



# Bryozoan faunal composition and community structure from the continental shelf off Cap de Creus (Northwestern Mediterranean)

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## ABSTRACT

Bryozoan specimens obtained in 2009–2010 from the continental shelf off Cap de Creus (Northwestern Mediterranean) were studied. Samples were collected using a Rauschert sled at depths ranging from 61 to 225 m. Bryozoans were present in all 26 samples examined, although they were only abundant in 20 of them. A total of 113 species of Bryozoa were identified (2 Ctenostomata, 90 Cheilostomata and 21 Cyclostomata), most of them are well known to science, although a few of the species have barely or never been cited in the Mediterranean Sea (*Hincksinoflustra octodon*, *Alderina imbellis*, *Escharella immersa*, *Neolagenipora collaris* and *Escharina johnstoni*), or are currently poorly described (*Lagenipora lepralioides*). The species *Palmicellaria* aff. *aviculifera* (sensu Gautier, 1957) is redescribed, for which the new name of *Palmiskenea gautieri* is proposed. Species richness, abundance and biomass were linked to the availability of suitable substrates. Multivariate analysis in relation to environmental data showed that the spatial distribution of the bryozoan species was related to the sediment type. Samples from areas dominated by silt and sandy sediments showed few or no bryozoans, whereas coarse sands and gravels presented higher diversity, abundance and biomass. Within the depth range studied, the faunistic composition of the bryozoan assemblages was similar for the whole continental shelf off Cap de Creus. The bulk of bryozoans was found near the canyon rim. This is related to the proximity of the submarine canyon and its associated hydrological processes. The high diversity and abundance of the bryozoan community located on the circalittoral and shelf-edge off Cap de Creus reflect the presence of critical habitats that are essential for the design of marine protected areas.

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## 1. Introduction

Knowledge of the Mediterranean Sea marine biodiversity is built on a long tradition of studies based mainly within the littoral zone (Gili et al., in press). Technological advances during the 70s, mainly the development of SCUBA diving, contributed to a significant increase of our knowledge of the sub-littoral down to depths of ca. 50 m. At the same time, Sanders' work (Sanders, 1968) promoted the interest for the Mediterranean deep-sea fauna. In this historical context, the continental shelf has always been excluded except for studies focussing on fishery research. Recent studies in submarine canyons have led to an increasing interest in the shelf-edge communities (Sink et al., 2006). Also, the ecosystem approach used to understand the functioning of marine protected areas has increased the importance of adjacent areas like the continental shelf and slope (UNEP-MAP RAC/SPA, 2010). This current interest revives an assertion already shown by the pioneers in marine biodiversity: the presence of high biodiversity in the continental shelf-edge with communities like those of offshore rocky bottoms ("roche du large") and the shelf-edge detritic ("DL fonds détritiques du large") (Pérès and Picard, 1964), the latter recently recognized as a

critical habitat for fish resources, especially juveniles of commercial species (e.g. Colloca et al., 2004).

The Cap de Creus region is considered a hotspot for marine biodiversity. Its submarine canyon is located less than two miles away from the peninsula of Cap de Creus, quickly reaching depths of over 2000 m and exhibiting a full zonation from littoral to bathyal communities in a narrow strip (Madurell et al., 2012; Rossi et al., 2008; Sardá et al., 2012). The presence of cold water corals (*Madrepora oculata*, *Dendrophyllia cornigera* and *Lophelia pertusa*) dwelling in the canyon head, the rich communities found at intermediate depths on the continental shelf and the risk of degradation due to human activities have promoted its study within the LIFE + INDEMARES project (Inventory and designation of marine Natura 2000 areas in the Spanish seas) and identified as a Site of Community Importance (SCI).

Regarding biodiversity, the bryozoan fauna of the NW Mediterranean has been the object of numerous studies from the beginning of oceanography as a science (e.g. Barroso, 1915; Calvet, 1900; Gautier, 1962). Such studies have provided a comprehensive knowledge of the Mediterranean fauna, although recent findings indicate that there are still some gaps to be filled (e.g. Ayari et al., 2008; Ben Ismail et al., 2009; Harmelin et al., 2009; Reverter-Gil et al., 2009; Rosso, 2009; Rosso and Novosel, 2010; Souto et al., 2010). Most of the work developed in recent years concerns the shallow infra- and circalittoral zones (e.g. Harmelin, 1968(1969),

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1973, 1984; Boronat, 1987; Zabala, 1986; Zabala and Maluquer, 1988). Other studies have focused on the bathyal fauna that dwells in the area of the Strait of Gibraltar (Harmelin and d'Hondt, 1992; López de la Cuadra and García-Gómez, 2001), in submarine caves (Harmelin, 1969) and in cold-water coral bottoms (Zabala et al., 1993). However, little attention has been paid to the deep bottoms of the Mediterranean continental shelf, although notable findings are continuously reported (e.g. Souto et al., 2010).

The objective of the present work is to describe the faunal composition and species assemblages of the bryozoan fauna from the continental shelf off Cap de Creus in relation to different environmental variables. The aim of the study is to improve our knowledge of the biodiversity of this poorly studied depth range.

## 2. Materials and methods

Sampling was conducted on the continental shelf off Cap de Creus during three INDEMARES cruises in 2009 and 2010. Table 1 shows the coordinates and the main characteristics of the samples that contained bryozoans. All specimens were collected using a Rauschert sled (Stransky, 2008), with a total of 26 samples located at depths between 61 and 225 m. In every sampling station, the epibenthic sled was towed for about 5 min at a constant speed of 1 kn, covering distances between 140 and 650 m over the seabed. Samples were sieved (0.5 mm mesh size), and then fixed in 4% formalin. The bryozoan specimens were sorted in the laboratory under a stereoscopic microscope, identified to species level, and the number of fragments counted. In addition, an estimate of the surface (mm<sup>2</sup>) of all fragments of bryozoans was calculated using the area obtained from the geometrical figure that was left when they were put together leaving no spaces between them. This methodology was applied to both erect and encrusting bryozoans and the calculated area was doubled to account for tops and bottoms.

For the species of taxonomic and biogeographical interest, besides coordinates and depth, we provide SEM images and biometrics to enable comparison with the Atlantic reference material. All photographs were taken using a scanning electron microscope (ESEM Quanta 200 FEI, XTE 325/D8395) at the University of Barcelona on coated and uncoated material. In order to clean the specimens, an ultrasonic treatment was

applied to all bryozoans prior to imaging. When ultrasonic cleaning was insufficient, bleach was used to remove all remaining organic material. All measurements are given in the text with the mean  $\pm$  the standard deviation, the observed range, and (in brackets) the number of measurements. All measurements are in  $\mu$ m. Zoecial characters are identified by the following acronyms and abbreviations: AvL avicularia length, AvW avicularia width, OL orifice length, OW orifice width, opL opesia length, opW opesia width, OVL oecium length, OVW oecium width, PAL peristome aperture length, PAW peristome aperture width, ZL zoecium length, and ZW zoecium width.

The collection of specimens is now deposited in the archive of the Natural Sciences Museum of Barcelona. We also examined and revised reference material of *Palmicellaria aviculifera* from the National Museum of Natural History, Smithsonian Institution (Washington); *P. aff. aviculifera* from the Centre d'Océanologie de Marseille (Endoume); and *P. skenei* from the Natural History Museum (London).

The characterization of the bathymetric affinities of the species was made using Prenant and Bobin (1956) for Ctenostomata, Gautier (1962) for Ascophora and Harmelin (1976) for Cyclostomata. Bryozoans collected were classified into four morphological categories: 1) erect species, rigid or articulated, of moderate size; 2) encrusting species with frontal growth, forming massive colonies of moderate or large size; 3) small-sized species, erect or encrusting, creeping on detritic gravels; and 4) species always found as dead fragments in the detritic component of the sediment (Table 2). Although we made an effort to standardize the sampling protocol, the sorting and the rigorous quantification of the number of fragments, the Rauschert sled is a semi-quantitative gear, adequate for collecting epibenthic organisms in good condition (Stransky, 2008), and therefore caution must be taken when interpreting the community results. With few exceptions (6 species, see Table 2), most of the species found dead were also found alive in at least one station. Therefore, the qualitative inventories performed with live and dead colonies can be considered representative of the community structure.

### 2.1. Statistical analyses

To evaluate the role that the volume of samples (number of fragments) plays in the species richness (Gotelli and Colwell, 2001),

**Table 1**  
Rauschert sled stations of the INDEMARES cruises from 2009 and 2010. Distance refers to the distance from the canyon.

Station	Lat_ini	Long_ini	Date	Depth (m)	Sp no.	No. fragments	Surface (mm <sup>2</sup> )	Substrate	Distance
0/70	42.374	3.215	07/24/09	61	1	4	30	Silt	>2 km
0/80	42.357	3.269	07/23/09	95	1	2	10	Silt	>2 km
0/96	42.365	3.294	07/24/09	108	4	6	215	Silt	>2 km
0/98	42.341	3.299	07/24/09	87	31	487	10,241	Coarse sand	>2 km
1/10	42.389	3.307	09/23/10	121	24	116	1044	Coarse sand	<2 km
1/108	42.339	3.336	09/29/10	116	17	151	10,561	Gravel	<2 km
1/12	42.360	3.327	09/23/10	148	60	505	14,482	Coarse sand	<2 km
1/17	42.347	3.325	09/23/10	106	31	409	3984	Gravel	<2 km
1/18	42.399	3.306	09/23/10	225	38	125	1223	Coarse sand	<2 km
1/19	42.399	3.325	09/24/10	200	25	148	1901	Coarse sand	<2 km
1/22	42.362	3.298	09/24/10	110	31	225	3124	Gravel	>2 km
1/27	42.365	3.322	09/24/10	160	18	48	2802	Gravel	<2 km
1/44	42.350	3.307	09/26/10	116	20	122	2303	Gravel	<2 km
1/6	42.385	3.273	09/23/10	103	5	8	21	Sand	>2 km
1/68	42.341	3.318	09/27/10	105	37	291	7509	Gravel	>2 km
1/9	42.384	3.283	09/23/10	108	8	26	0	Sand	>2 km
2/24	42.385	3.269	06/10/10	104	8	10	7	Sand	>2 km
2/26	42.296	3.377	06/10/10	104	39	529	526	Coarse sand	>2 km
2/27	42.378	3.269	06/10/10	103	9	23	355	Sand	>2 km
2/3	42.325	3.374	06/07/10	136	62	959	9142	Gravel	<2 km
2/39	42.340	3.314	06/12/10	100	23	44	370	Coarse sand	<2 km
2/4	42.305	3.402	06/07/10	128	58	397	880	Coarse sand	<2 km
2/5	42.293	3.436	06/07/10	123	37	198	694	Coarse sand	<2 km
2/6	42.278	3.398	06/07/10	136	29	242	246	Coarse sand	>2 km
2/7	42.279	3.443	06/07/10	132	35	166	138	Coarse sand	>2 km
2/8	42.302	3.467	06/07/10	216	41	895	7356	Coarse sand	<2 km

rarefaction curves were created and expected richness values calculated with the ESTIMATES® software. Rarefaction curves were also used to evaluate the quality of the inventory (Jiménez-Valverde and Hortal, 2003).

