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Effectiveness of different investigation procedures in detecting anthropogenic impacts on coralligenous assemblages

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Summary: Coralligenous habitat is one of the most important and sensitive habitats of the Mediterranean Sea and several different sampling procedures are currently used in the ecological investigations of coralligenous assemblages. This study aimed to assess the efficacy of different methods in detecting anthropogenic impacts on coralligenous habitat. In particular, the choice of sampling methods, the level of taxonomic resolution, the sampling area, the number of replicates and the spatial scales for detecting possible impacts were evaluated. Results showed that photographic samples larger than 1800 cm^2, numbers of replicates larger than 10, the use of taxa and morphological groups as assemblage descriptors, and sampling designs with a high replication at small spatial scales are a valid methodological procedure in impact evaluation studies based on coralligenous assemblages.

Keywords: coralligenous habitat; sampling methods; spatial scales; number of replicates; sampling surface; Mediterranean Sea.

Efectividad de los diferentes procedimientos de muestreo para detectar el impacto antrópico sobre la comunidad de coralígeno

Resumen: El hábitat coralígeno es uno de los más importantes y sensibles del mar Mediterráneo y actualmente se pueden aplicar varios métodos de muestreo en las investigaciones ecológicas de las comunidades macroalgales coralígenas. El objetivo del presente estudio es evaluar la efectividad de los diferentes procedimientos para detectar el impacto antrópico sobre el hábitat de coralígeno. Se evaluaron en particular la elección de los métodos de muestreo, el nivel de resolución a la que los taxones tienen que ser identificados, la superficie de muestreo, el número de repeticiones y las escalas espaciales adecuadas para la investigación de los posibles impactos. Los resultados indican que muestras fotográficas de 1800 cm^2, un número de repeticiones mayor que 10, el uso de taxones y grupos morfológicos como descriptores y diseños de muestreo con una alta replicación asociada a pequeñas escalas espaciales pueden representar elementos metodológicos válidos en los estudios de evaluación de impacto basados en las comunidades coralígenas.

Palabras clave: hábitat coralígeno; métodos de muestreo; escalas espaciales; número de repeticiones; superficie de muestreo; Mar Mediterráneo.

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INTRODUCTION

The relevance of sampling procedures in marine ecology is widely recognized and determining the sampling methods most responsive to the questions/objectives plays a fundamental role in research success (Benedetti-Cecchi et al. 1996). The choice of spatial scales, the definition of sampling effort and the identification of appropriate descriptors are major problems in defining suitable sampling methods in ecological studies.

Natural variability of marine benthic assemblages is scale-dependent (Underwood and Chapman 1996, Terlizzi et al. 2007) and the lack of knowledge concerning the spatial patterns of organism distribution makes it difficult to interpret results of environmental monitoring surveys and impact evaluation studies (Hewitt et al. 2001, Bishop et al. 2002, Fraschetti et al. 2005). The main goals for ecologists are to understand spatial patterns of variability in populations and assemblages and to identify the main scales of variability (Benedetti-Cecchi 2001a) in order to plan appropriate designs and to optimize environmental sampling programmes (Underwood 1993, Benedetti-Cecchi 2001b, Benedetti-Cecchi et al. 2003).

Another important consideration concerns sampling procedures in marine habitats. Destructive methods are widely utilized and recognized as suitable for describing benthic assemblages in relation to the assessment of patterns of diversity and detection of rare species (Piazzi et al. 2004, 2010, 2011). However, they may be difficult to apply in particular habitats, such as caves or deep water, or unsuitable for use in protected areas. In these cases, photographic techniques can be used to quickly obtain a suitable quantity of samples that may be analysed successively (Garrabou et al. 2002, Parravicini et al. 2009, 2010a, Deter et al. 2012b). Like all visual methods, photographic techniques do not permit a complete species identification, so grouping species in easily identifiable categories is necessary for the assemblage analysis.

Identifying suitable assemblage descriptors that are sensitive to human-induced stress is very important in impact evaluation studies, because it optimizes sampling efforts and allows representative patterns of assemblage variability to be obtained (Chapman 1998). According to the objectives of the study, the grouping of species sharing the same general taxonomic or morphological traits may be advantageous for many reasons. Species identification requires a high level of taxonomic expertise, so the time and cost are far greater than for a reduced taxonomic level of resolution (Terlizzi et al. 2003). Lower sorting costs may make it possible to analyse the high number of samples needed to accurately describe habitat variability. A widespread strategy used in studies concerning the marine zoobenthos is to group organisms at taxonomic levels higher than species (De Biasi et al. 2003, Hirst 2006), but this approach is not suitable for macroalgal assemblages (Hirst 2006) because species belonging to the same supra-specific taxon (genus or family) may show different ecological characteristics (Balata et al. 2011). A morpho-functional approach, grouping species with similar morphological traits and a similar response to environmental conditions, is widely used to describe both animals and macroalgal assemblages (Jackson 1979, Littler and Littler 1980, Steneck and Dethier 1994, Cocito et al. 1997, Konar and Iken 2009, Parravicini et al. 2010a, 2013). Despite the loss of information in this approach (Phillips et al. 1997), analysis of morpho-functional groups may detect impacts with an efficiency similar to that obtained by species analysis (Balata et al. 2011).

