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# PROPOSAL OF STANDARD METHODS FOR INVENTORYING AND MONITORING CORALLIGENOUS AND RHODOLITHS POPULATIONS

In the framework of a sustainable development approach, this document will be available only in electronic format during the meeting

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Mediterranean Action Plan
Regional Activity Centre for Specially Protected Areas
(RAC/SPA)
Boulevard du leader Yasser Arafat
B.P.337 - 1080 Tunis CEDEX
E-mail : car-asp@rac-spa.org

The document has been prepared for the Regional Activity Centre for Specially Protected Areas (RAC/SPA), by: Gérard Pergent (e-mail: pergent@wanadoo.fr)

With the contribution of the following experts: Sabrina Agnesi, Paul Arthur Antonioli, Lorenza Babbini, Said Belbacha, Kerim Ben Mustapha, Carlo Nike Bianchi, Ghazi Bitar, Silvia Cocito, Julie Deter, Joaquim Garrabou, Jean-Georges Harmelin, Florian Hollon, Giulia Mo, Monica Montefalcone, Carla Morri, Valeriano Parravicini, Andrea Peirano, Alfonso Ramos-Espla, Giulio Relini, Stéphane Sartoretto, Rachid Semroud, Leonardo Tunesi, Marc Verlaque

## Executive summary:

In the framework of the Action Plan 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 maërl populations. However, inventory and monitoring of coralligenous and maërl 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 maërl 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 maërl 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 presences of broken individuals, of necrosis are all factors to be considered as the precise description of the site.

Monitoring of coralligenous and maërl 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 maërl 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 maërl 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 Action Plan 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 maërl 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 (i) changes over time in the composition of these populations, (ii) viability of the floral and faunal populations which develop there, (iii) the impact of natural or anthropogenic disturbance, and (iv) 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.

## B- 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 maërl populations

Inventorying coralligenous and maërl 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 maërl 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<br>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.)<br>From 1 m<br>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 maërl 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, especially for coralligenous.

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 (Harmelin, 1990).

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 samples possible | 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 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) |

## 2. 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 maërl 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.

**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 |

Unlike the marine magnoliophyta 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; Annex A).

***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.

*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…* | |

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

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

- **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)**

**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 |

## C- 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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# Annex
# Draft list of the principal species to be considered in the inventorying and monitoring coralligenous and maërl populations

# LIST OF THE PRINCIPAL SPECIES TO BE CONSIDERED IN THE INVENTORYING

## Coralligenous Population

**Builders**

**Algal builders**

*Lithophyllum cabiochae* (Boudouresque & Verlaque) Athanasiadis
*Lithophyllum stictaeforme* (Areschoug) Hauck 1877
*Lithothamnion sonderi* Hauck 1883
*Lithothamnion philippii* Foslie 1897
*Mesophyllum alternans* (Foslie) Cabioch & Mendoza 1998
*Mesophyllum expansum* (Philippi) Cabioch & Mendoza 2003
*Mesophyllum macedonis* Athanasiadis 1999
*Mesophyllum macroblastum* (Foslie) Adey 1970
*Neogoniolithon mamillosum* (Hauck) Setchell & L.R.Mason 1943
*Peyssonnelia rosa-marina* Boudouresque & Denizot 1973
*Peyssonnelia polymorpha* (Zanardini) F.Schmitz in Falkenberg 1879
*Sporolithon ptychoides* Heydrich 1897

**Animal builders**

Foraminifera
*Miniacina miniacea* Pallas 1766

Bryozoans
*Myriapora truncata* Pallas 1766
*Schizomavella* spp.
*Turbicellepora* spp.
*Adeonella calveti* Canu & Bassler 1930
*Smittina cervicornis* Pallas 1766
*Pentapora fascialis* Pallas 1766
*Schizotheca serratimargo* Hincks 1886
*Myriapora truncata* Pallas 1766
*Rhynchozoon neapolitanum* Gautier 1962

Polychaeta
*Serpula* spp.
*Spirorbis* sp.
*Spirobranchus polytrema* Philippi 1844

