Marine caves of the Southern Th   nn

Abstract

This is the first paper documenting research on a selection of marine caves located along the coast of Capo Milazzo in the southern Tyrrhenian Sea. Three submarine and one semi-submerged caves were surveyed and sampled using underwater photo sampling. Surveys have only taken into account the sessile species belonging to the main taxa: Porifera, Anthozoa, Bryozoa and Polychaeta. Diversity indices and abundances were calculated for three sections within each explored cave: the Entrance Zone, Intermediate Zone and Bottom Zone. The richest group was Porifera with 21 taxa, followed by cnidarians, (Anthozoa), with 8 taxa, Polychaeta (5 taxa), and Bryozoa (5 taxa). Among Porifera, the presence of *Petrobiona massiliana*, a protected species according to SPA⁄BIO Protocol and the Bern Convention, must be highlighted. The encrusting forms were dominant in the Bottom Zone, the massive forms in the Intermediate Zone and the arborescent forms in the Entrance Zone. Generally, the percentage coverage of each morphological group showed a decline in the Intermediate Zone and a general increase in the Dark Zone within each cave. The S, H' and J values showed different trends in the five caves. These differences, also evidenced by Permanova analysis, depend on the topographic specificity of each cave which, in turn, affects the gradients of the biotic and abiotic parameters. Finally, no horizontal gradient of rarefaction of the benthic sessile fauna has been detected. This study represents an important step for the management and conservation practices of these fragile ecosystems, especially in view of the forthcoming establishment of the Marine Protected Area.

Keywords Marine caves; Benthic biodiversity; Photographic census; Mediterranean Sea; Conservation

Introduction

According to Annex 1 of the ‘Habitats’ EC Directive 92⁄43, the submerged and semi-submerged caves, (code 8330), are natuτw dark populations and permis s ecological [6] value in

and⁄or ecological islands. Moreover, the marine caves [l] are considered a link between closed habitats, (hard and so f substrata, seagrass bed, coralligenous assemblages) [6,7]. T e caves also play an important role economically for a local diving centre due to the high frequency of requests from divers to explore them (pers. comm.). Management action will need to be evaluated in order to reduce and prevent the impact of recreational divers on the benthic community [8,9].

Over the past 15 years, several studies focused on the biodiversity of marine caves [4,10-15], their conservation [9,16-19] and the occurrence of non indigenous species [20] and references therein] have been carried out worldwide. In Sicily, several studies were carried out on Bryozoa, Brachiopoda, Serpuloidea and Floristic macroalgal diversity of some submerged caves [21-25].

T e presence of submerged and semi-submerged caves has also helped to strengthen the decision making criteria in support of the establishment of marine protected areas in the Mediterranean Sea [26]; about 66

⁄refuge

Mediterranean caves surveyed versus only 738 in the eastern Mediterranean.

In Italy, several studies have been conducted on the benthic populations or single species of the underwater caves [6,11,16,29-33] and have often been limited to Marine Protected Areas [8,9,13,19,21,22,34-47].

There are still many caves to survey and further intensive studies on the biology and ecology of these areas are needed.

The description of the caves considered in this paper represents the first contribution to the knowledge of these environments along the north-eastern coast of Sicily.

Although the seabeds along the promontory of Capo Milazzo have been designated as Marine Protected Areas of forthcoming establishment and the terrestrial part of the promontory represents a Site of Community Interest (SCI), no scientific information is available on the faunal composition of local submerged and semi-submerged caves.

The purpose of this work is therefore: a) to provide the first data on the 2-D morphology of three submerged and one semi-submerged caves at Capo Milazzo; b) to provide further data on the biodiversity of these environments, paying special attention to the presence of protected species included in the lists of international conventions.

Material and Methods

Study Site

The promontory of Capo Milazzo is a small peninsula that stretches northwards for about 6 km from the northern coast of Sicily, (Figure 1), with a maximum width of about 1.3 km. The coastal profile appears steep and rugged.

The exposed area is classified as a Site of Community Importance, (code ITA030032 'Capo Milazzo'), according to the EC 'Habitats' Directive 92/43, (ordinary supplement n. 167 to the Official Gazette no. 170 of 24 July 2007). In addition, since January 2014, the submerged part of the promontory of Capo Milazzo was included in the list of the Marine Protected Areas of Gathering, (Law 27 December 2013, n. 147 ordinary supplement n. 87 to the Official Gazette n. 302 of 12.27.2013), and then, from August 2014, following the economic, social and environmental investigations commissioned by the Italian Ministry of the Environment and Protection of Land and Sea to ISPRA, Capo Milazzo was proposed as an MPA.

