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ACTION PLAN FOR THE CONSERVATION OF THE CORALLIGENOUS AND OTHER CALCAREOUS BIO-CONCRETIONS IN THE MEDITERRANEAN SEA

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1. CURRENT SITUATION OF CORALLIGENOUS ASSEMBLAGES

1.1. Current knowledge

At present there is a general knowledge on the distribution, species composition and functioning of coralligenous assemblages and other calcareous bio-concretions. However, and despite the efforts conducted since the adoption in 2008 of the Action Plan for Coralligenous and other Calcareous Bioconstructions, in the Mediterranean, there are essential questions that need to be addressed to guarantee the conservation of these emblematic Mediterranean habitats (see specific sections).

Probably the number and quality of presentations during the 2nd Mediterranean Symposium on the Conservation of coralligenous and other calcareous bio-concretions (Portorož, Slovenia 29-30 October 2014) are the best example on the interest of Mediterranean scientific/ managers community to improve the knowledge on these assemblages (Proceedings 2nd MSC&CBC 2014).

Despite of this, it was also noted that

(i) most actions regarded individual- national- based efforts and

(ii) the lack of structures for coordination in an efficient way of regional and/or pan-Mediterranean research actions.

There was a general consensus at the Symposium to establish a series of Working Groups to coordinate the human and resources in order to provide the needed general view on the coralligenous/maërl assemblages and overcome these gaps.

1.2. Distribution

Coralligenous buildups and maërl beds are common all around the Mediterranean coasts, even in the easternmost coasts (Giakoumi *et al.* 2013, Martin *et al.* 2014). The coralligenous habitats are abundant in the Adriatic, Aegean and Tyrrhenian Seas as well as in the Algero-Provençal Basin. The coralligenous is less abundant in the Levantine Sea and Tunisian Plateau/Gulf of Sidra (Martin *et al.* 2014). Overall, data available cover approximately 30 % of the Mediterranean coasts while for the remaining 70 % no information was found (Martin *et al.* 2014). Regarding the depth distribution, most information concern the 10 to 50 m depth less information exists for the deeper range of distribution of coralligenous 50-200 m depth. Besides these large-scale assessments on distribution, at local scale some progress in cartographical data have been acquired in some areas especially in marine protected areas (e.g.Réserve Naturelle de Scandola, Parc National de Zembra, Area Marina Protetta di Tavolara Punta Coda Cavallo,Zakynthos Marine Protected Area). Overall, we lack of a complete and precise distribution information on coralligenous and other calcareous bioconstructions habitats.

The main constraints to provide a global view on the distribution of coralligenous and other calcareous habitats are the 1) their intrinsic heterogeneous distribution related with the spatial patterns of the geophysical and oceanographic conditions allowing their development, and 2) the technical and financial constraints of field mapping operations resulting in an unbalanced

mapping efforts across the Mediterranean.

Geographical as well as depth distributional data are essential in order to know the real extent of these assemblages in the Mediterranean Sea as well as to implement appropriate management measures to guarantee their conservation.

1.3. Composition

Coralligenous concretions are the result of the building activities of algal and animal builders and the physical as well as biological eroding processes. The final result is a very complex structure composed of several microhabitats. Environmental factors (i.e., light, water movement and sedimentation rates) can vary by orders of magnitude in parts of the same concretion situated very close to each other. This great environmental heterogeneity allows several different assemblages to coexist in a reduced space. Assemblages situated in open waters (from horizontal to almost vertical surfaces) can be easily distinguished from those situated in overhangs and cavities.

Algae usually dominate in horizontal to sub-horizontal surfaces although their abundance decreases with decreasing irradiance. Two main algal communities have been distinguished in the western Mediterranean: an assemblage dominated by *Halimeda tuna* and *Mesophyllum alternans (Lithophyllo-Halimedetum tunae)*, thriving in relatively high light levels, and an assemblage dominated by encrusting corallines *(Lithophyllum frondosum, L. cabiochae, Neogoniolithon mamillosum)* and *Peyssonnelia rosamarina (Rodriguezelletum strafforelloi)*, and receiving low light levels.

Animal assemblages can greatly differ according to light levels reaching the coralligenous outcrop but also in relation to current intensity, sedimentation rates and geographical areas. In the richest, relatively more eutrophic zones, with rather constant and low water temperature, gorgonians usually dominate the community, but they are completely absent or rare in the more oligotrophic or low-current areas with rather high or seasonally variable temperature, being replaced by sponges, bryozoans or ascidians.

Maërl beds are also very diverse. Even if corallines are the main constituents *(Spongites fruticulosus, Lithothamnion corallioides, Phymatolithon calcareum, Lithothamnion valens, Lithothamnion minervae, Litophyllum racemus, Lithophyllum frondosum,* and others), *Peyssonnelia* species (mainly *Peyssonnelia rosamarina*) can also be very important. The cover of erect algae depends on each particular site, displaying several facies (*Osmundaria volubilis, Phyllophora crispa, Kallymeniales, Laminaria rodriguezii)*.