Protozoa
*Miniacina miniacea* Pallas 1766

Cnidaria
*Caryophyllia inornata* Duncan 1878
*Caryophyllia smithii* Stokes and Broderip 1828
*Leptopsammia pruvoti* Lacaze-Duthiers 1897
*Hoplangia durotrix* Gosse 1860
*Polycyathus muellerae* Abel 1959
*Cladocora caespitosa* Linnaeus 1767
*Phyllangia americana mouchezii* Lacaze-Duthiers 1897
*Dendrophyllia ramea* Linnaeus 1758
*Dendrophyllia cornigera* Lamarck 1816

**BIOERODERS**

Sponges
Clionidae (Cliona, Pione…)

Echinoids
*Echinus melo* Lamarck 1816
*Sphaerechinus granularis* (Lamarck, 1816)

Molluscs
*Gastrochaena dubia* Pennant 1777
*Hiatella arctica* Linnaeus 1767
*Lithophaga lithophaga* Linnaeus 1758
*Petricola lithophaga* Philippson 1788

Polychaetes
*Polydora* spp.
*Dipolydora* spp.
*Dodecaceria concharum* Örsted 1843

Sipunculids
*Aspidosiphon (Aspidosiphon) muelleri muelleri* Diesing, 1851
*Phascolosoma (Phascolosoma) stephensoni* Stephen 1942

**(OTHER) RELEVANT SPECIES (*invasive; **disturbed or stressed environments-usually, when abundant)**

Algae

Green algae

*Flabellia petiolata* (Turra) Nizamuddin 1987
*Halimeda tuna* (J.Ellis & Solander) J.V.Lamouroux 1816
*Palmophyllum crassum* (Naccari) Rabenhorst 1868
*Caulerpa racemosa* (Forsskål) J.Agardh 1873*
*Caulerpa taxifolia* (M.Vahl) C.Agardh 1817*
*Codium bursa* (Olivi) C.Agardh 1817**
*Codium fragile* (Suringar) Hariot 1889*
*Codium vermilara* (Olivi) Chiaje 1829**

Brown algae

*Cystoseira zosteroides* C.Agardh 1820
*Cystoseira spinosa* var. *compressa* (Ercegovic) Cormaci, G.Furnari, Giaccone, Scammacca & D.Serio 1992
*Laminaria rodriguezii* Bornet 1888
*Halopteris filicina* (Grateloup) Kützing 1843
*Phyllariopsis brevipes* (C.Agardh) E.C.Henry & G.R.South 1987
*Dictyopteris lucida* M.A.Ribera Siguán, A.Gómez Garreta, Pérez Ruzafa, Barceló Martí & Rull Lluch 2005**
*Dictyota* spp.**
*Stypopodium schimperi* (Buchinger ex Kützing) Verlaque & Boudouresque 1991*
*Acinetospora crinita* (Carmichael) Kornmann 1953**
*Stilophora tenella* (Esper) P.C.Silva in P.C. Silva, Basson & Moe 1996**
*Stictyosiphon adriaticus* Kützing 1843**

"Yellow" algae (Pelagophyceae)

*Nematochrysopsis marina* (J.Feldmann) C.Billard 2000**

Red algae

*Osmundaria volubilis* (Linnaeus) R.E.Norris 1991
*Rodriguezella* spp.
*Ptilophora mediterranea* (H.Huvé) R.E.Norris 1987
*Kallymenia* spp.
*Halymenia* spp.
*Sebdenia* spp.
*Peyssonnelia* spp. (non calcareous)
*Phyllophora crispa* (Hudson) P.S.Dixon 1964
*Gloiocladia* spp.
*Leptofauchea coralligena* Rodríguez-Prieto & De Clerck 2009
*Acrothamnion preissii* (Sonder) E.M.Wollaston 1968*
*Lophocladia lallemandii* (Montagne) F.Schmitz 1893*
*Asparagopsis taxiformis* (Delile) Trevisan de Saint-Léon 1845*
*Womersleyella setacea* (Hollenberg) R.E.Norris 1992*

