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Expert Meeting to propose standard methodologies for the inventory and monitoring of coralligenous/maërl communities and their main species
Rome, Italy, 7-8 April 2011

Proposal for the definition of standard methods for inventorying and monitoring coralligenous and maërl populations

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Executive summary :

In the framework of the Plan of Action for the Conservation of Coralligenous and other Mediterranean bio-constructions adopted by Contracting Parties to Barcelona Convention Barcelona in 2008, several priority actions are identified which relate in particular to :

(i) The strengthening the knowledge on the distribution and composition of these population,
(ii) The compiling a database of specialists and
(iii) the establishment of a spatio-temporal monitoring of coralligenous and marêl populations.

However, inventory and monitoring of coralligenous and marêl raise several problems, related to the accessibility of these populations, their heterogeneity and lack of standardized protocol used by different teams working in this field.

The aim of this document is to make a census of the main methods used in the Mediterranean for inventory and monitoring of coralligenous and marêl populations, , and to better understand their benefits, limitations and conditions of use.

The synthesis, which is divided into two parts (the methods of inventory and monitoring) is based on twenty sheets corresponding to protocols implemented by different Mediterranean teams Mediterranean.

The inventory of coralligenous and maerl could be apprehended at two levels:

(I) the location of population, which uses classic mapping techniques. If scuba diving is often used for small areas, it becomes unsuitable when the study area and / or the depth increase. The use of acoustic investigative methods or underwater observation systems is then necessary. However, acoustic techniques must be complemented by a large number of "field" data because often the answers reveal much more on the substrate than on populations.

(Ii) characterization of the populations, which is heavily dependent on the working scale and precision sought. Although the use of underwater photographs or video may be relevant, the use of specialists in taxonomy, enjoying a good experience in scuba diving, is often essential given the complexity of this habitat. If it is possible to estimate the abundance or coverage by standardized indices, detailed characterizations often requires the use of quadrats, transects, or even the removal of all organisms on a given surface. The presence of broken individuals, of necrosis are all factors to be considered as the precise description of the site.

Monitoring of coralligenous and maerl population relies mainly on the scuba diving but given the constraints, using other tools of investigation (ROV, towed camera, ..) should be considered because it allows monitoring with less precision but on larger surfaces.

Depending on the population taken into account, the techniques differ :

(I) monitoring coralligenous population on hard substrate requires the realization of a zero state or specific reference state, with guaranteed reproducibility of the measure over time. It requires the realization of micro-mapping and the use of descriptors. However, these descriptors vary widely from one team to another as well as their measurement protocol.

(Ii) monitoring of maerl populations and rhodoliths seabeds can also be done in scuba diving but the observation using the ROV, towed cameras and the collection using bins are privileged because of the greater homogeneity of these populations. However, there is no method for monitoring as accurate as in the case of coralligenous hard substrate because the action of hydrodynamics may cause a shift on the seabed.

Collected datasheets confirm the multiplicity of operational protocols for both inventory of coralligenous population, and monitoring of coralligenous populations on hard substrate. In contrast, monitoring maërl populations seems less documented.

Longtime ignored because of their location and limited means of investigation, coralligenous maërl and must be now adressed by priority programs. Their inventory and monitoring are therefore a unique challenge at the Mediterranean level because of their ecological and economic importance and threats to their survival.

The results obtained in this work should be discussed in the context of a specific workshop involving key specialists usually working on the monitoring of coralligenous and maerl populations (i) to initiate collaborations between the teams involved (ii) propose a number of "minimal" descriptors to be taken into account, and (iii) to validate methods that can be compared or cross-calibrated. It would indeed be relevant to be able to propose a "toolbox" in which different stakeholders could find to even validated protocols to meet their objectives and available resources. Effort should also be made in terms of training and technology transfer between institutes benefiting from proven and new players.

A- Context and aims

the Plan of Action for the Conservation of Coralligenous and other Mediterranean bio-constructions adopted by Contracting Parties to Barcelona Convention Barcelona in 2008 (UNEP-MAP, 2008).

Many priority actions were identified, mainly concerning (i) enhancing knowledge on the distribution (compiling existing information, carrying out field assignments in new sites or sites of particular interest) and the composition (list of species) of these populations, (ii) compiling a database that lists specialists and (iii) setting up a spatio-temporal monitoring of the coralligenous and marl populations.

Even if we have an overall knowledge about the composition and distribution of coralligenous and marl populations in the Mediterranean (Ballesteros, 2006; Georgiadis *et al*., 2009; UNEP-MAP-RAC/SPA, 2009), the absence of cartographical data on the overall distribution of these populations is one of the greatest lacunae from the conservation point of view (Agnesi *et al*., 2008). The summary crafted by these authors confirms the scarcity of available data, with less than 50 cartographies listed for the Mediterranean basin. Most of these maps are recent (a dozen years old) but basically concern the north-western basin.

