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Agenda Item 5: Conservation of Species and Habitats

5.4. Updating of the Action Plan for the conservation of the Coralligenous and Other Calcareous Bio-concretions in the Mediterranean Sea

Draft updated Action Plan for the conservation of the Coralligenous and Other Calcareous Bio-concretions in the Mediterranean Sea

UNEP/MAP
SPA/RAC - Tunis, 2025

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Note by the Secretariat

1. With regards to the update of the Action Plan for the conservation of the Coralligenous and Other Calcareous Bio-concretions in the Mediterranean Sea, an assessment of the implementation of its previous calendar has been done at national and regional levels. This evaluation appears in the annex I of the present document.

2. The assessment of the implementation of the Action Plan has considered the Progress activities achieved by SPA/RAC and the Contracting Parties, since 2018 as requested by the adopted timetable.

3. Multilateral Environment Agreements, regional organizations, and institutions as well as Partners to this Action Plan were also invited to report on their realisations for the conservation of these habitats. All the answers received in due time were incorporated on the evaluation.

4. The draft updated Action Plan for the Conservation of Coralligenous and Other Calcareous Bio-Concretions in the Mediterranean follows the structure outlined in Document WG.608/9 ("Evaluation of the Regional Action Plans Approach for Selected Species and Habitats Adopted Under the SPA/BD Protocol and Recommendations for the Way Forward"). The proposed structure includes:

- **Part I:** A **general section** covering the species/habitats concerned, current state of knowledge, relevant policies, key threats, assessment methods, vision, goals, and long-term targets. This section will undergo less frequent review.
- **Part II:** A **short-term action plan**, focusing on immediate conservation measures. This section will be evaluated and updated more regularly than Part I.

5. This draft is submitted to 17th meeting of the SPA/BD Focal Points for review and for agreement on its submission as appropriate to the meeting of MAP Focal Points and Barcelona COP 24 for adoption.

Acronyms list

CA	: Coralligenous Assemblages
CI	: Common Indicator (from IMAP)
CITES	: Convention on International Trade of Endangered Animal and Plant Species
COP	: Conference of the Parties
CP	: Contracting Party (Barcelona Convention)
EcAp	: Ecosystem Approach under the Barcelona Convention
EC	: European Commission
EEC	: European Economic Community
EMODnet	: European Marine Observation and Data Network
EO	: Ecological Objective
EU	: European Union
EUNIS	: European Nature Information System
FAO	: Food and Agriculture Organisation of the United Nations
FRA	: Fisheries Restricted Area
GES	: Good Environmental Status
GFCM	: General Fisheries Commission for the Mediterranean
IG	: Intergovernmental meetings/documents/decisions
IMAP	: Integrated Monitoring and Assessment Programme
IUCN	: International Union for Conservation of Nature
MAP or **PAM**	: Mediterranean Action Plan
MBES	: Multi-Beam Echo Sounder
MHW	: marine heat wave
MPA	: Marine Protected Area
MSFD	: Marine Strategy Framework Directive
NGO	: Non-Governmental Organisation
NFP	: National Focal Point
OFB	: Office Français de la Biodiversité
POST-2020 SAPBIO	: Post 2020 Strategic Action Programme for the Conservation of Biodiversity and sustainable management of natural resources in the Mediterranean Sea
ROV	: Remotely Operated Vehicle
RMB	: Rhodolith and Maerl Bed
SfM	: Structure from Motion
SPA/BD Protocol	: Protocol on Specially Protected Areas and Biological Diversity (Barcelona Convention)

SPAMI	: Specially Protected Areas of Mediterranean Interest
SPA/RAC or **RAC/SPA**	: Specially Protected Areas /Regional Activity Centre
SSS	: Side Scan Sonar
UNEP or **PNUE**	: United Nations Environment Programme
WG	: Working Group meetings/documents

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1. BACKGROUND

1. The Contracting Parties to the Barcelona Convention, within the framework of the Mediterranean Action Plan, give priority to the conservation of the marine environment and to the components of its biological diversity. This was confirmed by the adoption of the new 1995 Barcelona Convention Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol) and of its Annexes, among them a list of endangered or threatened species.

2. The development and implementation of action plans for the conservation of a species or group of species is an effective way of guiding, coordinating and reinforcing the efforts of Mediterranean countries to protect the natural heritage of the region.

3. Although not legally binding, these action plans have been adopted by the Contracting Parties as regional strategies setting out priorities and actions to be undertaken. In particular, they call for greater solidarity between the States of the region, and for coordination of efforts to protect the species concerned. This approach has been proved to be necessary to ensure the conservation and sustainable management of the species and habitats concerned in each Mediterranean area of their distribution.

4. These Action Plans are medium-term regional strategies that should be updated every five-year on the basis of an evaluation of their implementation at regional and national level.

5. The 2008 Ordinary Meeting of the Contracting Parties in Almeria (Spain) adopted the Action Plan for the Conservation of Coralligenous and other Calcareous Bio-concretions in the Mediterranean Sea (Decision IG17/15-2008), which resulted from the work programme drawn up at the ad hoc meeting held in Tabarka (Tunisia) on May 6th and 7th, 2006. The last update of the Action Plan dates back to 2016 (Decision IG.22/12-2016).

6. For the 2024-2025 biennium, the Contracting Parties to the Barcelona Convention requested SPA/RAC, during COP 23 (Portorož, Slovenia, 5-8 December 2023), to update (i) the Action Plan for the Conservation of the Coralligenous and Other Calcareous Bio-concretions in the Mediterranean Sea, (ii) the Action Plan for the Conservation of Mediterranean Marine Turtles, (iii) the Action Plan for the Conservation of Cartilaginous Fishes (Chondrichthyans) in the Mediterranean Sea, and (iv) the Regional Strategy for the Conservation of Monk Seal in the Mediterranean Sea, for consideration at COP 24.

2. HABITAT TYPES CONCERNED BY THE ACTION PLAN

7. The Action Plan is devoted to coralligenous assemblages and rhodolith/maerl1,2 beds as defined here after:
- **Coralligenous**: a typical Mediterranean underwater seascape comprising coralline algal frameworks that grow in dim light conditions and relatively calm waters.
- **Mediterranean rhodolith/maerl beds**: sedimentary bottoms covered by free-living calcareous algae growing in dim light.

8. Therefore, surface bio-concretions are not covered here, as they are already included in the Action Plan for the Conservation of Marine Vegetation in the Mediterranean Sea.

9. Coralligenous and other calcareous bio-concretions are biogenic constructions of calcareous algae, as well as erect invertebrates, complexing the assemblage, providing multiple micro-habitats for many species and harbouring high biological diversity (UNEP/MAP-SPA/RAC, 2015a).

10. Coralligenous and other calcareous bio-concretions develop on vertical cliffs, rocky reefs, and biodetritic horizontal or subhorizontal bottoms (Basso *et al.*, 2016a; Ingrosso *et al.*, 2018; Romagnoli *et al.*, 2021; UNEP/MAP – SPA/RAC, 2021b; Angiolillo *et al.*, 2022; Innangi *et al.*, 2024). They can be found all around the Mediterranean Sea.

11. Coralligenous assemblages (CAs) show high spatial, morphological, and biological variability (Basso *et al.*, 2022) and due to great environmental variability, several different assemblages can coexist in a reduced space. They are considered among the most important assemblages of the Mediterranean (Ingrosso *et al.*, 2018) with slow growth, developing on both vertical and horizontal substrates (Basso *et al.*, 2022). Several species forming the CAs are endemic of the Mediterranean (Ferrigno *et al.*, 2023). Further, CAs provide habitat and food for many species and represent some of the most productive assemblages (Constantini *et al.*, 2018).

12. Rhodolith and/or maerl beds (RMBs) develop on horizontal or sub-horizontal surfaces, with water motion (either currents or waves) keeping the rhodoliths unburied and are generally composed of several coralline species (Basso *et al.*, 2016a).

13. The classification units concerned by the Action Plan are as follows:
In the revised Barcelona Convention classification system (Montefalcone *et al.*, 2021):

- Coralligenous assemblages. Infralittoral : **MB1.55** Coralligenous (enclave of circalittoral). Circalittoral: **MC1.5** Circalittoral rock/**MC1.51** Coralligenous cliffs, **MC1.52** Continental shelf /**MC1.52a** Coralligenous outcrops/**MC1.52b** Coralligenous outcrops covered by sediment, **MC2.5** Circalittoral biogenic habitat/**MC2.51** Coralligenous platforms.
- Rhodolith/maerl beds. Infralittoral: **MB3.51** Infralittoral coarse sediment mixed by waves/**MB3.511** Association with maerl or rhodoliths, **MB3.52** Infralittoral coarse sediment under the influence of bottom currents/**MB3.521** Association with maerl or rhodoliths. Circalittoral: **MC3.5** Circalittoral coarse sediment/**MC3.52** Coastal detritic bottoms with rhodoliths/**MC3.521** Association with maerl.

[1] As written in Collin's Dictionary but can often be found spelled *maërl*. In this document the orthograph *maerl* is used except for references where it is spelled *maërl*.
[2] "Maerl beds" are included in the larger term of "rhodolith beds", but there is still debate on the exact definitions of rhodolith and maerl beds which should not be considered as synonyms. It was therefore decided to refer to this habitat as rhodolith/maerl beds (RMBs).

In the revised EUNIS classification system:

- Coralligenous assemblages. Infralittoral: **MB151a** Facies and association of coralligenous biocenosis (in enclave). Circalittoral: **MC151** Coralligenous biocenosis, **MC251** Coralligenous platforms, **MC252** Mediterranean circalittoral biogenic habitat.
- Rhodolith/maerl beds. Infralittoral: **MB3511** Association with rhodoliths in coarse sands and fine gravels mixed by waves. Circalittoral: **MC351** - Association with rhodoliths on coastal detritic bottoms, **MC352** - Assemblages of Mediterranean coastal detritic bottoms biocenosis with rhodoliths, **MC3523** - Association with maerl (*Lithothamnion corallioides* and *Phymatolithon calcareum*) on coastal dendritic bottoms.

3. STATE OF THE ART

14. Annual publications on coralligenous assemblages and rhodolith/maerl beds have increased significantly since 2015, especially from north-western Mediterranean countries but not only (Ferrigno *et al.*, 2023). These publications are related to spatial and bathymetric distribution, composition and structure, environmental status assessments, ecosystem conservation and management, and anthropogenic impacts.

15. There are about four times as many documents on Coralligenous Assemblages (CAs) as on Rhodolith and Maerl Beds (RMBs).

3.1. Scientific knowledge

3.1.1. Geographic and bathymetric distribution

16. Coralligenous and other calcareous bio-concretions develop on vertical cliffs, rocky reefs, and biodetritic horizontal or sub-horizontal bottoms from 10 to 180 meters (Basso *et al.*, 2016a; Ingrosso *et al.*, 2018; Romagnoli *et al.*, 2021; UNEP/MAP – SPA/RAC, 2021b; Radicioli *et al.*, 2022; Innangi *et al.*, 2024), but occur most frequently between 50 and 150 m depth. Depth ranges of coralligenous on sub-horizontal to horizontal bottoms for different areas can be found in the document RAC/SPA (2003).

17. Light is an important factor controlling the vertical distribution of coralligenous assemblages as their main builders are macroalgae, which require sufficient light to grow, but low levels of irradiance (Pérès & Picard, 1964 and Laubier 1966 in RAC/SPA, 2003). In areas of high turbidity, coralligenous assemblages can thrive in shallow waters, whereas in areas of high-water transparency, these assemblages are typically found at greater depths (RAC/SPA, 2003 and reference therein).

18. Other variables, such as nutrient availability, hydrodynamics, temperature and salinity, also play an important role in the geographic and bathymetric distribution of coralligenous assemblages.

19. An attempt to collate recent available data at Mediterranean scale is presented in the following table:

Table 1 Available recent data relative to geographic distribution of coralligenous assemblages and rhodolith/maerl beds by country

Country/Region	Area/Specificities	Coralligenous	Rhodolith/maerl beds
Mediterranean Sea (maps)	Mediterranean Sea (maps)	- Martin *et al.* (2014)	- Martin *et al.* (2014) - Basso *et al.* (2016a)
	Habitat forming invertebrates of Coralligenous Assemblages	- CorMedNet website - Linares *et al.* (2020) - Linares *et al.* (2022)	

Country/Region	Area/Specificities	Coralligenous	Rhodolith/maerl beds
	NE Mediterranean Coralligenous formation with *E. cavolini*	- Sini *et al.* (2019)	
	Modelled spatial distribution	- EMODnet (2021) see here	- EMODnet (2021) see here
Albania	National Marine Park of Karaburun-Sazan	- Giménez *et al.* (2022a) - Andromede Oceanology (2016)	
Algeria	Taza MPA	- Belbacha, Semroud, & Ramos-Esplá (2011)	
	Rachgoun island	- PNUE/PAM-CAR/ASP (2016)	
	Plane (Paloma) island in Oran Bay and Habibas islands	- Hussein & Bensahla-Talet (2019) - UNEP/MAP-SPA/RAC (2020b)	
Croatia	National	- A preliminary map is available in RAC/SPA-UNEP/MAP (2014) - Updated map that gives more precise distribution is publicly available in Croatian: https://bioportal.hr/gis/. (project "Mapping of coastal and seabed habitats in the Adriatic Sea under the national jurisdiction" (2018-2023))	- Updated map that gives more precise distribution is publicly available in Croatian: https://bioportal.hr/gis/. (project "Mapping of coastal and seabed habitats in the Adriatic Sea under the national jurisdiction" (2018-2023))
	E. cavolini, E. singularis, P. clavata (compilation 2019)	- Ponti *et al.* (2019)	
Cyprus	Cyprus UK Overseas Territories Mesophotic zone (50-200m)	- Programme : Cyprus UK Overseas Territories Mesophotic zone (50-200m) exploring (2024-2025) see here	- Programme : Cyprus UK Overseas Territories Mesophotic zone (50-200m) exploring (2024-2025) see here
France	French Mediterranean	- A map of coralligenous assemblages in the French Mediterranean is available on the OFB site here - The network of coralligenous sites and monitored sites RECOR maps their state of conservation here	- Inventory of available data on maerl beds in French Mediterranean is available on the OFB site : here
Greece	All Aegean Sea	- Sini *et al.* (2017) - Governmental site on selected species and habitats geographic distribution (maps)	- Sini *et al.* (2017) - Governmental site on selected species and habitats geographic distribution (maps)
Italy	National	- Ingrosso *et al.*(2018)	- Ingrassia *et al.* (2023)
	Coralligenous key species all around Italy, litter	- Ponti *et al.* (2019) - Angiolillo *et al.* (2023)	

Country/Region	Area/Specificities	Coralligenous	Rhodolith/maerl beds
	distribution on coralligenous outcrops		
	South-eastern area of Lampedusa		- Maggio *et al.* (2022)
Lebanon	Sayniq area St George area	- Aguilar *et al.* (2018)	- Aguilar *et al.* (2018)
	Batroun Medfoun Byblos	- SPA/RAC-UN Environment/MAP (2017)	- SPA/RAC-UN Environment/MAP (2017)
Malta	North East Malta rhodolith/maerl beds interpolation		- ERA data viewer here - Deidun *et al.* (2022)
	South East Malta rhodolith accumulations		- LIFE BAHAR for N2K viewer - Tabone *et al.* (2024)
Monaco	Roches profondes du plateau	- Fourt *et al.* (2015)	
Montenegro	All Montenegro coast	- Petović & Mačić (2021) - UNEP/MAP-PAP/RAC i MEPU (2021) - UNEP/MAP-PAP/RAC-SPA/RAC and MSDT (2019).	- No rhodolith/maerl beds
Morocco	El Hoceima National Park	- UNEP/MAP-SPA/RAC (2020a)	- UNEP/MAP-SPA/RAC (2020a)
	Jbel Moussa MPA	- SPA/RAC - ONU Environnement/PAM & HCEFLCD (2019)	- SPA/RAC - ONU Environnement/PAM & HCEFLCD (2019)
Spain	Key species: *Paramuricea clavata* *Eunicella cavolini*	- Ponti *et al.* (2019)	
	Balearic Islands (map)	- Barrientos *et al.* (2022a)	- Barrientos *et al.* (2022b) - Additional information on Formentera and Ibiza islands can be found in the original study (Domínguez *et al.*, 2014)
	Minorca Channel (Balearic Islands)	- Barberá *et al.* (2012)	- Farriols *et al.* (2024) - Barberá *et al.* (2012)
	Costa Brava	- See poster here	
	Southeastern Iberian Peninsula (map)		- REGINA-MSP Project in Muricia Region has mapped RMBs in some areas and potential overlapping with aquiculture activities
	Seamounts of the Mallorca Channel (Balearic Islands)		The presence of RMBs has been documented by Marín *et al.* (2011) and by Massutí *et al.* (2022). A preliminary spatial distribution model has been

Country/Region	Area/Specificities	Coralligenous	Rhodolith/maerl beds
			developed by Frank *et al.* (2024), with further analyses currently in preparation.
Tunisia	Tunisian coast (table)	- Mustapha *et al.* (2002)	- Ghanem *et al.* (2022)
	Cap Negro-Cap Serrat	- Torchia *et al.* (2016)	- Torchia *et al.* (2016)
Türkiye	Aegean Sea Levantine Sea	- Çinar *et al.* (2020)	
	Foça Special Environmental Protection Area	- UNEP/MAP-SPA/RAC (2020c)	
	Marmara Sea	- IUCN Red list of habitats (A4.26) (see Gubbay *et al.*, 2016)	

3.1.2. Composition and structure

20. The primary builders of coralligenous assemblages are encrusting red algae (Bracchi *et al.*, 2022), on which other species may develop, forming secondary and tertiary layers and creating a three-dimensional structure. Various environmental factors shape the composition and structure of both coralligenous and rhodolith/maerl assemblages (Piazzi *et al.*, 2021; Basso *et al.*, 2022). These variables also influence the geographic and bathymetric distribution of these assemblages.

21. Using an ecosystem-based approach, the associated mobile fauna can also be considered as being part of the composition of these assemblages. Such approaches are increasingly being developed. However, characterising the composition and structure of coralligenous and rhodolith/maerl assemblages is challenging due to the difficulty of accessing and assessing them, which are often deeper than 20-30 m, and due to the lack of taxonomic expertise.

22. According to the latest assessment of the implementation of the Action Plan (document under review), only five Member States have characterised coralligenous assemblages at the national scale, while six others are in the process of doing so. However, the characterisation of the composition and structure of coralligenous assemblages and rhodolith/maerl beds at national or sub-regional scales is essential to assess their vulnerability to anthropogenic pressures and the impacts of climate change.

23. Several documents are available to assist in defining the composition and structure of coralligenous and rhodolith/maerl assemblages:

- RAC/SPA. 2003. The coralligenous in the Mediterranean Sea. Definition of the coralligenous assemblage in the Mediterranean, its main builders, its richness and key role in benthic ecology as well as its threats. By Ballesteros E. RAC/SPA, Tunis.
- Ballesteros, E. 2006. Mediterranean coralligenous assemblages: A synthesis of present knowledge. Oceanography and Marine Biology, 44: 123–195.
- UNEP-MAP RAC/SPA. 2015. Standard methods for inventorying and monitoring coralligenous and rhodoliths assemblages.
- SPA/RAC-UNEP/MAP, 2021. Mediterranean coralligenous assemblages: a synthesis of present knowledge. By E. Ballesteros. Ed. SPA/RAC, Tunis: 149 pp.
- SPA/RAC-UN Environment/MAP. 2019. Updated Classification of Benthic Marine Habitat Types for the Mediterranean Region.

- UNEP/MAP. 2021. Interpretation manual of the reference list of marine habitat types in the Mediterranean Sea.

3.1.3. Population dynamics of typical/key species

24. The typical/key species of coralligenous assemblages, such as calcareous algae, gorgonians, sponges or bryozoans, are generally long-lived species with low growth, natural mortality, and recruitment rates. For these sessile species, dispersal generally occurs at the larval stage.