Animals

Sponges

*Acanthella acuta* Schmidt 1862
*Agelas oroides* Schmidt 1864
*Aplysina aerophoba* Nardo 1843
*Aplysina cavernicola* Vacelet 1959
*Axinella* spp.
*Chondrosia reniformis* Nardo 1847
*Clathrina clathrus* Schmidt 1864Cliona viridis
*Dysidea* spp.
*Haliclona (Reniera) mediterranea* Griessinger 1971
*Haliclona (Soestella) mucosa* Griessinger 1971
*Hemimycale columella* Bowerbank 1874
*Ircinia fasciculata* Esper 1794
*Ircinia oros* Schmidt 1864
*Ircinia variabilis* Schmidt 1862
*Oscarella* sp.
*Petrosia ficiformis* Poiret 1789
*Phorbas tenacior* Topsent 1925
*Spirastrella cunctatrix* Schmidt 1868
*Spongia officinalis* Linnaeus 1759
*Spongia (Spongia) lamella* Schulze 1879

Cnidaria

*Alcyonium acaule* Marion 1878
*Alcyonium palmatum* Pallas 1766
*Corallium rubrum* Linnaeus 1758
*Paramuricea clavata* Risso 1826
*Eunicella* spp.
*Leptogorgia sarmentosa* Esper 1789
*Ellisella paraplexauroides* Stiasny 1936
*Antipathes* spp.
*Parazoanthus axinellae* Schmidt 1862
*Savalia savaglia* Bertoloni 1819
*Callogorgia verticillata* Pallas 1766

Polychaeta
*Sabella spallanzanii* Gmelin 1791
*Filograna implexa* Berkeley 1835
*Salmacina dysteri* Huxley 1855
*Protula* spp.

Bryozoans
*Chartella tenella* Hincks 1887
*Margaretta cereoides* Ellis & Solander 1786
*Hornera frondiculata* Lamouroux 1821

Tunicates
*Pseudodistoma cyrnusense* Pérès 1952
*Aplidium* spp.
*Microcosmus sabatieri* Roule 1885
*Halocynthia papillosa* Linnaeus 1767

Molluscs
*Charonia lampas* Linnaeus 1758
*Charonia variegata* Lamarck 1816
*Pinna rudis* Linnaeus 1758
*Erosaria spurca* Linnaeus 1758
*Luria lurida* Linnaeus 1758

Decapoda
*Palinurus elephas* Fabricius 1787
*Scyllarides latus* Latreille 1803
*Maja squinado* Herbst 1788

Echinodermata
*Antedon mediterranea* Lamarck, 1816
*Hacelia attenuata* Gray 1840
*Centrostephanus longispinus* Philippi 1845
*Holothuria (Panningothuria) forskali* Delle Chiaje 1823
*Holothuria (Platyperona) sanctori* Delle Chiaje 1823

Pisces
*Epinephelus* spp.
*Mycteroperca rubra* Bloch 1793
*Sciaena umbra* Linnaeus 1758
*Scorpaena scrofa* Linnaeus 1758
*Raja* spp.
*Torpedo* spp.
*Mustelus* spp.
*Phycis phycis* Linnaeus 1766
*Serranus cabrilla* Linnaeus 1758
*Scyliorhinus canicula* Linnaeus 1758

# Rhodolith Communities

(*invasive; **disturbed or stressed environments- usually, when abundant).

Species that can be dominant or abundant are preceded by #

**Algae**

Red algae (calcareous)
# *Lithophyllum racemus* (Lamarck) Foslie 1901
# *Lithothamnion corallioides* (P.L.Crouan & H.M.Crouan) P.L.Crouan & H.M.Crouan 1867
# *Lithothamnion valens* Foslie 1909
# *Peyssonnelia crispata* Boudouresque & Denizot 1975
# *Peyssonnelia rosa-marina* Boudouresque & Denizot 1973
# *Phymatolithon calcareum* (Pallas) W.H.Adey & D.L.McKibbin 1970
# *Spongites fruticulosa* Kützing 1841
# *Tricleocarpa cylindrica* (J.Ellis & Solander) Huisman & Borowitzka 1990
*Lithophyllum cabiochae* (Boudouresque et Verlaque) Athanasiadis
*Lithophyllum stictaeforme* (Areschoug) Hauck 1877
*Lithothamnion minervae* Basso 1995
*Lithothamnion philippii* Foslie 1897
*Mesophyllum alternans* (Foslie) Cabioch & Mendoza 1998
*Mesophyllum expansum* (Philippi) Cabioch & Mendoza 2003
*Neogoniolithon brassica-florida* (Harvey) Setchell & L.R.Mason 1943
*Neogoniolithon mamillosum* (Hauck) Setchell & L.R.Mason 1943
*Peyssonnelia polymorpha* (Zanardini) F.Schmitz in Falkenberg 1879
*Sporolithon ptychoides* Heydrich 1897