Coralligenous habitats develop on deep subtidal rocky bottoms in the Mediterranean Sea, where they are one of the most important habitats in size, biodiversity and role in CO_2 dynamics (Laborel 1961, 1987, UNEP 2007). Coralligenous habitats are constituted primarily by calcareous structures edified by Rhodophyta belonging to Corallinales and Peyssonneliales and secondarily by several sessile animals, mostly Cnidaria, Polychaeta and Bryozoa (Ballesteros 2006). The ecological importance of coralligenous habitats and their scientific and biodiversity interest are recognized by international conventions (e.g. Barcelona 1995), so they can be considered one of the most important "special habitat types" that should be assessed under the Marine Strategy Framework Directive (EC 2008) through accurate monitoring plans. The development of monitoring programmes needs the assessment of effective sampling designs and methods in order to optimize efforts and to give appropriate responses to ecological problems. Coralligenous assemblages have been widely studied in relation to species composition (Laubier 1966, Hong 1982, Garrabou et al. 2002, Casellato and Stefanon 2008, Piazzi et al. 2010), patterns of spatial and temporal variability (Ferdeghini et al. 2000, Cocito et al. 2002, Piazzi et al. 2004, Balata et al. 2005, 2006a, 2006b, Virgilio et al. 2006, Piazzi and Balata 2011, Ponti et al. 2011), and responses to anthropogenic impacts (Hong 1983, Garrabou et al. 1998, Balata et al. 2007a, 2007b, Piazzi et al. 2007, 2011, 2012, Roghi et al. 2010). Recently, several methods have been developed to assess ecological quality of coralligenous assemblages through a non-destructive approach (Kipson et al. 2011, Deter et al. 2012a, Gatti et al. 2012). In this context, a minimal area was defined for photographic samples (Kipson et al. 2011, Teixido et al. 2013). However, several aspects necessary to assess the suitability of the sampling methods, such as the comparison between destructive and non-destructive approaches or the spatial scales to be examined, were not evaluated.

The aim of the present study was to contribute to the assessment of the most effective procedures for detecting effects of impacts on Mediterranean coralligenous habitats. In particular, the choice of sampling methods, the level of taxonomic resolution, the sampling area, the number of replicates and the proper spatial scales to study were evaluated. To achieve these objectives, multi-factorial sampling designs were used to find spatial scales with high variability and to compare results obtained with different descriptors, different numbers of replicates and different sampling areas.

MATERIALS AND METHODS

The study was carried out in the summer months along the coasts of Tuscany (northwestern Mediterranean Sea, Italy), on rocky vertical bottoms at 30-35 m depth. This depth was chosen because macroalgal coralligenous assemblages of this depth range are the most representative of the geographical area considered, in terms of structure and response to alterations of environmental conditions (Piazzi and Balata 2011).

Fig. 1. – Map of the study sites. White stars, reference sites; grey stars, stressed sites.

Comparison between sampling methods and assemblage descriptors

Two different ecological conditions were considered: a stressed condition consisting of marine areas affected by urban and/or industrial discharges and high sedimentation rates; and a reference condition consisting of areas subjected to absence of, or very minor, stress (Annex I, EC 2000). For each condition, two sites several kilometres from each other were chosen along the Tuscany coasts (Fig. 1) and in each site two areas hundreds of metres apart were studied. In each area of about 25 m^2, three destructive samples and three photographic samples were collected. Both destructive and photographic samples covered a bottom area of 400 cm^2, which is considered the minimum area for studying Mediterranean rocky macroalgal assemblages (Boudouresque 1971).

Destructive samples were collected by scraping the bottom with a hammer and a chisel, all sessile organisms were identified and the abundance of each sessile species was expressed as percentage cover of the sample area.