25. The key species of the most studied coralligenous assemblages in terms of population structure and dynamics are conspicuous anthozoans such as *Paramuricea clavata*, *Eunicella cavolini* and *Eunicella singularis*.

26. Palma *et al.* (2018) describe and test a Structure from Motion (SfM) based method for the estimation of gorgonian population structure (e.g. height, density, fan surface etc.). Although this method seemed more accurate for medium to low population densities than for dense populations, it may contribute to a more efficient assessment of the dynamics of large three-dimensional coralligenous species.

27. The dispersal potential of anthozoans had already been studied in the past (e.g. Linares, 2006; Linares *et al.*, 2007), and several recent studies contribute to further understand the dynamics of these key structuring species (e.g. Pilczynska *et al.*, 2016 for *Paramuricea clavata* in Italy; Padrón *et al.*, 2018 for *Eunicella singularis* in the Gulf of Lions; Sciascia *et al.*, 2022 for *P. clavata*).

28. Although larval dispersal of sessile benthic species depends on many variables (e.g. environmental factors such as currents or larval characteristics such as pelagic larval duration etc.), modelling of larval dispersal and gene flow studies to better capture connectivity processes between populations under climate change context could be efficient in designing a network of protected areas capable of maintaining connectivity between populations (see Padrón *et al.*, 2018b; Sciascia *et al.*, 2021). An interesting study by Blouet (2023) highlights the role of artificial reefs in enhancing connectivity between populations of structuring anthozoans, compensating for the absence or degradation of natural hard substrates.

29. Straight forward guidelines for larval dispersal simulations have been drawn by Sciascia *et al.* (2021), which could be useful for studies and simulations in other areas. However, connectivity predictions for gorgonian species require specific precautions (Sciascia *et al.*, 2022).

30. Pilczynska *et al.* (2016) studied the genetic diversity and connectivity of *P. clavata* in Italy. Their findings showed that larval exchange between sites supported the hypothesis that deeper subpopulations unaffected by marine heat waves (MHWs) could provide larvae for shallower populations and allow recovery after mortality events. However, more recent scientific publications on this topic are less optimistic.

31. Key species of Rhodolith and Maerl Beds have been less studied, especially concerning population dynamics. Research remains mainly focused on species inventories, such as calcareous red algae in Southern Spain (see Del Río *et al.*, 2022), sponge species in RMBs in Ustica, Italy (see Longo *et al.*, 2020). Research must be encouraged to better understand the dynamics and functioning of RMBs.

3.2. Legislation, regulation and conservation

32.Listing the legal texts, regulations, and strategic action plans concerning Mediterranean coralligenous assemblages and rhodolith/maerl beds (Table 2) highlights the lack of conservation and protection measures for these assemblages.

Table 2 Legislation and regulations relevant to coralligenous and other calcareous bio-concretions' protection in the Mediterranean Sea.

International	**Bern Convention on the conservation of European wildlife and natural habitats**
	Council decision (98/746/EC) of 21 December 1998 amended Appendices II and III (Protected fauna species) to the Berne Convention on the conservation of European wildlife and natural habitats, and added the following species to Appendix III. The underlined species may be found in coralligenous assemblages: *Hippospongia communis*, *Spongia agaricina* (now *S. lamella*), *Spongia officinalis*, *Spongia zimocca*, Antipathes sp. plur., *Corallium rubrun*, *Paracentrotus lividus*, *Homarus gammarus*, *Maja squinado, Palinurus elephas, Scyllarides latus, Scyllarides pigmaeus, Scyllarus arctus, Epinephelus marginatus, Isurus oxyrinchus, Lamna nasus, Mobula mobular, Prionace glauca, Raja alba, Sciaena umbra, Squatina squatina*, and *Umbrina cirrosa* (all 22 species in the Mediterranean). Article 7 specifies that "Each Contracting Party shall take appropriate and necessary legislative and administrative measures to ensure the protection of the wild fauna species specified in Appendix III."
	Convention on International Trade of Endangered animal and plant Species (CITES)
	Very few species from coralligenous and maerl assemblages are listed under this convention: Scleractinia spp. (e.g. *Leptopsammia pruvoti*, *Caryophyllia* spp., *Hoplongia durotrix*) and Antipatharia spp. (which includes *Antipathella subpinnata* and to a lesser degree *Antipathes dichotoma*) which may be found in coralligenous or maerl assemblages) are listed in Appendix II (Species that are not necessarily threatened with extinction, but trade must be controlled in order to avoid utilisation incompatible with their survival). Whereas other *Corallium* species are listed, the Mediterranean *Corallium rubrum* is not listed.
European countries	**Habitat Directive (Council Directive 92/43/EEC, 1992) and Natura 2000 network**
	The Habitat Directive does not specifically address the coralligenous and other calcareous bio-concretions. However, pursuant to the Directive (Art. 2.2), member states must "*maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of community interest*" listed in Annexes I and II of the Directive. Member States must designate, protect and manage core areas for habitat types listed in Annex I and species listed in Annex II of the Habitats Directive. Only *Corallium rubrum* which sometimes can be found in coralligenous habitats, is listed in Annex II. Annex I: *Natural habitat types of community interest whose conservation requires the designation of special areas of Conservation* includes the habitat 1170 "Reefs" which comprises coralligenous concretions as a sub-type, as long as they arise from the seafloor (topographically distinct from surrounding seafloor). Rhodolith/maerl beds are included in habitat 1100 "Sandbank" as long as depths do not exceed 20m depth (see the Interpretation manual of European Union Habitats listed under Annex I of the Habitats Directive). **Therefore, the large majority of the Mediterranean rhodolith/maerl beds**

	are not included in Annex I and specific protection of sub-types not being an obligation, coralligenous assemblages are not necessarily protected under this Directive. Discussions have been going on to include rhodolith/maerl beds as protected habitats under Annex I of the Habitat Directive (Aguilar *et al.*, 2018), without having yet succeeded. Annex V *Animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures* includes two corallinaceae *Lithothamnium coralloides* Crouan frat. and *Phymatolithon calcareum* (Poll.) Adey & McKibbin which are main coralligenous species but not exploited in the Mediterranean therefore not needing exploitation management.
	EU Marine Strategy Framework Directive (MSFD)
	EU countries assess and monitor coralligenous and rhodolith/maerl beds for the MSFD under D6 and to a lesser degree D1 and D10 (Italy). Good Environmental Status (GES) is to be attained or maintained.
	EU Biodiversity **strategy** for 2023 and Nature Restoration Law entered in force in August 2024
	Restoration measures are requested to be put in place: • By 2030, on at least 30% of the total area of seven groups of habitats including "*maerl beds*" and "*sponge, coral and coralligenous beds*" that is not in good condition • By 2040, on at least 60% and, by 2050 on at least 90%
	EU Council Regulation (EC) N° 1967/2006 of 21 December 2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea, amending Regulation (EEC) No 2847/93 and repealing Regulation (EC) No 1626/94
	Under this regulation, Article 4.2 stipulates "*Fishing with trawl nets, dredges, shore seines or similar nets above coralligenous habitats and maerl beds shall be prohibited*". Further in part4.4 "*The prohibition shall (…) apply to all Natura 2000 sites, all special protected areas and all specially protected areas of Mediterranean interest (SPAMI) which have been designated for the purpose of the conservation of these habitats under either Directive 92/43/EEC or Decision 1999/800/EC*".
	Regulation (EU) 2023/2124 of the European Parliament and of the council of 4/10/2023 on certain provisions for fishing in the General Fisheries Commission for the Mediterranean (GFCM) Agreement area
	Regulates the red coral (*Corallium rubrum*) harvesting in terms of depths, minimum size, gear to be used, landing points, data collection etc. Article 38 prohibits red coral retention on board, transhipment or landing of red coral for recreational fisheries. Article 39 requests national management plans for red coral that transpose this regulation.
Mediterranean Sea countries	Agreement for the Establishment of the General Fisheries Commission for the Mediterranean (GFCM)
	Article 8 b) iv) of the Agreement stipulates that the Commission can recommend "*to establish fisheries restricted areas for the protection of vulnerable marine ecosystems, including but not limited to nursery and spawning areas*". Several Fisheries Restricted Areas (FRAs) have been designated since to protect Vulnerable Marine Ecosystems.
	GFCM REC.CM-GFCM/46/2023/13 on the management plan for the sustainable exploitation of red coral in the Mediterranean Sea, amending Recommendation GFCM/45/2022/2 and GFCM/43/2019/4

	Management plan on the commercial exploitation of *Corallium rubrum* (red coral).
	IUCN Red list (see Otero *et al.*, 2017).
	Corallium rubrum is listed as Endangered and *Paramuricea clavata* is listed as Vulnerable.
Barcelona Convention	Integrated Monitoring and Assessment Programme (IMAP) (Decision IG.22/7)
	Member states are requested to assess and monitor specifically three habitats including coralligenous and rhodolith/maerl beds within IMAP under EO1/EO6. Good Environmental Status (GES) of these habitats is to be attained and/or maintained.
	SPA/BD Protocol of the Barcelona convention
	- Specially Protected Areas of Mediterranean Importance (SPAMI's List) (see criteria) - *Corallium rubrum* is listed in annex III, *list of species whose exploitation is regulated*. - *Axinella polypoides* which can be found in coralligenous assemblages is list in Annex II *list of endangered or threatened species.*
	Post-2020 SAPBIO
	The updated regional action plans for the selected priority habitats and species are expected to be adopted and passed on to national planning and implementation processes in most Mediterranean countries by 2027 (Action 1 of Post-2020 SAPBIO Actions table, UNEP/MAP-SPA/RAC, 2021a see Annex III) and **decline of coralligenous habitats is expected to be halted by 2030**.
	Regional Action Plan for the conservation of coralligenous and other calcareous bio-concretions in the Mediterranean Sea (Decision IG.22/12)
	The following recommendations had been made regarding legislation and regulations: • Coralligenous/maerl assemblages should be granted legal protection at the same level as *Posidonia oceanica* meadows. • Coralligenous concretions and maerl beds should be priority habitat type in the EU Habitat Directive (92/43/EU) which would enhance the number of Natura 2000 sites including these habitats. • It is necessary to further protect representative coralligenous/maerl assemblages by applying the protection and management measures recommended by Articles 6 and 7 of the SPA/BD Protocol.

33. It is of high importance and priority to acquire spatial data on coralligenous assemblages and rhodolith/maerl beds at national level in order to:

- apply fishing restrictions of the EU Council Regulation (EC) N° 1967/2006 in European Barcelona Convention Member States which prohibits fishing with trawl nets, dredges, shore seines or similar nets above coralligenous habitats and maerl beds,
- assess and monitor the state of these habitats for MSFD and IMAP,
- attain the objectives of the Restoration Law.

34. It is important to apply at national level the EU Council Regulation (EC) N° 1967/2006 relative to the prohibition of fishing with trawl nets, dredges, shore seines or similar nets over coralligenous habitats and maërl beds. Fournier *et al.* (2020) show that the intensity of bottom fishing was still high in 2019, with almost 3,700 hours over coralligenous beds and 2,280 hours occurring over maërl beds.

35. It has been suggested that the fishing restrictions of EU Council Regulation (EC) N° 1967/2006 relative to the prohibition of fishing with trawl nets, dredges, shore seines or similar nets above coralligenous habitats

and maerl beds, should be applied throughout the Mediterranean (see e.g. Aguilard *et al.*, 2018 ; Fournier *et al.*, 2020) through the Barcelona Convention - SPA/BD Protocol tools.

36.The European Habitats Directive (Council Directive 92/43/EEC, 1992) does not include Mediterranean rhodolith/maerl beds in Annex I (Natural habitat types of community interest whose conservation requires the designation of special areas of Conservation) and indirectly includes coralligenous assemblages (under habitat 1170 "Reefs")

37.Coralligenous assemblages and rhodolith/maerl beds should benefit of increased protection, similar to conservation/protection measures for the Posidonia oceanica beds.

38.The conservation of coralligenous assemblages and rhodolith/maerl beds can be managed through geographically defined areas such as Marine Protected Areas (MPAs) which may ultimately be SPAMIs, but also as suggested by Enrichetti *et al.* (2019), through area-based fisheries management tools such as Fisheries Restricted Areas (FRAs). FRAs are defined as "a geographically defined area in which all or certain fishing activities are temporarily or permanently banned or restricted in order to improve the exploitation and conservation of harvested living aquatic resources or the protection of marine ecosystems in the GFCM area of application" (FAO-GFCM, 2008). Therefore, it appears that a request for an FRA can be justified by the existence of vulnerable coralligenous assemblages and/or rhodolith/maerl beds that need to be protected from relevant fishing activities. This tool is of particular interest for international cooperative management.

3.3. Main threats

39.Coralligenous assemblages and rhodolith/maerl beds provide many ecosystem services to society. However, they are under high anthropogenic pressure.

40.The integrity of coralligenous assemblages can be affected by several anthropogenic threats such as:

- anchoring,
- sedimentation due to activities like aquaculture (Piazzi *et al.*, 2019),
- eutrophication/chemical pollution and litter (e.g. Giménez *et al.*, 2022b),
- abandoned fishing gear (e.g. Enrichetti *et al.* 2019; Ferrigno *et al.*, 2021; Angiolillo *et al.*, 2023),
- fishing activities (e.g. Ferrigno *et al.*, 2018),
- diving activities (Betti *et al.*, 2023),
- various climate change impacts (i.e. increase in sea temperature, acidification (Zunino *et al.*, 2019), Marine Heat Waves (MHW) (Garrabou *et al.*, 2022; Martínez *et al.*, 2023), instalment of Non-Indigenous Species (NIS), development of mucilaginous blooms (e.g. Piazzi *et al.*, 2018)), and
- cumulative effects (e.g. Bevilacqua *et al.*, 2018).

41.It is possible to assess the impact of each pressure using different metrics (see the stressor metrics listed by Di Camillo *et al.* (2023)) and this may be of interest. However, it is essential for MPAs and stakeholders to be able to easily assess the overall condition of coralligenous assemblages.

42.Several rapid methods have been developed to assess the state of conspicuous species, such as the Mortality Rapid Assessment Method proposed by Figuerola-Ferrando *et al.* (2024). This method, applicable to several marine habitat-forming species, was applied to Para*muricea clavata* colonies. Although such methods only provide information on the status of a selected species population within CAs, they can serve as a first assessment for stakeholders to identify vulnerable coralligenous assemblages.

43.A cumulative pressure and impact assessment (CPIA) approach was applied to coralligenous outcrops in Italy (Bevilacqua *et al.*, 2018). This approach mapped the expected cumulative pressures and impacts on CAs in six categories, but research has shown that the CPIA model needs refinement.

44. Three-dimensional structuring species of coralligenous assemblages can be severely affected by derelict fishing gear, that becomes entangled in their structures, injuring colonies and causing partial or total necrosis (e.g. as shown in Italy see Ferrigno *et al.*, 2018; Angiolillo & Fortibuoni, 2020; Enrichetti *et al.*, 2019; Giménez *et al.*, 2022b; Angiolillo *et al.*, 2023). In other cases, trawling activities may indirectly impact red coral populations by increasing turbidity (Ferrigno *et al.*, 2020).

45. However, recent scientific publications have mainly focused on the effects of climate change, such as increasing Sea Surface Temperature (SST), but especially on the effects of Marine Heat Waves (MHWs) and associated Mass Mortality Events (MMEs). These sudden events result in large-scale mortality of key species and alter the underwater landscape, particularly of coralligenous assemblages.

46. The loss of structural coralligenous species can (i) trigger a reduction in the resilience of the entire assemblages, especially at shallow depths, (ii) simplify habitat complexity, and (iii) increase vulnerability to colonisation by invasive species (Gómez-Gras *et al.*, 2021; Verdura *et al.*, 2019). The role of Marine Protected Areas in this context is crucial and should focus on mitigating local pressures, such as fishing and diving impacts (Zentner *et al.*, 2023), to reduce the vulnerability of these structural species.

47. Future scenarios of acidification impact on coralligenous and their ecosystem services have been modelled by Zunino *et al.* (2019), predicting significant changes in the near future.

48. Regarding the impact of MHWs and MMEs on coralligenous assemblages, it is important to work at sub-regional scale as highlighted by the studies of Crisci *et al.* (2017), Gómez-Gras *et al.* (2022), and Bramanti *et al.* (2023). However, agreement on definitions and common references as well as on how to determine threshold values and indices are essential at the Mediterranean scale to ensure comparability (see Hobday *et al.*, 2016; Amaya *et al.*, 2023; Martínez *et al.*, 2023). Hobday *et al.* (2016) proposed a quantitative definition of MHW3 based on a 30-year baseline value, which facilitates comparisons between different datasets across regions and seasons. However, other authors, such as Amaya *et al.* (2023), and Martínez *et al.* (2023) consider that while this approach is informative and appropriate for certain analyses, it is also necessary to use shifting baselines or detrended data.

49. TMEDNet is an initiative to develop an observational network of climate change impacts on coastal marine ecosystems through the widespread adoption of standard monitoring protocols for seawater temperature and biological indicators over large areas and long periods of time. The site provides guidance on monitoring mortality, temperature, and climate on fish. Data can be uploaded once logged in and visualized in different ways. Such initiatives at Mediterranean scale should be supported at the Mediterranean scale and could contribute to the Coralligenous Conservation Action Plan through collaboration between UNEP/MAP-SPA/RAC and TMEDNet.

50. Rhodolith/Maerl Beds are particularly vulnerable to several pressures, particularly trawling. Although they show recovery capacities (Farriols *et al.*, 2021, 2024), their resilience appears to be limited. Several studies have focused on the impacts of benthic trawling on RMBs in the Mediterranean Sea (e.g. Barberá *et al.*, 2017; Farriols *et al.*, 2021). Fragkopoulou *et al.* (2021) provide a global study of rhodolith distribution and threats, highlighting the combined impacts of climate change and benthic trawling on the distribution of rhodolith beds. Aquaculture activities have also been identified as a potential threat for RMBs off southern Iberian Peninsula (Aguado-Giménez & Ruiz-Fernández, 2012).

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[3] Hobday *et al.*, 2016 propose to define MHW with the use of the threshold of the 90th percentile based on a 30-year historical baseline period and that lasts at least five continuous days above the threshold.

3.4. Assessment and monitoring

51. CAs and RMBs are elements for MSFD GES criteria D6 (seafloor integrity) and are requested to be assessed under descriptor 6 criteria D6C3, D6C4 and D6C5. However, few EU countries have reported on the extent and other parameters for these habitats (see Tornero Alvarez *et al.*, 2023).

52. CAs and RMBs are requested to assess against IMAP EO1 Biodiversity CI1 (Habitat distribution range to include habitat extent as a relevant attribute) and CI2 (Condition of typical habitat's species and communities). However, very few CPs have reported on these indicators for CAs and RMBs.

53. Surveys to map CAs and other calcareous bioconstructions generally use a variety of remote sensing techniques based on acoustic means coupled with ground truthing by means of photographs, videos or samples. Images are often acquired using Remotely Operated Vehicles (ROVs) (e.g. Pierdomenico *et al.*, 2021). The integration of multibeam and side-scan sonar data with ROV observations allows the identification of coralligenous reefs based on geomorphological and acoustic components and the characterisation of the coralligenous assemblages. Such approaches are used for example in Italy (e.g. Pierdomenico *et al.*, 2021) for MSFD assessment.

54. The spatial distribution of coralligenous cliffs appears to be more difficult to determine because cliffs are more difficult to identify from acoustic data (see Piazzi *et al.*, 2023).

55. Side scan sonar (SSS) and multibeam echosounder (MBES) are the most frequently used techniques to detect coralligenous outcrops (see Dimas *et al.*, 2022). Together with ground truthing acoustic data are processed and interpreted and classified to produce habitat maps. The use of other acoustic data such as sub-bottom profilers (SBP) has also been reported as being successful (Dimas *et al.*, 2022). These authors propose a classification scheme that may be useful for other CA spatial distribution surveys.