The group of experts in Tabarka suggested using the Reference List of Habitat types appearing in the Standard Dataentry Form (SDF) for National Inventories when looking for the composition of coralligenous assemblages. In 2011 a list of species to be considered in the inventory and/or monitoring of coralligenous communities was provided by UNEP-MAP-SPA/RAC (2011)1. The species were arranged in the following categories:

- Algal builders
- Animal builders
- Agglomerative animals
- Bioeroders
- Species of particular importance (particularly abundant, sensitive, architecturally important or economically valuable)
- Invasive species

The characterization of coralligenous based on the above-mentioned categories list can greatly help in our understanding on the coralligenous patterns across the Mediterranean. Since different regions and areas within regions are characterized by different composition, the assessment considering the proposed morpho-functional categories can provide an interesting comparative basis towards a general view on Mediterranean coralligenous assemblages. This approach besides the composition data would provide a functional perspective which greatly facilitate the development of indicators for the monitoring of the Good Envrionmental Status (GES) within the Marine Strategy Framework Directive and "COP18 EcAp Decision" (see Legislation and regulation section).

The suggestion when describing the composition of the coralligenous assemblages or the maërl beds would be to provide quantitative or semi-quantitative estimate on the abundance of typical/indicator species. Different visual and photographic methods as well as the combination of both have been proposed to obtain abundance estimates. For instance, the adoption of Braun-Blanquet (1979) methodology for marine assemblages characterization (Cebrian & Ballesteros, 2004). Through these assessments besides composition data, the abundance estimates of species found in the considered categories would provide insights in the ecological/conservation status of assemblages. For instance, the presence of invasive species (either alien or not normally occurring in the habitat) are often considered very good indicators of poor conservation status.

For maërl beds assemblages the same approach could be addressed although the current knowledge need to be improved to better define the categories and composition lists. In maërl beds, description is also possible naming the main maërl species and erect algae, as well as the main macroinvertebrates.

2. DATA COLLECTION AND INVENTORIES

2.1. Specific inventories

As mentioned the coralligenous habitat includes several assemblages due to its great heterogeneity. There is a small scale heterogeneity in environmental factors throughout the coralligenous outcrops that determine different microhabitats containing different species. In the surface of coralligenous outcrops, coralline algae usually dominate, together with a variable amount of erect algae and of suspension-feeders. Holes and cavities within the coralligenous structure sustain complex communities without algae and dominated by suspension-feeders. Small crevices an interstices are inhabited by a diverse endofauna, while many vagile species swarm everywhere, thriving also in the small patches of sediment retained by the framework. Large fishes (e.g. *Epinephelus marginatus, Scorpaena scrofa, Phycis phycis*) and decapods (e.g. *Palinurus elephas, Homarus gammarus*) dwell in the coralligenous assemblages. One of the consequences of this great environmental heterogeneity is the presence of a high biodiversity and a wide array of organisms in each coralligenous outcrops.

Maërl beds are considerably less complex than coralligenous outcrops although they have some epiflora and epifauna that are more related to plants and animals usually found in rocky

substrata, but also they harbour typically invertebrates from sedimentary bottoms.

A considerable amount of research has been done on the biodiversity hosted by coralligenous outcrops. Ballesteros (2006) estimates a preliminary account of up to 1666 species at the scale of the Mediterranean Sea. However these estimates are far from providing us a general view of biodiversity dwelling in the coralligenous assemblages. There are at least two levels of information which should be considered i) in fine detailed taxonomic studies specially in less studied groups and ii) comprehensive biodiversity surveys in targeted geographical areas. This information would be complemented by the determination of typical/indicator species of coralligenous in different areas/regions across the Mediterranean (see Point 1.3. Composition).

Overall with this information we could improve the estimates on the total number of species associated to the coralligenous and analyze geographical variability biodiversity patterns considering different spatial scales. The same approach should be adopted for maërl beds.

Methods:For data collection several methodologies have been used in sampling rocky benthic systems and maërl beds (e.g. Bianchi *et al.*, 2004, Kipson *et al.* 2011, Cechi *et al.* 2010, Gatti *et al.* 2015) and all of them present advantages and disadvantages. Moreover, suitability of each sampling method depends on the purposes of the study and on the taxonomic group considered.

As no sampling methodology can be universally applied, a general recommendation when making the assessments on species composition is to take into account the following considerations:

- Use quantitative or semi-quantitative surveys instead of qualitative surveys wherever possible
- Clearly state the sampling and quantification methodology , including the period of the year, in order that it could be repeated in the future by independent teams for further comparison of data.
- Samples have to be geographically positioned in the most accurate way.
- Sampling has to be representative. Therefore, sampling areas should be larger than minimal sampling areas. It has to be noted that different taxonomic groups must be sampled using completely different representative areas.
- Use photographic surveys to help in the identification of species.