In the photographic samples, the percentage cover of the main taxa or morphological groups was evaluated using the "Image J" software (http://rsbweb.nih.gov/ij/download.html, Cecchi et al. 2010). In these samples, animals and seaweeds easily recognizable by visual census were considered at species or genus level, while taxa not easily recognizable were grouped into the following morphological groups: encrusting Corallinales, articulated Rhodophyta, algal turf, erect corticated algae, flattened Rhodophyta with cortication, madrepores, hydroids, encrusting and erect bryozoans, massive encrusting sponges and erect sponges.

To compare the efficiency of different methods (destructive vs. photographic) and the suitability of assemblage descriptors (species vs. taxa/morphological groups) in detecting responses to environmental stress, data obtained by analysing photographic samples, data obtained by analysing destructive samples at the species level and data obtained through a taxa/morphological groups analysis of assemblages carried out according to the photographic approach on the same destructive samples were analysed by permutational multivariate analysis of variance (PERMANOVA, Primer v6 program including the add-on package PERMANOVA plus, Anderson 2001) performed on a Bray-Curtis dissimilarity matrix of untransformed data (number of permutations 999). The Monte-Carlo procedure was used when the number of possible permutations was too low. A three-way model was used with Condition (reference vs. stressed) as a fixed factor, Site (2 levels) as a random factor nested in Condition and Area (2 levels) as a random factor nested in Site.

Comparison between sampling areas and number of replicates

In each of the two reference sites, 10 photographic samples of 400 cm^2 and 10 photographic samples of 1875 cm^2 (fitted with a frame 50×37.5 cm) were collected. Sampling surface and number of replicates were chosen according to pilot studies (Acunto 2000, Acunto et al. 2001). Abundance of taxa/morphological groups was obtained through the same methods described above. Data were analysed by a two-way PERMANOVA analysis, with Area (400 cm^2 vs. 1875 cm^2) as a fixed factor and Site (2 levels) as a random factor nested in Area.

At each of the two reference sites and two stressed sites, 20 photographic samples of 1875 cm^2 were collected. To compare the effectiveness of different sampling areas in detecting assemblage responses to stressors and in describing spatial patterns of variability, data obtained with 30, 25, 20, 15, 10 and 5 replicates for each site were analysed by two-way PERMANOVA with Condition (reference vs stressed) as a fixed factor and Site (2 levels) as a random factor nested in Condition.

Spatial variability of coralligenous assemblages

Two pristine or minor stressed sites were selected along the Tuscany coasts and, at each site, two locations several kilometres apart were chosen; at each location, two areas hundreds of metres apart were selected and 15 photographic samples of 1875 cm^2 were collected in each area about 1 m from each other.

To determine patterns of variability at each of the chosen spatial scales, data were analysed by a four-way PERMANOVA analysis, with Site (2 levels) as a random factor, Location (2 levels) as a random factor

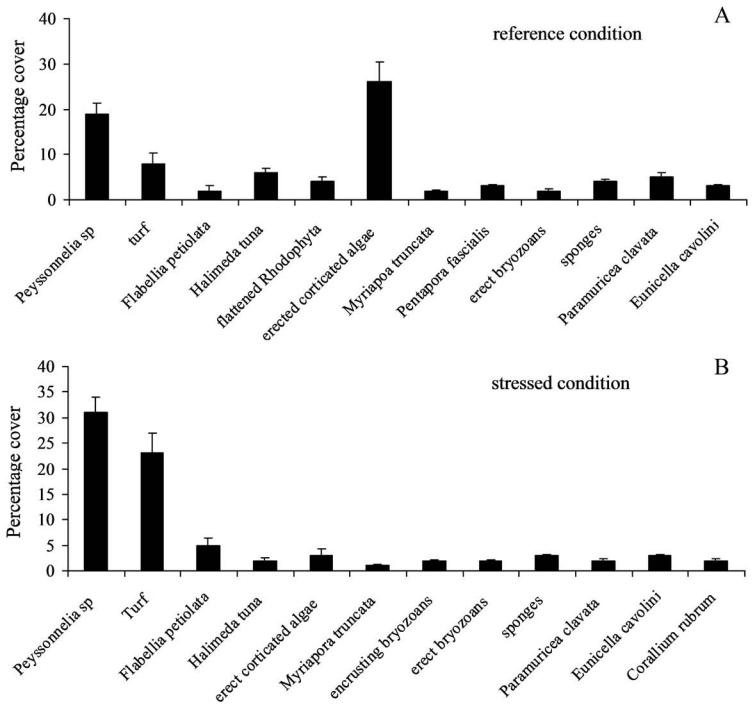

FIG. 2. – Percentage cover (mean±SE, n=12) of the main taxa/morphological groups (mean percentage cover greater than 2) in coralligenous assemblages. Encrusting Corallinales showed a cover of 100% and they are not considered in the figures.

nested in Site and Area (2 levels) as a random factor nested in Location. The pseudo-variance components were calculated for each spatial scale: site, location, area and sample.