56. Similar methods are used for the spatial and bathymetric delineation of RMBs (UNEP-MAP-RAC/SPA, 2015; Ingrassia *et al.*, 2019). A two-step approach for the definition, identification, delimitation, description and monitoring of RMBs is proposed by Basso *et al.* (2016b). Since then, it is recognized that the use of dredges for sampling RMBs should be discouraged. However, this sampling method can be necessary to characterize this habitat and hence to estimate condition (e.g. density of rhodoliths, species composition and biodiversity, rhodoliths size and shape) in the CI2 indicator.

57. The main methods used in the Mediterranean for inventory and monitoring coralligenous and maerl habitats have been developed in several documents:

- RAC/SPA - MedMPAnet Project (Ed.) 2014. Monitoring Protocol for Reefs - Coralligenous Community. By Garrabou J, Kipson S, Kaleb S, Kruzic P, Jaklin A, Zuljevic A, Rajkovic Z, Rodic P, Jelic K, and Zupan D. Tunis. 35 pp.+Annexes pp.
- UNEP/MAP-SPA/RAC. 2019. Monitoring Protocols for the Ecosystem Approach Common Indicators 1 and 2 related to marine benthic habitats. Guidelines for monitoring coralligenous and other calcareous bioconcretions (UNEP/MED WG.474/3, p51-98). UNEP/MAP-SPA/RAC, Tunis.
- UNEP/MAP-SPA/RAC. 2021c. Guidelines for the assessment of environmental impact on coralligenous and maerl assemblages. UNEP/MED WG.502/Inf.3. UNEP/MAP SPA/RAC, Tunis.
- SNPA 2024, Methodology sheets used in the second cycle of MSFD monitoring programmes in Italian marine waters. In fact, Italy has adopted specific standards applied on a national scale for monitoring coralligenous and rhodoliths/maerl within the MSFD and functional to the EcAp process.
- Other practical guidelines with **standard protocols** are available on the TMEDNet website for monitoring temperature conditions, mass mortality events, fish visual fish census in relation to climate change, urchin population assessment, rapid assessment of benthic habitat, rapid assessment of

Posidonia oceanica and *Pinna nobilis*, photogrammetry tool for monitoring benthic habitat structure and dynamics. These simple protocols are available in Garrabou *et al.* (2022).

58. Furthermore, in order to assess the ecological status of coralligenous assemblages and the anthropogenic impacts on them, more than 16 indexes have been defined for the Mediterranean Sea since 2009. Di Camillo *et al.* (2023) have published a comprehensive review and comparison of these indexes, with the aim of proposing a framework to support the development of a cost-effective and practical index to assess the status of CAs.

59. Few specific indices have been developed and published to assess the status of the RMBs in the Mediterranean Sea. However, an attempt to define an ecosystem-based assessment of the RMBs has been published by Astruch *et al.* (2023). Yet, the method proposed by these authors seems complex to be applied over large areas and at many sampling sites. Another potential problem is its use deeper than 80 m depth, with moderate currents.

60. Assessment and monitoring of coralligenous assemblages and rhodolith/maerl beds should be improved at national level and based on IMAP indicators, criteria and existing protocols.

4. NEEDS, GAPS AND CHALLENGES

4.1. Scientific knowledge on spatial distribution

61. Knowledge of the spatial distribution of the two habitats has progressed. However, no data were found on the spatial distribution of coralligenous assemblages and rhodolith/maerl beds for Bosnia & Herzegovina, Egypt, Israel, Libya, Slovenia, and Syria.

62. There may be no coralligenous assemblages in Israel as suggested by RAC/SPA (2003) and Laborel (1987) and in Bosnia and Herzegovina, but the absence of these assemblages should be clearly stated. It is important to know whether the habitats are present or not and to complete the information on spatial distribution at national level for countries without available data. The comparison between the table of available data and the EMODnet modelled spatial distribution of coralligenous suggests that further data collection is needed around Cyprus, along the western coast of the Peloponnese (Greece), in front of the Nile Delta (Egypt) and along the eastern coast of Libya. Efforts are also needed to collect existing spatial data in other countries (e.g. Spain, Türkiye).

63. Several studies show the presence of coralligenous and maerl beds along the Spanish coast, but no document or large-scale map that summarises the available data for Spain. In particular, mapping of RMBs is needed along the whole continental shelf of the Iberian Peninsula and especially in the Balearic Islands where these beds are widely distributed.

64. Several studies refer to the presence of coralligenous assemblages along the Turkish coast, but no synthetic document or map was found collating spatial data on coralligenous assemblages or rhodolith/maerl beds for Türkiye.

65. Where data are lacking at national level, efforts to collect data on the distribution of CA and RMB habitats should be intensified. Comparison of current knowledge of spatial distribution with modelled spatial distribution (e.g. EMODnet) to identify areas of interest for assessment. Information on the non-existence of these habitats is also important to improve spatial distribution models. Efforts could also be made to collate existing data at national level.

4.2. Composition and structure

66.Coralligenous and maerl assemblages are variable throughout the Mediterranean Sea. Knowledge of the composition and structure of coralligenous assemblages and rhodolith/maerl beds has increased mainly in the north-western Mediterranean and some knowledge has also been acquired through programmes in MPAs of the south-eastern Mediterranean. However, a synthetic view of the composition and structure of these habitats at a regional scale with sub-regional/national characteristics is still not possible. National factsheets based on the habitats and facies of the Classification of the Benthic Marine Habitat Types, containing information on their known spatial distribution, bathymetric distribution, further characterisation of the assemblages as well as specific threats and perhaps socio-economic values could greatly contribute to a regional view of these assemblages.

67.Knowledge acquisition on composition and structure of coralligenous and maerl assemblages is still necessary at national level together with an effort to collate available information at regional scale.

4.3. Conservation issues

68.Local anthropogenic threats to coralligenous assemblages and rhodolith/maerl beds are known and their impacts on these habitats relatively well identified. However, the long-term effects of climate change and cumulative impacts on these habitats and their key species are less well understood. In particular, repeated Mass Mortality Events due to intense Marine Heat Waves, represent currently one of the main threats to these habitats in certain areas of the Mediterranean.

69.Taking into account the rather weak international protection of the Mediterranean coralligenous assemblages and rhodolith/maerl beds, the vulnerability of these habitats, the slow growth rate of their key species, the multiple threats to which they are exposed as well as their socio-economic importance, it should be considered a priority to implement effective conservation measures at national, sub-regional and regional levels scale. The absence of complete mapping of these habitats, of coherent assessment approach and of coordinated management in the region hinders considerably the conservation efforts.

70.Contracting Parties may integrate these habitats into Marine Protected Areas by extending MPAs to include nearby coralligenous habitats, establishing new MPAs or using of FRAs (Fisheries Restricted Areas) to provide adequate protection for these habitats. In addition, national plans should be developed and improved to help reduce anthropogenic impacts on the habitats and to increase scientific knowledge and awareness. The specific inclusion of these habitats in national Environmental Impact Assessments could also contribute to a better conservation of these habitats.

71.Protection of coralligenous assemblages and rhodolith/maerl beds needs to be increased at Mediterranean and national scale.

4.4. Action Plan connexions with other policies and management tools

72.The assessment and monitoring required to better understand the habitats for an effective conservation should be carried out at national level using IMAP indicators. Existing, recognised protocols should be adopted, preferably common at least within a sub-region. The establishment of sub-regional working groups could help to homogenise protocols used and set up intercalibration exercises.

73.The data produced should be reported through the IMAP Info system. CP Reporting for the Action Plan could include a summary document on evaluation and monitoring, which could also be useful for future MED QSRs.

74. Further links could be sought with the assessment and monitoring of other benthic habitats such as Posidonia oceanica meadows and marine caves.

4.5. Cooperation at sub-regional scale

75. The sub-regional scale is important for the population dynamics of key species in coralligenous assemblages and rhodolith/maerl beds and for establishing a network of representative sites. In addition, assessment and monitoring methods should be similar enough to compare the status of these habitats at the sub-regional scale.

76. The development of subregional working groups could contribute to further cooperation between States on this issue, initiate international research programmes and conservation actions, and increase the interoperability of assessments through the organisation of calibration workshops.

4.6. Challenges

77. Coralligenous assemblages and rhodolith/maerl beds thrive mainly at depths between 50 and 150 meters. Therefore, access to these habitats is difficult and costly, often requiring remote acoustic sensing techniques coupled with ground-truthing methods either by diving or ROV. In general, CPs lack the resources and means to carry out such assessments effectively.

78. As these habitats exhibit considerable spatial variability in their composition and structure, the definition of baseline values or Good Environmental State (GES) at the Mediterranean or even sub-regional scale is challenging.

79. Geographical assessment data are often difficult to consolidate due to the use of heterogeneous references, scales and data quality. In addition, monitoring data are extensive and require considerable classification, organisation and storage capacity at national level and even more so at regional level. IMAP data submission, processing and analysis capacities need to be strengthened to better support the scientific knowledge required by all Action Programmes, including those for the conservation of coralligenous and other calcareous bio-concretions.

80. The integrity of benthic habitats can be affected by various local anthropogenic impacts. However, in recent years, climate change has had a significant impact on the Mediterranean Sea through rising sea temperatures, increased frequency and intensity of Marine Heat Waves causing Mass Mortality events, increased acidification and increased intensity and frequency of extreme events including flooding, affecting marine habitats even at greater depths. For vulnerable benthic habitats, such as coralligenous assemblages and rhodolith/maerl beds, which are already subject to local anthropogenic pressures, he effects of climate change may be irreversible.

5. VISION, GOALS, OBJECTIVES, PRIORTIES AND ACTIONS TIMETABLE

81.Following the structure of the Post-2020 SAPBIO and taking into account the Ecosystem Approach (EcAp)[4], the following long-term vision, strategic goals, objectives, priorities and actions are proposed to be led by SPA/RAC and GFCM at regional/sub-regional scale and by Contracting Parties at national and sub-regional level. The proposed actions are, to the extent possible, specific, measurable, achievable, relevant and time-bound.

5.1. Proposed long-term Vision (2050)

82.By 2050, the distribution, diversity, composition, structure and functions of coralligenous and other calcareous bio-concretions are sufficiently maintained to ensure the long-term conservation of these assemblages where they occur naturally in the Mediterranean.

5.2. Proposed strategic Goals (to 2030)

- **Goal 1.** To acquire sufficient scientific knowledge of these assemblages (spatial and bathymetric distribution, composition and structure, dynamics of key species…) to be able to act efficiently, adequately and effectively for their conservation and restoration.
- **Goal 2.** To share knowledge and resources on assessment and monitoring methods and to contribute to overcoming difficulties in the national implementation of the Action Plan on coralligenous/maerl assemblages.
- **Goal 3.** To reduce, prevent and manage the vulnerability of coralligenous and other calcareous bio-concretions to local and regional risks induced by human activities and natural events (close to strategic goals 3 of EcAp) in order to allow them to recover, function fully and maintain their resilience capacities.
- **Goal 4.** Increase awareness and communication on the distribution and the importance of these habitats and develop communication actions for targeted audiences.

5.3. Proposed objectives

The proposed objectives of the *Action Plan for the Conservation of Coralligenous and other Calcareous Bioconcretions in the Mediterranean Sea* are:

i) To improving knowledge of these assemblages (Goals 1 and 2), in particular, but not only, in relation to the impacts of climate change;
ii) To support and enhance national and cooperative sub-regional monitoring based on IMAP (Goals 1 and 2);
iii) To promote solidarity and scientific cooperation among Member States (Goal 2);
iv) To support the national implementation of action plans on coralligenous and other calcareous bioconcretions (Goal 3);
v) To increase, strengthen and improve the effectiveness of conservation actions for coralligenous and others calcareous bioconcretions in the Mediterranean Sea (Goal 3);
vi) To increase the number and the effectiveness of Marine Protected Areas focused on the conservation of coralligenous and other calcareous bioconcretions (Goal 3);
vii) To advocate for the extension of existing MPAs to include neighbouring coralligenous and rhodolith/maerl assemblages (Goal 3);

[4] See UNEP/MAP COP Decision IG.17/6 and Decision IG.22/7 for IMAP

viii) To consolidate available data on spatial distribution and human-induced impacts at the regional level (Goal 4).

5.4. Priorities

5.4.1. National level

83. Given the lack of scientific knowledge and the significant anthropogenic pressures that threaten the integrity of coralligenous assemblages and other calcareous bioconstructions, national priorities should be to:

- **Improve scientific knowledge**: Improve understanding of the geographical distribution, composition, structure and population dynamics of key species of these habitats considering current climate change conditions.
- **Conduct baseline studies and monitoring:** Establishing baseline studies and conducting continuous monitoring of a network of sites, including affected and less affected sites, and collecting data by using IMAP indicators and existing standardised protocols.
- **Centralise data collection and sharing:** Develop centralised data collection systems to facilitate data sharing and accessibility among stakeholders.
- **Strengthen habitat protection:** Strengthen habitat protection through spatial and/or management actions to mitigate natural and anthropogenic pressures.
- **Raise awareness:** Communicating the vulnerability of these habitats to target audiences (e.g. small-scale fishermen, recreational fishermen, etc.), to raise awareness and promote sustainable practices.

5.4.2. Regional level

84. Considering the scattered information available across the Mediterranean, the diversity of the habitat composition, the number of states surrounding the Mediterranean Sea, and the need to harmonise assessment methods, regional priorities should be set:

- **Coordination of exchanges and working groups:** Facilitating exchanges and organising working groups to address habitat-related challenges. A sub-regional level is recommended as an appropriate level for coordination efforts.
- **Strengthen cooperation:** Pursue further collaboration with other Mediterranean entities and policy instruments that can enhance the management of anthropogenic threats affecting these habitats at the Mediterranean level (e.g. GFCM).
- **Develop a centralised platform:** Create a platform for sharing and centralising key documents, which should be regularly updated. Cooperation with existing platforms should also be sought.
- **Support to Member States:** Assisting Member States to integrate this Action Plan at the national level by securing funding, promoting scientific exchanges, intercalibrating methods and protocols, and providing other appropriate support.

5.5. Proposed Actions for 2025-2030

Table 3 Proposed actions (2025-2030) for the Regional Action Plan for the conservation of coralligenous and other calcareous bioconcretions in the Mediterranean Sea

	Action	Deadline	Actors
	Acquiring scientific knowledge		
1	Contribute to the development of research programmes on coralligenous and other calcareous bioconcretions, particularly in relation to an ecosystem approach and/or climate change impacts.	Continuously to 2050	CPs
2	Establish or develop a network of representative sites (protected/unprotected, impacted/unimpacted, deep/shallow, etc.) for monitoring coralligenous assemblages and maerl beds, and produce a fact sheet on the network and the state of these habitats.	By end of 2027	CPs
3	Assess and monitor coralligenous assemblages and rhodolith/maerl beds based on IMAP indicators EO1 and EO6 or MSFD criteria, using existing standard protocols	Continuously	CPs
	Improve Knowledge Sharing and Implementation		
4	Organisation of the 5th Mediterranean Symposium on the Conservation of Coralligenous and other Calcareous Bioconcretions	By 2026	SPA/RAC Contribution by the CPs is expected
5	Establishment of four (4) sub-regional working groups on the conservation and assessment of benthic habitats at sub-regional scale (coralligenous and maerl beds, possibly together with *Posidonia oceanica* beds). Synthesised results of meetings should be shared with National Focal Points.	By 2027 initially	SPA/RAC organise online meetings. CPs participation to WG
6	Compile and share a list of MPAs hosting coralligenous and rhodolith/maerl assemblages.	2026	CPs
	Reducing Vulnerability and Building Resilience		
7	Work towards a ban on the use of harmful fishing gear (trawl nets, dredges, shore(bottom) seines or similar nets*)* over coralligenous and rhodolith/maerl beds in MPAs (including all Natura 2000 sites), all Special Protected Areas and all Specially Protected Areas of Mediterranean Interest (SPAMI) throughout the Mediterranean Sea.	By 2030	SPA/RAC and GFCM to consider elaborating a GFCM decision. CPs to integrate in national Action Plan or fisheries regulation.
8	Increase the representativeness of coralligenous assemblages and rhodolith/maerl beds in Marine Protected Areas and/or FRAs (Fisheries Restricted Areas)	By 2030	CPs
9	Identify (i) sites with impacted coralligenous assemblages and (ii) sites with impacted rhodolith/maerl beds where identified threats could be reduced, and restoration (passive or active) could be considered.	By end of 2027	CPs
	Awareness and communication building		
10	Development of a coordination platform: Collect, make available and regularly update spatial data; bring together and update available reports, guidelines, programmes initiatives and publications on coralligenous and other calcareous bioconcretions.	By end of 2027	SPA/RAC

6. ACTION PLAN PARTNERS

85. Implementing the present action plan is the province of the national authorities of the Contracting Parties. Relevant international organisations, NGOs, laboratories, and any other entities are invited to join in the efforts necessary for the successful implementation of the Action plan. During their ordinary meetings, the Contracting Parties may, upon the recommendation of the meeting of National Focal Points for SPAs/BD, grant the status of «Action Plan Partner» to any organization or laboratory that requests it. This status will be awarded to those that carry out, or support (financially or otherwise), concrete actions (such as conservation, research, etc.) That contribute to the implementation of the present action plan, in line with its priorities. The conditions and criteria for the award of the regional action plan partner title are outlined in Annex VI to the decision IG.26/5.

7. QUESTIONNAIRE FOR THE REPORTING FORMAT FOR THE IMPLEMENTATION OF ACTION PLAN FOR THE CONSERVATION OF CORALLIGENOUS AND OTHER CALCAREOUS BIO-CONCRETIONS

86.The following questionnaire is based and may need to be updated once the Action Plan has been approved by the Focal Points. It should be updated in the in the UNEP/MAP Barcelona Convention Reporting System (BCRS).

RAP for the conservation of coralligenous and other calcareous bio-concretions (COP Decision IG 22/12).