2.2. Sites of particular interest

Since the coralligenous and maërl assemblage in general thrive in deep waters, it is difficult to have an appropriate coverage of all the entire distribution range of the assemblage. Thus, it is recommended that inventories and monitoring be performed in selected sites of particular interest. The sites selection should be based in the most accurate previous information on the distribution, extension and ecological features and conservation status of coralligenous and maërl assemblages.

Amongst the criteria to be used in this selection, it is recommended the following ones:

- Existence of previous information on coralligenous assemblages or maërl beds at the site or, if there is no available information at all, sea bottom geomorphological features suitable for the development of coralligenous frameworks and/or rhodolits.
- Representativity of the coralligenous assemblages/maërl beds at a wide geographical area, whenever it is possible, according to present knowledge.
- Existence of control and/or management of anthropic activities at the site. In this sense, marine protected areas are suitable places to be selected.
- Especially healthy coralligenous and maërl assemblages are worth to be selected in order to assess the reference conditions.
- Coralligenous communities and maërl beds under the effects of direct or indirect anthropogenic disturbances are worth to be selected in order to assess the impact co

3. MONITORING ACTIVITIES

Even if coralligenous/maërl assemblages are characterized by very slow dynamics (Garrabou *et al.*, 2002, Teixidó *et al.* 2011), at least in the absence of punctual catastrophic disturbances (Teixidó *et al.* 2013), developing monitoring activities is of great interest to track their conservation status and detect changes associated to pressure and punctual human- as well as natural processes-related disturbances.

Monitoring is necessary to understand the processes behind long-term dynamics in the assemblages and is a central element for the implementation and evaluation of efficient management plans. Besides, the monitoring activities on coralligenous assemblages are required for the implementation of European Marine Strategy Framework Directive (MSFD 2008/56/EC) and the Barcelona Convention Decision2 (see Legislation and regulation section) seeking to maintain the Good Environmental Status of assemblages.

3.1. Sites of particular interest

The basic scheme of surveillance includes periodic monitoring of reference parameters (indicators) informing about the conservation status of coralligenous/maërl assemblages. The monitoring should be designed to be as simple as possible. Neither standard methods have been proposed nor environmental nor ecological quality indexes have been established yet for the coralligenous assemblages.

Due to the heterogeneity and habitat complexity monitoring should be conducted by a combination of methods to gather habitat, species and degree of impacts data.

Monitoring parameters should provide information on:

Structural and functional parameters of assemblages:.

- Species/Categories composition/abundance (semi- or quantitative data)
- Indicators on the degree of complexity of coralligenous habitats
- Indicators on coralligenous functioning: bioeroders and bioconstructors
- Qualitative, semi- and quantitative indicators on the impacts of different disturbances on coralligenous communities (e.g. presence of fishing nets, invasive species, high diving pressure)

Environmental parameters

- Temperature, sedimentation.

3.2. Monitoring methods

3.2.1. General Considerations for sampling strategies for monitoring schemes

Bearing in mind the depth distribution of coralligenous/maerl assemblages monitoring methods have to be adapted to limited bottom working time by scuba divers (due to long decompression times and limitation of diver performance in deep waters; Tetzaff & Thorsen, 2005; Germonpre, 2006) and the limitation of the use of Remote Operate Vehicles (ROVs) beyond the operational depth of scuba divers (0-40 m).

3.2.2. Spatial scales

The high scale heterogeneity of coralligenous outcrops implies a large sampling area to be representative (Ballesteros, 2006). At present, some studies have determined the minimum sampling areas in some assemblages (Kipson *et al.* 2011), similar approaches should be carried out in other coralligenous morpho-types. In general, in order to gather relevant data on the different indicators in each monitoring site the total sampling area (including different replication strategies) should cover about 5 to 30 m2 (Deter *et al.* 2012, Garrabou *et al.* 2014, Gatti *et al.* 2015).

At each site, determine a specific depth range where the monitoring will be carried out (e.g. 30-35 m), in order to avoid the potential effect of depth on the outcome of the surveys. Within the depth range selected, in order to limit the effects of local heterogeneity on the outcome of the surveys, determine when possible, with the help of remarkable seascape marks, the specific monitoring area (e.g. it should be an area of several 100 m2) of each sampling site. Eventually some marks can be fixed to help the sample in the same monitoring area. Finally, in each targeted geographic areas several sites should be monitored in order to better infer the conservation trends of assemblages.