RESULTS

Comparison between sampling methods and assemblage descriptors

A total of 123 taxa were identified by destructive samples (Appendix 1 with nomenclature authority). In photographic samples, 18 taxa and 10 morphological groups were considered (Appendix 1).

The studied assemblages were characterized by a stratified structure: encrusting Corallinales, mostly *Mesophyllum alternans, Mesophyllum macroblastum, Lithothamnion philippii, Lithophyllum pustulatum* and *Lithophyllum stictaeforme*, completely covered the rocky bottom, creating a secondary substrate colonized by prostate, intermediate and erect layers.

In reference condition the prostrate layer was mostly characterized by the macroalgae*, Palmophyllum crassum* and *Peyssonnelia* spp., while the encrusting bryozoan *Schizobrachiella sanguinea*, the erect bryozoan *Cradoscrupocellaria reptans*, the cnidarians *Parazoanthus axinellae* and *Leptopsammia pruvoti* and the sponges *Penares euastrum, Agelas oroides* and *Dictyonella incisa* were also common with variable abundance. The most common species in the intermediate layer were *Halimeda tuna, Flabellia petiolata*, erect corticated forms (*Osmundaea pelagosae* and *Laurencia chondrioides*) and flattened Rhodophyta with cortication (*Meredithia microphylla* and *Acrodiscus vidovichii*) among macroalgae and the erect bryozoans *Pentapora fascialis, Myriapora truncata* and *Smittina cervicornis* among animals (Fig. 2). The erect layer was characterized by the gorgonians *Paramuricea clavata* and *Eunicella cavolini*.

At all the stressed sites, several turf-forming macroalgae increased their abundance (*Womersleyella setacea, Anthithamnion piliferum, Heterosiphonia crispella, Polysiphonia subulifera* and *Pseudochlodesmis furcellata*), while several erect and prostrate macroalgae (*Halimeda tuna, Flabellia petiolata, Meredithia microphylla, Osmundaea pelagosae, Zanardinia typus*) and bryozoans (*Pentapora fascialis* and *Smittina cervicornis*) decreased (Fig. 2).

Results of PERMANOVA analyses showed significant differences between reference and stressed conditions for all three approaches used: photographic samples, destructive samples analysed at species level, and destructive samples analysed at taxa/morphological groups level. A significant variability between areas was only detected in the destructive samples (Table 1).

Comparison between sampling areas and number of replicates

PERMANOVA analysis detected no significant differences between samples collected using different areas (Table 2). The SIMPER test highlighted a dissimilarity of 52.3 between areas; differences were mostly related to erect corticated algae, which were overestimated in 400 cm^2 samples, and Gorgonacea, which showed an opposite pattern (Table 3).

A similar pattern of spatial variability of assemblages was obtained by analysing 10, 15, 20, 25 and 30 replicates, but the results obtained using the 5 replicates approach gave a different pattern (Table 4).

Table 1. – Results of PERMANOVA analyses on coralligenous assemblages subjected to different conditions obtained through destructive and photographic sampling methods. Results of the destructive samples referred both to the species and morphological groups levels of determination. Significant effects are in bold.

		Destructive species level			Destructive morphological groups level			Photographic morphological groups level		
Source	df	MS	Pseudo-F	P (perm)	MS	Pseudo-F	P (perm)	MS	Pseudo-F	P (perm)
Condition = C	1	7377.3	2.49	**0.047**	7823.2	3.95	**0.036**	7398.4	7.54	**0.022**
Site(C) = S (C)	2	2956.9	0.85	0.618	1979.3	1.10	0.388	968.8	1.11	0.392
Area(S(C))	4	3452.6	1.65	**0.039**	1792.3	1.93	**0.031**	862.7	2.10	0.069
Residual	16	2082.6			928.6			408.9		
Total	23									

Table 2. – Results of PERMANOVA analysis comparing the morphological groups composition and abundance datasets obtained through the photographic method and using different sampling areas (400 cm^2 and 1875 cm^2).

Source	df	MS	Pseudo-F	P (perm)
Area = A	1	4555.9	1.72	0.211
Site = S	2	2642.6	1.92	0.050
Residual	36	1376.2		
Total	39			

Table 3. – Results of SIMPER test showing taxa/groups responsible for differences between patterns obtained with 400 cm^2 and 1875 cm^2 sampling areas.