CAs: coralligenous assemblages, **RMBs:** rhodolith/maerl beds

<table>
<tr><th rowspan="3">Regional Plan requirements: measures and actions taken</th><th colspan="2">Changes in the information provided in the previous report (Please tick the box that applies)</th><th colspan="7">Status of implementation (Please tick the box that applies with an "X")</th><th colspan="5">Difficulties/Challenges (Please tick "X" to all that apply)</th></tr>
<tr><th rowspan="2">Yes</th><th rowspan="2">No</th><th rowspan="2">Not implemented</th><th rowspan="2">In project</th><th colspan="4">Implemented at:</th><th rowspan="2">Not applicable</th><th rowspan="2">Policy framework</th><th rowspan="2">Regulatory framework</th><th rowspan="2">Financial resources</th><th rowspan="2">Administrative management</th><th rowspan="2">Technical guidance capacities</th></tr>
<tr><th>1-25%</th><th>26-50%</th><th>51-75%</th><th>76-100%</th></tr>
<tr><td rowspan="3">Contribute to the development of research programmes on coralligenous assemblages (CAs) and rhodolith/maerl beds (RMBs), particularly in relation to an ecosystem approach and/or climate change impacts. <u>Timeline</u>: Continuously</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="2">If your answer is "Yes", please update accordingly
If your answer is "No", please go to next question</td><td colspan="7">If your answer is "Yes", on a voluntary basis please provide further information (Indicate website/URL link or other reference)</td><td colspan="5" rowspan="2">On a voluntary basis, please briefly describe difficulties/challenges and the type of attention or assistance that is required</td></tr>
<tr><td colspan="7">If your answer is "No", please in the column difficulties/challenges, tick all that apply</td></tr>
<tr><td rowspan="3">Establish a network of representative sites (protected/unprotected, impacted/unimpacted, deep/shallow, etc.) for monitoring CAs and RMBs. Timeline: Year 3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td colspan="7">If your answer is "No", please in the column difficulties/challenges, tick all that apply</td></tr>
<tr><td rowspan="3">Produce a fact sheet on the network of CAs and RMBs and the state of these habitats. Timeline: Year 3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td colspan="7">If your answer is "No", please in the column difficulties/challenges, tick all that apply</td></tr>
<tr><td rowspan="2">Assess and monitor CAs and RMBs based on IMAP indicators EO1 and EO6 or MSFD</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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</table>

Regional Plan requirements: measures and actions taken	**Changes in the information provided in the previous report** (Please tick the box that applies)		**Status of implementation** (Please tick the box that applies with an "**X**")							**Difficulties/Challenges** (Please tick "X" to all that apply)				
	Yes	No	Not implemented	In project	Implemented at: 1-25%	26-50%	51-75%	76-100%	Not applicable	Policy framework	Regulatory framework	Financial resources	Administrative management	Technical guidance capacities
criteria, using existing standard protocols			If your answer is "No", please in the column difficulties/challenges, tick all that apply											
Compile and share a list of MPAs hosting CAs and RMBs. Timeline: Year 2														
	If your answer is "Yes", please update accordingly If your answer is "No", please go to next question		If your answer is "Yes", **on a voluntary basis** please provide further information ***(Indicate website/URL link or other reference)*** If your answer is "No", please in the column difficulties/challenges, tick all that apply							**On a voluntary basis**, please briefly describe difficulties/challenges and the type of attention or assistance that is required				
Work towards a ban on the use of harmful fishing gear (trawl nets, dredges, shore(bottom) seines or similar nets*)* over CAs and RMBs in MPAs (including all Natura 2000 sites), all Special Protected Areas and all Specially Protected Areas of Mediterranean Interest (SPAMI) throughout the Mediterranean Sea. Timeline: Year 5														
	If your answer is "Yes", please update accordingly If your answer is "No", please go to next question		If your answer is "Yes", **on a voluntary basis** please provide further information ***(Indicate website/URL link or other reference)*** If your answer is "No", please in the column difficulties/challenges, tick all that apply							**On a voluntary basis**, please briefly describe difficulties/challenges and the type of attention or assistance that is required				
Increase the representativeness of CAs and RMBs in Marine Protected Areas and/or FRAs (Fisheries Restricted Areas). Timeline: Year 5														
	If your answer is "Yes", please update accordingly If your answer is "No", please go to next question		If your answer is "Yes", **on a voluntary basis** please provide further information ***(Indicate website/URL link or other reference)*** If your answer is "No", please in the column difficulties/challenges, tick all that apply							**On a voluntary basis**, please briefly describe difficulties/challenges and the type of attention or assistance that is required				

<table>
<tr><th rowspan="3">Regional Plan requirements: measures and actions taken</th><th colspan="2">Changes in the information provided in the previous report
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<tr><th rowspan="2">Yes</th><th rowspan="2">No</th><th rowspan="2">Not implemented</th><th rowspan="2">In project</th><th colspan="4">Implemented at:</th><th rowspan="2">Not applicable</th><th rowspan="2">Policy framework</th><th rowspan="2">Regulatory framework</th><th rowspan="2">Financial resources</th><th rowspan="2">Administrative management</th><th rowspan="2">Technical guidance capacities</th></tr>
<tr><th>1-25%</th><th>26-50%</th><th>51-75%</th><th>76-100%</th></tr>
<tr><td>Identify (i) sites with impacted CAs and (ii) sites with impacted RMBs where identified threats could be reduced and restoration could be considered. Timeline: Year 3</td><td colspan="2">If your answer is “Yes", please update accordingly
If your answer is “No", please go to next question</td><td colspan="7">If your answer is “Yes", on a voluntary basis please provide further information (Indicate website/URL link or other reference)</td><td colspan="5">On a voluntary basis, please briefly describe difficulties/challenges and the type of attention or assistance that is required</td></tr>
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ANNEX I
Status of implementation of the Action Plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea

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Acronym list

CA	:	Coralligenous Assemblages
CP	:	Contracting Party (Barcelona Convention)
CPIA	:	Cumulative Pressure and Impact Assessment
DVT	:	Deep Vertical Transect
EcAp	:	Ecosystem Approach under the Barcelona Convention
EO	:	Ecological Objective
EU	:	European Union
FAO	:	Food and Agriculture Organisation
FRA	:	Fisheries Restricted Areas
GES	:	Good Environmental Status
GFCM	:	General Fisheries Commission for the Mediterranean
IMAP	:	Integrated Monitoring and Assessment Programme
IUCN	:	International Union for Conservation of Nature
IUCN-Med	:	The Centre for Mediterranean Cooperation of the International Union for Conservation of Nature
MAP	:	Mediterranean Action Plan
MBES	:	Multi-Beam Echo Sounder
MedPAN	:	Mediterranean Protected Areas Network
MPA	:	Marine Protected Area
MS	:	Member State
MSFD	:	Marine Strategy Framework Directive
NIS	:	Non-Indigenous Species
OFB	:	*Office Français de la Biodiversité*
RMB	:	Rhodolith or maerl bed
ROV	:	Remotely Operated Vehicle
SBP	:	Sub-Bottom Profiler
SCUBA	:	Self-Contained Underwater Breathing Apparatus
SfM	:	Structure from Motion
SPA/BD Protocol	:	Protocol on Specially Protected Areas and Biological Diversity (Barcelona Convention)
SPA/RAC	:	Specially Protected Areas /Regional Activity Centre
SSS	:	Side Scan Sonar
SST	:	Sea Surface Temperature
UN	:	United Nations
UNEP	:	United Nations Environment Programme
UNEP-MAP	:	United Nations Environment Programme – Mediterranean Action Plan
UVC	:	Underwater Visual Census
VME	:	Vulnerable Marine Ecosystems

Introduction

The first Regional Action Plan *for the conservation of the Coralligenous and Other Calcareous Bio-concretions in the Mediterranean Sea* (Decision IG 17/15) defines the assemblages to be considered in the action plan as follows:

> *The* ***coralligenous*** *is considered as a typical Mediterranean underwater seascape comprising coralline algal frameworks that grow in dim light conditions and in relatively calm waters (Ballesteros, 2006). Mediterranean* ***maerl***[5] ***beds*** *should be considered as sedimentary bottoms covered by a carpet of free-living calcareous algae (Corallinales or Peyssonneliaceae) also developing in dim light conditions.*

The Interpretation Manual of Marine Habitat Types in the Mediterranean Sea (UNEP/MAP – SPA/RAC, 2021) defines **coralligenous** habitat as:

> "*a hard substrate of biogenic origin consisting of calcareous structures edified by coralline algae grown at low irradiance levels and in relatively calm waters. Normally coralligenous develops on circalittoral rocky substrates but, in some cases coralline algae build calcareous structures in infralittoral bottoms, alternating with seagrass or algal beds…Coralligenous as an enclave in the infralittoral, can form small discontinuous organogen formations"* (see MB1.55 habitat type).

In this same document, Mediterranean **maerl beds** are described as:

> "*maerl are rhodolith beds composed of non-nucleated, unattached and branched twig-like coralline algae. The characteristic species in the association are* Lithothamnion corallioides *and* Phymatolithon calcareum."

Coralligenous and other calcareous bio-construction develop on vertical cliffs, rocky reefs and biodetritic horizontal or subhorizontal bottoms from 10 to 180 meters (Basso *et al.*, 2016a; Ingrosso *et al.*, 2018; Romagnoli *et al.*, 2021; UNEP/MAP – SPA/RAC, 2021b; Radicioli *et al.*, 2022; Innangi *et al.*, 2024), but occur most frequently between 50 and 150 m depth. They can be found all around the Mediterranean Sea.

The classification used for these habitats may be found in ***Error! Reference source not found.*** of this document.

Coralligenous assemblages **(CAs)** show high spatial, morphological, and biological variability (Basso *et al.*, 2022) and because of great environmental variability, several different assemblages can coexist in a reduced space. They are considered among the most important assemblages of the Mediterranean (Ingrosso *et al.*, 2018) with a slow growth, developing on vertical and horizontal substrates (Basso *et al.*, 2022). Several species forming the CAs are endemic of the Mediterranean (Ferrigno *et al.*, 2023). Further, CAs provide habitat and food for many species and represent some of the most productive assemblages (Constantini *et al.*, 2018).

Rhodolith and/or maerl beds (**RMBs**) develop on horizontal or sub-horizontal surfaces with water motion (either currents or waves) to keep the rhodoliths unburied and are generally composed of several coralline species (Basso *et al.*, 2016a).

Coralligenous and other calcareous bio-constructions are biogenic constructions of calcareous algae but also of erect invertebrates which complexify the assemblage, offering multiple micro-habitats for many species and harbouring high biological diversity (UNEP/MAP-SPA/RAC, 2015a).

[5] As written in Collin's Dictionary but can often be found written *maërl*. In this document the orthograph *maerl* is used except for references where it is written *maërl*.

Interest for CAs and RMBs has increased during the last decades, and concerns regarding their conservation state are alarming especially under climate change threats.

Within the framework of the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol) of the Barcelona Convention, the Contracting Parties agreed on the *Action Plan for the conservation of the Coralligenous and Other Calcareous Bio-concretions in the Mediterranean Sea* (Decision IG 17/15) during the 15th Ordinary Meeting of the Contracting Parties in 2008. This Action Plan was updated in 2016 (Decision IG 22/12).

The updated regional action plans for the selected priority habitats and species are expected to be adopted and passed on to national planning and implementation processes in most Mediterranean countries by 2027 (Action 1 of Post-2020 SAPBIO Actions table, UNEP-MAP/SPA-RAC, 2021a see Annex III) and decline of coralligenous habitats is expected to be halted by 2030.

This document presents a general overview of the progress accomplished in knowledge acquisition, assessment and conservation of coralligenous and other calcareous bio-concretions since the adoption of the updated Action Plan for the conservation of the Coralligenous and Other Calcareous Bio-concretions in the Mediterranean Sea in 2016.

Further, it reviews the regional and nation implementation of the Action Plan since 2016 based on scientific publications, grey literature, reports and the results of prefilled questionnaires sent to the Focal Points of the Contracting Parties.

1. Progress in increasing knowledge on coralligenous and other calcareous bio-concretion in the Mediterranean Sea

Yearly publications on coralligenous assemblages have significantly increased since 2015 especially from north-western Mediterranean countries but not only (Ferrigno *et al.*, 2023). These are relative to spatial and bathymetric distribution, composition and structure, environmental state assessments, ecosystem conservation and management and anthropogenic impacts.

The following assessment of the progress in knowledge on coralligenous assemblages and rhodolith and maerl beds in the Mediterranean is mainly based on the analysis of over 260 documents (published peer-review literature, books, reports, conference papers, SPA/RAC documents) identified within bibliographic database and internet research. This documents essentially date from 2016 to 2024. This selection of documents also contributed to elaborate the prefilled questionnaire for each of the 21 Mediterranean CPs.

About four times more documents concerned Coralligenous Assemblages (CAs) than Rhodolith and Maerl Beds (RMBs).

1.1. Spatial and bathymetric distribution

Coralligenous assemblages (CAs) can be found all around the Mediterranean coasts (Ballesteros, 2006). The map of CAs presence published by Martin *et al.* (2014) (Figure 1) built with available data shows a lower density of coralligenous in the eastern and southern Mediterranean which could reflect the lesser presence of CAs but also reflect the lack of data from these areas.

In the study of Martin *et al.* (2014), CAs had been reported from 16 Mediterranean countries (Albania, Algeria, Croatia, Cyprus, France, Greece, Italy, Israel, Lebanon, Libya, Malta, Monaco, Morocco, Spain, Tunisia, and Turkey). Information was scarce from certain countries and inexistent from others, without in the latest case necessarily having the information if CAs were present or not in the country's territorial waters.

CAs are generally encountered at circalittoral level but can also be found in enclaves in lower infralittoral (Montefalcone *et al.*, 2021). In the infralittoral, Piazzi *et al.* (2023b) describe scattered biogenic calcareous outcrops on horizontal substrate in Italy with photophilous communities which should be considered, according to the authors, as a peculiar habitat for which further knowledge is needed.

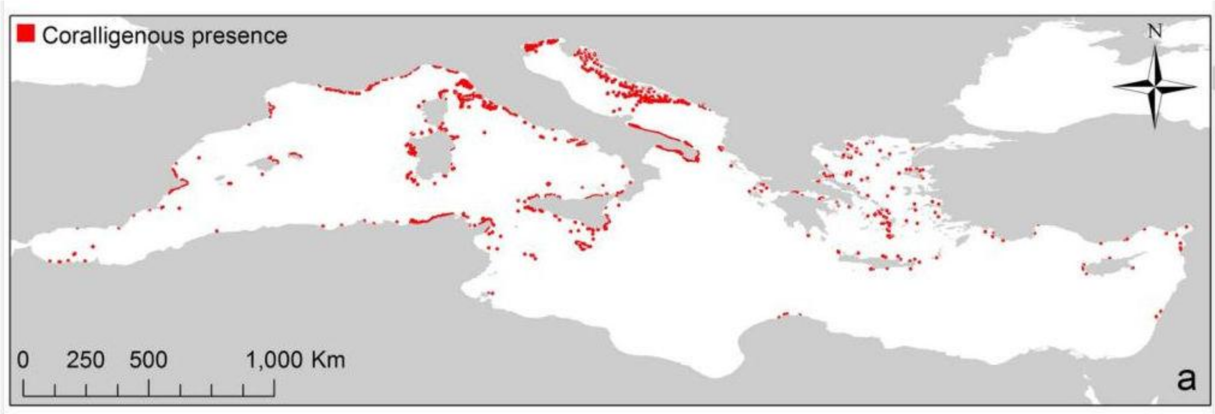


Figure 1. Distribution of coralligenous outcrops based on literature review and available data up to 2014 (from Martin *et al.*, 2014)

CAs can be found between 20 and 160 m depth depending on environmental conditions. Often CAs do not much exceed 110 m depth as around Linosa Island (Romagnoli *et al.*, 2021; Innangi *et al.*, 2024) and in Apulia (Bracchi *et al.*, 2017). They have been mapped down to 160 m depth in Western and northern Sardinia (Falco *et al.*, 2022) but this is unusually deep and could be due, according to the authors, to clear waters and existence of rocky seabed and coarse sediment down to 170-180 m.

CAs on cliffs are considered as shallower assemblages (between 20 and 50 m depth) by Piazzi *et al.* (2022), whereas CAs on platforms or sub-horizontal substrates of the continental shelf rock are below 50 m on detritic bottoms according to Piazzi *et al.* (2022) and bellow 30 m according to the *Interpretation manual of the reference list of marine habitat types in the Mediterranean Sea*, UNEP/MAP – SPA/RAC 2021.

Rhodolith and/or maerl beds (RMBs) can be found all around the Mediterranean Sea although the map of Martin *et al.* (2014) shows large areas with no presence of RMBs (Figure 2).

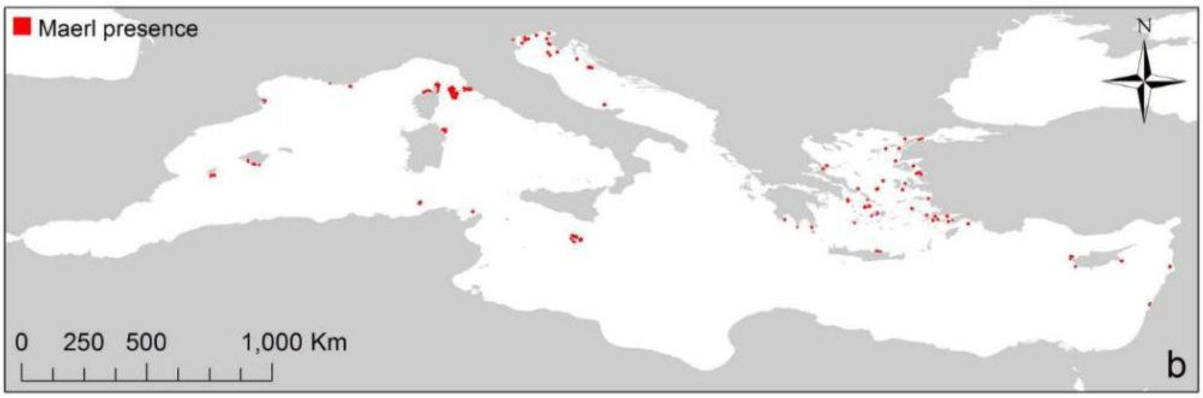


Figure 2. Maerl beds distribution map based on literature review (from Martin *et al.*, 2014)

The depth distribution of RMBs in the Mediterranean Sea ranges from 9 to 150 m depth (Basso *et al.*, 2016a; UNEP/MAP-SPA/RAC, 2021b, Del Rio *et al.*, 2022), with an average depth range between 30 and 70 m depth (Basso *et al.*, 2016a). Depth ranges are however variable between areas. For example, around Linosa Island the RMBs thrive between 50 and 95 m (Romagnoli *et al.*, 2021; Innangi *et al.*, 2024) whereas around the Pontine Archipelago (Tyrrhenian Sea) they are found mainly between 60 and

110 m (Sañé *et al.*, 2016). The deepest and largest RMBs in the Mediterranean are in the Balearic Sea (Basso *et al.*, 2016a).

Methods for the acquisition of spatial data

The document elaborated by SPA/RAC (UNEP/MAP-SPA/RAC. (2019). Monitoring protocols of the Ecosystem Approach Common Indicators 1 and 2 related to marine benthic habitats (Meeting Report No. UNEP/MED WG.474/3; p. 171). Tunis) lists the main methods for data acquisition at different depths and scales.

Surveys for mapping CAs and other calcareous bio-constructions generally use several remote sensing techniques based on acoustic means coupled with ground-truthing by use of photos, videos or samples. Images are often acquired through the use of Remotely Operated Vehicles (ROVs) (e.g. Pierdomenico *et al.*, 2021). Integrating multibeam and side scan sonar data with ROV observations allows the identification of coralligenous reefs based on geomorphological and acoustic characteristics and characterisation of the coralligenous assemblages. Such approaches are used for example in Italy (e.g. Pierdomenico *et al.*, 2021) for MSFD assessment.

The spatial distribution of coralligenous cliffs appears more delicate to determine since cliffs are more difficult to identify on acoustic data (see Piazzi *et al.*, 2023a).

To detect coralligenous outcrops, side scan sonar (SSS) and multi-beam echo sounder backscatter (MBES) are the techniques most frequently used (see Dimas *et al.*, 2022). Together with ground truthing acoustic data are processed and interpreted and classified to produce habitat maps. The use of other acoustic data such as sub-bottom profiler (SBP) has also been reported as being successful (Dimas *et al.*, 2022). These authors propose a classification scheme that could be useful for other CA spatial distribution surveys.

Similar methods are used for spatial and bathymetric delimitation of RMBs (UNEP-MAP-RAC/SPA, 2015b; Ingrassia *et al.*, 2019). A two-step approach is proposed for the definition, identification, delimitation, description and monitoring of RMBs by Basso *et al.* (2016b).

Recent data acquisition

Since the publication of Martin *et al.* (2014) and the adoption of the new Action Plan in 2016, progress has been made in data acquisition on spatial distribution of **CAs** and **RMBs** in several Contracting Parties. This recent data enriches the work on spatial distribution published by Martin *et al.* (2014). The following are of particular interest regarding this concern:

Table 4. Data acquisition relative to spatial distribution of CAs and RMBs in the Mediterranean Sea since 2016

In Albania, mapping of CAs was carried out in 2016 at the National Marine Park of Karaburun-Sazan (see Adromede Oceanology, 2016 and infographic here).

In Algeria, through the MedKeyHabitat Project (PNUE/PAM-CAR/ASP, 2016) habitats including **CAs** were mapped around the island of Rachgoun (Figure 3).