When selecting monitoring sites one should keep in mind the existence of previous information on the extension and ecological quality of the coralligenous habitat. During selection process, it is recommended to consider the following questions:

- Is there previous information available on coralligenous assemblages at the site or, if there is no available information at all, are the sea bottom geomorphological features suitable for the development of coralligenous frameworks?
- According to the present knowledge, are the considered coralligenous assemblages representative for a widergeographical area?
- Are the considered coralligenous assemblages especially healthy to be able to serve as reference points?
- Are the considered coralligenous assemblages under some clearly recognizable direct or indirect anthropogenic disturbance that would allow the assessment of the impact of these disturbances?

3.2.3. Temporal scales

The low dynamic of coralligenous assemblages (Garrabou *et al.*, 2002, Casas *et al.* 2015) allows to set the sampling periodicity between 3-5 years for monitoring purposes. Regarding the period of monitoring, the ideal period is late summer (late August to early October). At that time water transparency and temperature allow better performances on data gathering and photosampling. In addition, if any mass mortality occurred during summer it can be observed in this period.

3.2.4. Sampling techniques

During the last years different approaches have been adopted for the assessment of conservation status of coralligenous assemblages using visual and/or photographic surveys (e.g. Cormaci *et al.*, 2004, Kipson *et al.* 2011, Deter *et al.* 2012, Garrabou *et al.* 2014, Gatti *et al.* 2015).The sampling approaches developed are based on nondestructive methods aiming to furnish rapid quantitative and semi-quantitative assessments of different parameters.

The basic parameters assessed by photographic sampling and visual census are abundance (e.g. coverage, density) of species found in the assemblages and estimations on the degree of impact of different key processes (e.g. mortality events, bioerosion, fishing) related with the conservation of coralligenous assemblages.

Monitoring of environmental parameters is also needed if we want to relate changes in the coralligenous/maërl assemblages with disturbances related to hydrographic conditions. The most important variables to be monitored are: water temperature, sedimentation rates, nutrient concentration in seawater, particulate organic matter and water transparency.

Different initiatives (this Action Plan and EU directives) are focused on the development of indicators about the conservation and good environmental status of coralligenous. Through the monitoring activities presented we could obtain useful indicators (See Annex). These indicators are intended to inform decision makers and stakeholders and to support conservation and management planning (including MPAs network design) to guarantee the conservation of the coralligenous habitat.

Standardized protocols for the characterization of coralligenous/maërl assemblages need to be developed. The main goal of this action would be to do a comparative evaluation of the tools and sampling designs to be applied for the characterization of coralligenous habitats (e.g. in terms of species diversity (α, β, Y), structural complexity and main ecological processes) and to assess the level of impact of human pressures.

Indices and/or intercalibration initiatives to determine environmental status of coralligenous conservation should be developed to analyze the available indices developed to determine the Good Environmental Status of coralligenous to provide a common framework to compare the status of coralligenous across the Mediterranean.

4. RESEARCH ACTIVITIES

4.1. Taxonomy

Coralligenous/maërl assemblages probably are two of the most important hot-spots of species diversity in the Mediterranean, together with Posidonia oceanica meadows (Ballesteros, 2006; BIOMAERL team, 2003). In comparison to the large amount of literature devoted to the study of Posidonia oceanica meadows, studies devoted to strengthen the knowledge of coralligenous/maërl biodiversity are scarce. Therefore, due to the rich fauna, high heterogeneity at all scales, and complex structure of coralligenous/maërl assemblages, together with the paucity of studies dealing with coralligenous/maërl biodiversity, it can be assumed that at least coralligenous assemblages harbour more species than any other Mediterranean community. The check-list proposed in the second chapter of this Action plan should cover all the species found to date in coralligenous/maërl communities. However research in taxonomy is also needed as a large amount of taxonomic groups absolutely lack not only of a comprehensive study but almost any study dealing with species which can be found in coralligenous outcrops or maërl beds. The use of genetic tools can help in resolving taxonomic "problems" and discovering cryptic species (e.g. Dailianis *et al.* 2014).

Taking into account the current knowledge of biodiversity in coralligenous/maërl communities (Ballesteros, 2006), the following taxonomic groups need an important investment in research:

- Copepods
- Cumaceans
- Isopods
- Molluscs
- Mysids
- Nematods
- Nemerteans
- Ostracods
- Phyllocarids
- Polychaeta
- Pycnogonids
- Tanaidaceans

Further research on other groups is also acknowledged, as it will surely provide new reports of species for coralligenous outcrops and maërl beds.