Red algae (non builders)
# *Osmundaria volubilis* (Linnaeus) R.E.Norris 1991
# *Phyllophora crispa* (Hudson) P.S.Dixon 1964
#*Peyssonnelia* spp. (non calcareous)
*Acrothamnion preissii* (Sonder) E.M.Wollaston 1968*
*Aeodes marginata* (Roussel) F.Schmitz 1894
*Alsidium corallinum* C.Agardh 1827
*Brongniartella byssoides* (Goodenough & Woodward) F.Schmitz 1893

*Cryptonemia* spp.
*Gloiocladia microspora* (Bornet ex Bornet ex Rodríguez y Femenías) N.Sánchez & C.Rodríguez-Prieto ex Berecibar, M.J.Wynne, Barbara & R. Santos 2009
*Gloiocladia repens* (C.Agardh) Sánchez & Rodríguez-Prieto in Rodriguez-Prieto *et al.* 2007
*Gracilaria* spp.
*Halymenia* spp.
*Kallymenia* spp.
*Leptofauchea coralligena* Rodríguez-Prieto & De Clerck 2009
*Myriogramme tristromatica* (J.J.Rodríguez y Femenías ex Mazza) Boudouresque in Boudouresque & Perret-Boudouresque 1987
*Osmundea pelagosae* (Schiffner) K.W.Nam in K.W. Nam, Maggs & Garbary 1994
*Phyllophora heredia* (Clemente) J.Agardh 1842
*Polysiphonia subulifera* (C.Agardh) Harvey 1834
*Rhodophyllis divaricata* (Stackhouse) Papenfuss 1950
*Rytiphlaea tinctoria* (Clemente) C.Agardh 1824
*Sebdenia* spp.
*Womersleyella setacea* (Hollenberg) R.E.Norris 1992*

<u>Green algae</u>
# *Flabellia petiolata* (Turra) Nizamuddin 1987
*Caulerpa racemosa* (Forsskål) J.Agardh 1873*
*Caulerpa taxifolia* (M.Vahl) C.Agardh 1817*
*Codium bursa* (Olivi) C.Agardh 1817
*Microdictyon tenuius* J.E.Gray 1866
*Palmophyllum crassum* (Naccari) Rabenhorst 1868
*Umbraulva olivascens* (P.J.L.Dangeard) G.Furnari in Catra, Alongi, Serio, Cormaci & G. Furnari 2006

<u>Brown algae</u>
# *Arthrocladia villosa* (Hudson) Duby 1830
# *Laminaria rodriguezii* Bornet 1888
# *Sporochnus pedunculatus* (Hudson) C.Agardh 1820
*Acinetospora crinita* (Carmichael) Kornmann 1953**
*Carpomitra costata* (Stackhouse) Batters 1902
*Cystoseira abies-marina* (S.G.Gmelin) C.Agardh 1820
*Cystoseira foeniculacea* (Linnaeus) Greville 1830
*Cystoseira foeniculacea* f. *latiramosa* (Ercegovi?) A.Gómez Garreta, M.C.Barceló, M.A..Ribera & J.R.Lluch 2001
*Cystoseira spinosa* var. *compressa* (Ercegovic) Cormaci, G.Furnari, Giaccone, Scammacca & D.Serio 1992
*Cystoseira zosteroides* C.Agardh 1820
*Dictyopteris lucida* M.A.Ribera Siguán, A.Gómez Garreta, Pérez Ruzafa, Barceló Martí & Rull Lluch 2005
*Dictyota* spp.
*Halopteris filicina* (Grateloup) Kützing 1843
*Nereia filiformis* (J.Agardh) Zanardini 1846
*Phyllariopsis brevipes* (C.Agardh) E.C.Henry & G.R.South 1987
*Spermatochnus paradoxus* (Roth) Kützing 1843
*Stictyosiphon adriaticus* Kützing 1843
*Stilophora tenella* (Esper) P.C.Silva in P.C. Silva, Basson & Moe 1996
*Zanardinia typus* (Nardo) P.C.Silva in W.Greuter 2000