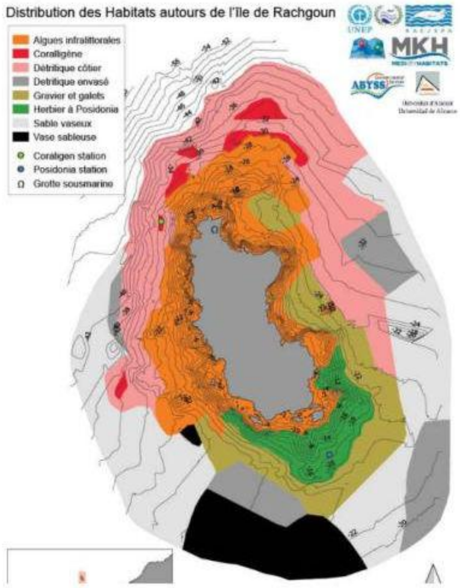


Figure 3. Distribution of habitats around the island of Rachgoun, Algeria (extracted from PNUE/PAM-CAR/ASP, 2016)

In Egypt, surveys have been done where **RMBs** although having a patchy distribution have been identified (UNEP/MAP –SPA/RAC, 2021d).

In France, within the Life Marha programme, the inventory of available spatial data on **RMBs** has been assembled, regularly updated (last update 2024) and made available by the *Office Français de la Biodiversité* (OFB). Metadata is available here.

In Greece habitats have been mapped locally including dense **RMBs** around Gyaros Island Marine Protected Area (Dimas *et al.*, 2022).

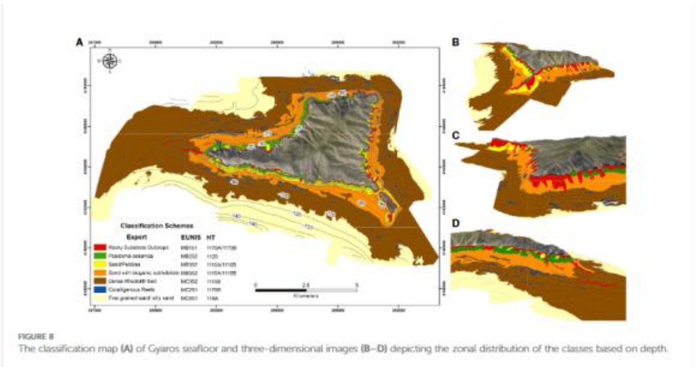


Figure 4. Classification map of Gyaros seafloor and three-dimensional images (from Dimas *et al.*, 2022)

In Greece, the action "Protecting Aegean Sea Coralligene" which is a collaboration among Archipelagos Institute of Marine Conservation, the international environmental organization Oceana, the Biology Department of Essex University, United Nations Regional Action Centre for the Mediterranean (UNEP / MAP – SPA RAC) and the Laboratory of Physical Geography of the National and Kapodistrian University of Athens, with the support of the Pure Ocean Fund, has identified **CAs** in the Aegean Sea.

In Greece, Sini *et al.* (2017) have mapped the known past information augmented by new data and ground-truthing for **CAs** and **RMBs** (Figure 5).

Maps are also available on governmental site here.

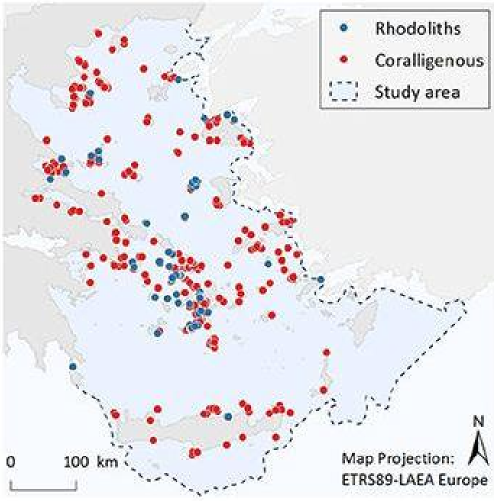


Figure 5. Distribution of coralligenous assemblages and rhodolith beds in the Aegean Sea (from Sini *et al.*, 2017)

In Italy, a distribution map of **RMBs** of the Italian Seas has been published by Ingrassia *et al.* (2023).

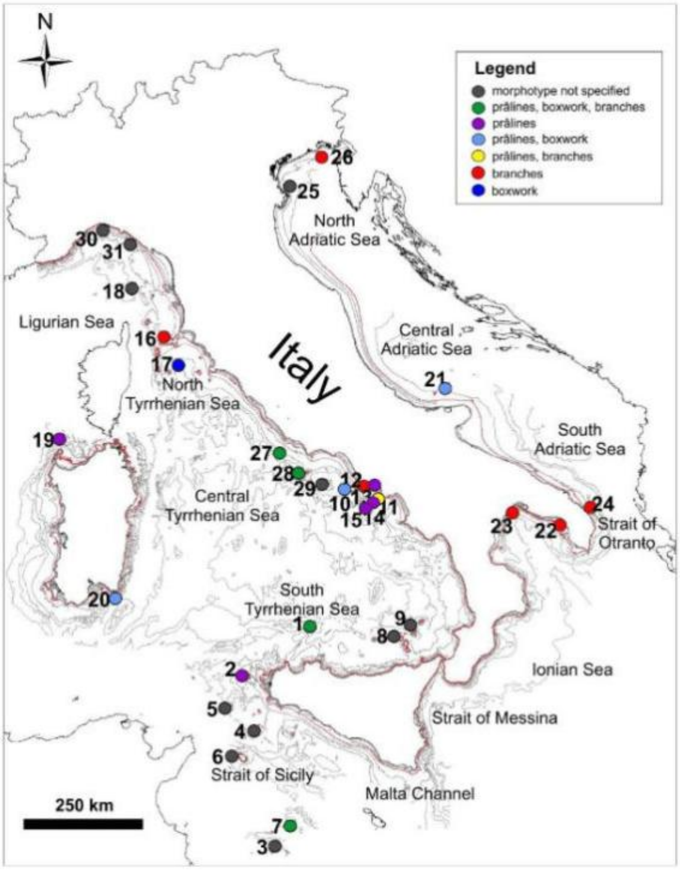


Figure 6. Distribution map of Italian rhodolith/maerl beds with their associated morphotypes (pralines, boxwork, and branches) (from Ingrassia *et al.*, 2023)

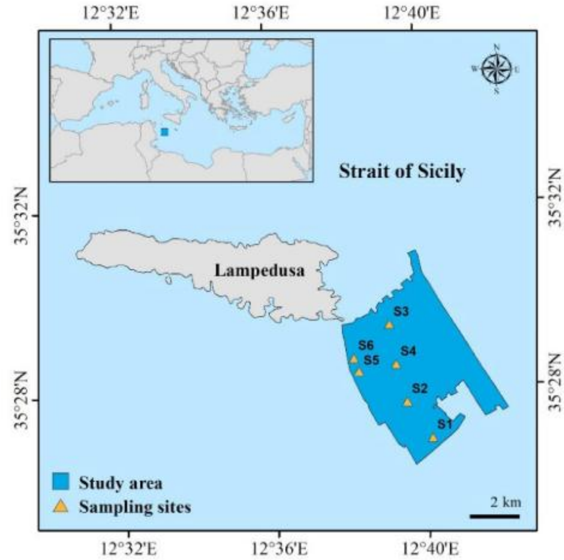
<table>
<tr><td>In <u>Italy</u>, not included in the previous distribution map of RMBs for the Italian Seas, Maggio et al. (2022) present a map of RMBs on southeastern part of Lampedousa</td><td>

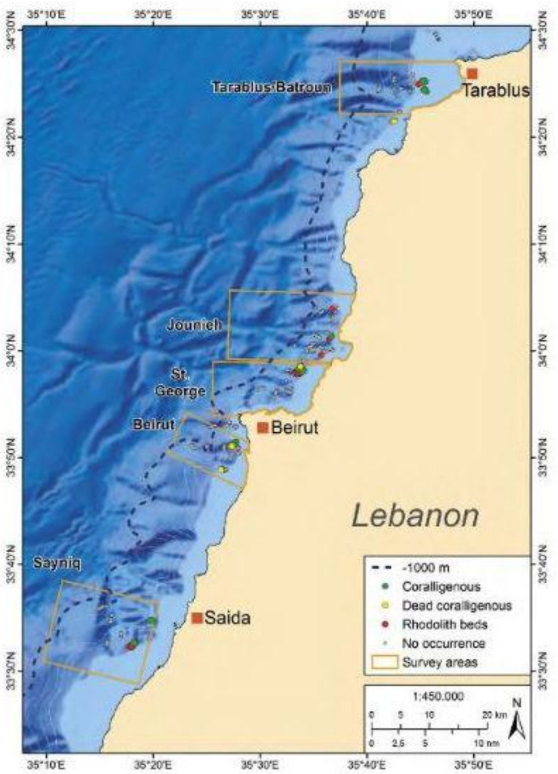
Figure 7. Distribution map of the sampling area for RMBs (from Maggio et al., 2022)</td></tr>
<tr><td colspan="2">In <u>Italy</u>, Molina et al. (2016), Enrichetti et al., 2019b in the Ligurian Sea, Falco et al., 2022 around Sardinia published spatial data on CAs.</td></tr>
<tr><td>In <u>Lebanon</u>, the Deep-sea Lebanon Expedition revealed CAs and RMBs along the continental shelf break and head of canyons of Lebanon (Aguilar et al., 2018) (Figure 8).</td><td>

Figure 8. Coralligenous assemblages and maerl beds observed during the Deep-sea Lebanon expedition (from Aguilar et al., 2018)</td></tr>
<tr><td>In Malta, Tabone et al. (2024) published a map on the distribution and density of RMBs in eastern part of Malta.</td><td></td></tr>
</table>

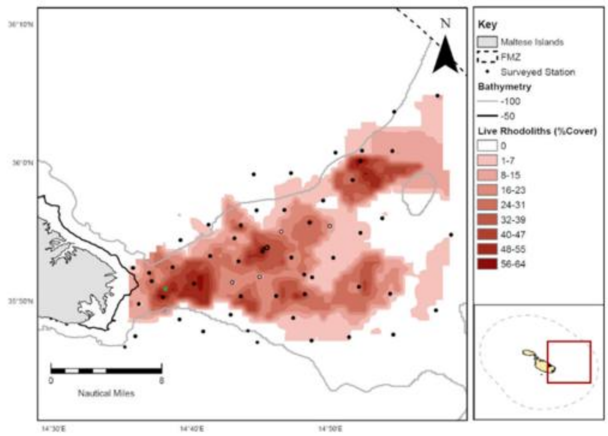


Figure 9. Live rhodolith density (% cover) within the surveyed area generated by ‘Kriging’ interpretation of the densities recorded at the surveyed stations (from Tabone *et al.*, 2024)

In Montenegro, the presence of **CAs** has been confirmed in three locations in Boka Kotorska Bay (see Gef Adriatic Project and infographic here).

In Spain, Illa-Lopez *et al.*, 2023 has further investigated **RMBs** along the east coast of Spain near the Balearic Islands by ROV

At the Mediterranean Sea level, the CorMedNet website (Linares *et al.*, 2022) regroups spatial distribution data concerning habitat-forming invertebrates from **CAs**.

At Mediterranean Sea scale, the latest map of **RMB** distribution has been published by Basso *et al.* (2016a) (see Figure 10). Three closer look ups of (i) the western Mediterranean including the coast of Spain, Morocco, Algeria and France, (ii) the coast of France including Corsica, Italy and Tunisia and (iii) the Levantine and Marmara Sea are available in the document.

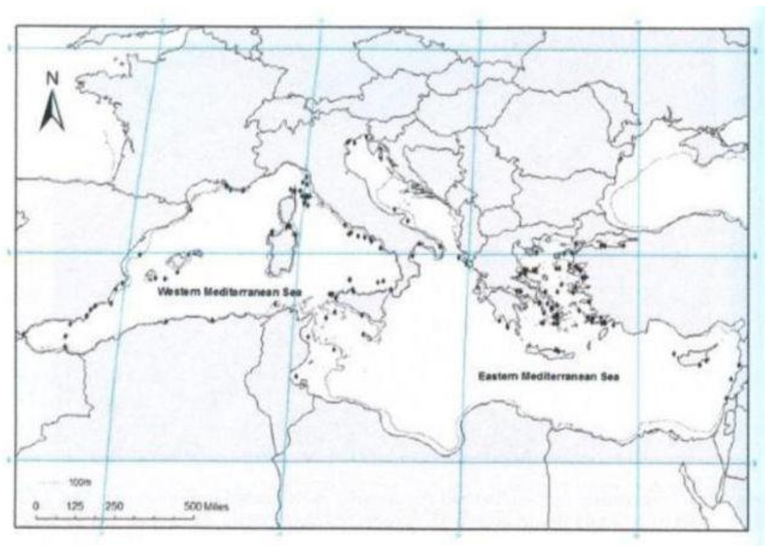


Figure 10. Rhodolith beds of the Mediterraen Sea (from Basso *et al.*, 2016)

Predictive modelling

Predictive habitat models can guide cost-effective field surveys for data acquisition. A few cases of fine scale predictive habitat distribution have been published such as in Italy in the Tyrrhenian Sea (Ingrassia *et al.*, 2019) and other larger scale approaches have been improved thanks to new existence/absence of coralligenous formations data (Fakiris *et al.*, 2023).

In 2021 EMODnet published modelled spatial distribution maps of CAs and RMBs at Mediterranean Sea scale (see Figure 11 and Figure 12). For the Mediterranean Sea, the modelled spatial distribution of maerl originates from Martin *et al.* ‘2014).

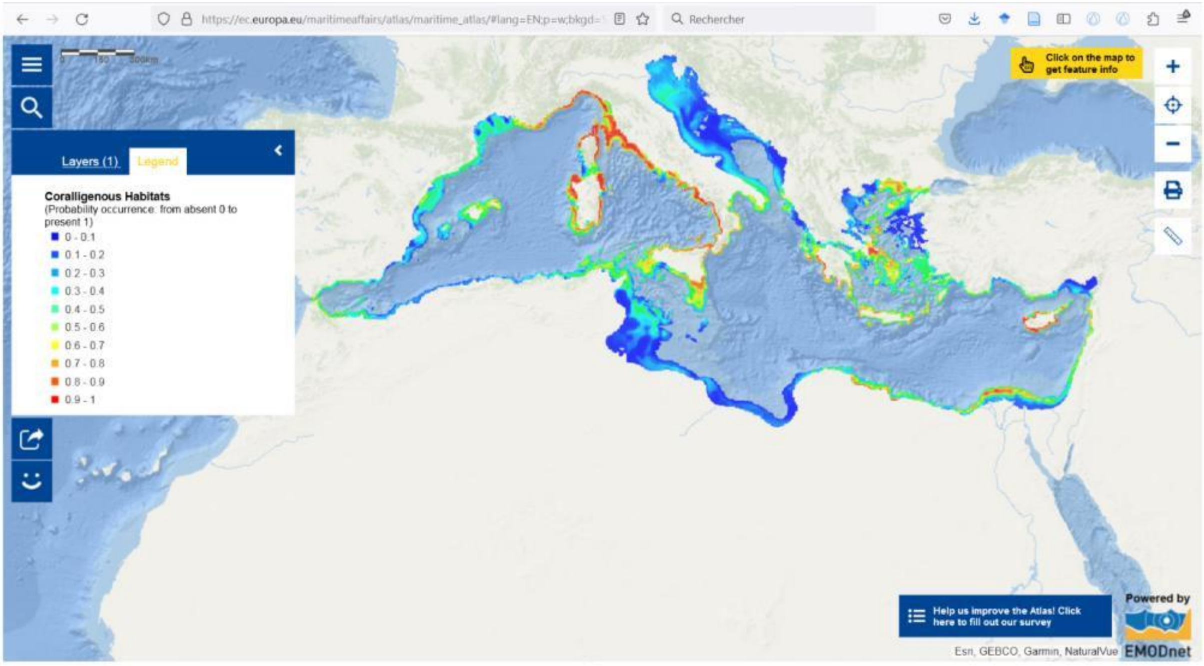


Figure 11. Predictive modelling of coralligenous assemblages (CAs) spatial distribution available through EMODnet website see here.

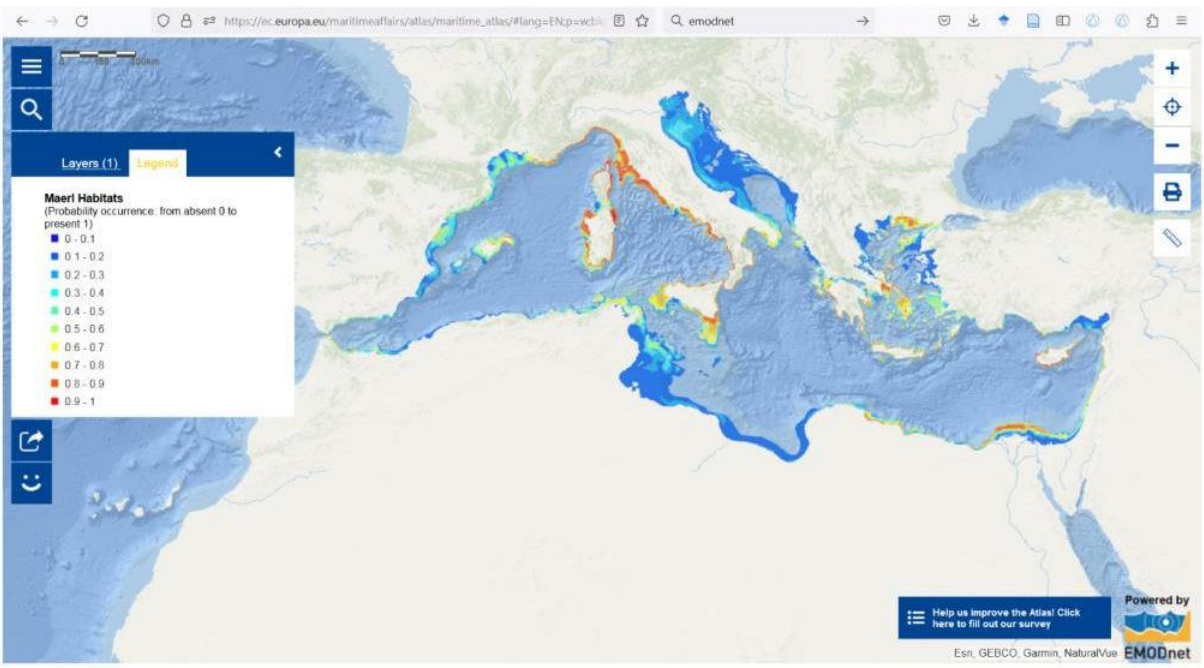


Figure 12. Predictive modelling of maerl beds spatial distribution in the Mediterranean available through EMODnet website see here.

Key points

Progress has been made in acquisition of data on spatial distribution of CAs and RMBs in the Mediterranean Sea since 2016. Yet, mapping rather deep habitats represents a challenge and although progress is ongoing, there is still a strong need to map and inventory CAs and RMBs as recognised in the Post-2020 SPABIO (UNEP-MAP/SPA-RAC, 2021a) and OCEANA (Fournier *et al.*, 2020).

A comparison of the modelled maps with the currently known spatial distribution of CAs and RMBs could help defining areas that would be of interest for survey.

When assessing spatial distribution of habitats, few studies will map the absence of CAs or RMBs although such information is very useful in particular for informing and refining predictive habitat modelling.

Further, mapping of typical species such as *Paramuricea clavata* or *Eunicella cavolini* could be considered (e.g. Ponti *et al.*, 2018 for Italy and Croatia) to inform spatial distribution of CAs.

1.2. Composition and structure

The encrusting calcareous red algae are the primary layer builders of CA communities (Bracchi *et al.*, 2022) on which other species may develop forming a second and third stratum. Variability of structure and dynamics will spatially vary depending on exposure to different environmental variables (Piazzi *et al.*, 2021; Basso *et al.*, 2022).