4.2. Long term evolution

To understand long-term dynamics of coralligenous assemblages in some selected areas sentinel/reference sites should be setup. Processes taking place in coralligenous communities in absence of disturbances usually display slow dynamics – i.e. decades – (Garrabou *et al.*,2002). Population dynamics of outstanding and key species show low growth rates and low population dynamics (e.g. Coma *et al.* 1998, Teixidó *et al.* 2011). Therefore, even if some of the patterns and processes that have been described so far occur in short time periods (e.g. mortality events; Cerrano *et al.*, 2000; Garrabou *et al.*, 2009), evolution of coralligenous can only be understood from a long-term perspective. Maërl beds are even less known as there are no comprehensive revisions in this subject regarding Mediterranean rhodolits.

Sentinel/reference sites are recommended to be visited once a year to obtain a robust temporal series. Even if seasonality in coralligenous/maërl communities is not as important as it is in shallower environments (Ballesteros, 2006, Garrabou *et al.* 2002), the monitoring is recommended to be always performed at the same period of the year in order to facilitate comparisons between years and sites.

These sites should be selected according to

(1) their representativeness at a large geographical scale,

(2) their accessibility and

(3) the logistical facilities that may contribute to guarantee and facilitate the monitoring operations.

We recommend the setup of sentinel/reference sites in fully protected zones within Marine Protected Areas. MPAs offer excellent facilities for long-term studies and are optimum conditions to approach to the "pristine" functioning of coralligenous assemblages. This precious information would serve as reference for guiding the adoption of conservation and management goals at different international and national levels.

4.3. Functioning

Special care is to be taken for the study of the functioning of particular associations and species. Specifically, longlived plants and animals that usually are the engineering species of the coralligenous or the most abundant calcareous algae in maërl beds, need a detailed knowledge of their growth, demographic patterns, vulnerability to disturbances and recovery capacities.

Research actions to fill the gaps of current knowledge should focus on

(a) Bioconcretion dynamics (building and erosion processes);

(b) Population dynamics of typical/indicator species;

(c) Establish response of key/typical species to different stressors.

5. CONSERVATION ACTIVITIES

5.1. Major threats

Major threats affecting coralligenous/maërl communities roughly coincide with threats affecting Mediterranean marine biodiversity and are listed in the Strategic Action Programme for the Conservation of Biological Diversity (SAP BIO). However, due to its special habitat and features, not all the threats listed in the SAP BIO affect coralligenous/maërl communities, but some of them are especially relevant. It follows a brief description of the main threats.

5.1.1. Trawling

Trawling is probably the most destructive impact currently affecting coralligenous communities. Trawling is also completely destructive in maërl beds, being the main cause of maërl disappearance in large Mediterranean areas. The action of trawling gear over coralligenous/maërl assemblages leads to the death of most engineering, dominant and builder species, completely changing the environmental conditions of the coralligenous microhabitats and the maërl environment. As most of these species are particularly long-lived, have low recruitment and complex demographic patterns, destruction of the coralligenous/maërl structure is critical as their recovery will probably take several decades or even centuries. Trawling has also a great impact on target species that, although not as vulnerable as most suspension feeders, they also suffer from this indiscriminate method of fishing.

Finally, even the performance of trawling close to coralligenous outcrops or maërl beds affects negatively to algal growth and suspension-feeding due to an increase in turbidity and sedimentation.

5.1.2. Artisanal and recreational fishing

Both traditional and recreational fishing also have an effect on coralligenous communities, although they mainly affect the target species. Fishing leads to a significant decrease in mean specific number of fish species, producing changes in the community composition. Certain fishes, mainly elasmobranchs, are severely decimated by artisanal fishing practices when fishing pressure is outstanding. This is the case, for example, of several small sharks such as *Scyliorhinus stellaris, Mustelus spp*. or *Squalus spp*. In several places, other species such as groupers and lobsters (e.g. *Epinephelus marginatus* and *Palinurus elephas*) need the implementation of adequate fishery management. Besides, fishing activities can degrade habitat complexity due to the breakage and mortality of fragile macrobenthic species during contact with fishing lines and nets (Bavestrello *et al.* 2000). The consequent erosion of complexity results from the reduction in the abundance and/or size of large gorgonian and other erect species (e.g. *Axinella spp*., *Hornera frondiculata*) (Tunesi *et al*., 1991). The reduction of complexity could infer further biodiversity loss, however the extent of this impact and the associated mechanisms are still poorly understood (Cerrano *et al.* 2010).

Special care has to be taken with the commercial exploitation of red coral (*Corallium rubrum*), whose stocks have strongly declined in most areas. Adequate management of this extremely valuable and long-lived species is necessary.

5.1.3. Anchoring

Anchoring has a very severe impact on coralligenous concretions, as most of the engineering organisms are very fragile and are easily detached or broken by anchors and chains. Coralligenous concretions of frequently visited sites by recreational fishing or diving activities are degraded by the destructive potential of anchors.and the associated mechanisms are still poorly understood (Cerrano *et al.* 2010).