Taxa/groups	400 cm^2 cover	1875 cm^2 cover	Contrib. %
Algal turf	49.04	40.03	26.5
Peyssonnelia spp.	19.6	22.91	20.59
Erect corticated algae	12.77	0.54	12.61
Encrusting Corallinales	4.33	12.31	11.64
Eunicella cavolini	0.63	4.86	4.69
Flabellia petiolata	2.43	4.23	3.78
Encrusting sponges	1.03	3.1	3.62
Halimeda tuna	3.4	0.28	3.47
Erect bryozoans	0.13	3.01	2.94
Reteporella spp.	2.2	1.13	2.89

Table 5. – Results of PERMANOVA analysis on morphological groups composition and abundance of coralligenous assemblages obtained with the photographic method applied at different spatial scales. Significant effects are in bold.

Source	df	MS	Pseudo-F	P(perm)
Site = S	1	27446	3.09	0.088
Location (A) = L(A)	2	8879	0.94	0.477
Area (L(A))	4	9376	9.78	**0.001**
Residual	112	958		
Total	119			

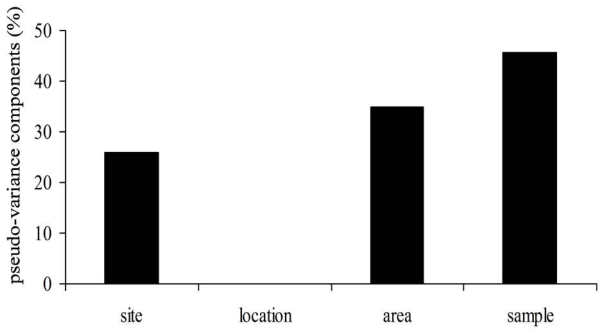

FIG. 3. – Percentage of pseudo-variance components at different spatial scales

Spatial variability of coralligenous assemblages

PERMANOVA analysis showed significant differences in coralligenous assemblages among areas, while differences between sites and locations were not significant (Table 5).

The pseudo-variance components showed the highest variability at the smallest spatial scales (area and sample), whereas the variability at the intermediate spatial scales (Location) was undetectable (Fig. 3).

DISCUSSION

The results of this study comparing different sampling procedures commonly used in the ecological investigation of coralligenous habitats provided indications about the method that could be most suitable for detecting changes in the structure of assemblages subjected to different levels of stress.

Both destructive and photographic methods detected significant differences between conditions and the

Table 4. – Results of PERMANOVA analyses on morphological groups abundance and composition datasets obtained through the photographic method with different numbers of replicates (5, 10, 15, 20, 25 and 30). MC, Monte-Carlo procedure. Significant effects are in bold.

Source	df	MS	Ps-F	P(MC)	df	MS	Ps-F	P(MC)
		5 replicates				10 replicates		
Condition = C	1	18991	6.45	**0.024**	1	31967	5.16	**0.030**
Site(C)	2	2942	2.07	0.097	2	6191	3.93	**0.001**
Residual	16	1415			36	1572		
Total	19				39			
		15 replicates				20 replicates		
Condition = C	1	55967	11.01	**0.005**	1	75768	7.59	**0.007**
Site(C)	2	5079	3.21	**0.008**	2	9975	6.32	**0.001**
Residual	56	1580			76	1577		
Total	59				79			
		25 replicates				30 replicates		
Condition = C	1	83417	64.33	**0.008**	1	92409	62.40	**0.010**
Site(C)	2	12967	79.26	**0.001**	2	14807	88.47	**0.001**
Residual	96	1635			116	1673		
Total	99				119			

same differences were observed when the destructive samples were analysed at the species level. These results, obtained considering both macroalgae and sessile animals, are in agreement with those highlighted by the comparison of macroalgal species and morphological groups chosen as descriptors of assemblages subjected to different stressors (Balata et al. 2011). Compared with the species level approach of the destructive method, loss of information concerning biodiversity assessment and occurrence of rare species due to the use of the photographic method seemed to be negligible for the purposes of the impact evaluation studies.

These findings suggest that the use of photographic techniques and the taxa/morphological groups approach may be a suitable and cost-effective method for studying coralligenous assemblages, in particular in monitoring programmes and environmental impact assessments; in fact, in these latter cases it is important to detect the early stages of environmental changes using procedures that allow a large number of samples to be examined in a limited time. Moreover, a non-destructive approach is suitable for sampling this particularly sensitive habitat, is the only one applicable in marine protected areas and is surely in line with the recent European Framework Directives.