Assessment of changes in composition and structure of CAs over time are most frequently based on visual methods, either by direct observation (e.g. Azzola *et al.*, 2022) or more frequently by using photo-quadrats by diving (e.g. Çinar *et al.*, 2020) or ROV (e.g. Ferrigno *et al.*, 2020), or both (Piazzi *et al.*, 2022). Casoli *et al.* (2021) used photo mosaicking on Giglio Island, Italy, which further informed on exposure and spatial structure at local scale. In 2021, for the sixth field campaign of the Gobessa expedition on the coralligenous/maerl rings discovered North of Cape Corse (Corsica, France) in 2011 (see Bonacorsi *et al.*, 2012), a pressurised module was used allowing the four divers to dive during 20 days with recyclers and avoiding decompression stops. They were therefor able to study and photograph in detail the structure and spatial architecture of these unusual coralligenous habitats (see here and Deter *et al.*, 2022).

García-Gómez *et al.* (2020) assessed long term temporal variation CA based on sessile bioindicators in the Straits of Gibraltar Natural Park using photos extracted from underwater video and fixed quadrats. Such temporal series (here 10 years) are very valuable for evaluating reference conditions and changes in the assemblages. Such image-based monitoring methods are low cost, request little effort and expertise and can be efficient to monitor changes on the long term in coralligenous communities. However, such approaches need to be well planned in terms of e.g. areas and surface selected to implement fixed quadrats, image definition and treatment.

Few recent studies have focused on the associated motile fauna of CAs. Soldo and Glavičić, (2020) describe a method of Underwater Visual Census (UVC) specific to deep vertical rocky reefs (Deep Vertical Transect DVT method) which was applied to a coralligenous cliff in Croatia between 9 and 60 m depth. The method is thought to increase SCUBA diving security when working deep and has proven efficient in assessing coralligenous cliff associated fish community. 56 species were identified of which 41 were reef associated fish. Later, this assessment was completed by the square with anaesthetics method for assessing cryptogenic fish with which 28 fish were recorded, including 15 species that had not been recorded in the DVT assessment (see Soldo *et al.*, 2021). The combination of methods in such complex habitats such as the CAs is considerably more efficient than the use of a single method (e.g. Piazzi *et al.*, 2012; Piazzi, 2016; Soldo and Glavičić, 2020) which have counted around 40 fish species associated to coralligenous reefs.

Two recent programmes in the Gulf of Lion Marine Park study (i) the relationship between habitat complexity and biodiversity using innovative tools in coralligenous assemblages and Posidonia (TISCO programme) and (ii) the links between the 3D structure of coralligenous assemblages and vagile and sessile populations (INNOMOTO programme). Results should be soon available.

CAs host the highest acoustic sound biodiversity reported so far in the Mediterranean Sea in comparison with other assemblages (Di Iorio *et al.*, 2021). Spatial variations in fish-related acoustic diversity identified for CAs could be related with structural heterogeneity of CAs (see Di Iorio *et al.*, 2021) however further studies are needed using these methods.

The structure of the coralligenous ecosystem food web was studied in Marseille, France by Belloni *et al.* (2019) who described a first attempt of an isotopic characterisation of the coralligenous food webs.

Metabarcoding approach appeared promising (De Jode *et al.*, 2019) for CAs diversity but requires destructive sampling and would need further studies to be used for CAs.

Just as CAs, **Rhodolith/maerl beds (RMBs)** are greatly variable habitats which composition and morphology can highly differ from one area to another and which are also dependant of environmental factors (Basso *et al.*, 2016a, 2016b; Chimienti *et al.*, 2020; Cabrito *et al.*, 2024a). Rhodoliths have been classified in (i) compact and nodular pralines, (ii) large and vacuolar boxwork rhodoliths and (iii) unattached branches depending on their forms (Basso *et al.*, 2016b and references therein). The criteria to identify rhodolith beds, the species of calcareous red algae that can be found, and essential elements for assessing and monitoring rhodolith beds have been proposed by Basso *et al.*, 2016b.

Cabrito *et al.*, 2024b have explored non-extractive technics to study fish diversity associated to rhodolith beds: still video cameras, environmental DNA metabarcoding and bioacoustics. Despite the difficulties and limitations of these new technics, the authors advocate the implementation of monitoring programmes using the three non-extractive technics that inform and document on fish species associated to rhodolith beds.

RMBs are structurally complex three-dimensional habitats which offer ecological niches for number of organisms (Cabrito *et al.*, 2024a). Their composition is variable and few rhodolith beds have been studied in terms of composition, structure and function except for those around the Balearic Islands and the adjacent coast of Spain where several studies have been led (e.g. Farriols *et al.*, 2021; Illa-López *et al.*, 2023; Cabrito *et al.*, 2024a, 2024b), and around the Maltese Islands (Deidun *et al.*, 2022) where grab samples were used combined with ROV video transects to describe the biodiversity associated to RMBs.

Key points

Studies on the composition of CAs and their variation in time and space are complex. CA patterns differ from one area to another of the Mediterranean (Casa-Güell *et al.*, 2016; Sini *et al.*, 2019; Çinar *et al.*, 2020). Although the compositions of north-western Mediterranean CAs have been quite well described, characterisation of the CAs and RMBs composition at CP and sub-regional level is still needed especially in the south-eastern part of the Mediterranean Sea.

Studies on composition and structure of CAs are most often based on sessile species, however studies with an ecosystem approach taking in consideration the species associated with CA sessile species are more informative and could further allow to understand the dynamics and resilience capacities of CAs and RMBs.

1.3. Population dynamics of typical/key species

As indicated in the previous status of implementation of the Action Plan (UNEP(DEPI)/MED WG.408/inf.7 see UNEP/MAP-SPA/RAC, 2015a), the **CAs**' typical/key species such as calcareous algae, gorgonians, sponges or bryozoans, are generally long-lived species with low growth, natural mortality and recruitment rates. For these sessile species, it is generally at larval stage that dispersal takes place.

The most studied CAs' key species in terms of population structure and dynamics are conspicuous anthozoans such as *Paramuricea clavata*, *Eunicella cavolini*, *Eunicella singularis.*

Palma *et al.* (2018) describe and test a Structure from Motion (SfM) based method for the estimation of gorgonian population structure (e.g. height, density, fan surface, etc.). Although this method seemed more accurate for medium to low densities of populations than for dense populations, it could contribute to assess more efficiently the dynamics of large three-dimensional CA species.

Dispersal potential of anthozoans had already been studied in the past (e.g. Linares *et al.*, 2006, 2007), and several recent studies contribute to further understand the dynamics of these key structuring species (e.g. Pilczynska *et al.*, 2016 for *P. clavata* in Italy; Padrón *et al.*, 2018a for *E. singularis* in the Gulf of Lions; Sciascia *et al.*, 2022 for *P. clavata*).

Although larval dispersal of sessile benthic species is dependant of many variables (e.g. environmental such as currents or larval traits such as pelagic larval duration etc.), modelling of larval dispersal and gene flow studies to better apprehend connectivity processes between populations under climate change context could be efficient in designing a protected areas network able to maintain connectivity between populations (see Padrón *et al.*, 2018a, b; Sciascia *et al.*, 2021). Moreover, Blouet (2023) studied the role of artificial reefs in enhancing connectivity between populations of structuring anthozoans by make up for inexistent or impacted hard substrates.

Strait forward guidelines for larval dispersal simulations have been drawn by Sciascia *et al.* (2021) and could be useful for studies and simulations in other areas, however, connectivity predictions for gorgonian species requires certain precautions (Sciascia *et al.*, 2022).

Pilczynska *et al.*, 2016 studied genetic diversity and connectivity of *P. clavata* in Italy and indicated that their observations of larval exchange between sites supported the hypothesis that deeper subpopulations unaffected by MHWs may provide larvae for shallower populations and enable recovery after mortality events. However, a few years later scientific publications on the subject are much less optimistic.

Key species of **Rhodolith and Maerl Beds** have been less studied especially in relation with population dynamics. Research is still mainly focused on species lists as for: calcareous red algae in Southern Spain (see Del Río *et al.*, 2022), sponge species in RMBs in Ustica, Italy (see Longo *et al.*, 2020). Research must be encouraged to better understand the dynamics and the functioning of RMBs.

Key points

Population dynamics of CA typical key species mainly concern large erect anthozoans. Assessing their population structure (height, density etc.) is difficult on photos due to their three-dimensional development and the fact that photos are generally taken at the perpendicular of their axis. This has probably limited such studies. However, the recent method of structure from motion (SfM) could be helpful to assess anthozoan population structure.

Larval dispersal of anthozoans is also studied and simulations can be done (see e.g. Sciascia *et al.*, 2021) however these depend on numerous environmental factors that can vary in time. Such studies are of great interest to define an efficient network of MPAs that would contribute to the conservation of CAs and their key species under climate change impacts.

Population dynamics of RMBs key species have been less studied.

1.4. Pressures and threats

CAs and RMBs are complex ecosystems that develop often under various local and global anthropogenic pressures.

The integrity of **CAs** can be threatened by several anthropogenic pressures such as:

- anchoring,
- sedimentation due to e.g. aquaculture activities (Piazzi *et al.*, 2019a),
- eutrophication/chemical pollution,
- litter (e.g. Giménez *et al.*, 2022),
- abandoned fishing gear (e.g. Enrichetti *et al.* 2019a; Ferrigno *et al.*, 2021; Angiolillo *et al.*, 2023),
- fishing activities (e.g. Ferrigno *et al.*, 2018),
- diving activities (Betti *et al.*, 2023)
- various climate change impacts (i.e. increase in sea temperature, acidification, Marine Heat Waves (MHW), instalment of Non Indigenous Species (NIS), development of mucilaginous blooms (Piazzi *et al.*, 2018)) and
- cumulative effects

Assessing the impact of each pressure is possible by using different metrics (see metrics by stressors listed by Di Camillo *et al.* (2023)) and can be of interest, but being able to assess in an easy way the general state of the CAs is essential for MPAs and stakeholders.

Several rapid methods have been developed to assess the state of CA conspicuous species such as the Mortality Rapid Assessment Method proposed by Figuerola-Ferrando *et al.* (2024) which may be applied to several marine habitat forming species and was in this case applied on *P. clavata* colonies. The authors indicate that it is a reliable, coast effective approach to assess the health status of *P. clavata* populations especially suffering from climate change or cumulated impacts. Such methods can be also applied by non-specialists extending the possibilities of data acquisition. Further, although such methods inform only on the state of a selected species population within CAs, it can be used as a first assessment by stakeholders to identify vulnerable CAs.

A cumulative pressure and impact assessment (CPIA) approach was applied to coralligenous outcrops in Italy (Bevilacqua *et al.*, 2018) which allowed to map expected cumulative pressures and impacts on CAs in six categories. The field surveys on these CAs showed a clear shift from bio-constructors to turf dominated assemblages as pressure increased but revealed also that the original CPIA model needed refinement and adaptation underlining the need of survey data (Bevilacqua *et al.*, 2018).

CA three-dimensional structuring species can be impacted by derelict fishing gear which get entangled in their structures and wound the colony leading to necrosis of part or the entire colony (e.g. as shown in Italy see Ferrigno *et al.*, 2018; Angiolillo & Fortibuoni, 2020; Giménez *et al.*, 2022; Angiolillo *et al.*, 2023). Such specific threats are rather easily identified and assemblages' vulnerability can be assessed in view of protective measures by limiting the identified known threat, fishing activities, in the area concerned (see Enrichetti *et al.*, 2023). Enrichetti *et al.*, 2019a describe a case study in Italy where CA anthozoans are impacted near a MPA. The authors suggest the creation of a Fisheries Restricted Area (FRA) or a no take zone for the conservation of this CA. Another example is given by Ferrigno *et al.* (2020) who reveal the case of red coral populations in Italy which are indirectly impacted by nearby trawling activities that increase turbidity.

However scientific publications of these last years have focused on climate change impacts on CAs such as increasing Sea Surface Temperature (SST) but above all **Marine Heat Waves** (MHWs) impacts and associated **Mass Mortality Events** (MMEs). These events are generally sudden and lead to mortality of large species which change the underwater landscape especially of CAs.

The past decades, SST has been increasing in the entire Mediterranean Sea although it is spatially variable, eastern Mediterranean Sea showing a more important positive trend (Martinez *et al.*, 2023). Adding to the positive trend of sea temperature, MHW have been described affecting unequally different areas of the Mediterranean Sea (Juza *et al.*, 2022) and frequently triggering Massive Mortality Events (MME) including within CAs (Garrabou *et al.*, 2022).

The Mediterranean Sea is undergoing an acceleration of climate change impacts with increasing mean temperatures but also increased frequency and intensity of MHWs (Dayan *et al.*, 2023) which induce MME of species from several phyla and down to 40-45 meters depth (Garrabou *et al.*, 2021, 2022; Estaque *et al.*, 2023 concerning *P. clavata* around Marseille; Grenier *et al.*, 2023 concerning coralligenous species in Marseille area; Orenes-Salazar *et al.*, 2023 concerning *E. singularis* resilience on long term survey). MHWs and consequent MMEs are considered as the biggest emerging threats to marine biodiversity in the Mediterranean Sea (Garrabou *et al.*, 2021; Di Camillo *et al.*, 2023) threatening the distribution and the survival of CA key structuring species such as anthozoans. Moreover, the anthozoan forest microbiomes are highly sensitive to thermal anomaly (Corinaldesi *et al.*, 2022). The authors reveal that anthozoan forest microbiomes composition and relative abundance change under heatwave period due to thermal stress and not to coral necrosis.

Several authors (e.g. Crisci *et al.*, 2017; Gómez-Gras *et al.*, 2022) have shown that 25°C is a critical temperature for the structuring coralligenous anthozoan *P. clavata.* Such temperatures for a week become even lethal for the specie (Crisci *et al.*, 2017). Experiments showed that thermal stress affect the colonies from different Mediterranean areas (Adriatic or Western Mediterranean) in the same way (Gómez-Gras *et al.*, 2022). Adaptability potential to MHW for *P. clavata* has been shown to be very limited (Ramírez Calero *et al.*, 2024; Rovira *et al.*, 2024) pointing to an alarming collapse of shallow populations of *P. clavata*. Capdevilla *et al.*, 2023 indicate that future climate conditions will increase octocoral populations' vulnerability to other pressures and *P. clavata*'s population decrease will accelerate. Further effects of MMEs appear to be cumulative so their resilience is currently decreasing (Orenes-Salazar *et al.*, 2023). Also, areas that had been considered as acting as climatic refuge (e.g. Medes Islands Marine Reserve or deep temporary refugee see Bramanti *et al.*, 2023), have been lately severely affected by MHWs (Rovira *et al.*, 2024).

The loss of structuring species of the coralligenous could trigger reduction in the resilience of the entire assemblages especially in shallow depths, simplify habitat complexity and increase vulnerability to be colonised by invasive species (Gómez-Gras *et al.*, 2021a; Verdura *et al.*, 2019). The role of Marine Protected Areas in such conditions is crucial and should aim at containing all local pressures on structural species such as fishing and diving impacts (Zentner *et al.*, 2023) to decrease vulnerability of these species.

Gómez-Gras *et al.* (2021a) have shown that in a well enforced MPA of Corsica, population of *P. clavata* and red coral (*Corallium rubrum*), two structuring species of the CAs, had not recovered 15 years after a sever MHW and were even showing a collapse trend. Further, by impacting these three-dimensional habitats forming octocorals, CAs become deficient in key functional traits, most probably affecting ecosystem functioning (Gómez-Gras *et al.*, 2021b). Further studies are needed to better understand how MHWs affect functional structure of CAs (Gómez-Gras *et al.*, 2021b), especially since it has been shown that several species from CAs are affected by thermal stress (Gómez-Gras *et al.*, 2019; Grenier *et al.*, 2023).

Martinez *et al.* (2023) have compiled a detailed catalogue (area concerned, duration etc.) of the main MHW events (20 events) detected in the Mediterranean Sea during the period 1982-2022 using detrended data. The authors compare original and detrended SST time series and show that the increase in MHW occurrence is mainly driven by a temperature trend. This may help distinguish temporary changes from long term changes and better adapt conservation and restoration actions. This point relating to what baseline to use is crucial and both approaches are informative (Amaya *et al.*, 2023).

Hobday *et al.*, 2016 have given a quantitative definition MHW[6] with reference a 30 year baseline value. Such a definition for MHWs facilitates comparisons between different datasets across regions and seasons in identifying MHWs. However, other authors such as Amaya *et al.* (2023) and Martinez *et al.* (2023) consider that although such an approach is informative and appropriate for certain analysis, using a shifting baseline or detrended data is also informative because of increasing mean sea temperature. In such approaches, MHWs will remain “exceptional” events whereas if compared to a long term mean temperature (e.g. 30 years), the Mediterranean Sea might soon be considered in a constant MHW situation.

Predictive models have been used to foresee MHW in the Mediterranean Sea (Darmaraki *et al.*, 2019) and what is considered as a MHW at the beginning of the 21st century could in a near future become the norm since the MHW will become longer and more intense.

Future scenarios of acidification impact on coralligenous and their ecosystem services have been modelled by Zunino *et al.* (2019) and profound changes are to be expected in the near future. Also, Vitelletti *et al.* (2023) have worked with predictive models in Northern Adriatic and describe that widespread modifications in CAs and shifts in habitat distribution are to be expected under severe climate change conditions.

Concerning MHWs impacts and MMEs relative to Coralligenous Assemblages, it is important to work at sub-regional level rather than national or Mediterranean scale as underlined by the studies of Crisci *et al.* (2017), Gómez-Gras *et al.* (2022), and Bramanti *et al.* (2023). However, agreeing on definitions and common references and how to determine threshold values and indexes are essential at Mediterranean Sea scale to ensure comparability (see Hobday *et al.*, 2016; Amaya *et al.*, 2023; Martinez *et al.*, 2023).

TMEDNet is an initiative devoted to *develop an observation network on climate change effects in marine coastal ecosystems by spreading the acquisition of standard monitoring protocols on seawater temperature and biological indicators over large-scale and long-term*. The site proposes guidance on monitoring mortality, temperature and climate fish. Data can be uploaded once logged in, and visualized in different ways. Such an initiative at Mediterranean scale should be supported and could represent a functional platform contributing to coralligenous conservation. Further collaboration could be searched between SPA/RAC and TMEDNet.

Environmental conditions highly contribute to shape **Rhodolith/Maerl Beds (RMBs)** which are also variable assemblages throughout the Mediterranean Sea. Their spatial distribution, composition, structures and functioning are poorly known in the Mediterranean (Basso *et al.*, 2016a). However, RMB appear vulnerable to several pressures, in particular trawling, and although RMBs show recovery capacities (Farriols *et al.*, 2021), their resilience appears limited. Several studies have focused on the impact of benthic trawling on RMBs in the Mediterranean Sea (e.g. Barberá *et al.*, 2017; Farriols *et al.*, 2021). Farriols *et al.* (2021) indicate that benthic trawling decreases the abundance of by-catched large ascidians, porifera and certain echinoderms in RMBs. Higher abundance of litter and fishing gear have also been correlated to lesser cover of rhodoliths (Rendina *et al.*, 2020). Fragkopoulou *et al.*, 2021 present a world-wide study on rhodolith distribution and threats and alert on the combined impacts of climate change and benthic trawling on the distribution of rhodolith beds.

[6] Hobday *et al.*, 2016 propose to define MHW with the use of the threshold of the 90th percentile based on a 30-year historical baseline period and that lasts at least five continuous days above the threshold.

Key points

RMBs and CAs are vulnerable to different anthropogenic pressures especially fishing gear and climate change. Entanglement with fishing gear (mainly long lines and gill nets) represents another important threat for CAs. Climate change impacts such as Marine Heat Waves (MHWs) which can trigger Mass Mortality Events (MMEs) have severely impacted populations of CA key species such as anthozoans and represent an important threat for CA composition and dynamics, especially for shallow assemblages.

what appears as the main threat to RMBs is the use of benthic trawling over the beds or around the RMBs. Climate change impacts on RMBs seem less visible and therefore less studied. Currently

1.5. Assessing the state of the assemblages

Numerous indexes have been developed to evaluate the state of the CAs and/or the pressure they undergo. They are based on different assessment means (e.g. visual methods, sampling, images by diving or ROV) and can assess general state or more specific anthropogenic pressures. Among the most recent published one can find:

→ Mesophotic Assemblages Ecological Status (**MAES**) and quick MAES (**q-MAES**) (see Canovas-Molina *et al.*, 2016)

→ Overall Complexity Index (**OCI**) (see Paoli *et al.*, 2016)

→ Coralligenous Bioconstructions Quality Index (**CBQI**) (see Ferrigno *et al.*, 2017) can compare different types of coralligenous habitat (rocky cliffs, submerged shoals and platform banks).