Three abiotic parameters were considered as possible driving factors: depth, sediment grain size and geographical position (i.e. distance to the canyon rim) (Table 1). All three variables were quantified in discrete categories. The depth range studied (61–225 m) was arbitrarily subdivided into three categories to split the samples in three groups of the same size: littoral (61–105 m), shelf (106–123 m) and deep (123–225 m). Characterisation of sediment type was performed using two different criteria: information obtained from the sedimentological map of the area in Lo Iacono et al. (2012), and directly from the grain size of the sediment extracted. When divergences occurred, the second criterion was preferred. Four arbitrary classes were selected: silt, sand (including pelitic and fine sands), coarse sand (coarse sands and fine gravels), and gravels (coarse gravels and shelly sediments). To explore the role the submarine canyon plays in the community composition, a line was drawn 2 km west of the 200 m isobath, producing two homogenous groups of 13 samples each (Table 1).

The relationship between bryozoan species richness and the abiotic parameters was determined by analyzing the distributional pattern of the number of species observed and expected, live surface and total number of fragments. These descriptors were then compared with depth distribution, sediment type and the distance to the canyon rim. The differences between groups were tested with a non-parametric Kruskal–Wallis test, using STATISTICA 6®.

Community analysis was performed using the software package PRIMER®. A multidimensional scaling (MDS) analysis was performed using the quantitative data (number of fragments) to discriminate between groups of stations with similar faunal composition. Similarity between samples was calculated using the Bray–Curtis similarity, on a fourth-root transformed matrix. Species that were present in fewer than 3 samples were ignored for the analysis and samples with fewer than 3 species were not considered (68 species from 22 samples in total). Subsequently, the similarity percentages routine (SIMPER) was performed to determine which species showed a higher contribution to the overall similarity within the resulting groups. ANOSIM test was used to test the differences in the community composition among significant groups.

### 3. Results

#### 3.1. Taxonomic analysis

Table 2 summarizes the list of 113 bryozoan species collected (2 Ctenostomata, 90 Cheilostomata and 21 Cyclostomata). Data on bathymetric affinity, morphology type, frequency of occurrence and total number of fragments are also given. The taxonomic classification for Cheilostomata, Cyclostomata and Ctenostomata is based on that adopted by the International Bryozoology Association (IBA, <http://bryozoa.net/iba.html>) and Pan-European species directories Infrastructure (PESI, <http://www.eu-nomen.eu/portal/>).

#### IDENTIFICATION

Almost all fragments and colonies analyzed were assigned to a specific category of the bryozoan fauna of the Atlantic–Mediterranean region. Uncertainties have only arisen with specimens of the genus *Crisia*, found as small and sterile fragments, and with rectanguloid cyclostomes that were tentatively assigned to the genus *Patinella* (Gordon and Taylor, 1997). The material corresponding to a species partially described by Gautier (1962) as *Palmicellaria* aff. *aviculifera* (Canu and Bassler, 1928) is described as a new species belonging to the current genus *Palmiskenea* (Bishop and Hayward, 1989).

#### SYSTEMATIC ACCOUNT

Family Porellidae Vigneaux, 1949

Genus *Palmiskenea*, Bishop and Hayward, 1989

*Palmiskenea gautieri* sp. nov.

(Figs. 1, 2, 3)

#### ETYMOLOGY

Gautier (1962) described and unusually sketched a species of *Palmicellaria* in his PhD thesis that he thought was close to the Caribbean species *P. aviculifera* (Canu and Bassler, 1928). We examined the material from the collection belonging to Gautier as well as other specimens collected afterwards by J-G. Harmelin and can confirm that they belong to the same species as the one found in our samples and that this species is different from *P. aviculifera*. For this reason, we dedicate the new species to this prominent bryozoologist who produced one of the most complete works about the taxonomy and ecology of bryozoans in the Mediterranean.

#### SYNONYMY

*Palmicellaria* aff. *aviculifera* Gautier, 1962: 201, fig. 18

*Palmicellaria* aff. *aviculifera* Harmelin, 1969: 297, fig. 5: 2–3

*Palmicellaria* aff. *aviculifera* Zabala, 1986: 410, fig. 136, Pl. 6D, E, F

*Palmicellaria* aff. *aviculifera* Zabala and Maluquer, 1988: 118, fig. 250, 251, pl. 9E

#### TYPE MATERIAL

Holotype: INDEMARES 1, Station 68, 105 m. (27/09/09), one live colony. MZB 2013-0072

Paratypes: INDEMARES 1, Station 68, 105 m. (27/09/09) 9 live colonies. MZB 2013-0073, MZB 2013-1602, MZB 2013-1603

All material is deposited in the Natural Sciences Museum of Barcelona

#### COMPARATIVE MATERIAL EXAMINED

*Palmicellaria* aff. *aviculifera*, Coll.: Gautier, St. 231, 52NB

*Palmicellaria* aff. *aviculifera*, Coll.: Harmelin, Grèce 32. MO67, Mangespin St. 72-13, 65 m depth, Port Cros St. 76.18\_2NB, 45 m depth

*Palmicellaria skenei*, Coll.: Harmelin, S. de Riou (St. 68-56, 105-110 m depth; St. 72-8, 90 m depth)

*Palmicellaria* aff. *aviculifera*, Coll.: Zabala, Illes Medes, 30 m depth

#### MEASUREMENTS

ZL,  $811 \pm 56$ , 700–950 (30); ZW,  $396 \pm 70$ , 300–530 (30); OL,  $157 \pm 20$ , 130–200 (24); OW,  $154 \pm 12$ , 140–180 (17); OVL,  $210 \pm 17$ , 186–251 (14); and OVW,  $262 \pm 12$ , 236–280 (12).

#### DESCRIPTION

Colony arising from an encrusting basis (Fig. 1a) to form loosely branching, cylindrical spikes up to 40 mm high (roughly resembling *Omalosecosa ramulosa* colonies), bristly in appearance and with a very different smoothness depending on its conservation status (Fig. 1b, c). Zooids disposed all around the branch, oval, convex, separated by thin, raised sutures. Frontal wall is smooth and fine grained, with a few, small, widely-spaced marginal pores, obscured and eventually occluded older zooids. Primary orifice always obscured by the peristome, longer than broad, with a semi-circular distal margin and a slightly concave proximal border, not provided with condyles (Fig. 1d). Spines are totally absent. Peristome developed as a stout and acute proximal mucro, developing one or two more lateral mucrones, each bearing a small elliptical avicularium on the distal side (Fig. 2a), finely denticulated in profile (Fig. 2b). Ovicell prominent, slightly broader than long, with a flattened proximal area provided with two round pores (Fig. 2c), obscured by secondary calcification (Fig. 2d). Neither embryos, nor the ancestrula was observed.

#### REMARKS

Bishop and Hayward (1989) created the genus *Palmiskenea* to include the species previously assigned to the genus *Palmicellaria* that showed an aperture longer than wide, with the proximal zone straight or convex but without a sinus, with erect colonies of flat branches and of Atlantic or boreal distribution. This criterion was followed by Hayward and Ryland (1999) in their second edition of the synopsis of the British fauna. According to these criteria, our species has to be assigned to the genus *Palmiskenea*.

**Table 2**  
List of bryozoan species with their frequency of occurrence in percentage (%F) and the total number of fragments live and dead. Depth group: Littoral (L), Shelf (S) and Deep (D); Morphology type: erect (1), encrusting frontal budding (2), shell epibionts (3), and always dead (4).