The bedrock of the peninsula is formed by metamorphic rocks covered by Upper Miocene reef limestones and Upper Pliocene- Lower Pleistocene marls and marly limestone [48].

The studied caves are located at different depths, (from 0 to -30 m u.s.l), and distances from the coast and show different morphogenesis. Three submerged caves ("Delle Corvine" (CCO) "Secca di Levante" (CLE) and "Del Cristo" (CCR) and one semi-submerged, "Gamba di Donna" (CGD)), have been described (Figure 2).

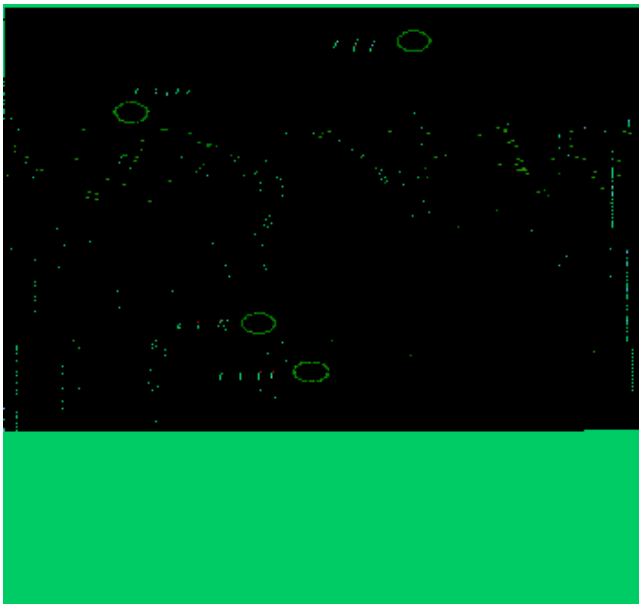

Figure 1: Study area with caves location.

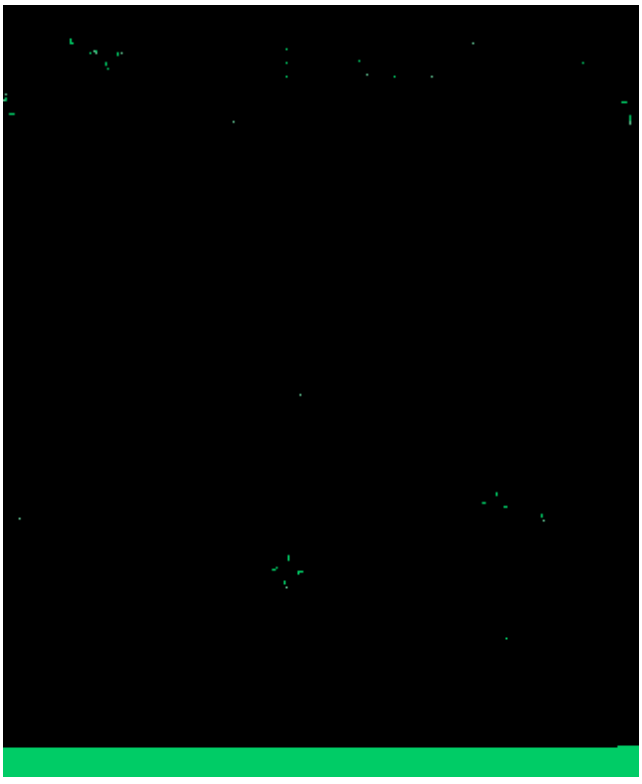

Figure 2: 2D plans of surveyed caves.