→ Ecological Status of Coralligenous Assemblages Total Assessment (**ESCA-TA**) (see Piazzi *et al.*, 2017)

→ Integrated Sensitivity Level of coralligenous Assemblages (**ISLA**) (see Montefalcone *et al.*, 2017)

→ **INDEX-COR** approach based on photographic sampling coupled with in situ observations (see Sartoretto *et al.*, 2017).

→ **Index of 3D Structural Complexity** which assesses different anthropogenic impacts (see Valisano *et al.*, 2019)

→ Mesophotic Assemblages Conservation Status (**MACS**) which includes two independent components an index on the status and one on the impact is described and applied to Italian sites in the WMed (Enrichetti *et al.*, 2019b).

→ STAndaRdized coralligenous evaluation procedure (**STAR**) (see Piazzi *et al.*, 2019 b)

→ Assessment of Ecological state, functioning and level of pressure through use of several indices defined in the document to evaluate the state of the CAs in France for each costal water body through the RECOR network (Andromède Océanologie & Agence de l'eau RMC (Ed.). (2020). *Atlas de synthèse – Année 2020. Surveillance biologique et qualité des eaux de Méditerranée*.)

→ **MedSens** sensitivity index which uses citizen science (see Turicchia *et al.*, 2021)

→ **NAMBER** index for assessing the ecological quality of N. Adriatic CAs which differ a lot from CAs in other areas (see Piazzi *et al.*, 2023c).

Since 2009, more than 16 indexes have been defined to assess the ecological quality of Mediterranean CAs and the impact of anthropogenic pressures on them. De Camillo *et al.* (2023) have published a comprehensive review and comparison of these indexes with the objective of

proposing a framework to support the development of a cost-effective and practical index to assess the status of CAs.

Hardly any specific indexes have been developed and published to assess the state of the **RMBs** in the Mediterranean Sea. However, an attempt to define an ecosystem approach assessment of the RMBs has been published by Astruch *et al.* (2023).

Key points

To be able to assess the state of the Coralligenous Assemblages and the Rhodolith/Maerl Beds at subregional and regional scale, data acquired and indexes used must be comparable and data acquired must be made available. De Camillo *et al.* (2023) have published a comprehensive review and comparison of 16 indexes.

1.6. Governance, protection and restoration

Governance and protection

Mediterranean CAs and RMBs are listed under the European Red List of marine habitats where they are classified as Data Deficient (see Gubbay *et al.*, 2016).

The legally protected species that can be found in CAs and RMBs are listed in: UNEP/MAP - SPA/RAC. (2021). Guidelines for the assessment of environmental impact on coralligenous and maërl assemblages (No. UNEP/MED WG.502/Inf.3; p. 58). Tunis: UNEP/MAP SPA/RAC.

Several species which can be found in CAs such as anthozoans and sponges are described as vulnerable species with regard to the Mediterranean fisheries in the *Identification guide of vulnerable species incidentally caught in Mediterranean fisheries* (see Otero *et al.*, 2019).

CAs and RMBs are elements for MSFD D6 (seafloor integrity) GES criteria and are requested to be assessed under D6C3, D6C4 and D6C5. However few EU countries have reported on the extent and other parameters (see Tornero Alvarez *et al.*, 2023).

It is considered that CAs and RMBs have been generally insufficiently mapped and protected in most EU member states (Fournier *et al.*, 2020). The report by Fournier *et al.* (2020) indicates that high intensity of bottom trawling over CAs occurs in one Mediterranean member state and over RMBs in another state underlining the need to enforce already existing legal instruments and perhaps extend deeper (e.g. 150 m depth) the prohibition of this fishing gear.

CAs and RMBs are requested to be assessed under IMAP EO1 *Biodiversity* CI1 (Habitat distributional range to also consider habitat extent as a relevant attribute) and CI2 (Condition of the habitat's typical species and communities). However, very few CPs have reported on these indicators for CAs and RMBs.

Within the Barcelona Convention and the SPA/BD Protocol, Contracting Parties have agreed on the *Action Plan for the Conservation of the coralligenous and other calcareous bio-constructions in the Mediterranean Sea* which is regularly evaluated and updated.

CAs and RMBs can be protected from several anthropogenic threats by being included in Marine Protected Areas. Moreover, CAs and RMBs being often heavily impacted by different fishing activities, their conservation could also be enhanced by protecting them under Fisheries Restricted Areas (FRAs) as suggested by Enrichietti *et al.* (2019a). A FRA has been defined by the GFCM as "*a geographically-defined area in which all or certain fishing activities are temporarily or permanently banned or restricted in order to improve the exploitation and conservation of harvested living aquatic resources or the protection of marine ecosystems in the GFCM area of application*." (FAO-GFCM, 2008). Therefor a request of a FRA can be justified by the existence of vulnerable CAs and RMBs that needs to be protected from relevant fishing activities.

Restoration

In the Post 2020-SAPBIO, it is requested that CPs develop the inventory of ecosystems with the highest ecological relevance and/or regeneration potential such as coralligenous assemblages and that restoration activities have started on 30% of the ecosystems favouring nature-based solutions by 2027 which should be completed on most of the priority areas by 2030 (Action 12, Post-2020 SAPBIO, see Actions Table Annex III in UNEP/MAP-SPA/RAC, 2021a).

Restoration can take place relatively to an area (surface), a species population or a habitat. Attempts to restore marine ecosystems or habitats will consist of protecting and enhancing the development of one or several key species.

Passive restoration consists of removing anthropogenic threats and leaving the ecosystem gradually regenerate and restore itself. Strictly protected Marine Protected Areas apply such a restorative approach in a given area. Active restoration in marine environment generally consists of assisting the recovery of a structure or function of a habitat or ecosystem or enhancing species population dynamics, either by adding or removing species, individuals or removing physical disturbance (e.g. fishing gear).

Few examples of active restoration relative to CAs have been published. They mainly concern the restoration of anthozoan populations such as gorgonians in Giglio Island, Italy after a wreck removal operation (see Casoli *et al.*, 2022), or the deployment of by-catched gorgonians in the Cap de Creus MPA, Spain (see Montseny *et al.*, 2019).

A research programme on transplantation of *Corallium rubrum* and *Paramuricea clavata* was led in Southern France to study the rate of survival of the transplants in view of using such techniques for active restoration in areas where the populations of these species have suffered from anthropogenic pressures and climate change impacts (see TRANCOR project, Estaque *et al.*, 2022).

Key points

CAs and RMBs are recognised as vulnerable and data deficient assemblages. They should be monitored through EU MSFD and IMAP to assess their state of conservation. However, effective monitoring is ongoing only in few Mediterranean countries.

Undergoing several threats, CAs and RMBs are often not in good condition and are in need of restoration actions (protection from anthropogenic threats or active restoration) to ensure their conservation and functions. Protecting from anthropogenic threats is an essential step towards restoration. Active restoration may be implemented generally by transplantation of gorgonians.

EU Nature Restoration Law[7] recently agreed on, sets legally binding targets to restore at least 30% of the total area of groups 1 to 6 of the habitat types listed in Annex II that is not in good condition by 2030, 60% by 2040 and at least 90% by 2050 (see Article 5 of the law). Maerl beds (group 4) and coralligenous beds (group 5) are included in the marine habitats concerned. This law is of high importance for Marine Protected Areas as underlined by MedPAN (see article here) and for CAs and RMBs.

Assessment and monitoring of CAs and MRBs is therefore a key point to be able to evaluate the effecttiveness of restoration actions.

2. Regional Activities carried out in accordance with the implementation timetable of the Action Plan

2.1. Activities conducted by SPA/RAC

SPA/RAC conducted or participated to the following projects:

[7] Regulation (EU) 2024/1991 of the European Parliament and of the Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869

➢ **MedKeyHabitats (2013-2016) and MedKeyHabitats II (2017-2019) projects**

These projects were executed by SPA/RAC in partnership with IUCN-Med and MedPAN and were financially supported by the MAVA Foundation. The projects aimed at mapping of marine key habitats and assessing their vulnerability and setting up a monitoring system. Beneficiary countries of the project were: Algeria, Cyprus, Libya, Malta, Montenegro, Tunisia, Türkiye and Morocco. In the framework of these projects, CAs and RMBs have been mapped in several MPAs and data is accessible on the Mediterranean Biodiversity Platform. Further, the following guiding book was published concerning CAs and RMBs:

→ UNEP-MAP-RAC/SPA. (2015). Standard methods for inventorying and monitoring coralligenous and rhodoliths assemblages. Pergent G., Agnesi S., Antonioli P-A., Babbini L., Belbacha S., Ben Mustapha K., Bianchi C. N., Bitar G., Cocito S., Deter J., Garrabou J., Harmelin J-G, Hollon F., Mo G., Montefalcone M., Morri M., Parravicini V., Peirano A., Ramos-Espla A., Relini G., Sartoretto S., Semroud R., Tunesi L., Verlaque M. (p. 20pp.+Annex) [Ed. RAC/SPA].

➢ **Deep Sea Lebanon Project (2016-2018)**

The "Deep Sea Lebanon" project was implemented by OCEANA in collaboration with the Ministry of Environment of Lebanon, as main government partner, and CNRS-Lebanon as supportive government partner, and in cooperation with IUCN and UNEP/MAP-SPA/RAC as executing partners; and ACCOBAMS, GFCM as supportive partners. The goal of the project was to build a coherent and comprehensive MPA network by 2020 in the Mediterranean region by strengthening Lebanon efforts to implement its MPA national strategy through the improvement of scientific knowledge about the deep-sea habitats and the identification of the areas that need to be protected and prepare the management guidelines for the official presentation of the MPA proposal to relevant authorities. The project was financially supported by the MAVA Foundation. **Although focusing on deep-sea habitats, at the head of canyons and at the shelf break several CAs and rhodolith/maerl beds were identified.** See the following document:

- Aguilar, R., García, S., Perry, A.L., Alvarez, H., Blanco, J., Bitar, G. 2018. 2016 Deep-sea Lebanon Expedition: Exploring Submarine Canyons. Oceana, Madrid. 94 pages.

➢ **MedMPA Network project (2016-2019)**

The regional project "Towards an ecologically representative and efficiently managed network of Mediterranean Marine Protected Areas" was managed by UNEP/MAP and co-executed by SPA/RAC, WWF-MedPO and MedPAN, with the financial support of the European Union. The global objective of the project consisted of supporting the development of a network of Marine Protected Areas (MPAs) in the Mediterranean which ensures the long-term conservation of key elements of the marine biodiversity and gives significant support to the sustainable development of the region.

SPA/RAC activities focused, among others, on establishing new MPAs through their ecological characterization, including the improvement of scientific knowledge about marine habitats in the areas of Batroun, Medfoun and Byblos in view to extend the national network of marine protected areas in Lebanon. Several CAs and maerl beds are included. See document:

- SPA/RAC–UN Environment/MAP, 2017. Ecological characterization of potential new Marine Protected Areas in Lebanon: Batroun, Medfoun and Byblos. By Ramos-Esplá, A.A., Bitar, G., Forcada, A., Valle, C., Ocaña, O., Sghaier, Y.R., Samaha, Z., Kheriji, A., & Limam A. Ed SPA/RAC. MedMPA Network Project, Tunis: 93 pages + annexes.

➢ **EcAp-MED I (2012-2015) and EcAp-Med II (2015-2019) projects**

The overall objective of these projects was to support the UNEP/MAP Barcelona Convention and its Southern Mediterranean Contracting Parties to implement the Ecosystem Approach (EcAp) roadmap in synergy and coherence with the implementation of the EU Marine Strategy Framework Directive (MSFD). The ultimate goal of the projects is to achieve Good Ecological Status (GES) in the Mediterranean Sea.

SPA/RAC with the Ecosystem Approach Correspondence Group on Monitoring (CORMON) on Biodiversity and Fisheries have published the Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species (see here) for Ecological Objectives (EO) 1 (*Biodiversity is maintained or enhanced*) and 2 (*NIS do not adversely alter the ecosystem*) and the respective Common Indicators: 1. Habitat distributional range (EO1); 2. Condition of the habitat's typical species and communities (EO1); 3. Species distributional range (EO1); 4. Population abundance of selected species (EO1); 5. Population demographic characteristics (EO1); 6. Trends in abundance, temporal occurrence and spatial distribution NIS, and particularly invasive NIS (EO2). Common indicators 1, 2 apply directly to CAs and rhodolith/maerl beds and CI 6 can also concern these assemblages.

Further, the reports of the National Monitoring Programme for marine biodiversity of Lebanon, Morocco and Tunisia (available here) elaborated under these projects include information on the presence of coralligenous assemblages and Rhodolith/maerl beds. The National Monitoring Programme of Israel does not mention CAs and RMBs perhaps because these habitats do not exist.

Additionally, SPA/RAC participated in the following actions:

- **Updating of the SPA/BD reporting system** and format including reporting on the Coralligenous and other calcareous bio-constructions.

- **Updating of classification of benthic marine habitat types in the Mediterranean Sea.** The updated classification includes several types of coralligenous assemblages.

- **Updating of Reference List of Marine Habitat Types for the Selection of Sites to be Included in the National Inventories of Natural Sites of Conservation Interest in the Mediterranean.** The updated reference list includes several types of coralligenous assemblages.

- **3rd Mediterranean Symposium on the conservation of coralligenous and other calcareous bio-concretions (Antalya, Türkiye, 15-16 January 2019) (see proceedings UNEP/MAP-SPA/RAC, 2019a).**

The *3rd Mediterranean Symposium on the conservation of coralligenous and other calcareous bio-constructions* was organised by SPA/RAC in partnership with the Turkish Ministry of Environment and Urbanization and to the Association TUDAV (Turkish Marine Research Foundation) as part of the "Mediterranean Symposia on Marine Key habitats and NIS" Antalya Türkiye (14-18th of January 2019). The proceedings have been published with the financial support of MAVA Foundation through the MedKeyHabitats II project and is available here.

- **4th Mediterranean Symposium on the conservation of coralligenous and other calcareous bio-constructions (Genoa, Italy, 20-21 September 2022) (see proceedings UNEP/MAP-SPA/RAC, 2022).**

The *4th Mediterranean Symposium on the conservation of coralligenous and other calcareous bio-constructions* was organised by SPA/RAC in collaboration with the Italian Institute for Environmental Protection and Research (ISPRA), the university of Genoa and its department of Earth, the Environment and Life Sciences of the University of Genoa (DISTAV) and the association "Società Italiana di Biologia

Marina" (SIBM) as part of the "Mediterranean Symposia on Marine Key habitats and NIS" Genoa, Italy (19-23 September 2022). The proceedings have been published with the financial support of MAVA Foundation and the European Union and is available here.

- As provided for in the Action Plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea, **SPA/RAC published the guidelines for the assessment of the environmental impact on coralligenous/maerl assemblages (UNEP/MAP-SPA/RAC, 2021c)**:
  - UNEP/MAP - SPA/RAC. (2021). *Guidelines for the assessment of environmental impact on coralligenous and maërl assemblages* (No. UNEP/MED WG.502/Inf.3; p. 58). Tunis: UNEP/MAP SPA/RAC.

- SPA/RAC is supporting the elaboration of **National Action Plans on coralligenous assemblages in Lebanon and Montenegro** (see UNEP/MED WG.502/4).

- Within the framework of the "Co-managed No-Take Zones/MPAs project" (July 2020-October 2022), SPA/RAC is supporting the relevant national authorities of Algeria, Morocco, Tunisia and Turkey in elaborating and adopting **National Action Plans for the conservation of marine vegetation and coralligenous habitats** (UNEP/MED WG.502/4).

- SPA/RAC has published a **guidance document on monitoring protocols** of the Ecosystem Approach CI 1 and 2 related to benthic habitats including monitoring guidelines of coralligenous and other calcareous bioconstructions (UNEP/MAP-SPA/RAC, 2019b). Standardized protocols for the characterisation of CAs and RMBs and list of reference species for CAs can be found in this document:
  - UNEP/MAP-SPA/RAC. (2019). Monitoring protocols of the Ecosystem Approach Common Indicators 1 and 2 related to marine benthic habitats (Meeting Report No. UNEP/MED WG.474/3; p. 171). Tunis.

- An inventory of all the spatial information available and accessible at Mediterranean level and at national level was undertaken. The collection of available data and its aggregation following established criteria (scale, habitat types following the updated Reference List of Marine Habitat Types for the Selection of Sites to be Included in the National Inventories of Natural Sites of Conservation Interest in the Mediterranean) was finalised. A national consultation has been organized to get feedback from the Contracting Parties to the Barcelona Convention and to validate the data. The production of the distribution maps of coralligenous habitats will soon be ready and available on the Mediterranean biodiversity platform. A paper on the elaboration and available maps and the distribution of the marine key habitats is being prepared to be submitted to peer journal. (see UNEP/MED WG.548/4).

- SPA/RAC published a Poster on Mediterranean coralligenous assemblages in 2017 available in 10 Mediterranean languages here.

2.2. Other actions and publications at a regional scale

Red coral (Corallium rubrum) is a species that can be found in coralligenous assemblages and whose population dynamics has changed and its population has decreased mainly due to overfishing whether legal or illegal. Its fishing is strictly regulated and variable depending on the country. To help the conservation of this species, **FAO/GFCM** has elaborated recommendations for a management plan for the sustainable exploitation of red coral in the Mediterranean Sea REC.CM-GFCM/46/2023/13 (which can be found here) and which amends decisions GFCM/45/2022/2 and GFCM/43/2019/4. Further, GFCM/46/2023/19 (available here), recommends the establishment of a catch documentation scheme for red coral to better fight illegal fishing of the species.

European Union and its Members States have recently agreed on the Nature Restoration Law[8] which sets legally binding targets to restore at least 30% of the total area of groups 1 to 6 of the habitat types listed in Annex II that is not in good condition by 2030, 60% by 2040 and at least 90% by 2050 (see Article 5 of the law available here). Maerl beds (group 4) and coralligenous beds (group 5) are included in the marine habitats concerned. This law is of high importance for Marine Protected Areas as underlined by MedPAN (see article here) and for CAs and RMBs.

IUCN has contributed to several programmes on CAs and RMBs with SPA/RAC. Further, IUCN has published since 2016 two documents relative to CAs:

- Otero, M. M., Numa, C., Bo, M., Orejas, C., Garrabou, J., Cerrano, C., … Özalp, B. (2017). Overview of the conservation status of Mediterranean Anthozoa. IUCN, Gland, Switzerland, and Malaga, Spain.

- Otero, M. M., Serena, F., Gerovasileiou, V., Barone, M., Bo, M., Arcos, J. M., … Xavier, J. (2019). Identification guide of vulnerable species incidentally caught in Mediterranean fisheries (p. 204) [IUCN, Malaga, Espagne].

3. Evaluation of the implementation of the Action Plan at national level

The present evaluation of the *Action Plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea* at national level covers the period 2016 to 2023. National reports of 2016-2017, 2018-2019, 2020-2021 and 2022-2023 when available were taken in account. Coralligenous Action Plan section was completed at least for one period by 16 CPs (although 4 indicated no changes since 2016), not completed by 4 CPs (Albania, Libya, Syria, Tunisia) and not applicable to 1 CP (Bosnia and Herzegovina) due to the absence of the habitats.