**Animals**
<u>Sponges</u>
*Aplysina* spp.
*Axinella* spp.
*Cliona viridis* Schmidt 1862
*Dysidea* spp.
*Haliclona* spp.
*Hemimycale columella* Bowerbank 1874
*Oscarella* spp.
*Phorbas tenacior* Topsent 1925
*Spongia officinalis* Linnaeus 1759
*Spongia (Spongia) lamella* Schulze 1879

<u>Cnidaria</u>
# *Alcyonium palmatum* Pallas 1766
# *Eunicella verrucosa* Pallas 1766
# *Paramuricea macrospina* Koch 1882
#*Aglaophenia* spp.
*Adamsia palliata* Fabricius 1779
*Calliactis parasitica* Couch 1838
*Cereus pedunculatus* Pennant 1777
*Cerianthus membranaceus* Spallanzani 1784
*Funiculina quadrangularis* Pallas 1766
*Leptogorgia sarmentosa* Esper 1789
*Nemertesia antennina* Linnaeus 1758
*Pennatula* spp.
*Veretillum cynomorium* Pallas 1766
*Virgularia mirabilis* Müller 1776

Polychaetes
*Aphrodita aculeata* Linnaeus 1758
*Sabella pavonina* Savigny 1822
*Sabella spallanzanii* Gmelin 1791

Bryozoans
*Cellaria fistulosa* Linnaeus 1758
*Hornera frondiculata* Lamouroux 1821
*Pentapora fascialis* Pallas 1766
*Turbicellepora* spp.

Tunicates
#*Aplidium* spp.
*Ascidia mentula* Müller 1776
*Diazona violacea* Savigny 1816
*Halocynthia papillosa* Linnaeus 1767
*Microcosmus* spp.
*Phallusia mammillata* Cuvier 1815
*Polycarpa* spp.
*Pseudodistoma crucigaster* Gaill 1972
*Pyura dura* Heller 1877
*Rhopalaea neapolitana* Philippi 1843
*Synoicum blochmanni* Heiden 1894

Echinodermata
*Astropecten irregularis* Pennant 1777
*Chaetaster longipes* Retzius 1805
*Echinaster (Echinaster) sepositus* Retzius 1783
*Hacelia attenuata* Gray 1840
*Holothuria (Panningothuria) forskali* Delle Chiaje 1823
*Leptometra phalangium* Müller 1841
*Luidia ciliaris* Philippi 1837
*Ophiocomina nigra* Abildgaard in O.F. Müller 1789
*Parastichopus regalis* Cuvier 1817
*Spatangus purpureus* O.F. Müller 1776
*Sphaerechinus granularis* Lamarck 1816
*Stylocidaris affinis* Philippi 1845

Pisces
*Mustelus* spp.
*Pagellus acarne* (Risso, 1827)
*Pagellus erythrinus* (Linnaeus, 1758)
*Raja undulata* Lacepède, 1802
*Scyliorhinus canicula* (Linnaeus, 1758)
*Squatina* spp.
*Trachinus radiatus* Cuvier, 1829

# LIST OF THE PRINCIPAL SPECIES TOP BE CONSIDERED ON THE MONITORING

## Coralligenous Populations

**CORALLIGENOUS BUILDERS**

**Algal builders**

*Lithophyllum cabiochae* (Boudouresque et Verlaque) Athanasiadis
*Lithophyllum stictaeforme* (Areschoug) Hauck 1877
*Mesophyllum alternans* (Foslie) Cabioch & Mendoza 1998
*Mesophyllum expansum* (Philippi) Cabioch & Mendoza 2003
*Mesophyllum macedonis* Athanasiadis 1999
*Mesophyllum macroblastum* (Foslie) Adey 1970
*Peyssonnelia polymorpha* (Zanardini) F.Schmitz in Falkenberg 1879
*Peyssonnelia rosa-marina* Boudouresque & Denizot 1973

**Animal builders**

Bryozoans
*Adeonella calveti* Canu & Bassler 1930
*Pentapora fascialis* Pallas 1766
*Schizotheca serratimargo* Hincks 1886
*Smittina cervicornis* Pallas 1766