Sampling

Sampling was conducted during summer 2010. Photographic

Clathrina clathrus and *Agelas oroides*

EN	Polychaeta	*Vermiliopsis infundibulum*	18.56		EZ, BZ
AR	Gymnolaemata	*Margaretta cereoides*		27.5	EZ
AR	Gymnolaemata	*Myriapora truncata*	26.75	14.3	EZ,IZ
MA	Gymnolaemata	*Reteporella grimaldii*		4.6	EZ,IZ,BZ

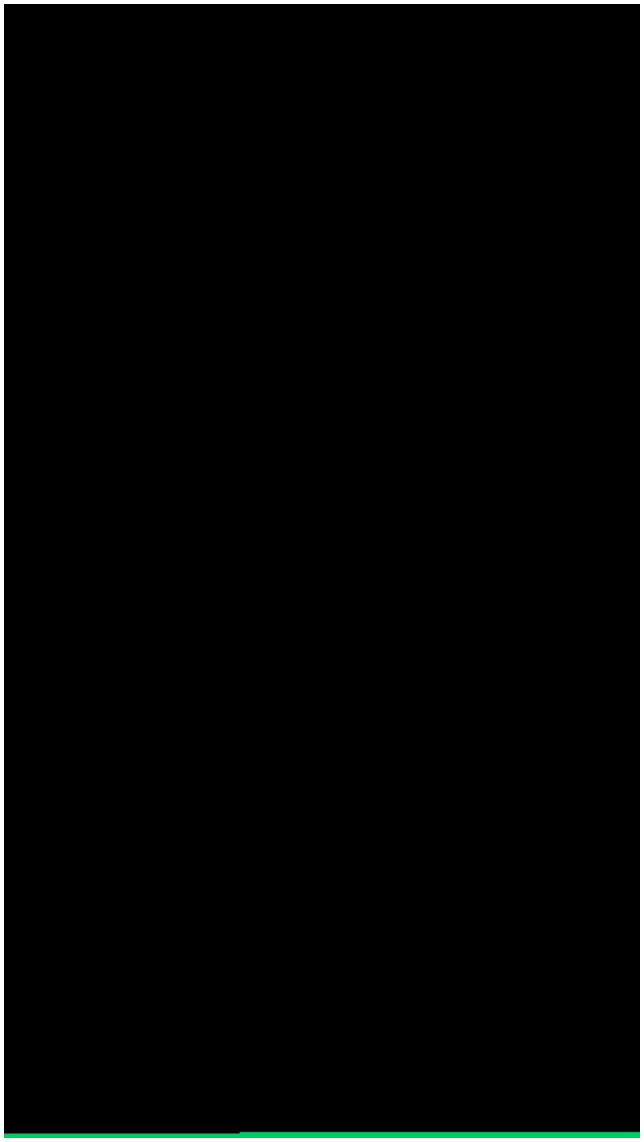

Figure 4: % coverage of each morphological groups in each cave sector: entrance, intermediate and bottom zone. EN: encrusting; MA: massive; TU: tubular; AR: arborescent; CCO: Corvine Cave; CLE: Levante Cave; CCR: Cristo cave; CGD: Gamba di Donna cave.

Biodiversity patterns of the benthic assemblages

T e average values of the diversity indices for each sector of the caves are reported in Table 2.

On the whole, the richest and most diverse macrobenthic community resulted in CLE, (S=5.3 ± 2.1; H'=1.2 ± 0.5), while the lowest average values of the diversity indices were recorded in CGD, (S=2.3 ± 1.2; H'=0.5 ± 0.4). Regarding the sectors, the highest average values of species richness, (S=7.0 ± 1.9), and the Shannon diversity index, (H'=1.6 ± 0.2), were recorded in the Intermediate Zone of CLE.

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S, H' and J' values showed di f erent trends in each of the f ve caves.

Cave	Sector	S	H'	J
Corvine (CCO)	entrance	2	0.2	0.5
	intermediate	3.6	1	0.8
	bottom	2.8	0.6	0.6
	total	2.8	0.6	0.6
Cristo (CCR)	entrance	5.2	0.4	0.8
	intermediate	3.6	1	0.9
	bottom	3.4	0.7	0.6
	total	4.1	0.7	0.8
Gamba donna (CGD)	entrance	3	0.7	0.7
	intermediate	1.8	0.3	0.7
	bottom	2	0.7	1
	total	2.3	0.5	0.8
Levante (CLE)	entrance	4.2	0.7	0.8
	intermediate	7	1.6	0.9
	bottom	4.8	1.4	0.9
	total	5.3	1.2	0.9