Species name	% F	Fragments N°	Depth group	Morphology
<i>Ctenostomata</i>				
<i>Amathia semiconvoluta</i> Lamouroux, 1824	3.8	1	L	1
<i>Alcyonidium cellarioides</i> Calvet, 1900	3.8	1	S	1
<i>Cheilostomata</i>				
<i>Aetea sica</i> (Couch, 1844)	15.4	7	S	3
<i>Aetea truncata</i> (Landsborough, 1852)	19.2	19	S	3
<i>Alderina imbellis</i> (Hincks, 1860)	11.5	10	D	3
<i>Amphiblestrum lyrulatum</i> (Calvet, 1907)	42.3	55	D	2
<i>Callopora dumerilii</i> (Audouin, 1826)	23.1	7	L	3
<i>Callopora lineata</i> (Linnaeus, 1758)	11.5	6	D	3
<i>Copidozoum tenuirostre</i> (Hincks, 1880)	7.7	2	S	3
<i>Collarina balzaci</i> (Audouin, 1826)	3.8	1	L	3
<i>Figularia figularis</i> (Johnston, 1847)	26.9	18	S	3
<i>Puellina arrecta</i> Bishop & Househam, 1987	15.4	7	D	3
<i>Puellina cassidainis</i> (Harmelin, 1984)	3.8	2	D	3
<i>Puellina innominata</i> (Couch, 1844)	34.6	53	S	3
<i>Puellina radiata</i> (Moll, 1803)	30.8	35	S	3
<i>Chorizopora brongniartii</i> (Audouin, 1826)	34.6	66	S	3
<i>Hippothoa flagellum</i> Manzoni, 1870	15.4	27	S	3
<i>Buffonellaria divergens</i> (Smitt, 1873)	15.4	24	S	3
<i>Buskea dichotoma</i> (Hincks, 1862)	38.5	55	S	1
<i>Buskea nitida</i> Heller, 1867	42.3	70	L	1
<i>Cellepora pumicosa</i> (Pallas, 1766)	3.8	3	S	2
<i>Celleporina caminata</i> (Waters, 1879)	7.7	14	L	2
<i>Lagenipora lepralioides</i> (Norman, 1868)	34.6	51	S	3
<i>Omalosecosa ramulosa</i> (Linnaeus, 1767)	30.8	54	S	1
<i>Turbicellepora avicularis</i> (Hincks, 1860)	38.5	51	L	4
<i>Turbicellepora coronopus</i> (Wood, 1844)	34.6	32	S	3
<i>Reteporella couchii</i> (Hincks, 1878)	11.5	6	S	1
<i>Reteporella grimaldii</i> (Jullien, 1903)	3.8	6	L	1
<i>Reteporella mediterranea</i> Hass, 1948	57.7	175	S	1
<i>Schizoretepora solanderia</i> (Risso, 1826)	7.7	6	D	1
<i>Schizotheca fissa</i> (Busk, 1856)	11.5	18	S	3
<i>Escharina hyndmanni</i> (Johnston, 1847)	30.8	53	D	3
<i>Escharina johnstoni</i> (Quelch, 1884)	15.4	13	D	3
<i>Escharina dutertrei protecta</i> Zabala, Maluquer & Harmelin, 1993	3.8	1	D	3
<i>Escharina vulgaris</i> (Moll, 1803)	26.9	18	S	3
<i>Arthropoma cecilii</i> (Audouin, 1826)	11.5	2	S	3
<i>Cribellopora simplex</i> Gautier, 1957	11.5	7	S	3
<i>Diporula verrucosa</i> (Peach, 1868)	34.6	34	S	1
<i>Microporella ciliata</i> (Pallas, 1766)	53.8	51	S	2
<i>Microporella appendiculata</i> (Heller, 1867)	23.1	25	S	2
<i>Metroporella gay</i> Reverter-Gil, Souto & Fernández-Pulpeiro, 2009	23.1	24	L	2
<i>Pentapora fascialis</i> (Pallas, 1766)	61.5	364	S	4
<i>Schizomavella auriculata</i> (Hassall, 1842)	3.8	1	L	2
<i>Schizomavella cornuta</i> (Heller, 1867)	23.1	63	D	2
<i>Schizomavella discoidea</i> (Busk, 1859)	19.2	9	S	3
<i>Schizomavella hastata</i> (Hincks, 1862)	3.8	1	S	2
<i>Schizomavella linearis</i> (Hassall, 1841)	26.9	19	S	2
<i>Schizomavella mamillata</i> (Hincks, 1880)	3.8	2	S	2
<i>Schizomavella monoecensis</i> (Calvet, 1927)	3.8	3	S	2
<i>Schizomavella rudis</i> (Manzoni, 1869)	34.6	26	S	2
<i>Schizoporella dunkeri</i> (Reuss, 1848)	15.4	14	L	3
<i>Schizoporella mutabilis</i> Calvet, 1927	15.4	9	S	2
<i>Parasmittina trispinosa</i> (Johnston, 1838)	7.7	4	S	2
<i>Prenantia cheilostoma</i> (Manzoni, 1869)	3.8	2	S	3
<i>Prenantia inerma</i> (Calvet, 1906)	15.4	18	L	3
<i>Smittina cervicornis</i> (Pallas, 1766)	65.4	428	S	4
<i>Smittina landsborovii</i> (Johnston, 1847)	30.8	101	S	4
<i>Smittoidea marmorea</i> (Hincks, 1877)	19.2	12	S	2
<i>Smittoidea reticulata</i> (MacGillivray, 1842)	3.8	1	L	2
<i>Watersipora complanata</i> (Norman, 1864)	15.4	17	L	4
<i>Adeonella calveti</i> (Canu and Bassler, 1930)	11.5	24	S	4
<i>Reptadeonella violacea</i> (Johnston, 1847)	34.6	42	S	2
<i>Escharella immersa</i> (Fleming, 1828)	15.4	26	D	2
<i>Escharella octodentata</i> (Hincks, 1880)	3.8	2	S	2
<i>Escharella variolosa</i> (Johnston, 1838)	26.9	11	S	2
<i>Escharella ventricosa</i> (Hassall, 1842)	42.3	52	D	2
<i>Palmiskenea gautieri</i>	46.2	104	S	1
<i>Porella minuta</i> (Norman, 1868)	3.8	4	S	3
<i>Escharoides mamillata</i> (Wood, 1844)	23.1	15	S	2
<i>Fenestulina malusii</i> (Audouin, 1826)	38.5	22	S	3
<i>Neolagenipora collaris</i> (Norman, 1867)	11.5	10	D	3
<i>Beania mirabilis</i> Johnston, 1840	11.5	13	L	1

Table 2 (continued)

Species name	% F	Fragments N°	Depth group	Morphology
<i>Beania robusta</i> (Hincks, 1881)	3.8	4	S	1
<i>Caberea boryi</i> (Audouin, 1826)	7.7	3	S	1
<i>Scrupocellaria delilii</i> (Audouin, 1826)	7.7	6	S	1
<i>Scrupocellaria maderensis</i> Busk, 1860	11.5	46	L	1
<i>Scrupocellaria scruposa</i> (Linnaeus, 1758)	38.5	203	S	1
<i>Epistomia bursaria</i> (Linnaeus, 1758)	3.8	2	L	1
<i>Savignyella lafontii</i> (Audouin, 1826)	30.8	25	L	1
<i>Setosellina capriensis</i> (Waters, 1926)	11.5	10	D	3
<i>Parellisina curvirostris</i> (Hincks, 1862)	3.8	2	S	3
<i>Cellaria fistulosa</i> (Linnaeus, 1758)	19.2	293	S	1
<i>Cellaria salicornioides</i> Lamouroux, 1816	61.5	711	S	1
<i>Cellaria sinuosa</i> (Hassall, 1840)	42.3	110	S	1
<i>Chartella papyrea</i> (Pallas, 1766)	3.8	1	S	1
<i>Hincksina flustroides</i> (Hincks, 1877)	19.2	17	S	2
<i>Hincksinoflustra octodon</i> (Busk, 1852)	7.7	2	D	1
<i>Gregarinidra gregaria</i> (Heller, 1867)	26.9	31	S	2
<i>Coronellina fagei</i> Gautier, 1962	7.7	26	S	3
<i>Micropora coriacea</i> (Johnston, 1847)	3.8	2	S	2
<i>Onychocella marioni</i> (Jullien, 1882)	42.3	57	S	2
<i>Setosella vulnerata</i> (Busk, 1860)	11.5	22	S	3
<i>Cyclostomata</i>				
<i>Crisia cuneata</i> Maplestone, 1905	3.8	1	L	1
<i>Crisia ramosa</i> Harmer, 1891	11.5	12	S	1
<i>Crisia sigmoidea</i> Waters, 1916	3.8	40	L	1
<i>Crisia</i> sp. Lamouroux, 1812	26.9	18	1	
<i>Fron dipora verrucosa</i> (Lamouroux, 1821)	53.8	122	L	1
<i>Disporella hispida</i> (Fleming, 1828)	23.1	10	S	3
<i>Patinella</i> sp.	19.2	16	3	
<i>Annectocyma arcuata</i> (Harmelin, 1976)	3.8	2	S	3
<i>Annectocyma indistincta</i> (Canu & Bassler, 1929)	3.8	5	S	3
<i>Annectocyma major</i> (Johnston, 1847)	42.3	106	S	3
<i>Annectocyma tubulosa</i> (Busk, 1875)	57.7	256	S	3
<i>Entalophoroecia gracilis</i> Harmelin, 1976	57.7	515	S	3
<i>Entalophoroecia robusta</i> Harmelin, 1976	15.4	77	S	3
<i>Cardioecia watersi</i> (O'Donoghue & de Watteville, 1939)	15.4	13	D	1
<i>Diplosolen obelia</i> (Johnston, 1838)	19.2	15	L	3
<i>Plagioecia patina</i> (Lamarck, 1816)	11.5	26	L	3
<i>Plagioecia dorsalis</i> (Waters, 1879)	38.5	33	S	1
<i>Tervia irregularis</i> (Meneghini, 1844)	53.8	347	D	1
<i>Tubulipora liliacea</i> (Pallas, 1766)	34.6	26	S	3
<i>Tubulipora notomale</i> (Busk, 1875)	38.5	89	S	1
<i>Exidmonea triforis</i> (Heller, 1867)	38.5	268	S	1

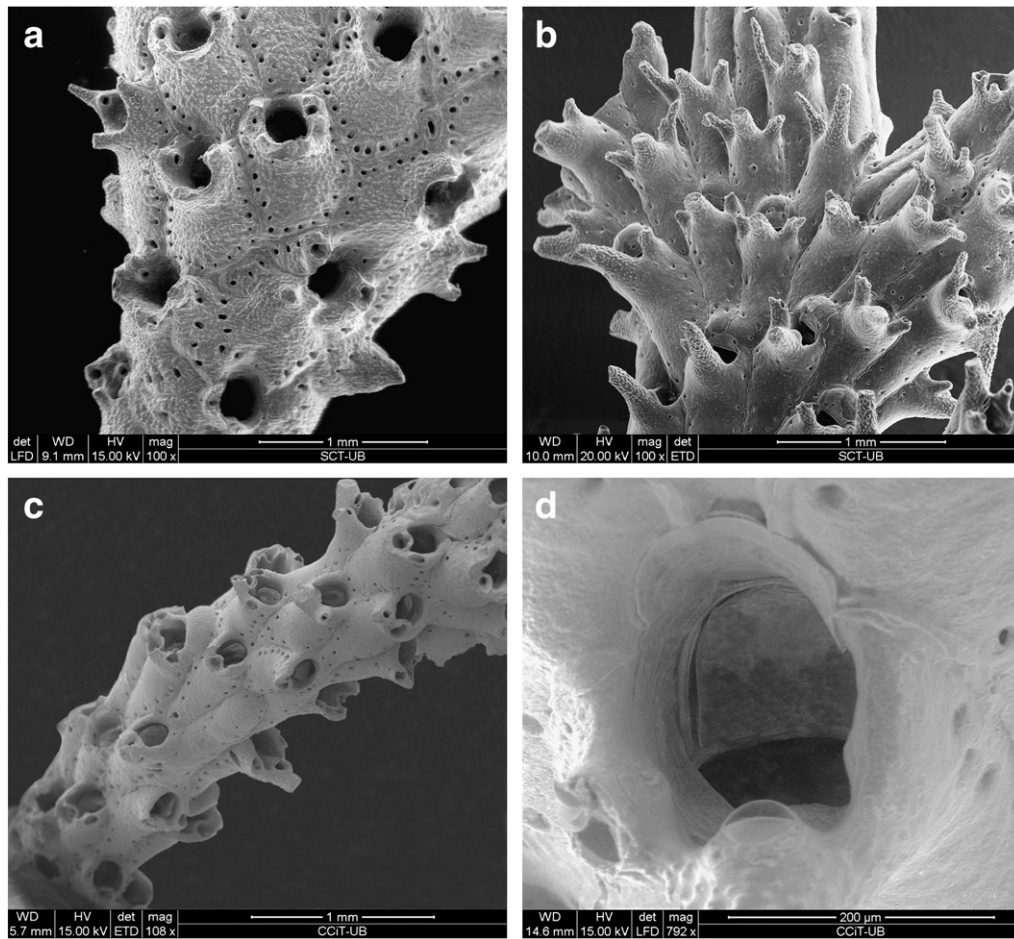
*P. aviculifera* was first described by Canu and Bassler (1928) using specimens from the Gulf of Mexico, their work providing very little detail and a small figure. Fortunately, the type material is deposited in the National Museum of Natural History, Smithsonian Institution (Washington, USA), which was used to verify that *P. aviculifera* is an encrusting species with an apparent resemblance to the species described in this paper. Although both species bear some similarities, four important differences can be observed: 1) *P. aviculifera* is always an encrusting species; 2) four to five irregularly distributed avicularia can always be found around the peristome; 3) although not cited by the authors in the original description, SEM photographs revealed numerous pores of irregular shape and size on the ovicell surface (Fig. 3a) which can be hidden due to secondary calcification; and 4) two spines can occasionally be seen at the distal end of the aperture (Fig. 3b).