The implementation of a spatio-temporal monitoring must enable answers to be found to questions about (1) changes over time in the composition of these populations, (2) viability of the floral and faunal populations which develop there, (3) the impact of natural or anthropogenic disturbance, and (4) selection of species that can be used as bio-indicators.

We have to admit that, unlike the marine magnoliophyte meadows, for which we now have a great many methods that can account for their distribution, state of health and evolution, inventorying and monitoring the coralligenous and marl populations presents several problems linked to the accessibility of these populations, their heterogeneity and the absence of a standardised protocol used for different teams working in this field (Ballesteros, 2006).

These lacunae are particularly worrying in that these populations are undergoing very great pressures linked to their direct exploitation as a source of calcium for soil improvement1, fishing activities, development of pleasure diving and climate change-linked acidification of the water (Grall *et al*., 2009; UNEP-MAP-RAC/SPA, 2009). Beyond the mechanical degradation of these populations the excessive exploitation of living resources associated is likely to significantly alter the ichthyofauna (Harmelin & Marinopoulos, 1994).

This document aims at listing the main methods used for inventorying and monitoring the coralligenous and marl populations in the Mediterranean and better understanding their advantages, restrictions and conditions of use. Starting from these bits of information, a meeting of specialists must be held to choose a set of standardised methods to be implemented as part of a regional strategy.

A. Summary of the main methods used

Bearing in mind the aims pursued and the investigative tools to be implemented, the summary will be subdivided into two parts, inventorying methods and monitoring methods.

1. Inventorying coralligenous and maerl populations

Inventorying coralligenous and maerl populations can be understood at two levels:

- Locating the populations (bathymetric distribution, substrata, mapping etc.)
- Characterisation of the populations (species present, vitality, abundance, etc.).

Locating the coralligenous and marl populations calls on ‘traditional’ mapping techniques similar to those used for the deep magnoliophyte meadows. Although underwater diving is often used for small areas (e.g. transects, quadrates), this method of investigation quickly shows its limits when the area of study and the depth increase significantly, even if the technique can be optimised for a general description of the site (dragged diver, video transects; Cinelli, 2009). Having recourse to acoustic methods of investigation (side sweep sonar, multi-bundle sounder; Georgiadis *et al*., 2009) or submerged observation systems (Remote Operating Vehicle; dragged cameras) is found to be necessary. However, acoustic techniques must be supplemented by a great deal of ‘field data’, for the answers obtained usually concern the substratum rather than the population that develops there, and submerged observation systems require a very long acquisition time given their limited speed and range. Finally, given the 3-D distribution of the populations over hard substrata, ‘quality’ bathymetric data often constitutes an appreciation element that is indispensable. The strategy to be implemented will thus depend on the aim of the study and the area concerned, means and time available (Table I).

Table I: Main tools used for mapping the coralligenous and marl populations in the Mediterranean. Whenever possible, the bathymetric bracket, surface of use, precision, area mapped per hour, interest or limits of uses are stated.

Survey tool	Depth	Surface to be mapped	Geometrical precision	Mapped area (sq.km./hour)	Interest	Limit
Underwater diving	Bathymetric bracket (0 to -50 m)	Areas less than sq.km.	From 0.1 m (relative)	0.001 to 0.01	Very great precision for the identification (taxonomy) and distribution of species (micro-mapping). Non-destructive method. Low cost, easy to implement	Small area inventoried. Work takes a lot of time. Limited depth. Top-level divers (safety). Variable geo-referencing Légal problems
Transects by dragged divers	Bathymetric bracket (0 to -50 m)	Intermediary areas (a few sq.km.)	From 1-10 m	0.01 to 0.025	Easy to implement and possibility of taking pictures. Good identification of populations. Non-destructive method. Low cost. Area covered	Time to acquire and go through data. Limited depth. Top-level divers (safety). Variable positioning of diver (geo-referencing). Water transparency.
Side sweep sonar	From -8 m to over 100 m	Can be used for big areas (a few dozen to a few hundred sq.km.)From 1 m 1 to 4	From 1 m A	1 to 4	Realistic representation allowing good distinction of the nature of the bed and of certain populations (marl) with location of edges. Good geo-referencing. Non-destructive method. Speedy. Wide bathymetric bracket .	Flat (2-D) picture to represent 3-D populations (hard substrata). Acquisition of field data necessary to validate sonograms. High cost, major means out at sea. Very big mass of data