5.1.4. Invasive species

Currently, at least three algal species are threatening coralligenous/maërl communities in the Western Mediterranean:

Womersleyella setacea, Acrothamnion preissii, Caulerpa racemosa v. cylindracea and *Caulerpa taxifolia* (e.g. Cebrian *et al.* 2012, De Caralt & Cebrian 2013, Cebrian & Rodríguez-Prieto 2012). All of them are only invasive in relatively shallow water coralligenous outcrops and maërl beds (until 60 m), where irradiance levels are sufficient to permit their growth. However, they are especially dangerous, because they completely cover the basal stratum of encrusting corallines and increase sedimentation rates which lead to a total shut down of coralligenous growth or the survival of rhodolits. Most studies have been carried in the Western Mediterranean. There is an absolute lack of knowledge on the effects that lessepsian species have on coralligenous/maërl communities in the Eastern Mediterranean.

5.1.5. Global warming

Anomalous high water temperatures were concomitant with large scale mortalities of several suspension feeders (mainly sponges and anthozoans) growing in coralligenous assemblages (Cerrano *et al.*, 2000; Garrabou *et al.* 2009). Thus, it is expected that under the current trend of global warming (Somot *et al.* 2008), coralligenous assemblages will be affected by new mortality events during next decades especially in areas where coralligenous assemblages are situated above the summer level of the thermocline.

5.1.6. Waste water discharges

Waste waters profoundly affect the structure of coralligenous communities by inhibiting coralline algal growth, increasing bioerosion rates, decreasing species richness and densities of the largest individuals of the epifauna, eliminating some taxonomical groups and increasing the abundance of highly tolerant species (Hong, 1980, 1982; Cormaci *et al.*, 1985; Ballesteros, 2006). Although no information is available on the impact of eutrophication in Mediterranean maërl beds, the effects must be similar to those reported for coralligenous concretions.

5.1.7. Aquaculture

Although there are no studies on the impact of aquaculture facilities situated over or at the proximity of coralligenous outcrops, nor maërl beds, their effects should match those produced by waste water dumping.

5.1.8. Changes in land use and coastal infrastructure construction and urbanization

Although there are no studies on the impact of aquaculture facilities situated over or at the proximity of coralligenous outcrops, nor maërl beds, their effects should match those produced by waste water dumping.

5.1.9. Recreational activities (excluding fishing)

Uncontrolled or over-frequentation of divers in coralligenous communities has been described to produce an important effect over certain large or fragile suspension feeders inhabiting coralligenous communities (Sala *et al.*, 1996; Garrabou *et al.*, 1998; Coma *et al.*, 2004; Linares *et al.* 2012).

5.1.10. Mucilaginous and filamentous algal aggregates

Blooms of mucilaginous and filamentous algal aggregates can cause severe damage over erect suspension feeders (mainly gorgonians). These blooms are still not well understood but they are apparently caused by eutrophication (Giuliani *et al.* 2005, Danovaro *et al.* 2009).

5.2. Legislation and regulations

Coralligenous/maërl assemblages should be granted legal protection at the same level as *Posidonia oceanica* meadows. A first step would be the inclusion of coralligenous concretions and maërl beds as a priority natural habitat type in the EU Habitats Directive (92/43/EU), which would enable EU countries to undertake surveillance of the conservation status of coralligenous/maërl assemblages and also to set an ecological network of areas of conservation (LICs/ZECs) hosting coralligenous/maërl assemblages, which would ensure their conservation or restoration at a favorable conservation status. Although *Phymatolithon calcareum* and *Lithothamnion corallioides* are present in the Annex V of the Habitats Directive and as such they should be provided by management measures in case of exploitation (which is never the case in the Mediterranean), there is no specific protection for maërl beds. Similar actions should be encouraged in non-EU countries through the existing tools of the Barcelona Convention.

Regarding again European countries, recently (21 December 2006), it was published a Council Regulation (EC) No 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea, amending Regulation (EU) No 2847/93 and repealing Regulation (EC) No 1626/94 which states that "Fishing trawl nets, dredges, shore seines or similar nets above coralligenous habitats and maërl beds shall be prohibited" (Article 4.2) and that this prohibition "shall apply to all Natura 2000 sites, all special protected areas and all specially protected areas of Mediterranean importance (SPAMIs) which have been designated for the purpose of the conservation of these habitats under either Directive 92/43/EU or Decision 1999/800/EU" (Article 4.4).

In 2008 the European Union adopted the Marine Strategy Framework Directive (MSFD 2008/56/EC) which requires to maintain European marine waters in "Good Environmental Status" (GES). The MSFD included 11 descriptors for the assessment of GES among them the Sea-floor Integrity is defined as "Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected." (Rice *et al.* 2012). This descriptor directly concerns biogenic structures such as the Mediterranean coralligenous and different initiatives are underway to determine the GES of coralligenous habitats (e.g. Gatti *et al.*2015). The monitoring of different indicators (such as those indicated in this document and other proposed by otherauthors) should allow determining reference conditions at regional scales and the proposal of a quantitative index to evaluate the GES in each area. The final aim of MSFD is to guide management and conservation actions for maintaining and when necessary recovering the good environmental status of waters.