Out of the three Atlantic species of *Palmiskeneia*, only *P. skenei* (Ellis & Solander) shows similar characters: 1) the general shape of the zooids; 2) the appearance of the frontal; 3) the general shape of the aperture, oval and longer than wide; and 4) the prominent peristomial umbos with an oval avicularium. Although *P. skenei* has been described as a species generally having a sole proximal mucro, Hayward and Ryland (1999, p.178, fig. 67) stated that "several varieties have been described, notably var. *bicornis* Busk and var. *tridens* Busk in which the suboral mucro may be bifid or trifid, one or both limbs bearing an avicularium", in total agreement with the zooidal shape of our Mediterranean species.

However, three differences separate them: 1) the shape of the colonies that are erect, with a cylindrical cross-section, whereas for *P. skenei* they are flat; 2) the precise shape of the aperture, in this case with no lateral condyles and with the proximal margin erect or slightly concave, whereas *P. skenei* shows two weak condyles and has a convex proximal margin; and 3) the ovicell shows two round pores whereas *P. skenei* has multiple pores of irregular shape.

Even though we have not been able to examine the type material for *P. skenei* (unfortunately the specimens of this species deposited in the Natural History Museum, London, no longer exist, M Spencer pers. comm.), specialists consulted confirmed that the specimens belong to two different species (PJ Hayward, JS Ryland, and JDD Bishop, pers. comms.).

There is no doubt that the material collected during the INDEMARES cruises and the material deposited in the collection of Gautier (Fig. 3c) belongs to the same species. There are also no doubts with the specimen from the coasts of Riou that Harmelin classified as *P. skenei*. However, the material from Harmelin assigned to the species *P. aff. aviculifera* is uncertain. Specifically, in the description of the samples collected in Greece (Eastern Mediterranean) (Harmelin, 1969, fig. 5-2), an ovicell perforated by small pores can be observed. On the other hand, the specimen found in Port Cross frequently shows more than three avicularia in the peristome, so it would be closer to the Caribbean species described by Canu and Bassler (Fig. 3d).



**Fig. 1.** *Palmiskenea gautieri* sp. nov. a) Encrusting base of a colony; b) colony with zooidal peristomes well preserved; c) eroded colony; and d) primary orifice without condyles and partially occluded by the peristome.

### 3.2. Biogeographical analysis

The bryozoan samples collected from the continental shelf off Cap de Creus during the INDEMARES cruises can be considered an accurate representation of the bryozoan fauna of the NW Mediterranean (Rosso, 2003; Rosso et al., 2010a; Zabala and Maluquer, 1988). However, six species stand out from this collection, mainly due to their biogeographical distributions in the Mediterranean. To our knowledge, two of these species have never been reported in the Mediterranean Sea further away from the Strait of Gibraltar.

Family Flustridae Smitt, 1868  
Genus *Hincksinoflustra* Bobin & Prenant, 1961  
*Hincksinoflustra octodon* (Busk, 1852)  
(Fig. 4a)

#### SYNONYMY

*Flustra octodon* Busk, 1852: 49, fig. 4, 5, pl. 56, 58  
*Spiralaria strictocella* Canu & Bassler, 1925: 13, fig. 1-3, pl. 1  
*Hincksina octodon* Gautier, 1962: 51  
*Hincksinoflustra octodon* Prenant & Bobin, 1966: 196, fig. 60

#### MATERIAL EXAMINED

INDEMARES 0, Station 44, 116 m, (26/09/09) 2 fragments, 350 mm<sup>2</sup>

INDEMARES 1, Station 3, 136 m, (07/06/10) 1 fragment, 60 mm<sup>2</sup>

#### MEASUREMENTS

ZL, 254 ± 21, 210–300 (29); ZW, 49 ± 8, 30–60 (29); AvL, 80 ± 9, 70–100 (14); and AvW, 52 ± 11, 40–80 (14).

#### DESCRIPTION

See Prenant & Bobin, 1966, pp. 196–200, fig. 60.

#### REMARKS

This species seems confined to the sandy or muddy bottoms of the continental shelf since it has never been reported in the littoral rocky bottoms of the Catalan coast. Although endemic to the Mediterranean Sea, it has been scarcely cited. Most of the references come from the Strait of Gibraltar area and the African coasts of Algeria, Morocco and Tunisia (Gautier, 1962; Prenant and Bobin, 1966; López de la Cuadra and García-Gómez, 1988), although Busk (1852) mentioned its presence in Spanish coasts and more recently Rosso (1996a) found it in Sicily (SE section of the Mediterranean basin). The only reference in the Catalan Coast comes from Gonse (1952), who precisely described material collected from Port Vendres (France).

Family Calloporidae Norman, 1903

Genus *Alderina* Norman, 1903  
*Alderina imbellis* (Hincks, 1860)  
(Fig. 4b)

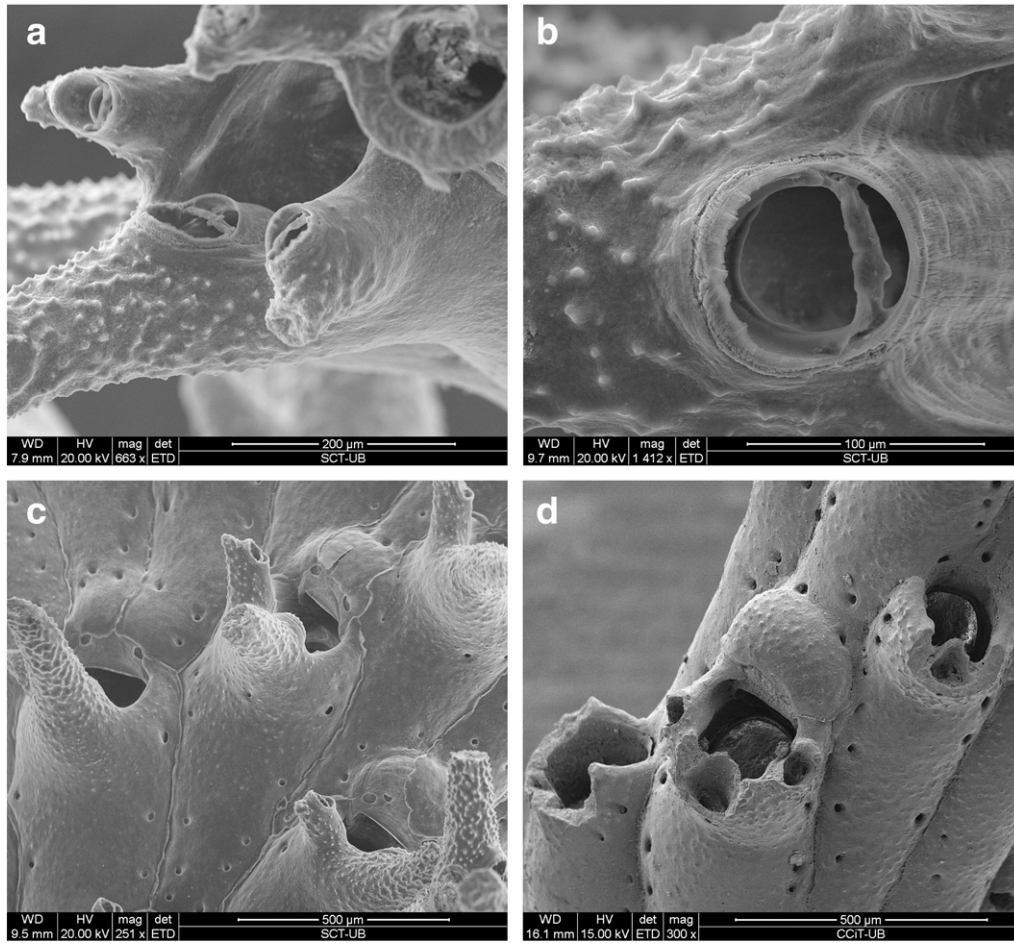
#### SYNONYMY

*Membranipora imbellis* Hincks, 1860: 275  
*Membranipora imbellis* Hincks, 1880: 160, fig. 1-2, pl. 20  
*Alderina imbellis* Prenant & Bobin, 1966: 212, fig. 66, III-V  
*Alderina imbellis* Ryland & Hayward, 1977: 96, fig. 40

#### EXAMINED MATERIAL

INDEMARES 2, Station 5, 123 m, (07/06/10). 1 dead fragment, 4 mm<sup>2</sup>

INDEMARES 2, Station 6, 136 m, (07/06/10). 8 live colonies, 120 mm<sup>2</sup>



**Fig. 2.** *Palmiskenea gautieri* sp. nov. a) Granular peristomial mucrones with elliptical avicularia; b) detail of avicularium (note the denticulated distal margin); c) ovicell with two round pores; and d) ovicell with secondary calcification.

INDEMARES 2, Station 7, 132 m, (07/06/10). 1 live colony, 18 mm<sup>2</sup>

#### MEASUREMENTS

ZL, 468 ± 90, 363–631 (8); ZW, 371 ± 50, 331–473 (7); opL, 177 ± 19, 148–200 (5); and opW, 309 ± 19, 292–337 (6).

#### DESCRIPTION

See Ryland & Hayward, 1977, pp. 96, fig. 40.

#### REMARKS

*A. imbellis* seems to be a cool temperate species, formerly regarded as strictly Atlantic in distribution, although it has not been extensively reported in the literature. It has been found from the coasts of Norway to the coasts of Cantabria in North Spain (Barroso, 1918). In the Mediterranean the only previous records come from Tunisia (Canu and Bassler, 1930) and Chios (Eastern Mediterranean) (Hayward, 1974).