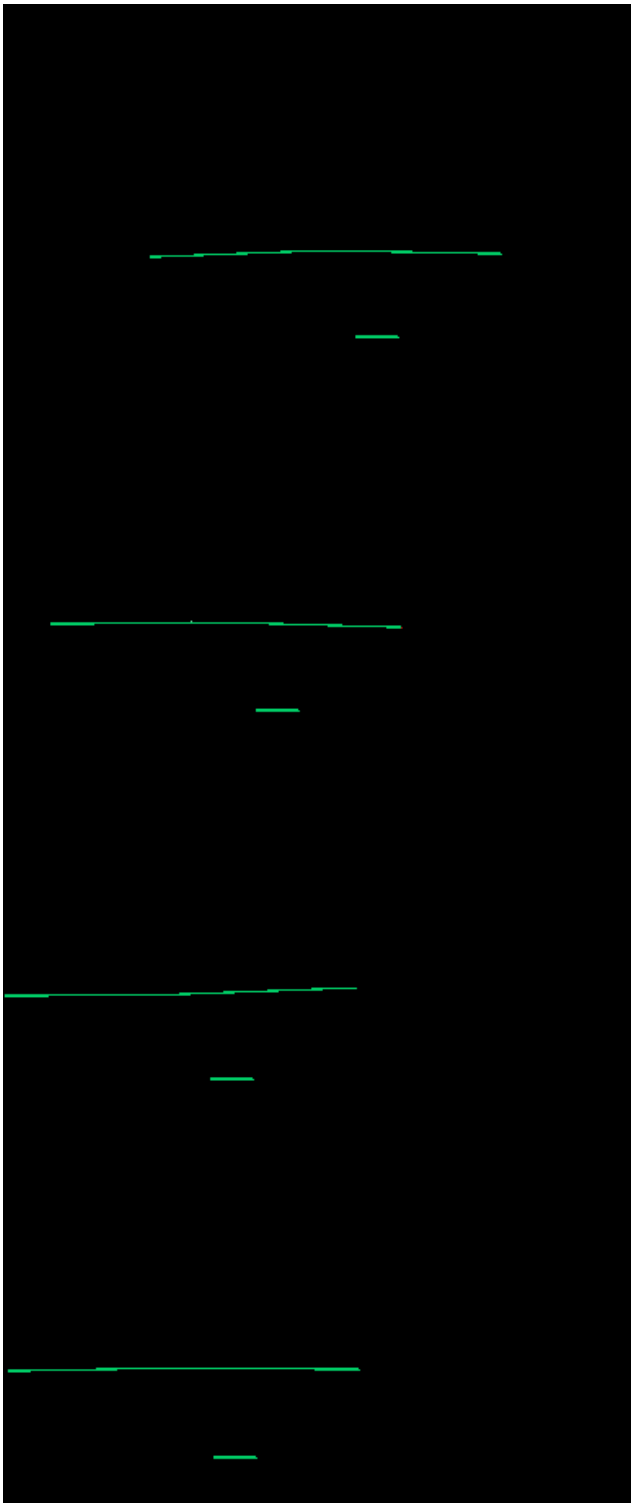

Figure 5: Trend of biodiversity indices calculated for the benthic communities of each of the surveyed cave and in each cave sector: entrance, intermediate and bottom zone. CCO: Corvine Cave; CLE: Levante Cave; CCR: Cristo cave; CGD: Gamba di Donna cave; H': Shannon-Wiener diversity; S: Species richness; J: Pielou's evenness index.

The same test conducted on the "Cave sector" factor indicated significant differences among all the levels considered, ($p<0.01$), except for the comparison between the Bottom Zone and Intermediate Zone.

Examining the Pielou Evenness Index, (J), the PERMANOVA analysis revealed significant differences for the Cave factor, ($F=3.0864$; $p<0.05$), and the interaction factor Cave x Sector ($F=2.3545$; $p<0.05$). Pairwise comparisons performed on the Cave factor, showed significant differences between CCO Vs CCR and CCO Vs CLE, (Table 3).

Species Richness			**Shannon diversity**			**Pielou Evenness**		
Groups	T	p	Groups	T	p	Groups	T	p
CCO vs CCR	3.042	**	CCO vs CCR	1.172	n.s	CCO vs CCR	2.277	*
CCO vs CGD	1.254	n.s.	CCO vs CGD					

specifcity of each cave which, in turn, afects the gradients of biotic and abiotic parameters [14,16,55,58-60]. Strong currents in the CLE cave, for example, may be responsible for the presence of *Margaretta cereoides* in the Entrance Zone.

In conclusion, it is possible to recognize a pool of species, distributed along a horizontal axis, Entrance-Bottom Zone, whose specifc

28. Giakoumi