Multi-bundle sounder	From -2 m to over 100 m	Can be used for big areas (a few dozen to a few hundred sq.km.)	From 1 m (linear) <1 m (depth)	0.5 to 6	Possibility of obtaining 3-D picture. Double information (bathymetric and imaging). Very precise bathymetry. Good geo-referencing. Non-destructive method. Speedy. Wide bathymetric bracket	Very great mass of data. Complex processing of information (MNT). Less precise imaging (nature of bed) than side sweep sonar. Acquisition of field data indispensable. High cost, major means out at sea
Remote Operating Vehicle (ROV)	From -2 m to over 100 m	Suits small areas (a few sq.km.)	From 1 m to 10 m	0.01 to 0.025	Non-destructive method. Possibility of taking pictures. Good identification of populations. Wide bathymetric bracket. Identification and distribution of species	Small area inventoried. High cost, major means out at sea. Slow processing and recording of information. Variable positioning. Difficult to handle in currents
Dragged camera	From -2 m to over 100 m	Intermediary areas (a few sq.km.)	From 1 m to 10 m	0.025 to 1	Easy to implement and possibility of taking pictures. Good identification of populations. Non-destructive method. Large area covered	Limited to homogeneous and horizontal beds. Slow acquiring and processing of data. Variable positioning (geo-referencing). Water transparency

Characterisation of the coralligenous and maerl populations depends greatly on the scale of work and the precision sought (Table II). Even if the use of photographs or underwater videos can be pertinent, for it enables the relationship between information obtained and diving time to be optimised, having recourse to specialists in taxonomy (validity of the information) with good experience in underwater diving (safety) is often indispensable, given the complexity of this habitat (3-D distribution of species). The acoustic methods that were described above are totally inoperative.

For a rough characterisation of the populations, semi-quantitative evaluations often give sufficient information; thus it is possible to estimate the cover or abundance by standardised indices directly *in situ* or using photographs (UNEP-MAP-RAC/SPA, 2008). But a quality characterisation of the populations often requires the use of quadrates or transects (with or without photographs; Fraschetti *et al*., 2001; Coma *et al*., 2006) or even the sampling of all the organisms present over a given area for laboratory analysis (destructive method; Boudouresque, 1971).As well as the presence or abundance of a given species, assessing its vitality seems a particularly interesting parameter. The presence of broken individuals, and necrosis, are elements to be taken into consideration (Garrabou *et al*., 1998; 2001). Finally, the nature of the substratum (silted up, roughness, interstices, exposure, slope), the temperature of the water, the ichthyological population associated, the cover by epibionta and the presence of invasive species must also be considered to give a clear characterisation of the population.

Table II: Main methods used to characterise the coralligenous and marl populations in the Mediterranean. Whenever possible, the bathymetric bracket, surface of use, precision, area mapped per hour, interest or limits of uses are stated.

Method	Depth	Surface studied	Geometrical precision	Studied area (sq.m./hour)	Interest	Limit
Remote Operating Vehicle (ROV)	From -2 m to over 100 m	Suits areas of about 1 sq.km.)	From 1 m to 10 m	0.0025 to 0.01 2,500 to 40,000 sq.m	Non-destructive method. Possibility of taking pictures. Wide bathymetric bracket. Good identification of facies and associations. Possibility of semi-quantitative evaluation. Determining big species. On-off collections	Needs recourse to specialists in taxonomy. High cost, major means out at sea. Slow processing and recording of information. Positioning difficult in the presence of currents. Difficulty of observation and access according to the complexity of the populations
Simple underwater diving	Bathymetric bracket (0 to -50 m)	Areas less than 250,000 sq.m.	From 1 m	100 to 2,500 sq.m.	Great precision for the identification, characterisation and distribution of species. Non-destructive method. Low cost, easy to implement. Taking of samples possible	Need to have recourse to specialists in taxonomy. Small area inventoried. Work takes a lot of time. Limited depth. Top-level divers (safety). Pretty imprecise survey. Limited number of species observed
Underwater diving with shots	Bathymetric bracket (0 to -50 m)	Areas less than 250,000 sq.m.	From 1 m	100 to 10,000 sq.m.	Great precision for the identification, characterisation and distribution of species. Non-destructive method. *A posteriori* identification possible. Low cost, easy to implement. Taking of	Need to have recourse to specialists in taxonomy. Small area inventoried. Work takes a lot of time. Limited depth. Material for taking shots necessary. Top-level divers (safety). Limited number of species

					samples possible	observed. 2-D observation possible
Underwater diving with sampling	Bathymetric bracket (0 to -50 m)	Areas less than 10 sq.m.	From 1 m	1 to 2 sq.m.	Very great precision for the identification (taxonomy) and distribution of species (micro-mapping). All species taken into account. *A posteriori* identification. Low cost, easy to implement.	Destructive method. Very small area inventoried. Sampling material needed. Work takes a lot of time. Limited depth. Top-level divers (safety)