Family Romancheinidae, Jullien 1888

Genus *Escharella* Gray, 1848

*Escharella immersa* (Fleming, 1828)

(Fig. 4c)

#### SYNONYMY

*Lepralia immersa* Fleming, 1828: 533

*Mucronella peachii*: Hincks, 1880: 360, fig. 1–5, pl. 50

*Escharella immersa* Hayward & Ryland, 1979: 138, fig. 53

#### EXAMINED MATERIAL

INDEMARES 1, Station 12, 148 m, (23/09/09). 14 live colonies and dead, 1138 mm<sup>2</sup>

INDEMARES 1, Station 18, 225 m, (23/09/09). 3 live colonies, 88 mm<sup>2</sup>

INDEMARES 2, Station 6, 136 m, (07/06/10). 6 dead fragments, 42 mm<sup>2</sup>

INDEMARES 2, Station 7, 132 m, (07/06/10). 1 dead fragment 2 mm<sup>2</sup>

#### MEASUREMENTS

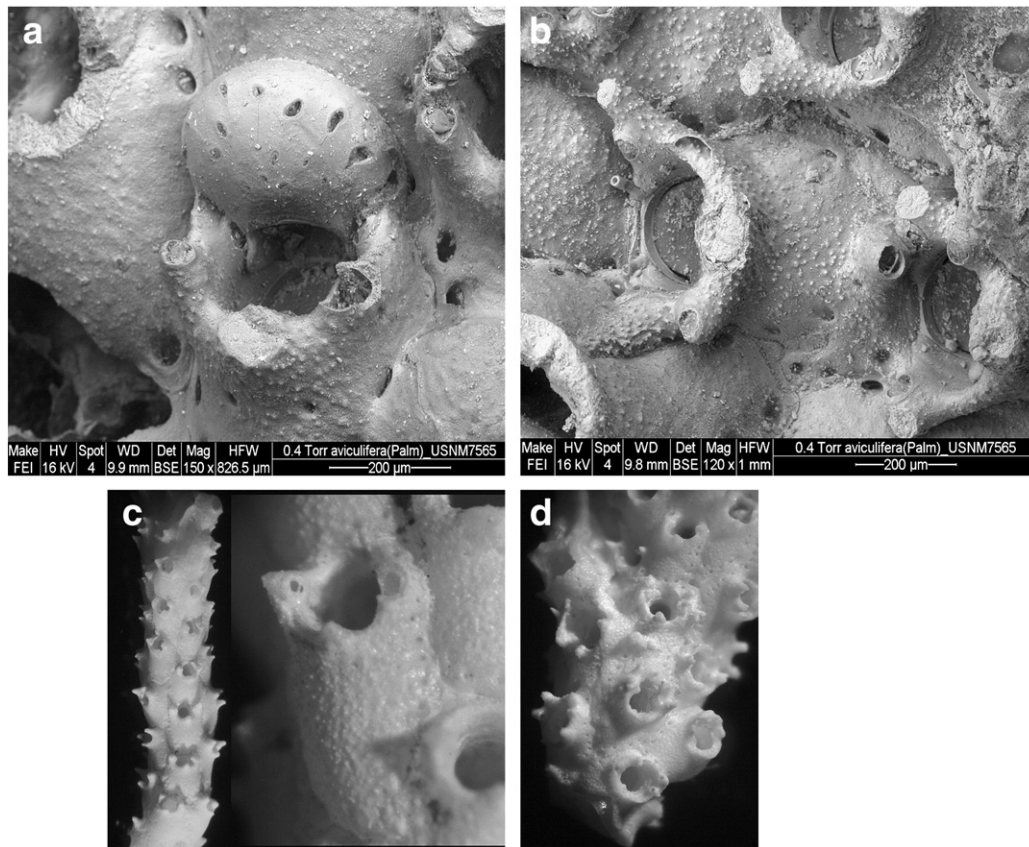
ZL, 499 ± 48, 400–625 (21); ZW, 457 ± 71, 375–550 (21); OL, 83 ± 12, 75–100 (21); and OW, 106 ± 11, 100–125 (21).

#### DESCRIPTION

See Hayward & Ryland, 1979, pp. 138, fig. 53

#### REMARKS

A cold-water boreal-arctic species, *E. immersa* seemed to be absent from the Mediterranean (Hayward and Ryland, 1999), although it was dredged from deep waters (1378 m, 145 m) at the two sides of the Gibraltar strait by the BALGIM cruise (Harmelin and d'Hondt, 1992). J-G Harmelin (pers. comm.) found it dead on a fragment of *Turbicellepora avicularis* as part of a thanatocoenosis in the Cassidagne canyon at 200 m depth. To our knowledge, this is the first report of this species well inside the Mediterranean basin, or at least in NW Mediterranean waters. *Escharella acuta* Zabala et al., 1993 is closely related to *E. immersa*. They share the same spine formula (six, but only four in the ovicellate zooids), and show an identically shaped aperture with a very similar lyrula. The only differences observed are the larger and sharper umbo and the size of the zooids (larger in *E. acuta*), maybe it just represents a junior synonym of *E. immersa*. The finding of the characteristic Atlantic specimens of *E. immersa*



**Fig. 3.** *Palmicellaria aviculifera* from the Museum of Natural History, Smithsonian Institution, [Canu and Bassler \(1928\)](#) collection a) ovicell with irregular pores; b) spines on the distal part of the orifice; c) *Palmicellaria* aff. *aviculifera* from the [Gautier's](#) collection (Port Cross St231\_52NB); d) *P.* aff. *aviculifera* from the [Harmelin](#) collection (Port Cross St76.18\_2NB).

(also similar in size) in the Cap de Creus region at similar depths and localities to those where *E. acuta* was found could indicate that the status of the latter species needs revising.

Family Romancheinidae, [Jullien 1888](#)  
Genus *Lagenipora* [Hincks, 1877](#)  
*Lagenipora lepralioides* ([Norman, 1868](#))  
([Figs. 4d, 5a](#))

#### SYNONYMY

*Celleporella lepralioides* [Norman, 1868](#)

*Lagenipora lepralioides* [Gautier 1962: 252](#)

*Lagenipora* sp. [Zabala & Maluquer, 1988: 160, fig. 445, 446, pl. 26E, F](#)

*Lagenipora lepralioides* [Hayward, 1994: 203, fig. 12E](#)

*Lagenipora lepralioides* [De Blauwe, 2009: 410, fig. 441](#)

#### EXAMINED MATERIAL

INDEMARES 0 Station 96, 108 m (24/07/09). 1 live colony

INDEMARES 1 Station 12, 148 m (23/09/09). 5 live colonies

INDEMARES 1 Station 22, 110 m (23/09/09). 1 dead colony

INDEMARES 2 Station 3, 136 m (07/06/10). 2 live colonies and 12 dead colonies

INDEMARES 2 Station 4, 128 m (07/06/10). 3 live colonies and 16 dead colonies

INDEMARES 2 Station 5, 123 m (07/06/10). 2 dead colonies

INDEMARES 2 Station 7, 132 m (07/06/10). 1 dead colony

INDEMARES 2 Station 39, 100 m (07/06/10). 1 live colony

#### MEASUREMENTS

ZL,  $480 \pm 73$ , 313–557 (17); ZW,  $283 \pm 32$ , 224–326 (16); PAL,  $162 \pm 23$ , 109–200 (21); and PAW,  $172 \pm 23$ , 137–226 (17).

#### DESCRIPTION

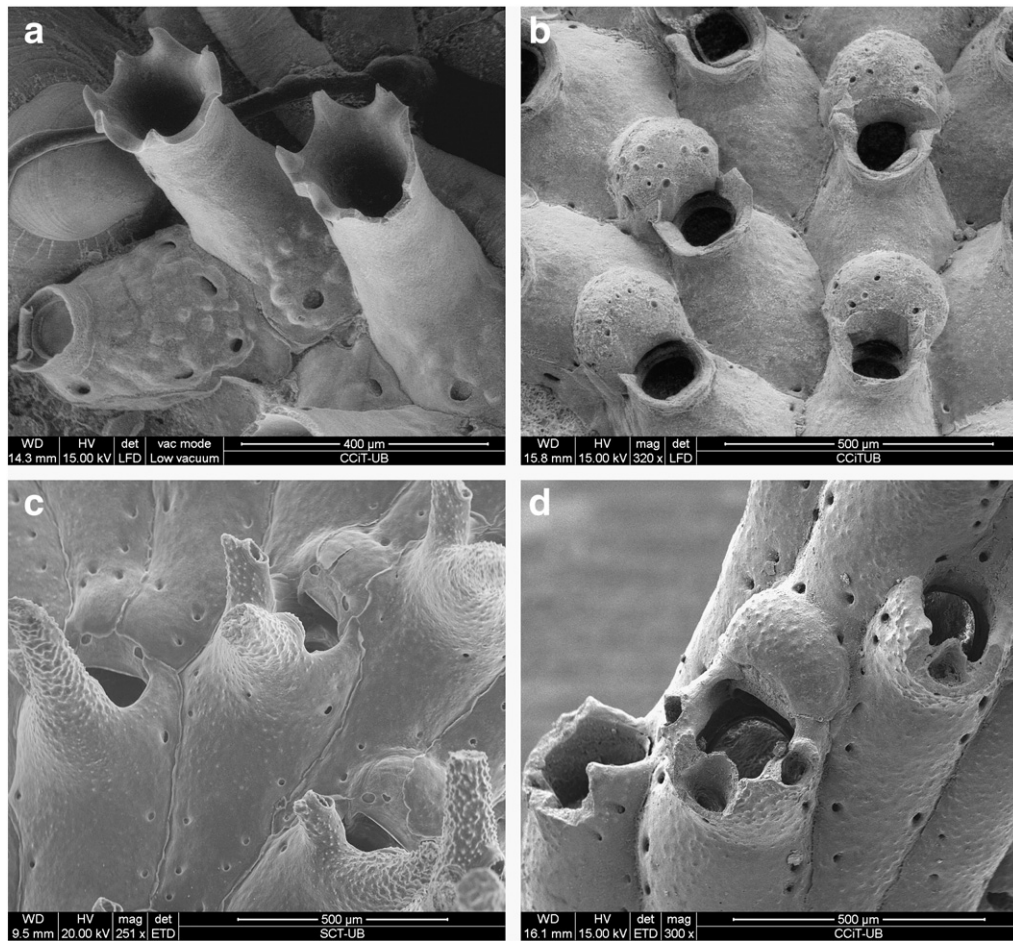
See [Hayward, 1994](#), pp. 203, fig. 12E.

