ballesteros *et al*., 1993) and their abundance is related to depth, currents and available particulate organic matter (Zabala and Ballesteros, 1989). On the other hand, the coralligenous structure is absent in Atlantic waters near the straits of Gibraltar, and kelp beds dominated by *Laminaria ochroleuca* and *Cystoseira usneoides* develop at the 20-50 m bathymetric range (Werner, 1962). Coralligenous or kelp beds are absent in La Herradura deep waters and the floristic component is very poor and scarcely developed. The dominance corresponds to big suspension feeders such as *Cerianthus membranaceus*, *Salmacina dysteri*, *Pentapora fascialis* and *Dendrophyllia ramea*, species that are also common in both the southwestern Mediterranean and Atlantic deep waters.

Most species of fauna and flora dwelling in La Herradura sea bottoms have an Atlantic-Mediterranean distribution, and are common in both. Benthic communities are neither typically Atlantic nor typically Mediterranean, since most genus and species defining Atlantic or Mediterranean communities are lacking. We suggest that deep water upwellings peculiar to this area (Lanoix, 1974; Cano, 1978; Rodríguez, 1990) prevent the development of the typical Mediterranean species and communities thriving in shallow waters. However, since the deep waters are of Mediterranean origin, pure Atlantic species and communities are also absent. This situation described for La Herradura can probably be extrapolated to the coasts of southern Spain affected by the upwelling, that is between 3° and 4°30’W. This reasoning could also explain the biogeographical asymmetry found between southern Spain and northern Morocco. Much research is needed in this geographical area to support this assessment.

The zonation patterns of La Herradura are well defined, as can be easily observed in Figures 3 and 4 and has been demonstrated in the ordination analysis for the rocky bottoms. Both axes I and II are related to depth, a situation that is predictable when sampling has been performed along a strong environmental gradient (Legendre and Legendre, 1979; Ballesteros and Romero, 1988). The ordination of samples defined by the first and second axes highlights two discontinuities. The first, situated at around 25 m depth, can be interpreted as the change from algal to animal dominance and can be interpreted as the boundary between the infralittoral and the circalittoral zone. The second one is situated above 5 m depth and may be related to the change from highly reophilic species that withstand heavy surf and hydrodynamism (upper infralittoral zone) to species not adapted to surf or to strong water movement (lower infralittoral zone).

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