In line with the MSFD, the contracting parties to the Barcelona Convention set targets for achieving GES of the Mediterranean Sea and its coastal zone by 2020. In achieving these targets it has been recognized the importance to apply the ecosystem approach (EcAp) to the management of human activities that may affect the Mediterranean marine and coastal environment for the promotion of sustainable development (UNEP/MAP 2007). In addition, through Decision IG 21/3 (the so-called "COP 18 EcAp Decision") the contracting Parties agreed to design an Integrated Monitoring and Assessment Program for the next meeting of the contracting parties (COP19) and mandated the Secretariat to carry out an assessment of the state of the Mediterranean environment in 2017 which necessarily will include the coralligenous/maërl habitats (UNEP/MAP, 2013).

5.3. Creation of Marine Protected Areas

Within the Convention on Biological Diversity (CBD) countries have committed to protect by 2020 "10 % of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and the effective area-based conservation measures" (Target 11 of the Aichi Strategic Plan for Biodiversity 2020) and the Roadmap for a comprehensive coherent network of well managed MPAs to achieve Aichi Target 11 in the Mediterranean. Overall, only about 1 % of Mediterranean coastal waters susceptible to harbor coralligenous/maërl assemblages are protected.

Most present Mediterranean MPAs are devoted to protect Posidonia oceanica meadows and other shallow water assemblages, in such a way that the percentage of coralligenous/maërl habitat currently protected in the Mediterranean is extremely low. Thus, it is necessary to protect representative coralligenous/maërl assemblages by applying the protection and management measures recommended by Articles 6 and 7 of the SPA/BD protocol. In fact, Marine Protected Areas (MPAs) have to be established taking into account the seascape diversity and trying to include places with several relevant assemblages, as has been already applied in the creation and zonation of some MPAs (Villa *et al.*, 2002; Di Nora *et al.*, 2007).

Countries have to identify and cartography as soon as possible sea bottoms covered by coralligenous outcrops and maërl beds in order to design a network of MPAs that enables the protection of coralligenous/maërl assemblages.

Those Mediterranean MPAs, which contain coralligenous/maërl assemblages and for which management and monitoring plans have not yet been developed and implemented, must develop and implement such plans as soon as possible.

5.4. National plans

To ensure more efficiency in the measures envisaged in the implementation of this Action Plan, Mediterranean countries are invited to establish national plans for the conservation of Coralligenous and other calcareous bioconcretions. Each national plan should take into account the concerned country's, or even areas', specific features. It must suggest appropriate legislative measures, particularly for the environmental impact assessment of coastal infrastructure (building works, pipelines out to sea, and deposits of material from

dredging) and to control activities which could affect coralligenous/maërl assemblages. The national plan shall be based on the available scientific data and will include programmes for

(i) collection and regular updating of data,

(ii) training and refresher courses for specialists,

(iii) awareness-raising and education for the general public, actors and decision-makers and

(iv) the conservation of coralligenous/maërl assemblages of importance for the Mediterranean marine environment.

The national plans must be brought to the attention of all concerned actors and, when possible, coordinated with the relevant national plans (e.g. emergency plan to deal with pollution).

5.5. Coordination of this Action plan with other tools and initiatives

The Standard Data-Entry Form (SDF), developed by SPA/RAC, can be used to identify potentially good sites for the establishment of MPAs devoted to protect coralligenous/maërl assemblages. Besides the analysis of current data on the distribution of coralligenous assemblages along with information derived from distribution modelling tools can help guiding cost-effective future surveys and monitoring efforts towards the development of basin-wide marine protected areas network for coralligenous/maërl assemblages (Martin *et al.* 2014).

However the SDF is not appropriate to be used in the monitoring of coralligenous/maërl assemblages since it has been designed for the inventory of sites and habitats but not for an accurate assessment of multi-species population densities and their evolution. Annex B (habitat types) from the SDF should be slightly modified in the point IV.3.1 (Coralligenous biocenosis), according to current knowledge. Species appearing in Annex C should be slightly enlarged in order to include several engineering coralligenous species according to the adopted criteria for amendments of the Annexes (II & III) of the Protocol SPA/BD.

MPAs classified as SPAMIs and containing coralligenous/maërl assemblages inside their protected areas should develop management and protection plans to ensure their conservation.