#### REMARKS

This species is probably widely distributed and cited in the Western Mediterranean, however, it has not been properly illustrated. [Gautier \(1962\)](#) reported a Mediterranean *Lagenipora lepralioides* that he identified as *Lagenipora socialis* described by [Hincks \(1880, p. 235, figs. 7–8, pl. 34\)](#), as well as *Celleporella lepralioides* of [Norman \(1868\)](#) and *Lagenipora socialis* of [Osburn \(1952, p. 488, figs. 3–4, pl. 60\)](#). It is certain that the specimens found in our samples do not correspond to *Lagenipora socialis* of [Osburn](#), which shows a pair of avicularia in the peristome. The description given by [Gautier \(1962\)](#) of the peristome (... “peristome crénelé, évasé” ...) and the measurements from his specimens are compatible with the species here presented, but unfortunately his description was not accompanied by any illustration and his material got lost. On the other hand, the illustrations from the Atlantic material provided by [Hayward and Ryland \(1998\)](#) do not seem to be appropriate because they do not show the sharp-edged peristome so characteristic of this species. However, given the fragility of such structure (in our samples, only 2 out of the 40 colonies examined kept the entire peristome), it seems reasonable to figurate this species under the appearance shown by the specimens with broken peristomes. The only graphical representation of the entire zooids that seems adequate enough to classify this species is found in [Hayward \(1994, fig. 12E\)](#) and in [Zabala and Maluquer \(1988, fig. 445, pl. 26E, F\)](#).

The small colonies of this species were found growing preferentially on the edges of lamellibranch shells and they seem to be fairly abundant on the shelly-detritic bottoms of this part of the continental shelf off Cap de Creus. *L. lepralioides* seems to have a





**Fig. 4.** a) Detail of *Hincksinoflustra octodon* with non-ovicellate zooids; b) detail of a colony of *Alderina imbellis* with ovicellate zooids; c) colony of *Escharella immersa* (note the characteristic areolation and four spines remaining on the ovicellate zooids); and d) encrusting colony of *Lagenipora lepralioides*.

boreal-Atlantic distribution (Hayward and Ryland, 1999). It has been reported in the Mediterranean from marine sediments of the Rhône delta in France, probably from a thanatocoenoses since very few live specimens were found (Lagaaij and Gautier, 1965). Its presence has also been signaled from detritic bottoms from the surroundings of Port-Cross (French Mediterranean coast) (Harmelin, 1978) and in Sicily (Rosso, 1996a).

Genus *Neolagenipora* Vigneaux, 1949  
*Neolagenipora collaris* (Norman, 1867)  
 (Fig. 5b)

#### SYNONYMY

*Lepralia collaris* Norman, 1867: 204.

*Phylactella collaris*: Hincks, 1880: 358, fig. 3, pl. 43.

*Phylactellipora collaris*: Hayward & Ryland, 1979: 162, fig. 65.

#### MATERIAL EXAMINED

INDEMARES 1, Station 12, 148 m, (23/09/09). 3 live colonies

INDEMARES 2, Station 3, 136 m, (07/06/10). 2 live colonies and 1 dead colony

INDEMARES 2, Station 4, 128 m, (07/06/10). 1 live colony and 2 dead colonies

#### MEASUREMENTS

ZL,  $321 \pm 25$ , 284–367 (18); ZW,  $288 \pm 21$ , 260–331 (21); OL,  $92 \pm 7$ , 76–101 (21); OW,  $107 \pm 9$ , 86–122 (21); OVL,  $170 \pm 11$ , 154–189 (19); and OVW,  $226 \pm 16$ , 201–266 (19). Zoecium length was measured to the basis of the peristome.

#### DESCRIPTION

See Hayward & Ryland, 1979, pp. 162, fig. 65.

#### REMARKS

An encrusting species found on the inner surface of lamellibranch valves from detritic bottoms of the continental shelf, *N. collaris* is an Atlantic species that has never been reported alive in Mediterranean waters. It has only been found as a fossil in palaeocommunities from Sicily (Rosso and Sanfilippo, 2005).

Family Schizoporellidae Jullien, 1903  
 Genus *Escharina* Milne-Edwards, 1836  
*Escharina johnstoni* (Quelch, 1884)  
 (Fig. 5c, d)

#### SYNONYMY

*Schizoporella (Lepralia) johnstoni* Quelch, 1884

*Lepralia simplex* Johnston 1847: 305, fig. 4, pl. 54.

*Schizoporella simplex* Hincks 1880: 246, figs. 9,10, pl. 35.

*Escharina johnstoni* Quelch in Ryland 1969: 219.

*Escharina johnstoni* Hayward & Ryland, 1979: 194, fig. 81.

#### MATERIAL EXAMINED

INDEMARES 1, Station 12, 148 m, (23/09/09). 2 live colonies

INDEMARES 2, Station 3, 136 m, (07/06/10). 1 live colony and 4 dead fragments (20 and 54 mm<sup>2</sup>)

INDEMARES 2, Station 4, 128 m, (07/06/10). 4 dead fragments, 54 mm<sup>2</sup>

#### MEASUREMENTS

ZL,  $696 \pm 49$ , 580–770 (30); ZW,  $479 \pm 56$ , 400–580 (30); OL,  $132 \pm 20$ , 90–190 (30); OW,  $117 \pm 19$ , 90–160 (30); OVL,  $396 \pm 48$ , 300–480 (15); OVW,  $407 \pm 43$ , 300–500 (16); AvL,  $113 \pm 23$ , 90–170 (9); and AvW,  $85 \pm 15$ , 70–110 (8).

#### DESCRIPTION

See Hayward & Ryland, 1979, pp. 194, fig. 81

#### REMARKS

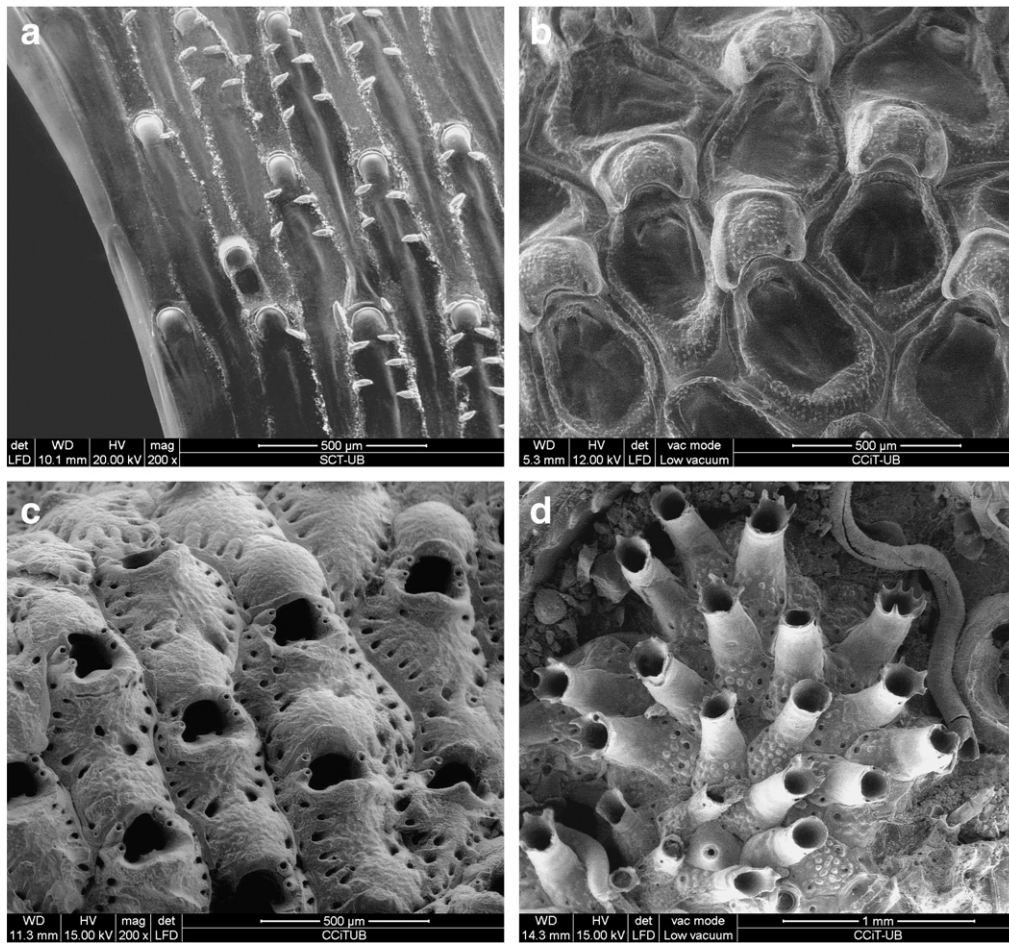


Fig. 5. a) Detail of ovicellate zooids of *Lagenipora lepralioides* showing the characteristic but fragile peristomes; b) *Neolagenipora collaris* (note zooids with ovicells); c) fragment of a colony of *Escharina johnstoni*, and d) detail of an ovicellate zooid in *E. johnstoni*.

According to Hayward and Ryland (1999), *E. johnstoni* is a poorly known species, possibly related to the edge of the continental shelf and strictly Atlantic. Its known distribution was limited to the western coasts of the British Isles, but Saguar and Boronat (1987) reported its presence in the Columbretes islands (NW Mediterranean) but gave no details and also by López de la Cuadra and García-Gómez (1988) in the Alboran Sea. Much more accurate is the report from Harmelin and d'Hondt (1992) who collected this species in six stations on both sides

of the Gibraltar Strait, between 145 and 170 m depth. Although its distribution seemed restricted to these areas, new records for this species have been made in the open shelf of Sicily (Rosso, 1996a, 2003).