The minimum area considered for studying rocky sessile assemblages in the Mediterranean Sea is 400 cm^2, but this area was obtained through destructive sampling of macroalgal assemblages collected in the shallow subtidal systems (Boudouresque 1971), so it is not suitable for studying coralligenous assemblages with photographic methods. In fact, the abundance of large colonial animals in coralligenous habitats may be underestimated if small sampling areas are used. Although the results of the present study are limited to only two sampling areas, they showed no significant differences between data obtained with sampling areas of 400 and 1878 cm^2. However, a dissimilarity of 52.3 was detected and several taxa/morphological groups were over- or underestimated using replicates of 400 cm^2. A larger area may be more suitable for describing coralligenous assemblages through photographic methods (Bianchi et al. 2004). Also, the number of replicates is an important factor for coralligenous habitats. In fact, great small-scale variability has been described for this system (Piazzi et al. 2004, Balata et al. 2005) and an appropriate number of replicates is necessary to separate patterns of natural variability from those caused by external factors. In the present study, no differences in results were found using 10, 15, 20, 25 and 30 replicates, and 5 replicates was insufficient to describe the variability of the system. A larger number of replicates than 10 is recommended as best suited to sampling coralligenous habitats by photographic methods. The total sampling area to be investigated for each study area with 10 replicates was 18750 cm^2, which is in agreement with the total area suggested for western Mediterranean coralligenous habitats (15000 cm^2 obtained through three replicates of 5000 cm^2, Kipson et al. 2011).

Differences between locations tens of kilometres apart were low, suggesting that coralligenous assemblages show a homogeneous structure if subjected to similar environmental conditions, at least within the same geographic area. By contrast, coralligenous assemblages showed a high variability at small spatial scales, between plots one metre apart and areas hundreds of metres apart, while variability between sites several kilometres apart was very small. This finding agrees with results of previous studies (Ferdeghini et al. 2000, Piazzi et al. 2004, Balata et al. 2005, 2006b) and may reflect a patch distribution of organisms. Organism distribution in coralligenous habitats may be regulated by both substrate morphology and biotic interactions. In fact, the heterogeneity of biogenic substrate may create microhabitats characterized by different environmental conditions (Lapoint and Bourget 1999, Cocito 2004), which can influence the recruitment of spores and larvae (Walters and Wethey 1996). Moreover, the attenuation of effects of physical factors with depth leads to a greater influence of biotic factor in the control of assemblages. Competition for space is considered one of the main processes determining patterns of distribution in coralligenous habitats, where encrusting organisms compete intensely for substratum because they are limited to using space in only two dimensions (Balata et al. 2005). These findings suggest that sampling designs should focus on high replication at small scales, with little or no consideration of intermediate scales.

The assessment of the most suitable relation between the sampling area and the number of replicates is an interesting topic for coralligenous ecologists. Large organisms are usually studied using sampling areas (Kipson et al. 2011) or landscape approaches (Gatti et al. 2012), whereas phytobenthos is studied using a larger number of replicates (Acunto et al. 2001, Balata et al. 2005). The results of this study showed that the total sampling area detected for photographic samples agrees with that proposed by other studies (Kipson et al. 2011). The distribution of this area between samples and replicates may be an interesting goal for further research.

Summarizing the main results, impact evaluation on coralligenous assemblages may be effectively carried out through photographic samples larger than 1800 cm^2, with a number of replicates larger than 10, by using taxa/morphological groups as descriptors and planning sampling designs with a high replication at the small spatial scales. This kind of methodological procedures seems to be a good compromise between habitat conservation, scientific validity and time/cost effort requirements.

Concerning this latter aspect, photographic sampling reduces the time of field work and makes it possible to quickly collect the high number of samples required in a habitat with high variability at small spatial scales. It also involves relatively little laboratory analysis, reducing the time and cost of sorting and taxonomist work. However, photographic samplings require a longer time of image analysis than in situ visual methods (Parravicini et al. 2010b, Gatti et al. 2012). It is also important to optimize the sampling effort and the present study may provide useful information for

optimizing monitoring programmes and impact evaluation studies in coralligenous habitats.

Although the study covered a limited geographical area, the results could provide basic information that can be integrated with data collected in other Mediterranean areas and in other studies using different approaches, in order to validate a sampling procedure applicable to the whole Mediterranean basin.

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Appendix 1. – List of taxa identified in the destructive samples. Groups used in the photographic samples are indicated when taxa were not considered at the species level. Species identified with photographs are indicated with an asterisk.