1. Monitoring coralligenous and marl populations

Monitoring coralligenous and marl populations basically calls on underwater diving, although this technique gives rise to many constraints due to the conditions of the environment in which these formations develop (great depths, weak luminosity, low temperatures, presence of currents etc.); it can only be done by confirmed divers and over a limited time (Bianchi *et al*., 2004; Tetzaff & Thorsen, 2005). To break free of these constraints, it is possible to call on new investigation tools (ROV) that open up possibilities of a monitoring that is less precise but over greater areas of these populations. The complementarity of these techniques must be taken into account when crafting an operational strategy.

Also, although it cannot be denied that there are constraints linked to the observation of coralligenous and marl populations, their slow growth rate enables sampling to be done at long intervals of time to monitor them in the long term, outside those sectors where human pressure is great (Garrabou *et al*., 2002).

Monitoring the coralligenous populations on hard substratum requires achieving a zero state, or precise reference state, with an additional requirement: the data gathered must be able to be reproduced over time. Thus, the experimental protocol has capital importance. As well as very precise locating of the measurement, often requiring the making of a micro-map (quadrates, transects), the descriptors taken into account have to be the subject of a standardised protocol and not be restricted to the presence or abundance of a few target species (cf. Characterisation of the coralligenous and marl populations).

Although destructive methods (sampling of all the organisms present over a given area) have long been used, because they offer excellent results for sedentary fauna and flora, they are not desirable for long-term regular monitoring (UNEP-MAP-RAC/SPA, 2008). It is more suitable to favour non-destructive methods like photographic sampling or direct observation in given areas (quadrates). Neither method requires sampling of organisms and both are therefore absolutely appropriate for long-term monitoring. These different methods can be used separately or together according to the aims of the study, area inventoried and means available (Table III). Non-destructive methods are increasingly used and – mainly for photographic sampling – enjoy significant technological advances.

Unlike the marine magnoliophyte meadows, the descriptors to be taken into account vary greatly from one team to another, as does their measuring protocol (Harmelin & Marinopoulos, 1994; Pérez *et al*., 2000; Bianchi *et al*., 2004; Cinelli, 2009). 'Standardised' sheets are being crafted by scientific teams, particularly in the context of the Natura 2000 sea programmes, and should enable these difficulties to be at least partially solved (Figure 1).

Monitoring the marl populations and those on rhodolith beds may also be done by underwater diving, but observation using the ROV, dragged cameras, or more usually sampling using buckets are favoured because of the greater homogeneity of these populations (Table IV). Similarly, having recourse to acoustic techniques (side sweep sonar) associated with good geo-location means that the expansion of these populations can be monitored over time (Bonacorsi *et al*., 2010). However, there is no method that is as precise as those developed for the coralligenous populations of the hard substratum (micro-mapping, photographic sampling). Indeed, the movement of these populations over the bed, particularly in response to hydrodynamics, does not suit this kind of technique.

Table III: Comparison between three traditional methods of sampling hard substratum populations (Bianchi *et al*., 2004)

In situ sampling	
Advantages	Taxonomical precision, objective evaluation, reference samples
Drawbacks	High cost, slow laborious work, intervention of specialists, limited area inventoried, destructive method
Use	Studies integrating a strong taxonomical element
Video or photo monitoring	
Advantages	Objective evaluation, can be reproduced, reference samples, can be automated, speedy diving work, big area inventoried, non-destructive method
Drawbacks	Low taxonomical precision, problem of *a posteriori* interpreting of pictures
Use	Studies on the biological cycle or over-time monitoring, great depth of study
Direct observation	
Advantages	Low cost, results immediately available, big area inventoried, can be reproduced, non-destructive method
Drawbacks	Risk of taxonomic subjectivity, slow diving work
Use	Exploratory studies, monitoring of populations, bionomic studies