### 3.3. Species richness and sampling representativity

Rarefaction curves for the number of fragments accumulated over the 26 samples approached an asymptotic distribution, suggesting that the

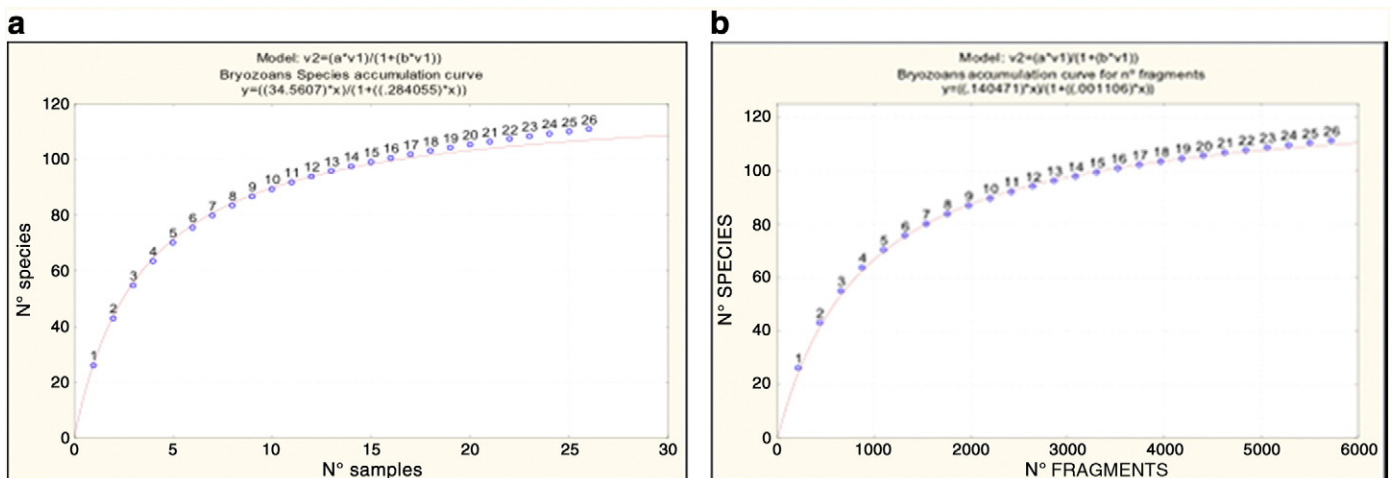


Fig. 6. a) Bryozoan species number versus number of samples (per curve) and b) number of fragments (lower curve) examined with ESTIMATES (Mao-Tau coefficient) from the continental shelf of Cap de Creus.

**Table 3**

Richness (number of species), expected Richness, abundance (number of fragments) and biomass (surface live) and Kruskal–Wallis test results (H) and probability (p) by depth, substrate type and distance from canyon.

	No species		Expected richness		No of fragments		Surface live (mm2)		
	Mean	SD	n	Mean	SD	n	Mean	SD	
<i>Depth range</i>									
Shallow (61–105 m)	16.9	± 15.2	9	15.0	± 19.9	9	1900.0	± 3417.5	9
Medium (106–123 m)	20.5	± 11.0	8	17.5	± 12.3	8	2293.8	± 3436.4	8
Deep (123–225 m)	39.4	± 15.4	9	33.2	± 21.2	9	4188.2	± 4394.8	9
K–W test results	H 7.677			H 4.903			H 4.076		
	p 0.022*			p 0.086			p 0.130		
<i>Substrate type</i>									
Silt	2.0	± 1.7	3	0.6	± 0.3	3	71.7	± 115.6	3
Sand	7.5	± 1.7	4	2.3	± 1.2	4	95.8	± 173.1	4
Coarse sand	35.5	± 11.3	12	30.1	± 17.2	12	3095.8	± 4089.0	12
Gravel	29.9	± 15.9	7	28.7	± 19.5	7	5056.6	± 3763.5	7
K–W test results	H 16.148			H 15.152			H 15.208		
	p 0.001*			p 0.002*			p 0.002*		
<i>Distance from canyon</i>									
<2 km	17.9	± 14.9	13	15.8	± 17.5	13	1502.8	± 2914.1	13
>2 km	33.7	± 15.6	13	28.3	± 20.2	13	4123.7	± 4190.7	13
K–W test results	H 4.124			H 2.778			H 8.698		
	p 0.042*			p 0.096			p 0.002*		

\* Indicates significant results.

sampling conducted in the study area was representative (Fig. 6). By applying the Clench function (Jiménez-Valverde and Hortal, 2003) we estimated that the regional species richness is around 122 species. This approach suggests that with our sampling of 26 samples 91% of the community species we identified. However, in order to identify 95% of the species that dwell in the area we would need a much larger sampling effort, of around 67 samples.

3.4. Environmental analysis of species richness

Neither the number of species nor the biomass showed a clear pattern with depth, whereas differences in species richness, abundance and biomass among substrate types were significant (Table 3). Few bryozoans were found on samples with silt and fine sand sediments and these showed low abundance and biomass. In contrast, samples on coarse sand and gravelly substrates yielded a higher number of bryozoans (up to 62 species per sample) and biomass. Also, species richness and biomass significantly increased towards the canyon rim (Table 3).

3.5. Community analysis

The MDS analysis on the total number of fragments (live and dead) displayed two groups of samples, discriminating the sand samples from the coarse sand and gravel samples (Fig. 7). The ANOSIM test showed that differences in bryozoan composition between substrate types

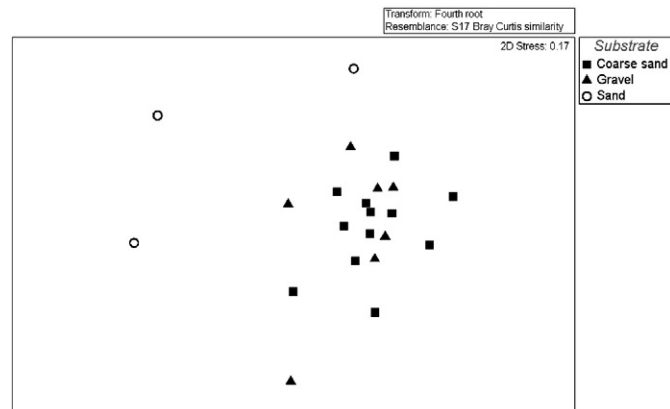


Fig. 7. Non-parametric MDS ordination plot of total number of fragments data of bryozoans from the continental shelf off Cap de Creus.

were statistically significant (Global R = 0.368, P = 0.002). Pairwise contrast between sand and both coarse sand and gravel were significant (R = 0.907, P = 0.002; R = 0.774, P = 0.017 respectively) while no

**Table 4**

Bryozoan taxa contributing most (cut-off applied at 2% contribution) to the average similarity within substrate groups. Species are ordered in decreasing contribution.

	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
<i>Coarse sand average similarity: 43.71%</i>					
<i>Entalophorecia gracilis</i>	1.89	3.4	1.82	7.79	7.79
<i>Smittina cervicornis</i>	1.72	3.33	3.7	7.62	15.41
<i>Cellaria salicornioides</i>	1.71	2.58	1.29	5.9	21.31
<i>Annectocyma tubulosa</i>	1.51	2.35	1.35	5.39	26.69
<i>Tervia irregularis</i>	1.52	2.17	1.3	4.96	31.65
<i>Reteporella mediterranea</i>	1.27	1.84	1.01	4.21	35.86
<i>Pentapora fascialis</i>	1.42	1.78	1.01	4.07	39.93
<i>Buskea nitida</i>	1.05	1.51	1.06	3.44	43.37
<i>Exidmonea trifloris</i>	1.27	1.41	0.83	3.24	46.61
<i>Palmiskenea gautieri</i>	1.03	1.4	1.02	3.2	49.8
<i>Cellaria sinuosa</i>	1.07	1.27	0.81	2.9	52.71
<i>Onychoceia marioni</i>	1.01	1.26	1.06	2.88	55.58
<i>Ramphonotus minax</i>	0.89	1.07	0.81	2.45	58.03
<i>Fron dipora verrucosa</i>	0.85	0.97	0.82	2.22	60.25
<i>Turbicellepora avicularis</i>	0.85	0.96	0.82	2.19	62.44
<i>Gravel average similarity: 40.55%</i>					
<i>Smittina cervicornis</i>	2.08	3.76	1.32	9.26	9.26
<i>Cellaria salicornioides</i>	2.1	3.62	1.31	8.93	18.19
<i>Escharella ventricosa</i>	1.18	2.99	2.69	7.37	25.57
<i>Pentapora fascialis</i>	1.71	2.68	1.25	6.6	32.17
<i>Microporella ciliata</i>	1.04	2.17	1.28	5.36	37.53
<i>Tervia irregularis</i>	1.45	1.97	0.84	4.86	42.39
<i>Annectocyma tubulosa</i>	1.27	1.61	0.89	3.98	46.37
<i>Fron dipora verrucosa</i>	1.22	1.57	0.85	3.87	50.24
<i>Entalophorecia gracilis</i>	1.45	1.53	0.87	3.76	54
<i>Tubulipora notomale</i>	1.06	1.39	0.86	3.43	57.43
<i>Crisia sp.</i>	0.81	1.28	0.83	3.16	60.59
<i>Reteporella mediterranea</i>	1.01	1.1	0.57	2.72	63.31
<i>Annectocyma major</i>	0.99	1.01	0.56	2.48	65.8
<i>Cellaria sinuosa</i>	0.87	1.01	0.61	2.48	68.28
<i>Microporella pseudomarsupiata</i>	0.76	0.93	0.55	2.29	70.57
<i>Reptadeonella violacea</i>	0.67	0.9	0.54	2.21	72.78
<i>Palmiskenea gautieri</i>	0.96	0.82	0.54	2.03	74.81
<i>Sand average similarity: 19.14%</i>					
<i>Cellaria salicornioides</i>	0.84	4.92	0.58	25.7	25.7
<i>Fenestulina malusii</i>	0.8	3.88	0.58	20.29	45.99
<i>Scrupocellaria scruposa</i>	0.67	3.88	0.58	20.29	66.27
<i>Pentapora fascialis</i>	0.73	3.23	0.58	16.86	83.14
<i>Turbicellepora avicularis</i>	0.77	3.23	0.58	16.86	100

differences were found between samples on coarse sand and gravels. SIMPER analysis showed that the differences between the two groups are more quantitative than qualitative. The discriminant species were common to all samples, although their abundances changed according to substrate type (Table 4). The number of species that contributed to within-groups similarity was very large, with low Sim/SD contribution values (Table 4).

### 3.6. Community description

According to the known bathymetric distributions, most of the collected species ( $n = 72$ , 63.7%) are characteristic shelf species, with a range of 50 to 200 m depth. Littoral species, mainly occurring at depths of less than 50 m, and species from deep waters, always found at depths of more than 100 m, were less frequent ( $n = 22$ , 19.5% and  $n = 17$ , 15%, respectively) (Table 2). According to their morphology, the bryozoans collected on the continental shelf off the Cap de Creus were dominated by groups 3 (small-sized, creeping) (41%) and 1 (erect) (34%), whereas species from group 2 (massive encrusting) were not that well represented in our samples (27%) and group 4 (dead fragments) showed a high contribution in number of fragments but with few characteristic species (6%) (Table 2).