OCHROPHYTA		
Asperococcus bullosus J.V. Lamouroux		erect corticated algae
Dictyota linearis (C. Agardh) Greville		*Dictyota* spp
Halopteris filicina (Grateloup) Kützing		erect corticated algae
Nereia filiformis (J. Agardh) Zanardini		erect corticated algae
Sphacelaria cirrosa (P.H. Roth) C. Agardh		algal turf
Sphacelaria plumula Zanardini		algal turf
Zanardinia typus (Nardo) P.C. Silva		*
CHLOROPHYTA		
Cladophora echinus (Biasoletto) Kützing		algal turf
Cladophora prolifera (Roth) Kützing		algal turf
Flabellia petiolata (Turra) Nizamuddin		*
Halimeda tuna (J. Ellis *et* Solander) J.V. Lamouroux		*
Microdictyon tenuius Decaisne *ex* J.E. Gray		algal turf
Palmophyllum crassum (Naccari) Rabenhorst		*
Pseudochlorodesmis furcellata (Zanardini) Børgesen		*
Valonia macrophysa Kützing		*Valonia* spp.
RHODOPHYTA		
Acrodiscus vidovichii (Meneghini) Zanardini		flattened Rhodophyta
Acrosorium ciliolatum (Harvey) Kylin		algal turf
Acrothamnion preissii (Sonder) Wollaston		algal turf
Aglaothamnion tenuissimum (Bonnemaison) Feldmann-Mazoyer		algal turf
Antithamnion cruciatum (C. Agardh) Nägeli		algal turf
Anthithamnion piliferum Cormaci *et* G. Furnari		algal turf
Antithamnion tenuissimum (Hauck) Schiffner		algal turf
Apoglossum ruscifolium (Turner) J. Agardh		algal turf
Botryocladia botryoides (Wulfen) Feldmann		erect corticated algae
Ceramium bertholdii Funk		algal turf
Ceramium codii (H. Richards) Feldmann-Mazoyer		algal turf
Ceramium diaphanum (Lightfoot) P.H. Roth		algal turf
Ceramium flaccidum (Kützing) Ardissone		algal turf
Champia parvula (C. Agardh) Harvey		algal turf
Dasya corymbifera J. Agardh		algal turf
Dasya ocellata (Grateloup) Harvey		algal turf
Erythroglossum sandrianum (Kützing) Kylin		algal turf
Eupogodon planus (C. Agardh) Kützing		algal turf
Feldmannophycus rayssiae (Feldmann *et* Feldmann-Mazoyer)	Augier *et* Boudouresque	algal turf
Gelidium bipectinatum G. Furnari		erect corticated algae
Griffithsia schousboei Montagne		algal turf
Halydyction mirabile Zanardini		algal turf
Heterosiphonia crispella (C. Agardh) M.J. Wynne		algal turf
Hypoglossum hypoglossoides (Stackhouse) Collins *et* Harvey		algal turf
Jania adhaerens J.V. Lamouroux		articulated Rhodophyta
Laurencia chondrioides Børgesen		erect corticated algae
Lithophyllum pustulatum (J.V. Lamouroux) Foslie		encrusting Corallinales
Lithophyllum stictaeforme (Areshough) Hauck		encrusting Corallinales
Lithothamnion philippii Foslie		encrusting Corallinales
Lomentaria chylocladiella Funk		algal turf
Meredithia microphylla (J. Agardh) J. Agardh		flattened Rhodophyta
Mesophyllum alternans (Foslie) Cabioch et Mendoza		encrusting Corallinales
Mesophyllum macroblastum (Foslie) W.H. Adey		encrusting Corallinales
Monosporus pedicellatus (J.E. Smith) Solier		algal turf
Neurocaulon foliosum (Meneghini) Zanardini		flattened Rhodophyta
Osmundea pelagosae (Schiffner) F.W. Nam		erect corticated algae
Peyssonnelia rubra (Greville) J. Agardh		*Peyssonnelia* spp
Peyssonnelia squamaria (S.G. Gmelin) Decaisne		*Peyssonnelia* spp
Peyssonnelia stoechas Boudouresque *et* Denizot		*Peyssonnelia* spp
Phyllophora crispa (Hudson) P.S. Dixon		flattened Rhodophyta
Plocamium cartilagineum (Linnaeus) P.S. Dixon		algal turf
Polysiphonia elongata (Hudson) Sprengel		algal turf
Polysiphonia furcellata (C. Agardh) Harvey		algal turf
Polysiphonia perforans Cormaci, G. Furnari, Pizzuto *et* Serio		algal turf
Polysiphonia subulifera (C. Agardh) Harvey		algal turf
Pterothamnion plumula (J. Ellis) Nägeli		algal turf
Ptilothamnion pluma (Dillwyn) Thuret		algal turf
Radicilingua reptans (Kylin) Papenfuss		algal turf
Rhodophyllis divaricata (Stackhouse) Papenfuss		algal turf
Rhodymenia ardissonei J. Feldmann		flattened Rhodophyta
Rodriguezella pinnata Ercegovic		erect corticated algae
Rodriguezella strafforelloi F. Schmitz		erect corticated algae
Tricleocarpa fragilis (Linnaeus) Huisman *et* R.A. Towsend		articulated Rhodophyta
Womersleyella setacea (Hollenberg) R.E. Norris		algal turf