**Bioeroders**

Echinoids
*Echinus melo* Lamarck 1816

**(Other) Relevant species (*invasive; ^disturbed or stressed environments-usually, when abundant)**

Algae

Green algae

*Caulerpa racemosa* (Forsskål) J.Agardh 1873*
*Caulerpa taxifolia* (M.Vahl) C.Agardh 1817*

Brown algae

*Acinetospora crinita* (Carmichael) Kornmann 1953^
*Dictyopteris lucida* M.A.Ribera Siguán, A.Gómez Garreta, Pérez Ruzafa, Barceló Martí & Rull Lluch 2005^
*Dictyota* spp.^
*Laminaria rodriguezii* Bornet 1888
*Stictyosiphon adriaticus* Kützing 1843^
*Stilophora tenella* (Esper) P.C.Silva in P.C. Silva, Basson & Moe 1996^

“Yellow” algae (Pelagophyceae)

*Nematochrysopsis marina* (J.Feldmann) C.Billard 2000^

Red algae

*Acrothamnion preissii* (Sonder) E.M.Wollaston 1968*
*Lophocladia lallemandii* (Montagne) F.Schmitz 1893*
*Womersleyella setacea* (Hollenberg) R.E.Norris 1992*

Animals

Sponges

*Axinella* spp.
*Spongia officinalis* Linnaeus 1759
*Spongia (Spongia) lamella* Schulze 1879

Cnidaria

*Corallium rubrum* Linnaeus 1758
*Eunicella* spp.
*Leptogorgia* spp.
*Paramuricea clavata* Risso 1826
*Savalia savaglia* Bertoloni 1819

Polychaeta

*Filograna implexa* Berkeley 1835
*Salmacina dysteri* Huxley 1855

Bryozoans

*Hornera frondiculata* Lamouroux 1821

Tunicates

*Halocynthia papillosa* Linnaeus 1767

Molluscs

*Charonia lampas* Linnaeus 1758
*Charonia variegata* Lamarck 1816

Decapoda

*Homarus gammarus* Linnaeus 1758
*Maja squinado* Herbst 1788
Palinurus spp.
*Scyllarides latus* Latreille 1803

Pisces

*Epinephelus* spp.
*Mustelus* spp.
*Mycteroperca rubra* Bloch 1793
*Phycis phycis* Linnaeus 1766
*Raja* spp.
*Sciaena umbra* Linnaeus 1758
*Scorpaena scrofa* Linnaeus 1758
*Scyliorhinus canicula* Linnaeus 1758
*Serranus cabrilla* Linnaeus 1758
*Torpedo* spp.

# Rhodolith populations

(*invasive; **disturbed or stressed environments-usually, when abundant).

Species that can be dominant or abundant are preceded by #

**Algae**

Red algae (calcareous)

Brunch

# *Lithophyllum racemus* (Lamarck) Foslie 1901
# *Lithothamnion corallioides* (P.L.Crouan & H.M.Crouan) P.L.Crouan & H.M.Crouan 1867
# *Lithothamnion valens* Foslie 1909
# *Phymatolithon calcareum* (Pallas) W.H.Adey & D.L.McKibbin 1970

Crust

*Lithophyllum cabiochae* (Boudouresque et Verlaque) Athanasiadis
*Lithophyllum stictaeforme* (Areschoug) Hauck 1877
*Neogoniolithon brassica-florida* (Harvey) Setchell & L.R.Mason 1943
*Neogoniolithon mamillosum* (Hauck) Setchell & L.R.Mason 1943
*Sporolithon ptychoides* Heydrich 1897

Peyssonneliaceae

# *Peyssonnelia crispata* Boudouresque & Denizot 1975
# *Peyssonnelia rosa-marina* Boudouresque & Denizot 1973
*Peyssonnelia polymorpha* (Zanardini) F.Schmitz in Falkenberg 1879

Thin encrusting coralline

# *Spongites fruticulosa* Kützing 1841
*Lithothamnion minervae* Basso 1995
*Lithothamnion philippii* Foslie 1897
*Mesophyllum alternans* (Foslie) Cabioch & Mendoza 1998
*Mesophyllum expansum* (Philippi) Cabioch & Mendoza 2003

# *Tricleocarpa cylindrica* (J.Ellis & Solander) Huisman & Borowitzka 1990

Brown algae

# *Laminaria rodriguezii* Bornet 1888

**Animals**

Sponges

*Axinella* spp.