Where coarse sand and gravels characterize the sediment, the bryozoan community is dominated by the small, erect species *Cellaria salicornioides*, *Cellaria fistulosa*, *Cellaria sinuosa*, *Scrupocellaria scruposa*, *Buskea dichotoma*, *P. gautieri* sp. nov., *Exidmonea triforis*, *Tervia irregularis* and *Fron dipora verrucosa*; the small species adapted to growing on dead shells like *Escharella ventricosa*, *Fenestulina malusii*, *Turbicellepora*

*coronopus*, *Entalophoroecia gracilis*, *Onychocella marioni*, *Annectocyma tubulosa* and *Annectocyma major*; the only representative species of large size is the lace-like *Reteporella mediterranea*. Also characteristic of this community, but always found as dead components of the gravels, were *Smittina cervicornis*, *Pentapora fascialis*, *Smittina landsborovii* and *T. avicularis*. In the poorest version of the community (on fine sands) the species left were *C. salicornioides*, *C. fistulosa*, *C. sinuosa*, *S. scruposa* and *T. irregularis*.

## 4. Discussion

### 4.1. Taxonomy

The high number of bryozoan species recorded in the relatively low number of samples collected can be regarded as an indication of the high biodiversity of the continental shelf off Cap de Creus, and provides new arguments to promote the conservation of this area. In spite of the high diversity observed, there are few taxonomic novelties for the regional fauna, which probably reflects the great taxonomic knowledge of bryozoans in the NW Mediterranean (Harmelin, 1992; Rosso, 2003; Zabala and Maluquer, 1988). Noteworthy therefore, are the presence of four Atlantic species rarely found or previously unknown in the Mediterranean Sea (*A. imbellis*, *E. immersa*, *N. collaris* and *E. johnstoni*), a poorly described species (*L. lepralioides*), and two Mediterranean endemic species (*H. octodon* and *P. aff. aviculifera*) that have been rarely reported. The latter is redescribed in the present work as a new species: *P. gautieri* sp. nov.

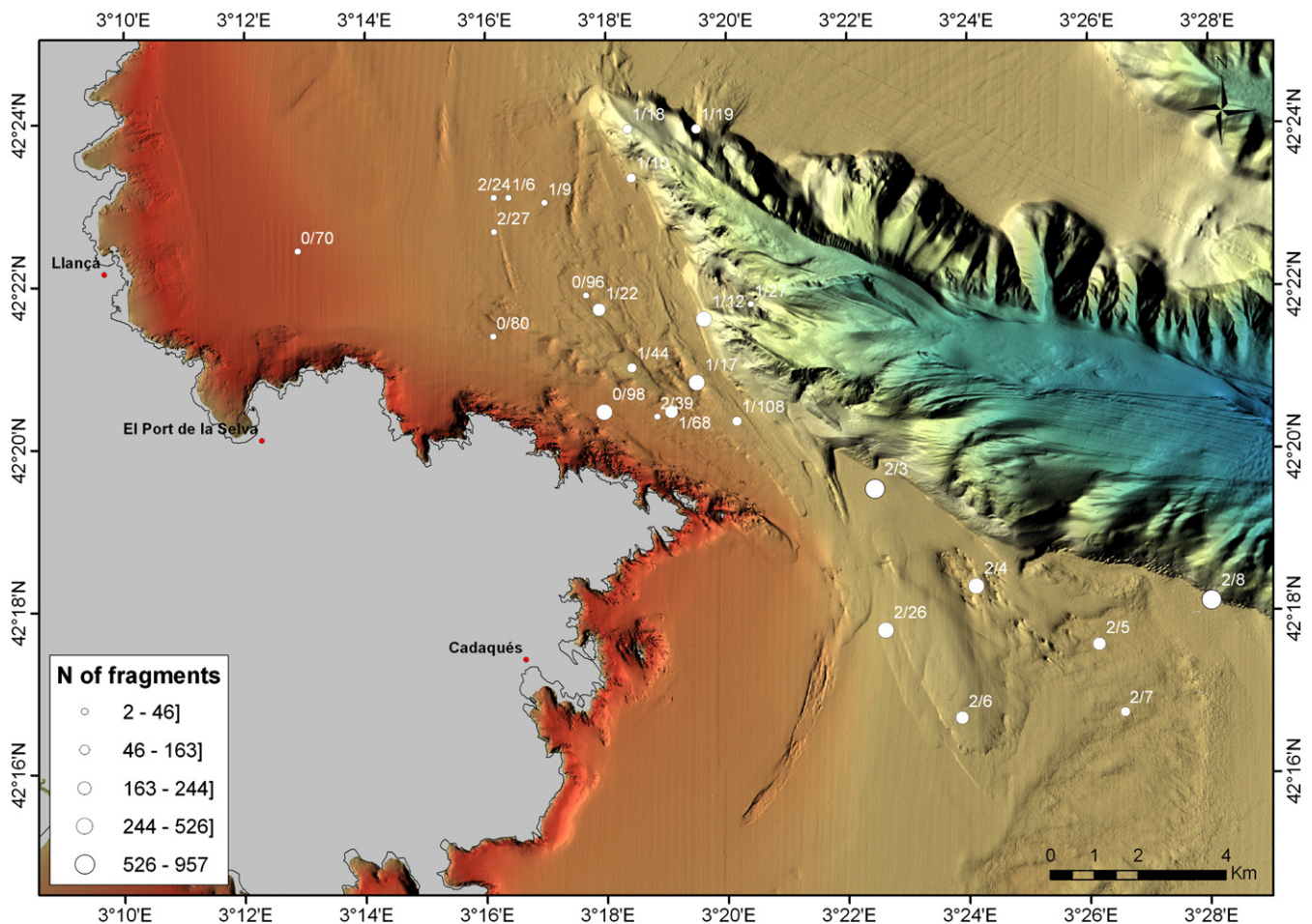


Fig. 8. Map of continental shelf off Cap de Creus showing the total number of fragments collected at each sampling station.

The reason for the occurrence of these temperate and boreo-Atlantic species in the Mediterranean is controversial. The distribution of deep-water Atlantic species confined to the Alboran Sea could represent recent introductions, as believed for *E. johnstoni* whose presence was related to the favorable trophic conditions characteristic of the area (Harmelin, 1992; Harmelin and d'Hondt, 1993). However, although there are no fossil records for this species, its irregular but wide distribution in the Eastern and Western Mediterranean indicates that it is possibly an ancient resident (Rosso, 1996a, 2003; Rosso and Di Geronimo, 1998). On the other hand, fossil evidence points to a relict distribution from a Plio-Pleistocene origin (Hayward, 1974; Rosso, 2003) for most of these species. This is most likely the case for *A. imbellis* that has an irregular distribution in the Mediterranean (Canu and Bassler, 1930; Hayward, 1974); *E. immersa*, which has been found dead as part of a thanatocoenosis in Cassidagne Canyon in France (J-G Harmelin, pers. comm.), and *N. collaris*, known from Pleistocene skeletobiont communities on the coast of Sicily (Rosso and Sanfilippo, 2005).

#### 4.2. Community

The bryozoan community descriptors (species richness, abundance and biomass) were related to the type of substrate. Samples on coarse-sands and gravel sediments yielded higher richness, abundance and biomass than samples on sand and silt sediments. Likewise, analysis of similarity suggests that there is a single community, portrayed in two different forms: a rich community on coarse sands and gravels, and a more impoverished one on sand. It is known that the availability of suitable substrates determines bryozoan distribution and abundance (Ryland, 1976; Taylor, 2000) as well as depth (e.g. Kuklinski and Barnes, 2005; Kuklinski et al., 2005). In the present study, depth was not a discriminating factor in the community studied, although this may only be in appearance. Taking into account the narrow range of depths examined in this study, it is not expected to find clear bathymetric boundaries contributing to discriminate bryozoan assemblages.

In fact, the dominant species that characterize this community are mainly shelf species common in detritic bottoms (e.g. *B. dichotoma*, *Reteporella mediteranea*, *F. malusii*, *S. scruposa*, *C. salicornioides*, *C. fistulosa*, *C. sinuosa*, *O. marioni*, *A. tubulosa*, *A. major*, *E. gracilis*, *E. triforis*), with few representatives of deep waters (e.g. *E. ventricosa*, *T. irregularis*) (Hayward and Ryland, 1998; Zabala, 1986). This species composition is similar to that found by Harmelin (1978) in the surrounding waters of Port-Cross (NW Mediterranean) at similar depths.

Dominant characteristically littoral species like *P. fascialis* and *S. cervicornis* have wide bathymetric distributions (Zabala, 1986), although they were always found dead in our samples. The sources of these species are probably multiple. In large part, they may have been swept from shallower areas into the sediment. Both species grow on hard substrates like bedrock and large boulders, so the absence of live specimens might also be explained by the lack of sampling in such substrates. However, thanatofacies normally originate in situ, thus the skeletal remains of an organism stays in place (e.g. Rosso, 1996b; Rosso et al., 2010b), giving information about the species that inhabit in the area. The community sampled corresponds to the biocoenosis of the shelf-edge detritic' defined by Pérès and Picard (1964) as a mixture of gravels, sand and mud, where most of the gravel fraction is made up of remnants of Quaternary thanatocoenoses.

The spatial distribution of the bryozoans in the study area was not homogeneous. Instead, it was clustered near the canyon rim (Fig. 8), corresponding with the greatest availability of coarse sands and gravels. Hydrological processes related to the proximity of the submarine canyon might explain this distribution. The sediments of the inner north continental shelf off Cap de Creus are mainly composed of silt and muds, and the composition changes to coarser fractions towards the outer shelf and the canyon head, reflecting an intensification of the bottom currents flowing from the north (Lo Iacono et al., 2012). It has been suggested that the highest species densities of

macrofaunal species occur at the shelf-slope break, in areas with high hydrodynamics and with significant exchange of productive waters (Oliver et al., 2011). The existence of suitable substrates for attachment, low sedimentation rates and a rich food supply are critical factors for bryozoan richness and abundance (Hayward and Ryland, 1998; Ryland, 1976; Taylor, 2000). High levels of disturbance may be an unfavorable factor, but the presence of strong currents ensures a rich food supply and prevents the deposition of sediment. Recent studies on the sediment transport in the submarine canyons of the Gulf of Lions, one of the most productive areas in the Mediterranean, show that most of the organic-matter-rich sediment transport occurs through the Cap de Creus canyon because of the preferential direction of coastal currents, narrowing of the shelf, coastal topographic constraints and local atmospheric forcing in the area (Palanques et al., 2006). Thus, good conditions occur for bryozoan colonization in the study area with detritic bottoms swept by bottom currents.

The high diversity and abundance of the bryozoan community found on the circalittoral and shelf-edge area over coarse sands and gravels are particularly sensitive to fishing disturbances because of the potential destruction of habitat complexity that it produces. The irregular distributional richness of bryozoans in the continental shelf off Cap de Creus reflects therefore the presence of critical habitats and taxa that are essential to the design of the future Marine Protected Area.

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