A desk review preceded this evaluation and contributed to complete the information of the prefilled questionnaire for each of the 21 Mediterranean countries. These prefilled questionnaires were sent by SPA/RAC to CP's Focal Points for review, completion and amendments. Three countries sent feedback on the prefilled questionnaires. The information and data for the elaboration of the prefilled questionnaires originate from:

- the 2016-2017, 2018-2019, 2020-2021, 2022-2023 National Reports transmitted from the CPs through the BCRS reporting system concerning the implementation of the Protocol concerning Specially Protected Areas and Biological diversity in the Mediterranean (SPA/BD Protocol).
- the 2017, 2019, 2021 and 2023 reports on the implementation of the SPA/BD Protocol
- the SPA/RAC progress reports 2017, 2019, 2021 and 2023
- other UNEP/MAP-SPA/RAC reports
- scientific publications
- other reports and grey literature

The following analysis is based on the prefilled questionnaires and includes the feedback from the three countries. The prefilled questionnaire was considered as accepted by the Party when no feedback was sent.

[8] Regulation (EU) 2024/1991 of the European Parliament and of the Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869

The Parties were asked to inform about the status of implementation of the following actions and measures required to attain the objectives of the *Action Plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea:*

1. Improve habitat modelling methods which could provide new predictive models on coralligenous distribution and guide cost-effective field surveys for data acquisition.
2. Promote research programs on coralligenous assemblages and maerl beds.
3. Develop and implement legislation initiatives for the conservation of coralligenous assemblages.
4. Coordinate the design of an Integrated Monitoring and Assessment Program (IMAP) for the assessment of the state of coralligenous/maerl assemblages in view to be included in the assessment of the state of the Mediterranean.
5. Characterisation of coralligenous assemblages at national level.
6. Promote the declaration of marine protected areas to preserve coralligenous/maerl assemblages.
7. Identification and monitoring specific threats that impact coralligenous/ maerl assemblages.
8. Build-up a coralligenous/maerl distribution map.
9. Identification of potential sentinel sites of coralligenous assemblages to contribute to a Mediterranean network.

The results of the prefilled questionnaires concerning the above questions for 21 Mediterranean countries are synthesised in Table 5 and Figure 13.

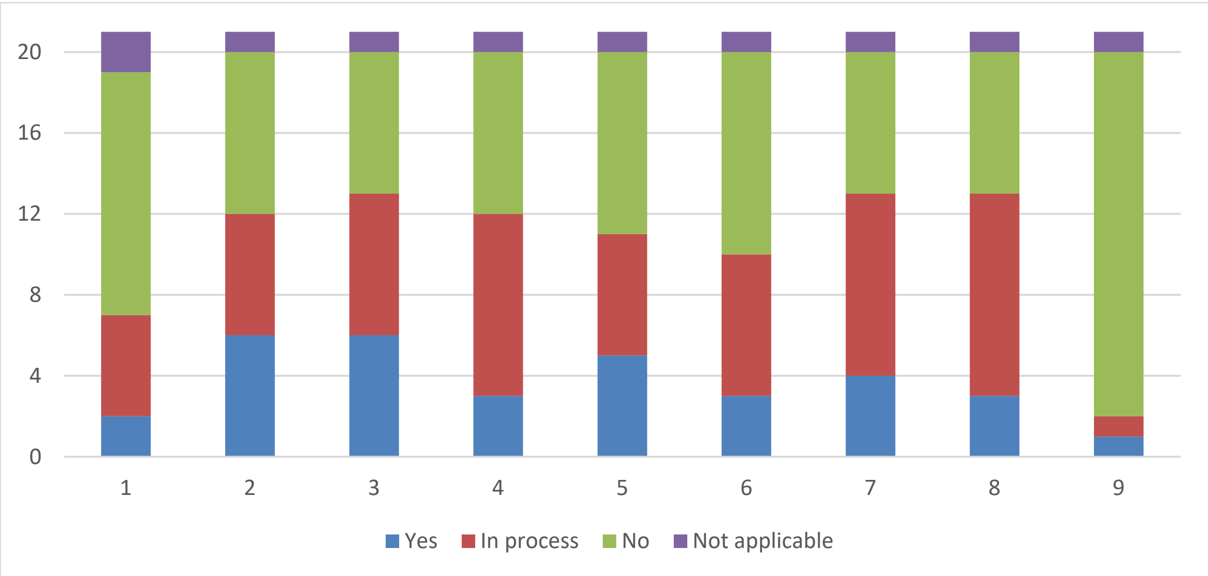


Figure 13. Bar chart of the results of the prefilled questionnaires regarding the implementation of the Action Plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea for 21 Contracting Parties.

Only 2 Contracting Parties have implemented and finalised at least 5 actions required in the 2016 Coralligenous Action Plan. Further, 13 CPs have implemented or are in process of implementing 5 or more actions. Actions 3 (legislation initiatives), 7 (monitoring specific threats) and 8 (build a distribution map) are the most implemented or in process of being implemented by the CPs. Action nine on the selection of sentinel sites is the least implemented followed by action 1 on improving habitat modelling.

The main challenges indicated by the Parties were the lack of financial resources and the administrative management barriers.

Table 5. Results of the prefilled questionnaires concerning the 9 questions regarding the implementation of the Action Plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea. Countries are listed in alphabetical order.

Country	**Question 1** Improve habitat modelling methods	**Question 2** Promote research programs	**Question 3** Develop and implement legislation initiatives	**Question 4** Coordinate the design of an IMAP on CAs and RMBs	**Question 5** Characterisation of CAs at national level	**Question 6** Promote the declaration of MPAs to preserve these assemblages	**Question 7** Identification and monitoring specific threats	**Question 8** Build-up a coralligenous /maerl distribution map	**Question 9** Identification of potential sentinel sites of CAs to contribute to a Mediterranean network
Albania	No	In process	In process	No	No	In process	No	No	No
Algeria	No	In process	No	In process	No	In process	In process	In process	No
B&H	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Croatia	In process	In process	Yes	In process	Yes	No	In process	In process	No
Cyprus	In process	Yes	Yes	In process	In process	Yes	In process	In process	No
Egypt	In process	In process	In process	In process	No	No	No	In process	No
France	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Greece	Yes	In process	In process	No	In process	No	In process	Yes	No
Israel	No	No	No	In process	No	No	No	No	No
Italy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	In process	Yes
Lebanon	No	No	In process	No	In process	In process	In process	In process	No
Libya	No	No	No	No	No	No	No	No	No
Malta	In process	Yes	Yes	Yes	Yes	In process	In process	No	No
Monaco	No	No	No	No	No	No	No	In process	No
Montenegro	No	In process	Yes	In process	Yes	No	Yes	Yes	No
Morocco	No	No	In process	In process	In process	In process	In process	In process	No
Slovenia	Not applicable	Yes	In process	No	In process	No	In process	No	No
Spain	In process	Yes	No	In process	In process	In process	Yes	In process	In process
Syria	No	No	No	No	No	No	No	No	No
Tunisia	No	No	In process	In process	No	In process	In process	In process	No
Türkiye	No	No	No	No	No	No	No	No	No

4. Conclusion

Since the 2016 *Action Plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea*, knowledge on the distribution, the composition, the vulnerability and the threats of these assemblages has improved. However, this knowledge is spatially uneven and often scattered underlining the fact that mapping of these assemblages at national scale must be enhanced.

Efforts are also needed to aggregate existing knowledge on spatial distribution of these assemblages at sub-regional and regional level. This means collecting spatial data on the existence of these assemblages, but also, information on the non-existence of the assemblages. This information is particularly important to refine predictive models.

Data acquisition methods tend to be based on acoustic means and images and appear as quite comparable throughout the Mediterranean. However, further inter-calibration and validation of agreed methods and indexes within sub-regions would allow to better compare the state of conservation of the assemblages throughout the Mediterranean Sea and facilitate integration of spatial data.

Coralligenous Assemblages (CAs) and Rhodolith and Maerl Beds (RMBs) which are considered priority habitats should be assessed and monitored through IMAP EO1 CI1 and CI2 and through MSFD EO6 D6C3, D6C4 and D6C5. They are also part of the priority habitats in the recent Restoration Law. This underlines the fact that these habitats are of high importance and their conservation must be a priority especially since they undergo high threat by climate change impacts.

Few CPs have implemented the actions requested by the 2016 *Action Plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea* and several CPs are in progress for their implementation. Table 5 and Figure 13 detail the implementation status by the CPs. Deadlines and actions agreed on in the 2016 Action Plan appear as too ambitious.

Annex 2 summarises the evaluation of the implementation of the actions scheduled in the 2016 Action Pan at national and regional scale.

Recent mortality events affecting CA key species on large geographic scales and with high frequency ring the bell for effective and rapid measures and actions at national and sub-regional scale for the conservation of these habitats.

5. Recommendations

- Due to the impact of Marine Heat Waves on erect gorgonians which are part of the coralligenous assemblages, it is meaningful to include deep coralligenous in MPA since deep areas (below 40 m) appear for the moment as refuge areas (Bramanti *et al.*, 2023).

- Given the mass mortality events it is worth considering to add threatened erect anthozoans such as *Paramuricea clavata* and perhaps *Eunicella* spp. (and perhaps other species) in the SPA/BD protocol Annex II list. This would strengthen cohesion between SPA/BD and the Action Plan.

- For monitoring, many replicates are needed due to the natural variability of the assemblages even on local scale (see Casas-Güell *et al.*, 2016)

- For CPs that have not yet mapped spatial and bathyal distribution of coralligenous and other calcareous bio-concretions, the approach adopted by Molina *et al.*, 2016 consisting of proceeding first with an extensive literature review and completing information, when necessary, by acoustic mapping and *in situ* observations could be a cost-effective assessment procedure.

- Data availability is a key issue to assess the state of CAs and MRBs at regional scale. All collaborative platforms, including volunteer quality checked data acquisition or citizen science (see Gerovasileiou *et al.*, 2016; Di Camillo *et al.*, 2018; Turicchia *et al.*, 2021) should be encouraged to enable a regional view especially regarding key structuring species populations that undergo severe damages from climate change and mortality events (e.g. Garrabou *et al.*, 2019, 2022 see also Di Camillo *et al.*, 2018).

- Initiatives such as CorMedNet which is a collaborative platform (see Linares *et al.*, 2020 for the dataset and Linares *et al.*, 2022) that has already gathered information on distribution, demography and conservation status of key coralligenous species between 1881 and 2019, should be supported. Further, contributions to this platform from the CPs should be encouraged. Several publications have used these available datasets to publish analysis on the assemblages (e.g. Bramanti *et al.*, 2023). Perhaps mapping of CAs could be added to construct an accessible and up to date map of spatial distribution of CAs.

- By comparing updated map of CAs based on literature and national reports with predictive map of CAs, priority areas for data acquisition on spatial distribution could be defined at regional level. The same could be proposed for RMBs (see https://emodnet.ec.europa.eu/en/map-week-maerl-habitats). However as already mentioned, it is also important to use the information of non-presence of CAs and RMBs where spatial distribution models estimate a high probability of harbouring these habitats in order to enforce the reliability of prediction maps.

- The resolution GFCM/43/2019/6 on the establishment of a set of measures to protect vulnerable marine ecosystems formed by cnidarian (coral) communities in the Mediterranean Sea does not include cnidarians from coralligenous assemblages. Perhaps cnidarians such as *Paramuricea* spp. and *Eunicella* spp. could be considered as indicators of Mediterranean VMEs given the impact of fishing gear on coralligenous assemblages.

- Deadlines and actions agreed on in the 2016 Action Plan appear as too ambitious. It is important to define feasible actions that can be led by a majority of CPs.

- The new action plan could further integrate approach and requests from IMAP, Ecosystem approach and MSFD.

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Appendix I
Coralligenous assemblages (CAs) and Rhodolith/Maerl beds (RMBs) classification

	Revised EUNIS classification system	**Revised Barcelona convention classification system (Montefalcone *et al.*, 2021)**	**European Red List of habitats (LRMED)**
Infralittoral			
Coralligenous assemblages	**MB151a** Facies and association of coralligenous biocenosis (in enclave)	**MB1.55** Coralligenous (enclave of circalittoral)	**MEDA5.6x** Infralittoral biogenic habitats in the Mediterranean - coralligenous bioconcretions
Rhodolith/Maerl beds	**MB3511** Association with rhodoliths in coarse sands and fine gravels mixed by waves	**MB3.51** Infralittoral coarse sediment mixed by waves → **MB3.511** Association with maerl or rhodoliths **MB3.52** Infralittoral coarse sediment under the influence of bottom currents → **MB3.521** Association with maerl or rhodoliths	**MEDA5.51** Rhodolith beds in the Mediterranean
Circalittoral			
Coralligenous assemblages	**MC151** Coralligenous biocenosis **MC251** Coralligenous platforms **MC252** Mediterranean circalittoral biogenic habitat	**MC1.5** Circalittoral rock → **MC1.51** Coralligenous cliffs → **MC1.52** Continental shelf ○ **MC1.52a** Coralligenous outcrops ○ **MC1.52b** Coralligenous outcrops covered by sediment **MC2.5** Circalittoral biogenic habitat → **MC2.51** Coralligenous platforms	**MEDA5.6y** Circalittoral biogenic habitats in the Mediterranean - coralligenous bioconcretions
Rhodolith/Maerl beds	**MC351** - Association with rhodoliths on coastal detritic bottoms **MC352** - Assemblages of Mediterranean coastal detritic bottoms biocenosis with rhodoliths → **MC3523** - Association with maerl (*Lithothamnion corallioides* and *Phymatolithon calcareum*) on coastal dendritic bottoms	**MC3.5** Circalittoral coarse sediment → **MC3.52** Coastal detritic bottoms with rhodoliths ○ **MC3.521** Association with maerl	**MEDA5.51** Rhodolith beds in the Mediterranean

Appendix II
Global evaluation of the actions scheduled in the 2016 AP Implementation table

Action	To be implemented by	Deadline	Status of implementation	Finalised/under development
1. Build and publish the database of scientists and research institutions working on the coralligenous assemblages and maerl beds.	SPA/RAC	2016		Under development
2. Guidelines for the assessment of environmental impact on coralligenous/maerl assemblages	SPA/RAC	2017	Document published by UNEP/MAP-SPA/RAC: UNEP/MAP - SPA/RAC. (2021c). *Guidelines for the assessment of environmental impact on coralligenous and maërl assemblages* (No. UNEP/MED WG.502/Inf.3; p. 58). Tunis: UNEP/MAP SPA/RAC.	**Finalised**
3. Development of Working Groups on coralligenous assemblages and maerl beds.	SPA/RAC Contracting Parties	2016		Under development
4. Buid-up a coralligenous/maerl assemblages distribution online database	SPA/RAC Contracting Parties	2018		Under development
5. Improve habitat modelling methods could provide new predictive models on coralligenous distribution and guide cost-effective field surveys for data acquisition	Contracting Parties	2017	Some CPs have provided new predictive maps but this action seems less a priority since predictive maps of CA and RMB have been elaborated by EMODnet and are available online for the Mediterranean Sea. However, CPs could further inform on the absence of CA and RMB in areas where these were predicted by EMODnet maps.	**Finalised**
6. Characterization of coralligenous habitats at regional scale	SPA/RAC Contracting Parties	2018	Document published by UNEP/MAP-SPA/RAC: : UNEP/MAP-SPA/RAC. (2021b). *Interpretation Manual of Marine Habitat Types in the Mediterranean Sea (UNEP/MED WG.502/Inf.4)* (p. 426). Tunis.	**Finalised**
7. Build-up a Check-list / Reference species list for the coralligenous assemblages	SPA/RAC	2016	Typical species of associated communities can be found in the document published by UNEP/MAP-SPA/RAC: UNEP/MAP-SPA/RAC. (2021b). *Interpretation Manual of Marine Habitat Types in*	Under development

Action	To be implemented by	Deadline	Status of implementation	Finalised/under development
			the Mediterranean Sea (UNEP/MED WG.502/Inf.4) (p. 426). Tunis. However an exhaustive list was not identified.	
8. Development of standardized protocols for the characterization of coralligenous /maerl assemblages.	Contracting Parties SPA/RAC-	2017	Document published by UNEP/MAP-SPA/RAC: UNEP-MAP-RAC/SPA. (2015b). *Standard methods for inventorying and monitoring coralligenous and rhodoliths assemblages. Pergent G., Agnesi S., Antonioli P-A., Babbini L., Belbacha S., Ben Mustapha K., Bianchi C. N., Bitar G., Cocito S., Deter J., Garrabou J., Harmelin J-G, Hollon F., Mo G., Montefalcone M., Morri M., Parravicini V., Peirano A., Ramos-Espla A., Relini G., Sartoretto S., Semroud R., Tunesi L., Verlaque M.* (p. 20pp.+Annex) [Ed. RAC/SPA].	**Finalised**
9. Development of indices and/or intercalibration initiatives to determine conservation environmental status of coralligenous	Contracting Parties SPA/RAC-	2017	Document published by UNEP/MAP-SPA/RAC: UNEP/MAP-SPA/RAC. (2019b). *Monitoring protocols of the Ecosystem Approach Common Indicators 1 and 2 related to marine benthic habitats* (Meeting Report No. UNEP/MED WG.474/3; p. 171). Many indices have been defined in the scientific literature. A selection could be done on the most cost effective and informative for proposed use by the CPs. Intercalibration of evaluation of environmental status of coralligenous assemblages still need to be carried out.	Under development
10. Set a network of sentinel sites on coralligenous across the Mediterranean	SPA/RAC Contracting Parties	2020	Mapping of coralligenous assemblages have been carried out in several MPAs that could serve as sentinel sites however they are not formally	Under development

Action	To be implemented by	Deadline	Status of implementation	Finalised/under development
			identified as sentinel sites. Further, impacted areas should also be part of such a network.	
11. Promote research programs on coralligenous assemblages and maerl beds	Contracting Parties	2016	Several CPs have contributed to SPA/RAC efforts to map CAs and RMBs. Also, several EU states have set research programmes to assess the state of these assemblages. This action still needs to be continued especially under climate change impacts on the assemblages.	To be continued
12. Develop and implement legislation initiatives for the conservation of coralligenous assemblages	Contracting Parties	ongoing	Out of 20 CPs concerned, 6 CPs have implemented this action, 7 are in process of implementing it, 7 haven't yet implemented it.	Under development
13. Coordinate the design of an Integrated Monitoring and Assessment Program for the assessment of the state coralligenous/maerl assemblages in view to be included the assessment of the state of the Mediterranean	Contracting Parties	2016	As reported by Kipson *et al.* (2022), over 50% of the CPs include coralligenous and circalittoral rhodolith beds in their national monitoring programmes which are either on ongoing phase, planning phase or unknown phase (>60% for CI1, >50% for CI2). However, efforts are still needed. Published national monitoring programmes with the contribution of SPA/RAC under EcApMed II project including CAs /RMBs: Lebanon, Marocco, Tunisia,	Under development
14. Promote the declaration of marine protected areas to preserve coralligenous assemblages in coastal and offshore areas	Contracting Parties SPA/RAC-	2018	UNEP/MAP-SPA/RAC has deployed considerable efforts in collaboration with the concerned CPs to assess coralligenous assemblages either in existing MPAs or in view of the establishment of a MPAs in several CPs Marocco (Jbel Moussa), Lebanon (Batroun, Medfoun and Byblos), Lebanon (Jounieh),	Should be continued
15. Build-up a coordination platform on different initiatives devoted to the coralligenous/maerl assemblages	SPA/RAC	2017		Under development

Action	To be implemented by	Deadline	Status of implementation	Finalised/under development
16. Organize a Symposium on coralligenous assemblages and maerl beds every 3years	SPA/RAC	2018	3rd Mediterranean Symposium on the conservation of coralligenous & other calcareous bio-constructions, 15-16 January 2019, Antalya Turkey. Proceedings 4th Mediterranean Symposium on the conservation of coralligenous & other calcareous bio-constructions, 20-21 September 2022, Genoa, Italy. Proceedings	**Finalised for the period but should be continued**
17. Preparation of a communication plan to raise the awareness on the importance of coralligenous assemblages and maerl beds for the conservation of Mediterranean biodiversity	SPA/RAC	2017	Poster on coralligenous but no real communication plan found.	under development