5.6. Regional coordination structure

Regional coordination of the implementing of the present Action Plan will be guaranteed by the Mediterranean Action Plan's (MAP) secretariat through the Specially Protected Areas Regional Activity Centre. The main functions of the coordinating structure shall consist in:

- collecting, validating and circulating data at Mediterranean level.
- promoting the drawing up of inventories of species, coralligenous/maërl assemblages of importance for the Mediterranean marine environment.
- promoting trans-boundary cooperation.
- promoting and supporting the setting up of coralligenous/maërl assemblages monitoring networks.
- preparation of reports on progress in the implementation of the Action Plan, to be submitted to the meeting of national focal points for SPAs and to meetings of the Contracting Parties.
- organizing meetings of experts on specific subjects relating to coralligenous/maërl assemblages and training sessions.

Complementary work done by other international organizations, and aiming at the same objectives, shall be encouraged, promoting coordination and avoiding possible duplication of efforts.

5.7. Participation in the implementation

Implementing the present Action Plan is the province of the national authorities of the Contracting Parties. The concerned international organizations and/or NGOs, laboratories and any organization or body are invited to join in the work necessary for implementing the present Action Plan. At their ordinary meetings, the Contracting Parties may, at the suggestion of the meeting of National Focal Points for SPAs, grant the status of «Action Plan Associate» to any organization or laboratory which so requests and which carries out, or supports (financially or otherwise) the carrying out of concrete actions (conservation, research, etc.) likely to facilitate the implementation of the present Action Plan, taking into account the priorities contained therein.

The coordination structure shall set up a mechanism for regular dialogue between the participating organizations and, where necessary, organize meetings to this effect. Dialogue should be made mainly by mail, including E-mail.

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ANNEX: IMPLEMENTATION TIMETABLE

Action	Deadline	To be implemented by
Build and publish the database of scientists and research institutions working on the coralligenous assemblages and maërl beds.	2016	SPA/RAC
Guidelines for the assessment of environmental impact on coralligenous/maërl assemblagess	2017	SPA/RAC
Development of Working Groups on coralligenous assemblages and maërl beds.	2016	SPA/RAC Contracting Parties
Buid-up a coralligenous/maërl assemblages distribution online database	2018	SPA/RAC Contracting Parties
Improve habitat modeling methods could provide new predictive models on coralligenous distribution and guide cost-effective field surveys for data acquisition	2017	Contracting Parties
Characterization of coralligenous habitats at regional scale	2018	SPA/RAC Contracting Parties
Build-up a Check-list / Reference species list for the coralligenous assemblages	2016	SPA/RAC
Development of standardized protocols for the characterization of coralligenous /maërl assemblages.	2017	SPA/RAC Contracting Parties
Development of indices and/or intercalibration initiatives to determine conservation environmental status of coralligenous	2017	SPA/RAC Contracting Parties
Set a network of sentinel sites on coralligenous across the Mediterranean	2020	SPA/RAC Contracting Parties
Promote research programs on coralligenous assemblages and maerl beds	2016	Contracting Parties
Develop and implement legislation initiatives for the conservation of coralligenous assemblages	Ongoing	Contracting Parties
Coordinate the design of an Integrated Monitoring and Assessment Program for the assessment of the state coralligenous/maërl assemblages in view to be included the assessment of the state of the Mediterranean	2016	Contracting Parties
Promote the declaration of marine protected areas to preserve coralligenous assemblages in coastal and offshore areas	2018	SPA/RAC Contracting Parties
Build-up a coordination platform on different initiatives devoted to the coralligenous/maërl assemblages	2017	SPA/RAC
Organize a Symposium on coralligenous assemblages and maërl beds every 3 years	2018	SPA/RAC
Preparation of a communication plan to raise the awareness on the importance of coralligenous assemblages and maërl beds for the conservation of Mediterranean biodiversity	2017	SPA/RAC

SPA/RAC WORKING AREAS

*SPA/ RAC, the UNEP/ MAP **Specially Protected Areas Regional Activity Centre**, was created in 1985 to assist the Contracting Parties to the Barcelona Convention (21 Mediterranean contries and the European Union) in implementing the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol).*

POST-2020 SAPBIO

Strategic Action Programme for the **Conservation** of **Biodiversity** and **Sustainable Management** of **Natural Resources** in the **Mediterranean Region**

SPAMI

Specially Protected Areas of **Mediterranean Importance**

Marine turtles

Cetaceans

Specially Protected Areas

Monitoring

Mediterranean Monk Seal

Cartilaginous fishes
(Chondrichtyans)

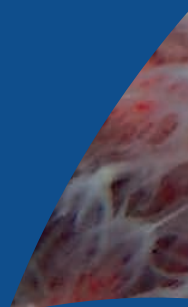
Coralligenous and other calcareous bio-concretions

Marine vegetation

Marine and coastal bird species
Listed in Annex II of the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean

Dark Habitats
Habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemo-synthetic phenomena

Species introduction and invasive species



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