Table IV: Methods used to monitor marl populations and those of rhodolith beds

Diving observation	
Advantages	Low cost, results immediately available, pretty non-destructive method, reference samples, taxonomical precision, distribution of species
Drawbacks	Work limited as regards depth, small area inventoried
Use	Exploratory studies, monitoring of populations, bionomic studies
Blind sampling (bucket, dragging)	
Advantages	Low cost, easy to implement, taxonomical precision, reference samples, analysis of substratum (granulometry, calcimetry, % of organic matter), great depth of study
Drawbacks	Imprecision of observation, several repeats needed, limited area inventoried, destructive method
Use	Localised studies integrating a taxonomical element, validation of acoustic methods
Monitoring with ROV and dragged cameras	
Advantages	Objective evaluation, reference samples (pictures), big area inventoried, non-destructive method, distribution of species, great depth of study
Drawbacks	High cost, low taxonomical precision, problem of *a posteriori* interpretation of pictures, superficial observation, little information on the substratum
Use	Studies on distribution and temporal monitoring, validation of acoustic methods
Side sweep sonar	
Advantages	Very big areas inventoried, information on hydrodynamics (sedimentary figures), can be reproduced, non-destructive method, great depth of study
Drawbacks	High cost, interpreting of sonograms, additional validation (inter-calibration), superficial observation, no taxonomical information
Use	Studies over big areas, monitoring of populations, bionomic studies

Natura 2000 - Fiche Coralligène – ANTONIOLI 2010 – GIS Posidonie

- Date : …………………. - Observateur :…………………… - N° de plongée & site :……………………

- **Type de faciès :** *Cystoseira zosteroides* ☐ *Eunicella singularis* ☐
  Eunicella cavolinii ☐ *Lophogorgia sarmentosa* ☐
  Paramuricea clavata ☐ Autre : ………………… ☐

- **Gorgone :**

Non → Oui

	- -	-	+	+ +
Toutes les classes de taille				
Nécrose				
Gorgone arrachée				
Epibiontes				
Recrutement (<3cm)				

Gorgonaire	**Espèce :**……………
……………cm	……………cm
……………cm	……………cm
……………cm	……………cm
……………cm	……………cm
……………cm	……………cm
……………cm	……………cm

- **Aspect général :**

Non → Oui

	- -	-	+	+ +
Sédimentation / vase				
Voiles algaux				
Impression de diversité (très coloré)				
Faune cryptique riche				

Filet ☐
Ancrage ☐
Fil ☐
Déchet ☐

Profondeur d'observation des gorgonaires :
- Max :
- Min :

- **Inventaire :**

Macrophytes	
Lithophyllum & Mesophyllum en 3D	
Couverture de *Lithophyllum incrusans* sans relief	
Taches blanches sur Lithophyllum ou Mesophyllum	
Présence d'espèces dressées *Halimeda*, *Udotea* ; *Cystoseira*…	

Spongiaire & Bryozoaire	
Eponges perforantes (Clione)	
Espèces dressées (*Axinella sp.*, *Spongia agaricina*,…)	
Grands bryozoaires branchus	

Ichtyofaune	
Présence d'espèces-cibles avec grands individus	
Poissons benthiques ou nectobenthiques	

- **Observation :**

Photos quadrats et paysagères à réaliser

Figure 1: Example of synthetic sheet used in the context of the Natura 2000 studies by GIS Posidonie (Antonioli, 2010)

B. Recommendations

Following on the first Mediterranean symposium on the conservation of the coralligenous and other calcareous assemblages (Tabarka, January 2009; UNEP-MAP-RAC/SPA, 2009), that brought together over 120 participants from 11 Mediterranean countries, it was recommended that:

- knowledge on coralligenous populations should be enhanced by deciding on reference states, acquiring long chronological sets and setting up a network of Mediterranean experts
- monitoring networks, locally managed and coordinated on a regional scale, should be started, and standardised protocols suggested that could be applied to the entire Mediterranean
- species that are indicators of the state of health of these formations should be identified, as well as quality criteria giving information on specific human impacts.

We have to say that two years after this symposium was held, although an enhancing of knowledge was started via (i) the Natura 2000 sea programmes and the Maritime Strategy Directive for the European countries, or (ii) the transfer of skills for researchers on the southern shores (CapCoral Programme; Bonacorsi, 2010), there is still no overall strategy or efficacious coordination at regional level. It thus seems urgent that a work group be set up to meet the expectations expressed at this symposium.

Inventorying and monitoring the coralligenous and marl populations in the Mediterranean constitutes a unique challenge given the ecological and economic importance of these populations and the threats that hang over their continued existence. Long ignored due to their location and the limited means of investigation, today these populations must be the subject of priority programmes.

This approach must be encouraged and coordinated at regional level via the holding of a specific workshop that brings together the main specialists usually working on monitoring coralligenous and marl populations. Even if it is hard to suggest one single standard method for monitoring, this kind of workshop is always useful to (i) initiate collaboration, (ii) propose a minimal number of descriptors, and (iii) validate methods that can be compared or inter-calibrated (UNEP-MAP-RAC/SPA, 2008).

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