PORIFERA	
Clathrina clathrus (Schmidt, 1864)	massive encrusting sponges
Acanthella acuta Schmidt, 1862	massive encrusting sponges
Agelas oroides (Schmidt, 1864)	massive encrusting sponges
Aplysina aerophoba Nardo, 1843	erect sponges
Axinella cannabina (Esper, 1794)	erect sponges
Axinella damicornis (Esper, 1794)	erect sponges
Axinella verrucosa (Esper, 1794)	erect sponges
Clathria coralloides (Scopoli, 1772)	massive encrusting sponges
Cliona schmidti (Ridley, 1881)	massive encrusting sponges
Crambe crambe Schmidt, 1862	massive encrusting sponges
Dysidea avara (Schmidt, 1862)	massive encrusting sponges
Ircinia variabilis (Schmidt, 1862)	massive encrusting sponges
Mycale massa (Schmidt, 1862)	massive encrusting sponges
Oscarella lobularis (Schmidt, 1862)	massive encrusting sponges
Penares euastrum (Schmidt, 1868)	massive encrusting sponges
Petrosia clavata (Esper, 1794)	massive encrusting sponges
Petrosia ficiformis (Poiret, 1789)	massive encrusting sponges
Phorbas tenacior (Topsent, 1925)	massive encrusting sponges
Plakortis simplex Schulze, 1880	massive encrusting sponges
Spirastrella cunctatrix Schmidt, 1868	massive encrusting sponges
Spongia agaricina Pallas, 1766	massive encrusting sponges
Spongia officinalis Linnaeus, 1759	massive encrusting sponges
Tedania anhelans (Vio in Olivi, 1792)	massive encrusting sponges
CNIDARIA	
Anthozoa	
Caryophyllia inornata (Duncan 1878)	madrepores
Corallium rubrum (Linnaeus, 1758)	*
Eunicella cavolini (Koch, 1887)	*
Leptopsammia pruvoti Lacaze-Duthiers, 1897	*
Paramuricea clavata (Risso, 1826)	*
Parazoanthus axinellae (Schmidt, 1862)	*
Hydrozoa	
Clytia hemisphaerica (Linnaeus, 1767)	hydroids
Eudendrium racemosum (Cavolini, 1785)	hydroids
Eudendrium rameum (Pallas, 1766)	hydroids
Sertularella ellissii (Deshayes & Milne-Edwards, 1836)	hydroids
BRYOZOA	
Caberea boryi (Audouin, 1826)	encrusting bryozoans
Cellaria salicornioides Lamouroux, 1816	encrusting bryozoans
Chorizopora brongniartii (Audouin, 1826)	encrusting bryozoans
Collarina balzaci (Audouin, 1826)	encrusting bryozoans
Diplosolen obelia (Johnston,1838)	encrusting bryozoans
Margaretta cereoides (Ellis & Solander, 1786)	erect bryozoans
Myriapora truncata (Pallas, 1766)	*
Pentapora fascialis (Pallas, 1766)	*
Puellina radiata (Moll, 1803)	encrusting bryozoans
Reteporella grimaldii (Jullien, 1903)	*Reteporella* spp
Schizobrachiella sanguinea (Norman, 1868)	encrusting bryozoans
Schizomavella auriculata (Hassall, 1842)	encrusting bryozoans
Schizomavella discoidea (Busk, 1859)	encrusting bryozoans
Schizoporella dunkeri (Reuss, 1848)	encrusting bryozoans
Cradoscrupocellaria reptans (Linnaeus, 1758)	erect bryozoans
Smittina cervicornis (Pallas, 1766)	*
Tubulipora flabellaris (O. Fabricius, 1780)	encrusting bryozoans
Tubulipora hemiphragmata Harmelin, 1976	encrusting bryozoans
CHORDATA	
Ascidiacea	
Didemnum maculosum (Milne-Edwards, 1841)	ascidiaceans
Diplosoma listerianum (Milne-Edwards, 1841)	ascidiaceans
Halocynthia papillosa (Linnaeus, 1767)	ascidiaceans